Semester – III

General Biology

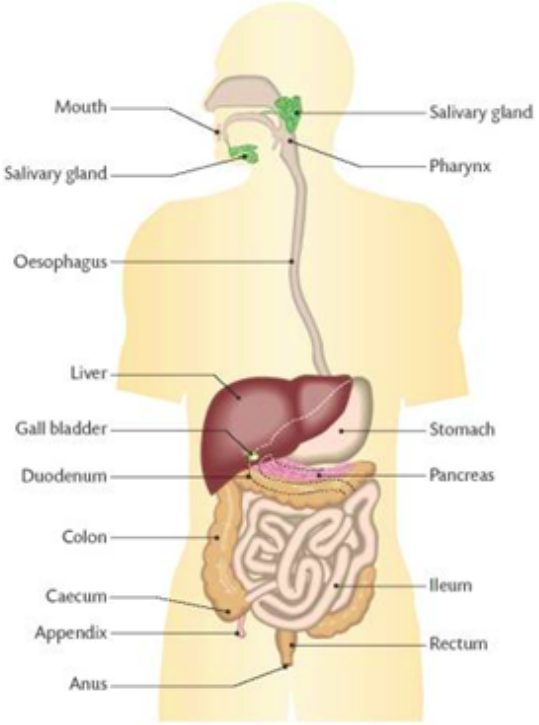
Unit I: Human Physiology – I

Module No: 1 (III) The alimentary canal: Structure, Function and Peristalsis

Digestion is the process that involves chemical breakdown of complex food materials into simpler molecules which can be readily used by the animal through absorption and assimilation. The organs of the digestive system carry out these processes. The digestive system consists of the alimentary canal (also known as gastro intestinal tract) and the digestive glands. The structure of the human digestive system is adapted to the ominivorous diet.

Alimentary canal

The human digestive system consists of an alimentary canal which is approximately 8meters long through which food passes. The alimentary canal carries out digestion, absorption and egestion. The alimentary canal is a long, coiled tube of variable diameter. It is suspended in the body cavity by the mesentery. It consists of mouth, buccal cavity, pharynx, oesophagus, stomach, small intestine, large intestine and anus.



Mouth and Buccal cavity

It is anterior most opening of alimentary canal guarded by two lips which ingest food. The mouth opens into buccal cavity. It has a muscular tongue on which are arranged taste buds. There are two rows of teeth – Upper and lower. Teeth are thecodont, diphyodont and heterodont. The total number of teeth in an adult Man is 32, which are four different types namely incisors (I), canines (C), Premolars (Pm) and molars (M)

Dental formula is I 2/2, C 1/1, Pm 2/2, M 3/3

In Man three pairs of salivary glands are present (Parotid, Sub maxillary, and sublingual glands) and secrete saliva which keeps the buccal cavity moist.

The food is masticated in the mouth by teeth and mixed with the saliva. The tongue helps to keep the food between the chewing surfaces of the upper and lower teeth by manipulating it against the hard palate, the bony membrane – covered roof of the mouth. The ball of food formed with the help of the tongue is known as bolus.

Pharynx

It is the portion of the alimentary canal after the mouth. It is a funnel shaped passage common to air and food. The oesophagus and the trachea open into the pharynx. Opening of trachea is called glottis. A cartilaginous flap called epiglottis prevents the entry of food into the glottis.

Oesophagus

It is a long, narrow straight muscular but dilatable tube, which passes backwards through the neck and thorax. It pierces the diaphragm to open into the stomach which is situated in the abdominal cavity. A muscular sphincter regulates the opening of oesophagus into the stomach.

Stomach

The oesophagus opens into the stomach. The stomach lies on the left side of the abdomen. It is a J – shaped, dilated sac like organ, which is connected to the oesophagus at the anterior end by a cardiac sphincter and to the small intestine at the posterior end by a pyloric sphincter. The stomach is an elastic organ with the wall having folds. These folds open out to accommodate more food.

The stomach is divided into three regions: the fundus, the body and the pyloric antrum. At the distal end of the pyloric antrum is the pyloric sphincter, guarding the opening between the stomach and the duodenum. The fundus and body are thin walled and act as a reservoir for ingested food.

The presence of the bolus in the pharynx stimulates a wave of peristalsis that propels the bolus through the oesophagus to the stomach. In the stomach, the food is mixed with gastric juices and then passes to the duodenum from pyloric antrum. The mixture of food is known as chyme. Epithelial lining of stomach has mucous secreting and gastric juice secreting cells. The epithelium also forms long infolds that act as gastric glands.

Gastric muscle contraction consists of churning movement that breaks down the bolus and mixes it with gastric juice, and peristaltic waves that propel the stomach contents towards the pylorus. Strong peristaltic contraction of the pyloric antrum forces chyme, gastric contents after they are sufficiently liquefied, through the pylorus into the duodenum in small spurts.

Small intestine

It is a long structure of about 6 meters in length, which is narrower than stomach. It has 3 main portions.

a) **Duodenum**

It is a short and is about 25cm long and 'C' shaped portion of the small intestine closest to the stomach. Secretions from gall bladder and pancreas are released into the duodenum through hepato pancreatic duct.

b) **Jejunum**

It is the middle region of small intestine about 2-5m length where no digestion occurs.

c) **Ileum**

The ileum is highly coiled and narrow region measuring about 3 meters in length and ends at the ileocaecal valve, which controls the flow of the materials from ileum to the caecum, the first part of the large intestine and prevents regurgitation. The walls of the small intestine are thrown into number of folds. Further, the walls also show finger like projections called the villi.

Villi

Each villus is made up of connective tissue and smooth muscles. The free surfaces of the villi towards the lumen of the small intestine have microvilli. The intestinal folds, villi and microvilli together greatly increase the surface area of the small intestine. This allows for maximum absorption of digested food by the intestinal wall.

At the junction of the adjacent villi are found crypts of Lieberkuhn which secrete intestinal juice (succus entericus). At the base of crypts are found paneth cells that secrete lysozyme an antibacterial enzyme.

Large intestine

Small intestine enlarges slightly to form a tubular large intestine which is about 1.5 meters long. It has three portions.

a) **Caecum**

It is a portion of the large intestine that is not very well developed in man. In man, it shows a small projection called the appendix. It is a vestigial organ without any function.

b) **Colon**

It has four portions – the ascending colon, transverse colon, descending colon and the pelvic colon.

c) **Rectum**

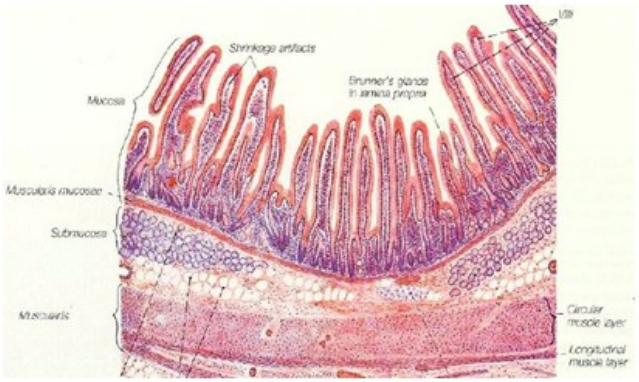
It is a bag like structure which ends in an opening called the anus. The rectum stores the undigested food as faecal matter till it can be passed out. Two sphincter muscles control the anus; the internal sphincter consisting of smooth muscle is under the control of the autonomic nervous system and the external sphincter, formed by skeletal muscle, is under voluntary control.

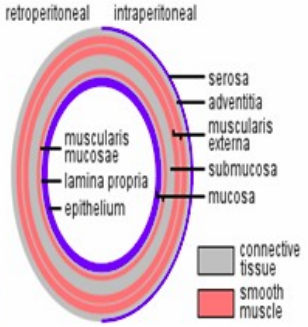
Histology of Alimentary Canal

The wall of alimentary canal is formed by four layers, namely outer serosa, muscle layer, sub mucosa and mucosa. Serosa is the outermost layer of squamous epithelium and connective tissue. Inner to serosa, muscle layer is present and is composed of outer longitudinal muscles and inner circular muscles. Both are smooth muscles and help in peristalsis. An oblique muscle layer may be present in some regions. Below the muscle layer is present sub mucosa. The sub mucosa consists of loose connective tissue richly supplied with blood and lymph capillaries. Mucosa is the inner most layer. It secretes mucous to lubricate inner lining of the gut. It is composed of three layers

a. **Muscularis mucosa** – Present just below the sub mucosa
b. **Lamina propria** – It is the middle layer consists of loose connective tissue, blood vessels and glands
c. **Epithelium** – It is the innermost layer which consists of gastric glands in the stomach and intestinal glands and villi in small intestine

All the four layers show modifications in different parts of the alimentary canal.





Digestive Glands

The alimentary canal is actually equipped with its legendary power of digestion due to its association with a variety of digestive glands beginning from buccal cavity to the intestine.

The digestive glands associated with the alimentary canal include salivary glands, gastric glands, intestinal glands, liver and pancreas

Liver (will be covered in detail in future modules)

It is the largest gland of the body, reddish brown in colour situated in the upper right side of the abdominal cavity just below the diaphragm and has two lobes. The hepatic lobules are the structural and functional units of liver. Liver secretes bile. Bile is an alkaline secretion which is responsible for emulsification of fats in the duodenum

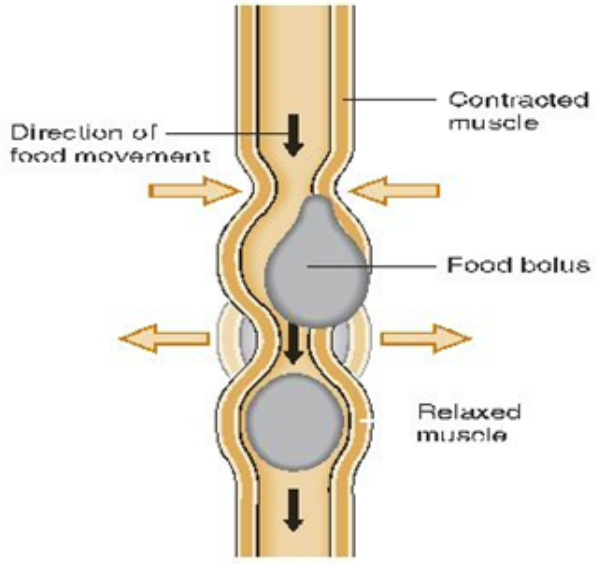
Pancreas (will be covered in detail in future modules)

Pancreas is elongated C-shaped organ situated between the limbs of the 'U' shaped duodenum. Pancreas is both an exocrine and an endocrine organ. The exocrine portion secretes an alkaline pancreatic juice containing enzymes for the digestion of proteins, carbohydrates and fats while the endocrine portion secretes hormones like insulin and glucagon.

Peristalsis

Peristalsis is a special method of muscular contraction by which the food bolus is carried down the oesophagus or any other segment of the alimentary canal. Peristalsis may be defined as a wave of rhythmic Co-ordinated muscular contraction preceded by a wave of relaxation which causes the contents of gastro intestinal tract to be passed onwards. Peristaltic movement is initiated by circular smooth muscles. The circular muscles of the digestive tube immediately behind the bolus contract and those directly in front of it relax. This results in the bolus being forced into the relaxed portion. The contraction of muscles follows closely behind the bolus and further relaxation occurs in front of it, thus the bolus of food passes steadily forwards.

Peristalsis takes place throughout the digestive tract. Peristalsis is involuntary and is controlled by nerve impulses stimulated by the tracts contents. You cannot control it. It is also what allows you to eat and drink while upside down.



Check points

- The digestive system consists of alimentary canal and the digestive glands
- Human alimentary canal is about 8 meters long
- Teeth are thecodont, diphyodont, and heterodont
- Dental formula of man is $\frac{2\text{-}1\text{-}2\text{-}3}{2\text{-}1\text{-}2\text{-}3}$
- Three pairs of salivary glands are present in man and secrete saliva.
- Epiglottis prevents the entry of food into the glottis
- Stomach is "J" shaped sac like organ divided into fundus, the body and the pyloric antrum
- Partially digested food present in the stomach is called chyme
- Small intestine is about 6 meters in length and divisible into duodenum, jejunum and ileum
- The intestinal folds, villi and microvilli together increase the surface area of absorption
- Crypts of Lieberkuhn secrete intestinal juice
- Paneth cells secrete antibacterial enzymes known as lysozyme
- Large intestine has three portions namely caecum, colon and rectum
- Appendix is vestigial organ without any function.
- Histological structure of the alimentary canal shows the presence of four layers namely – serosa, muscle layer, sub mucosa and mucosa
- Liver secretes bile which helps in emulsification of fats
- Pancreas acts both as an exocrine and endocrine gland
- Peristalsis is a wave of smooth muscle contractions that propels food materials along the digestive tract.

Glossary

Thecodont: Teeth fixed in sockets of jaw bone.

Heterodont: Different types of teeth.

Diphyodont: Two sets of teeth develop during the life time.

Regurgitate: To bring food that has been swallowed back up into the mouth again.

Sphincter: A ring of muscle that surrounds an opening in the body and can contract to close it.

Mesentery: A thin sheet of tissue, bounded on each side by peritoneum, that supports the gut and other organs in the body cavities of animals.

Palate: The roof of the mouth of vertebrates, which separates buccal and nasal cavities.

Semester – III

General Biology

Unit: I Human Physiology – 1

Module No: 2 (III) Digestion

Digestion can be defined as a process that involves chemical break down of complex food materials into simpler molecules which can be readily used by the animal through absorption and assimilation. The process is divided into mechanical and chemical digestion. Mechanical digestion comprises liquifying of food by the digestive juices, mastication, swallowing etc.

Chemical digestion is a process of hydrolysis in which a complex food molecule combines chemically with water in the presence of an enzyme and is split into two or more simpler molecules. The structural plan of the alimentary canal consists of the following essential regions- mouth, buccal cavity, pharynx, oesophagus, stomach, small and large intestines. In addition, there are several digestive glands.

The digestion can be discussed under the following heads.

1. Digestion in the mouth

The food enters the digestive tract through the mouth or oral cavity. The food is chewed or masticated with the help of teeth to breakdown the food material into smaller pieces. There it mixes up with the saliva secreted by the salivary glands. In man three types of saliva glands are present in pairs i.e., parotid glands in the upper jaw, sublingual and sub maxillary in the lower jaw. The saliva (Ph 6.8) contains water (99.4 %), mucous and a digestive enzyme called the salivary amylase (ptyalin) that acts on starch. Mucous in saliva helps in lubricating and adhering the masticated food particles into a bolus. Salivary amylase act on starch converting it into maltose.

There are no digestive juices secreted into the oesophagus, and the food simply passes through the oesophagus to the stomach.

$$\text{Starch} \xrightarrow[\text{Ph 6.8}]{\text{Salivary Amylase}} \text{Maltose}$$

2. Digestion in the stomach

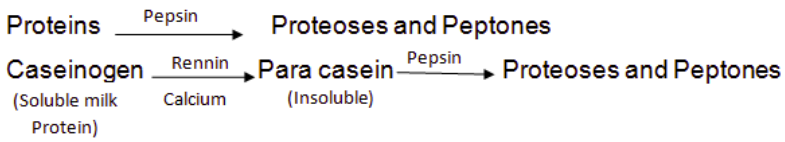
When stimulated by the presence of food, the gastric mucosa produces a hormone called gastrin which passes directly into the circulating blood. This hormone stimulates the gastric glands in the stomach wall to produce gastric juice.

The gastric glands consist of 3 kinds of cells:

1. Chief cells or Peptic cells which secrete pepsinogen.
2. Oxyntic cells or Parietal cells which produce Hcl and
3. Mucous cells which secrete mucous.

The gastric juice is composed of water, mucin, salts, Hcl and three enzymes, pepsin, rennin and gastric lipase. The pepsin is produced as the inactive precursor pepsinogen. The Hcl performs several functions in the stomach. First, it kills several bacteria that are swallowed with the food. It converts inactive pepsinogen into active pepsin and provides an acid medium for the action of pepsin.

Pepsin is a proteolytic enzyme and reacts with food materials only in the acid medium. It converts proteins into proteoses and peptones. The mucous and bicarbonates present in the gastric juice play an important role in lubrication and protection of the mucosal epithelium from Hcl. Rennin is a proteolytic enzyme found in the gastric juice of infants which helps in the digestion of milk proteins (caseinogen). Small amounts of lipases (Fat splitting enzymes), are also secreted by the gastric glands and acts on the fats.



3. Digestion in the small intestine

The semi digested food or Chyme from the stomach passes into the upper part of the intestine or duodenum where it is finally digested.

Three types of juices enter the intestine in the duodenum. They are

1. Intestinal juice secreted by the duodenal wall
2. Pancreatic juice from the Pancreas
3. Bile from the Liver.

The pancreas secretes its digestive juice almost entirely by means of hormonal stimulation. The hormones secretion and pancreozymin secreted by duodenum as a result of stimulation by Hcl and partially digested food stuffs, stimulate pancreas for secreting pancreatic juice. The hormone cholecystokinin , secreted by the wall of the small intestine , stimulates the gall bladder to undergo contraction which result in the flow of bile into the duodenum. On entering the small Intestine, chyme stimulates the mucous membrane to secrete the hormone enterocrinin which induces the flow of intestinal juice from intestinal glands.

The Pancreatic juice

The pancreatic juice and bile are released through the hepato-pancreatic duct. The pancreatic juice contains enzymes for the digestion of complex food materials like proteins, carbohydrates, fats and nucleic acids. The action of pancreatic enzymes on food material depends upon the emulsifying action of bile.

The three proteases present in the pancreatic juice are chymotrypsin, trypsin and corboxy- polypeptidase. The Chymotrypsin and trypsin are secreted in inactive form like Chymotrypsinogen and trypsinogen. Trypsinogen is converted into active trypsin by the intestinal enzyme, the enterokinase. In turn the trypsin activates the Chymotrypsinogen into chymotrypsin. The trypsin and chymotrypsin react with proteins, hydrolyzing them to proteoses, peptones, polypeptides and into amino acids. Carboxy polypeptidase hydrolyzes polypeptides to simpler peptides and amino acids.

Pancreatic Amylase hydrolyses starch to maltose. Fats are broken down by pancreatic lipase to monoglycerides and diglycerides. Nucleases in the pancreatic juice acts on nucleic acids to form nucleotides and nucleosides. Bile helps in emulsification of fats. Bile also activates lipases. Bile contains bile pigments (bilirubin and biliverdin), bile salts, cholesterol and phospholipids but no enzymes.

The intestinal juice: (Succus entericus)

Intestinal juice contains several enzymes which are necessary to complete the gastric digestion. The enzymes present in the intestinal juice and their functions are as follows:

1. Erepsin - complete the gastric digestion of peptones and proteoses and splits them into amino acids.
2. Maltase – converts maltose into glucose.
3. Sucrase – splits sucrose to glucose and fructose.
4. Lactase – breakdown lactose (milk sugar) into glucose and galactose.
5. Peptidases – the intestinal juice also contains some peptidases (amino peptidases, dipeptidases) which complete the digestion of various peptides to amino acids.

In addition, a lipase, as well as a number of enzymes for the hydrolysis of nucleic acids (nucleases, nucleotidase, nucleosidase) also occur in the intestinal juice.

$$\text{Nucleotides} \xrightarrow{\text{Nucleotidase}} \text{Nucleosides} \xrightarrow{\text{Nucleosidases}} \text{Salts + Bases.}$$

$$\text{Di and Monoglycerides} \xrightarrow[\text{Lipases}]{} \text{Fatty acids + Glycerol.}$$

The simple substances thus formed are absorbed in the jejunum and ileum regions of the small intestine. The undigested and unabsorbed substances are passed on to the large intestine. No significant digestive activity occurs in the large intestine.

Absorption and assimilation

It is the process by which the end products of digestion pass through the intestinal epithelium and enter the blood stream. In humans, there is little absorption in the stomach which can absorb water, alcohol and small amounts of mineral salts. Small intestine is the most suitable and well adapted region for absorption. The small intestine has an expensive absorbing surface formed due to the large number of small papilliform intestinal villi containing network of blood and lymph capillaries, which can readily absorb the digested food substances. The absorption is carried out by passive, active or facilitated transport mechanisms.

Carbohydrates of the food are converted into monosaccharides (glucose, fructose and galactose) during digestion. These monosaccharides are directly absorbed into the blood by simple diffusion depending upon the concentration gradient. However, some substances like fructose and some amino acids are absorbed with the help of the carrier ions like Na^+ by facilitated transport.

Fats are converted into glycerol and fatty acids. Fatty acids and glycerol being insoluble cannot be absorbed into the blood; they are first incorporated into small droplets called micelles which move into the intestinal mucosa. They are reformed into very small protein coated fat globules called the chylomicron which are transported into the lymph vessels (lacteals) in the villi. These lymph vessels ultimately release the absorbed substances into the blood stream. Thus, micelles markedly increase the rate of delivery of the fatty acids and glycerol to the intestinal mucosa, which represents the absorptive surface. This process of absorption is largely completed in the upper jejunum.

At the end of proteins digestion most of the proteins are converted to amino acids. The free amino acids are absorbed both by diffusion and active transport. Nucleic acids are hydrolyzed to nucleotides and nucleosides. These substances are absorbed by the mucosal cells of small intestine. Most of the water is reabsorbed into the blood throughout the length of intestine.

The absorbed substances finally reach the tissues which utilize them for their activities. This process is called assimilation.

Undigested materials are eliminated from the lower part of the intestine in the form of faeces. The egestion of faeces to the outside through the anal opening is a voluntary process and is carried by a mass peristaltic movement.

Check Points

- Digestion is the process which changes insoluble food into soluble substances. The changes are brought about by chemicals called digestive enzymes. Digestion takes place in the alimentary canal.
- In man three pairs of salivary glands are present. Saliva contains ptyalin or salivary amylase enzyme which acts on starch converting it into maltose.
- Oxyntic cells of the gastric glands produce Hcl, which converts inactive pepsinogen into active pepsin. Pepsin converts proteins into proteoses and peptones.
- The three proteases (Protein splitting enzymes) present in pancreatic juice are Trypsin, Chymotrypsin and Carboxy polypeptidase.
- Pancreatic amylase splits starch to maltose.
- Maltase is an intestinal enzyme hydrolyses maltose to glucose.
- Sucrase digests sucrose to glucose and fructose.
- Lactase digests lactose to glucose and galactose.
- Lipases are fat digesting enzymes present in pancreatic and intestinal juice. They hydrolyse fats into diglycerides, mono glycerides and fattyacids in alkaline medium.
- Absorption of digested food takes place through villi.
- The elimination of faeces through anus is called egestion or defecation.

Glossary

Facilitated transport:

The transport of molecules across the outer membrane of a living cell by a process that involves a specific carrier located within the cell membrane but doesn't require expenditure of energy by the cell. The carrier is believed to combine with a molecule on one side of the membrane, move through the membrane, and release the molecule on the other side.

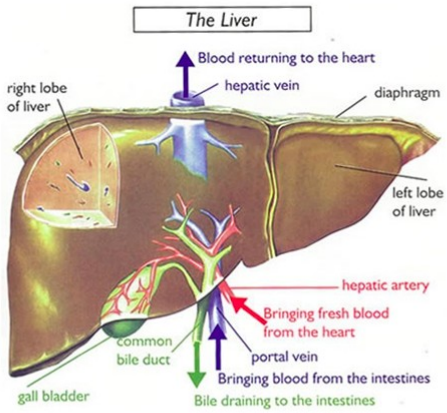
Semester – III

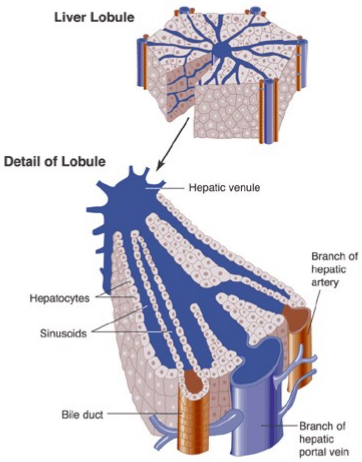
General Biology

Unit II: Human Physiology – II

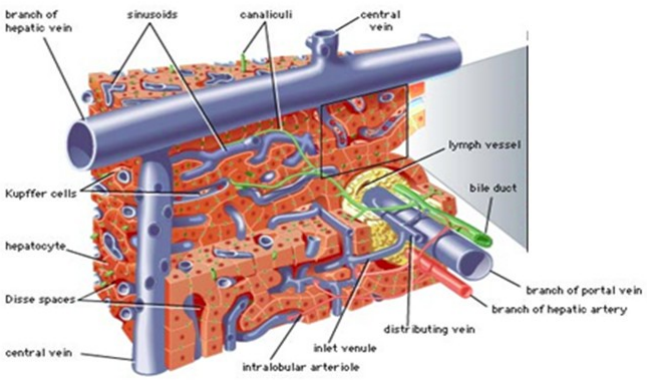
Module No: 10 (III) Physiology of Liver

Liver is the largest gland in the body present on the right side of the stomach below the diaphragm. It is reddish brown in color and made up of 4 lobes in man – right, left, quadrate and caudate lobe. Between the right and left lobes is present a green colored sac called gall bladder. Gall bladder is absent in many mammals like rodents, whales etc. Each lobe of liver is formed by several hepatic lobules. Each lobular unit consists of parenchyma and sinusoids. Parenchyma is composed of closely packed hepatocytes arranged radially to form of hepatic cords.





Bile is secreted by hepatocytes. Bile is collected by the bile canaliculi present between the hepatocytes. Bile canaliculi open into bile ducts. Opening of the bile duct is guarded by Sphincter of oddi. Between the hepatic cords, blood filled sinusoids are present. Large, irregular shaped von kupffer cells are present in sinusoids. Digestive enzymes are absent in bile juice.



Functions of Liver

1. **Secretion:**
   Liver secretes bile. Bile contains bile salts like taurocholate and glycocholate of sodium and potassium, bile pigments (biliverdin and bilirubin), Cholesterol, mucin, lecithin and fats etc. Bile helps in digestion by emulsifying fats, and helps in the absorption of fats from the intestine. Bile prevents putrification of food by checking the growth of bacteria, makes the chyme better suited for pancreatic digestion by neutralizing the acid in it.

2. **Excretion:**
   Bile pigments such as bilirubin and biliverdin are the waste products formed by the break down of haemoglobin of worn out erythrocytes in the liver. Bile is their route of excretion.

3. **Glycogenesis:**
   Excess of carbohydrates (glucose) are converted into glycogen in the presence of insulin in liver cells.
4. **Glycogenolysis:**
   When there is a need of Glucose, the glycogen (reserve food material) is broken down to glucose and released into the blood by the liver.

5. **Gluconeogenesis:**
   Liver converts proteins and fats into glucose by complex chemical reaction.

6. **Lipogenesis:**
   The liver converts excess glucose of blood into fats and store them.

7. **Transamination and Deamination:**
   Proteins are digested to amino acids. These amino acids come into the liver from intestine. They are partly released into the blood as per the requirement and partly converted into other amino acids by a process called Transamination. Amino group from amino acids is removed by a process called Deamination and free ammonia is liberated. The toxic ammonia is converted into urea in the liver.

8. **Haemopoiesis:**
   In the embryo, red blood cells are manufactured by the liver.

9. **Blood clotting:**
   Fibrinogen, prothrombin and certain other blood coagulation factors are formed in the liver which are instrumental in blood clotting. Liver produces Heparin an anticoagulant, which prevents the blood coagulation in blood vessels.

10. **Production of Plasma proteins:**
    Liver also produces plasma albumens and Globulins.

11. **Synthesis and storage of Vitamins:**
    Liver synthesizes vitamin A from carotenes. It also stores vitamins like A, D, K, E and B_{12}.

12. **Detoxification:**
    Liver is the detoxifying organ. It detoxifies different toxic substances either produced in the body or taken along with food.

13. **Alcohol metabolism:**
    The metabolism of alcohol takes place in liver. Alcohol is converted to acetaldehyde and acetyl CoA in the liver.

14. **Phagocytosis:**
    The von kupffer cells of liver sinusoids capture and destroy bacteria by phagocytosis.

15. **Heat production:**
    Liver is the heat producing organ of the body. Number of chemical reactions takes place in liver that involve production of heat.

16. **Other function of Liver:**
    a. Liver stores iron and copper
    b. It helps in the formation of Lymph
    c. Liver helps in the cholesterol synthesis and in production of triglycerides (Fats).

Check Points:

- Liver is the largest gland in the body and made up of 4 lobes.
- Gall bladder is present between right and left lobes absent in some mammals.
- Liver produces the alkaline bile juice. It has no enzymes but has bile salts and bile pigments.
- Liver is commonly called as metabolic organ.
- Bile emulsifies fats and helps in the digestion and absorption of fats.
- Liver stores Vitamin A and D.
- Liver is haemopoeitic in embryo.
- Heparin, fibrinogen and prothrombin necessary for blood clotting are formed in liver.
- The metabolism of alcohol, carbohydrates and proteins takes place in liver.
- Transamination, Deamination and detoxification take place in liver.
- Liver is the site for glycogenesis, Glycogenolysis, and Gluconeogenesis.

Semester – III

General Biology

Unit II: Human Physiology – II

Module No: 6 (III) Lung structure: Air passages and Alveoli

The human respiratory system consists of the nose, pharynx, larynx, trachea, two bronchi (one bronchus to each lung), bronchioles and smaller air passages, two lungs and their coverings (the pleura), muscles of breathing (the intercostal muscles and the diaphragm).

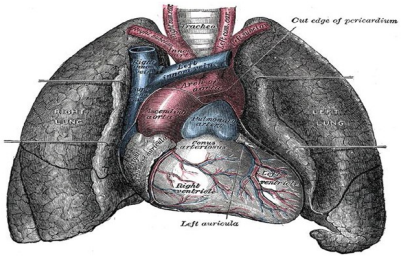
Respiration begins as air enters the nose. In the human body air must be cleaned, warmed and humidified before the lungs can extract oxygen from it. Millions of airborne bacteria and dust particles enter the nose each day. Ciliated epithelium in the nose forms a mucous membrane that filters, moistens and warms incoming air. Hair at the entrance of the nasal cavities first filter incoming air. Most bacteria and particles that pass the hairs catch in sticky mucus or if inhaled further, are trapped by mucus lower in the respiratory tract and swept back out by waving cilia. The nose also protects lung tissue by adjusting the temperature and humidity of incoming air.

The back of the nose leads into the pharynx or throat that conducts food and air. The larynx or Adam's apple is a boxlike structure below and in front of the pharynx that passes materials through and also produces the voice. Inhaled air passes through the glottis, the opening to the larynx. Swallowing moves the larynx upward, flipping down a piece of cartilage called the epiglottis that covers the glottis like a trap door. This prevents food from entering the respiratory tract.

Stretched over the glottis are two elastic bands of tissue, the vocal cords, that vibrate when air passes them. The vibrations produce sounds that can be molded into speech. The larynx sits atop the wind pipe or trachea.

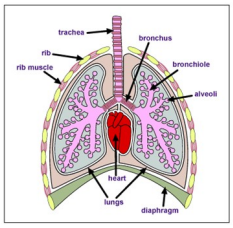
Lung structure

In man a pair of large, lobed lungs are present in the thoracic cavity on either side of the heart. They are hollow and spongy structures covered by two peritoneal membranes – the outer parietal pleural membrane and inner visceral pleural membrane. The space present between these two layers is called pleural cavity filled with pleural fluid. This fluid helps in lubrication of the pleural cavity and protect the lungs from external shocks. In man right lung is divided into three distinct lobes (superior, middle and inferior). The left lung is smaller and it is divided into only two lobes (superior and inferior).



The lungs are composed of the bronchi and smaller air passages, alveoli, connective tissue, blood vessels, lymph vessels and nerves, all embedded in an elastic connective tissue matrix. Within each lobe the lung tissue is further divided by fine sheets of connective tissue into large number of lobules.

Trachea starts from the larynx passes through the neck and enters thorax where it divides into two branches called bronchii. Trachea is otherwise called wind pipe. Trachea and bronchus are supported by incomplete cartilage rings which keep the tube always open. Inside each lung the bronchus divides and redivides into secondary and tertiary bronchii. They divide into respiratory bronchioles which end in alveolar ducts. Cartilage rings are absent in bronchioles. Each alveolar duct opens into an atrium. Varying from 2 to 5 alveolar sacs open off from each atrium. Each alveolar sac is composed of many thin walled, minor compartments, the alveoli, all of which open into the main lumen of the sac. The functional unit of the lungs is the alveoli. There are about 150 million alveoli in the adult lung. It is in these structures that the process of gas exchange occurs. In man total surface area of the lungs is 100 sq. meters which is 50 times more than skin surface.



The trachea and the bronchii are lined by ciliated columnar epithelium which contain many mucous gland cells. The cilia drive the dust particles towards the larynx. As airways progressively divide and become smaller and smaller, their walls gradually become thinner until muscle and connective tissue disappear, leaving a singe layer of simple squamous epithelial cells in the alveolar ducts and alveoli. These distal respiratory passages are supported by a loose net work of elastic connective tissue in which macrophages, fibroblasts, nerves, blood and lymph vessels are embedded. The alveoli are surrounded by a dense network of capillaries. Exchange of gases in the lungs (external respiration) takes place across a membrane made up of the alveolar wall and the capillary wall fused firmly together. This is called the respiratory membrane.

Lying between the squamous cells are septal cells that secrete surfactant, a phospholipid fluid which prevents the alveoli from drying out. In addition, surfactant reduce surface tension and prevents alveolar walls collapsing during expiration.

Path of Air		
Structure	**Description**	**Function**
Nasal Cavities	Hollow spaces in nose	Filter, warm, and moisten air
Pharynx	Chamber behind oral cavity and between nasal cavity and larynx	Connection to surrounding regions
Glottis	Opening into larynx	Passage of air into larynx
Larynx	Cartilaginous organ that contains vocal cords(voice box)	Sound production
Trachea	Flexible tube that connects larynx with bronchi (windpipe)	Passage of air to bronchi
Bronchi	Major divisions of the trachea that enter lungs	Passage of air to each lung
Bronchioles	Branched tubes that lead from the bronchi to the alveoli	Passage of air to each alveolus
Lungs	Soft, cone-shaped organs that occupy a large portion of the thoracic cavity	Gas exchange

Check Points

- A pair of large, lobed lungs are present in man.
- Right lung is large with three lobes and left lung is smaller with two lobes.
- Pleural fluid helps in lubrication and protect the lungs from external shocks.
- Functional unit of the lung is alveoli.
- Each adult lung contains about 150 million alveoli.
- Exchange of gases takes place through the walls of alveoli.
- Bronchii are lined with ciliated columnar epithelium where as alveolar ducts and alveoli are lined with simple squamous epithelial cells.
- Septal cells secrete surfactant which reduce surface tensin and also prevents alveoli from drying out.

Semester – III

General Biology

Unit II: Human Physiology - II

Module No: 7 (III) Breathing and gases exchanges

Breathing

Breathing is other wise called pulmonary ventilation. Breathing is the entry and exit of air into and from the lungs. Breathing supplies oxygen to the alveoli, and eliminates carbon dioxide. The average respiratory rate is 12 to 15 breaths per minute. Each breath consists of three phases: Inspiration, expiration and pause. Inter costal muscles and diaphragm help in breathing. There are 11 pairs of intercostals muscles that occupy the spaces between the 12 pairs of ribs. They are arranged in two layers, the external and internal intercostals muscles. The diaphragm is a dome shaped muscular structure separating the thoracic and abdominal cavities. The inter costal muscles and the diaphragm contract simultaneously, enlarging the thoracic cavity in all directions.

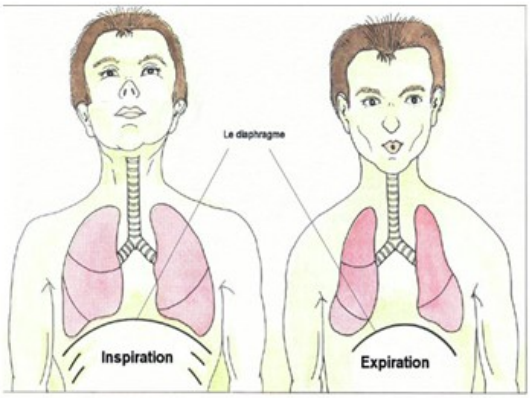
Inspiration

The process of taking air from outside into the lungs is called inspiration. During inspiration external intercostals muscles and the diaphragm contract simultaneously as a result the thoracic cavity increases results in expansion of the lungs.

This results in air being drawn into the lungs from out side. Diffusion of gases like O_2 and Co_2 takes place in the alveoli between air of alveoli and blood. The process of inspiration is active as it needs energy for muscle contraction.

Expiration

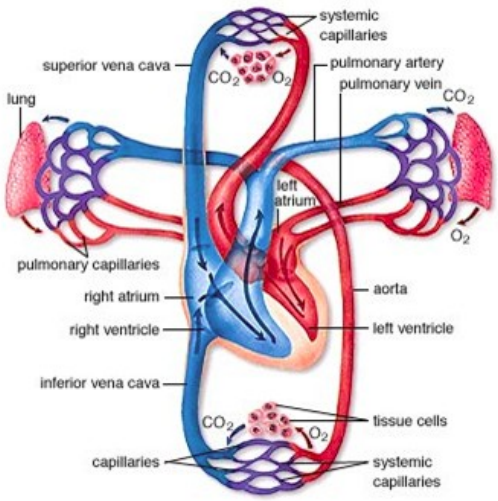
Expiration is a process in which air from the lungs is expelled to outside. During expiration external intercostal muscles and diaphragm relax, the ribs fall back into place, the diaphragm becomes dome shaped and the chest goes back wards.



With all this the volume of thoracic cavity decreases and increases pressure on the lungs as a result the lungs expel the air to outside. This process is passive as it does not require the expenditure of energy. After expiration there is a pause before the next cycle begins.

Exchanges of gases – Uptake of oxygen and removal of carbon dioxide

Between the process of inspiration and expiration the interchange of respiratory gases takes place between the blood in the capillary network which surrounds the alveoli and the air in the alveoli of the lungs.



The uptake of oxygen and the removal of carbon dioxide by the blood of the alveolar capillaries can be explained by diffusion where the gases pass from the regions of high pressure to those of low pressure. The pressure of the gas refers to the partial pressure that the gas exerts in a mixture of gases.

The atmospheric pressure at the sea level is 760 mm of mercury, the partial pressure of oxygen will be 21% (percentage of O_2 in air) of 760 mm Hg or 159 mm Hg.

Partial pressure of O_2 = $\frac{21}{100}$x760 = 159.2 mm Hg.

The partial pressure of Co_2 will be 0.04% (percentage of Co_2 in air) of 760 mm Hg.

Partial pressure of Co2 = $\frac{0.04}{100}$x760 = 0.3 mm Hg.

It is also important to remember that when atmospheric air is inhaled, it is warmed and maximally humified by the time it reaches the alveoli of the lungs. Since water vapours possess mass and also these occupy space, there should be a change in the partial pressure. The water vapour pressure at 37°c is 47mm Hg. There fore, the sum total partial pressure of other constituents of air must be 760 – 47 = 713mm Hg. The total pressure of dry air in the alveoli is 713 mm Hg of which oxygen constitutes about 14%. The partial pressure of O_2 in alveoli is 100 mmHg approximately ($\frac{14}{100}$x713 = 99.82)

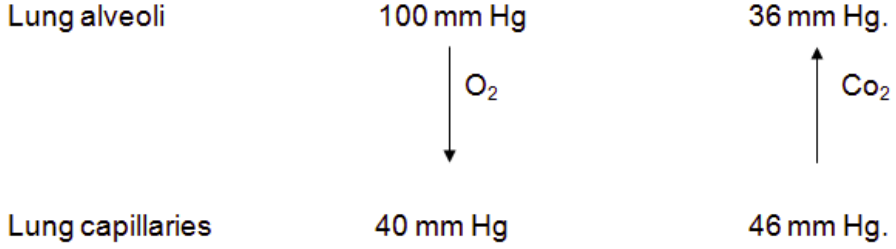
The partial pressure of O_2 in the blood of the alveolar capillaries is considerably lower, being only about 40 mm Hg.

Partial pressure of O_2 in alveolar air = 100 mm Hg.
Partial pressure of O_2 in Venus blood = 40 mm Hg.

A pressure difference of 60 mm Hg serves to drive oxygen from the alveoli of the lung into the blood.

The partial pressure of Co_2 of the alveolar air is 36 mm Hg where as the partial pressure of Co_2 in the venus blood of alveolar capillaries is 46 mm Hg. A relatively small difference of 10 mm Hg is sufficient to drive Co_2 from the blood into the lungs.

The exchange of gases in the lung according to their partial pressures may be shown as follows:



By this mechanism Co_2 is excreted from the body and O_2 is absorbed and transported round the body in combination with haemoglobin in the erythrocytes.

Effect of smoking on lungs and respiratory system

The most important of the pulmonary abnormalities is the pulmonary emphysema, which means excess air in the lungs.

Emphysema is a chronic disorder in which alveolar walls are damaged due to which respiratory surface is decreased. Long term cigarette smoking causes chronic pulmonary emphysema. Due to the damage to alveolar walls greatly decreases the diffusing capacity of the lung, which reduces the lung ability to oxygenate the blood and remove Co_2. The person develops both hypoxia (O_2 not available to tissues) and Hypercapnia (too much Co_2 in the blood). The net result of these effects may be severe, prolonged, devasting air hunger that can continue for years until the hypoxia and hypercapnia cause death, a high penalty for smoking.

Check Points

- Process of taking air from out side into the lungs is called inspiration.
- Process by which air is expelled to out side from the lungs is called expiration.
- Inspiration and expiration are carried out by creating pressure gradients between the atmosphere and the alveoli with the help of intercostals muscles and the diaphragm.
- Exchange of gases takes place between the capillaries of alveoli and the air in the alveoli by diffusion. Rate of diffusion is dependent on the partial pressure gradients of oxygen and carbon dioxide.
- Inspiration is active process and expiration is passive process.
- Long term cigarette smoking causes pulmonary emphysema.

Semester – III

General Biology

Unit 1: Human Physiology – 1

Module No: 3 (III) Composition and functions of Blood

Blood is a fluid connective tissue composed of yellow transparent fluid called plasma and floating in this fluid are numerous corpuscles. Plasma constitute 55% and corpuscles about 45% of the volume of blood.

Plasma

The pale yellow colored fluid part of the blood is called plasma, which constitutes 55% of blood volume. It is a complex mixture of amino compounds, fats, carbohydrates, hormones, enzymes, inorganic substances and gases. Blood plasma generally contains 90% water, 8% proteins, 0.9% salts, and 0.1% glucose. The plasma proteins are in the form of fibrinogen, lipoproteins, albumin and globulins. The salts are in the form of bicarbonates, chlorides, phosphates and sulphates of Na, K, Ca, Mg and Fe. Gases like O_2 and CO_2 are present.

Blood Corpuscles: They are three types

1. Erythrocytes or Red blood Corpuscles (RBC)
2. Leucocytes or White blood Corpuscles (WBC)
3. Blood Platelets

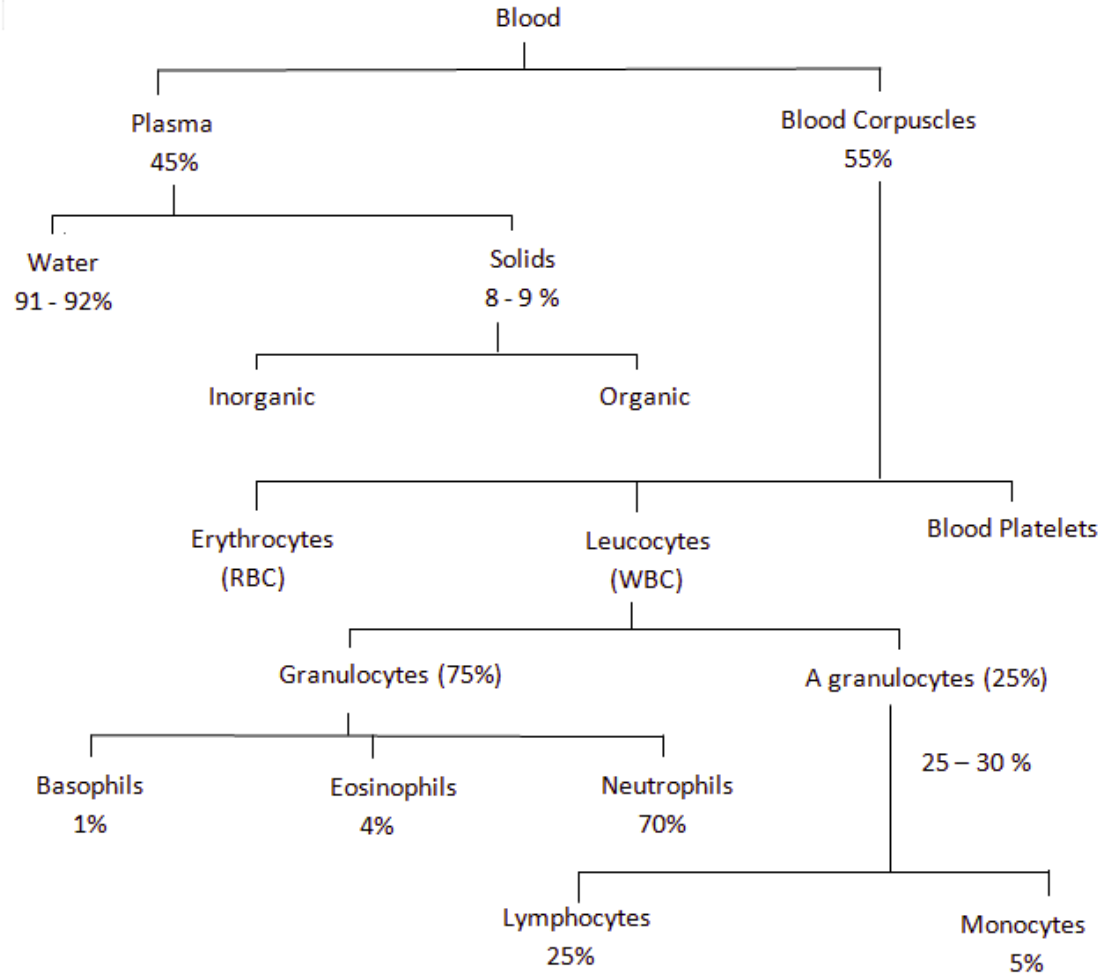
Erythrocytes (RBC)

They are circular, biconcave and non - nucleated discs and about 7.5 μ in diameter. They are red in color because of the presence of iron containing respiratory pigment Haemoglobin. They are immobile and move with the flow of blood. They are formed inside the bone marrow. The average life span of RBC is about 120 days in man. Haemoglobin in the erythrocytes carries oxygen from the lungs to all the cells of the body. Absence of nucleus increases respiratory efficiency of the RBC. When RBC count decreases it is called **anaemia**, while an increased RBC count is **Polycythemia**.

White Blood corpuscles (WBC) or Leucocytes

WBC are colourless or transparent cells without haemoglobin but contain one or two or many nuclei. The nucleus may be independent or lobed. They are irregular or amoeboid in shape and move by means of pseudopodia. Their amoebic capability enables them to pass through the walls of the capillaries into the tissue spaces and this process is known as diapedesis.

The WBC are phagocytic in nature. An increase in the number of WBC is called **leucocytosis** and decrease in number is called **leucopenia**. These cells develop in the red bone marrow, the lymph nodes and the spleen. Their life span is shorter and different verities of leucocytes differ in their life span from 1 to 15 days. They are larger than erythrocytes measuring from 8-15μ in diameter depending on the type. Depending upon the absence or presence of granules in the cytoplasm, the leucocytes are categorized into Agranular leucocytes and Granular leucocytes.



A granular Leucocytes

The cytoplasm does not contain granules and the nucleus is large and not lobed. They constitute about 25-30% of total WBC. They are two types.

1. Lymphocytes

They are two types – large and small lymphocytes. The nucleus is large and bean shaped. They play an important role in immunological reactions and helps in the production of antibodies. Lymphocytes helps in repair of damaged tissues. They don't function as phagocytes.

2. Monocytes

They are the largest of all WBC. The nucleus is large with horse – shoe shaped nucleus. These cells are phagocytic in action. They act as scavengers and help in removing damaged tissues and dead cells.

Granular Leucocytes

They are large in size and their cytoplasm is granular. The granulocytes constitute about 75% of total WBC. The nucleus is irregular or divided into many lobes. They are categorized into three types on the basis of structure of nucleus and the affinity of the granules to acidic or basic dyes.

a. **Neutrophils:** They are most abundant of the WBC. The nucleus is with 3 to 5 lobes connected by thin chromatin strands. They are phagocytic in function. They protect the body against the invasion of bacteria. They are capable of squeezing out of the capillary wall and moving to the infected areas to ingest or kill microbes. The life span of neutrophils is about 30 hours.
b. **Eosinophils:** They are phagocytic in nature and with bilobed nucleus. The number of eosinophils increase in the allergic conditions such as asthma and parasitic infections.
c. **Basophils:** They have irregular shaped nucleus. They are stained with basic dyes. Basophils release heparin and histamine in the blood and are responsible for anticoagulatory function and inflammatory response. Basophils play crucial role in allergic reactions.

Blood Platelets

They are very small cells 2- 3 μ in diameter having cytoplasm but nucleus is absent. They are not true cells but are fragments of large cells of bone marrow called megakaryocytes. There are approximately 3,00,000 platelets in a cubic millimeter of blood. Their life span is about 10 days. They play an important role in the coagulation or clotting of Blood.

Functions of Blood

The blood performs many important functions.

1. Blood carries O_2 to the tissues for oxidation of food materials and transporting CO_2 from tissues to the lungs for its removal.
2. The digested and absorbed food materials are transported to the various parts of the body by the blood.
3. It carries nitrogenous waste materials from the tissues or organs where they are formed to the excretory organs for elimination.
4. It regulates the body temperature.
5. Blood carries hormones from endocrine glands to the place of their action.
6. WBC of blood fight infections and act as soldiers, scavengers of the body. They engulf foreign germs that may enter the body by phagocytosis and protect the body.
7. Blood maintain normal acid – base balance in the body.
8. Blood platelets help in blood clotting.
9. Blood also maintains the water balance of the body by exchanging it between the blood and the tissue fluids.
10. Immunoglobulins of the plasma act as antibodies and neutralize the harmful effects of foreign agents.
11. Mineral ions of plasma and plasma proteins maintain pH balance, osmotic balance and buffer capacity.
12. Blood transport required materials for healing of wounds or repair and regeneration of body parts.
13. Heparin of the blood prevents clotting of blood within the blood vessels.

Check Points:

- Blood is fluid connective tissue circulating in the body.
- Blood is composed of transparent fluid called plasma and blood corpuscles of different kinds.
- Three varieties of corpuscles are present in the blood. They are

A) Erythrocytes or Red blood corpuscles

B) Leucocytes or White blood corpuscles and

C) Blood platelets

- Absence of nucleus in RBC increases their respiratory efficiency.
- The respiratory pigment present in RBC is haemoglobin.
- RBC are formed in liver, spleen and lymph nodes in the embryo and in the red bone marrow in the adult.
- Haemoglobin of RBC carries oxygen from the lungs to all the cells of the body.
- WBC are divided into two main varieties. They are a) Granulocytes and b) A granulocytes
- Granulocytes are of three types. They are 1) Neutrophils 2) Eosinophils and 3) Basophils
- A granulocytes are of two varieties a) Lymphocytes and b) Monocytes
- Blood platelets are associated with blood clotting.
- The blood performs many important and vital functions such as carry O_2 to tissues, fight diseases, transport nutrition, disposal of Co_2, transportation of excretory products, hormones, vitamins etc., maintains osmotic balance, pH, regulate body temperature etc.

Additional information

1. The blood constitutes approximately 8% of the body weight or 5.6 liters in a 70kg man.
2. Normal erythrocyte count
   Women: 4.5 to 5 million per cubic millimeter of blood.
   Men: 5 to 5.5 million per cubic millimeter of blood.
3. The process of formation of erythrocytes is called erythropoiesis.
4. The normal haemoglobin levels in the blood
   Men: 14g per 100ml of blood
   Women: 12g per 100 ml of blood
5. Blood is often described as “the river of life”
6. Serum is plasma minus fibrinogen.

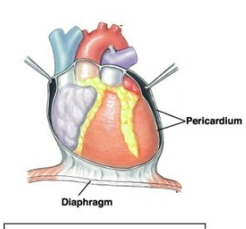
Semester - III

General Biology

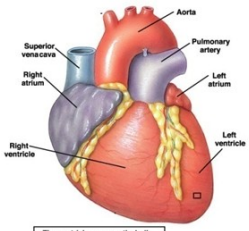
Unit 1: Human Physiology – I

Module No: 4 (III) Structure and Function of Heart

The heart pumps blood through the circulatory system all round the body. The human heart is pear-shaped or conical shaped muscular organ of reddish colour. It lies between the two lungs (mediastinum) in the thoracic cavity. It is enclosed in a double layered, membranous sac known as pericardium. Space present between these layers is called pericardial cavity and this cavity is filled with a watery fluid called pericardial fluid. This fluid protects the heart from shocks and mechanical injuries. The major portion of the heart, called myocardium, consists largely of cardiac muscle tissue. The muscle fibers of the myocardium are branched and tightly joined to one another. The inner surface of the heart is lined with endocardium which consists of connective tissue and endothelial tissue.

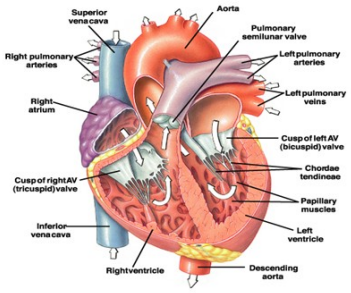


The heart is encased within a membranous fluid-filled sac, the pericardium.



The ventricles occupy the bulk of the heart. The arteries and veins all attach to the base of the heart.

The human heart is four chambered having two auricles or atria and two ventricles. The two auricles are thin walled structures occupy anterior part of the heart. They receive blood from various parts of the body and hence also known as receiving chambers. Ventricles form a large posterior part of the heart and supplies blood to various body organs thus is also called the distributing chambers. The two auricles are separated from the lower ventricles by a deep auriculo-ventricular grove. The two ventricles are demarcated externally by inter ventricular grove.



One-way flow through the heart is ensured by two sets of valves.

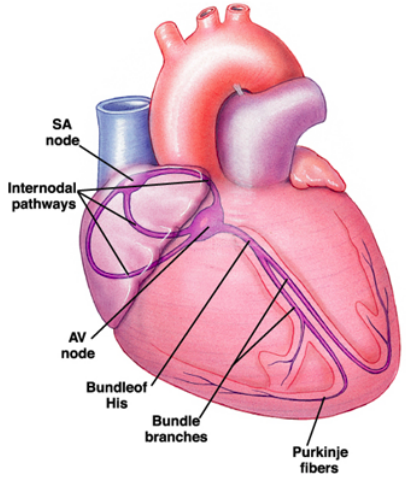
The two auricles are separated from each other by inter auricular or inter atrial septum. Similarly ventricles are thick walled and are separated internally by the inter ventricular septum. The right auricle receives deoxygenated blood from the body parts through a pre caval and a post caval veins. The left auricle is smaller than the right auricle and receives oxygenated blood from the lungs through four pulmonary veins.

The right auricle opens into right ventricle through auriculo – ventricular aperture which is guarded by a tricuspid valve. This valve allows the deoxygenated blood to pass into the right ventricle when right auricle contracts, but prevent back flow of blood. The left auricle open into the ventricle through a left auriculo – ventricular opening guarded by a bicuspid or mitral valve.

The inner surface of the ventricular wall project inwards into irregular, muscular ridges called muscular papillae or columnae carnae. The flaps of the tricuspid valve and bicuspid valve are connected to the columnae carnae by a long, tough fibers called chordae tendinae. When the ventricle contracts, chordae tendinae and flaps of bicuspid valve and tricuspid valve prevents the back flow of blood from ventricle into auricles. From the left side of the right ventricle arises the pulmonary trunk whose opening is guarded by three semilunar valves (whose flaps resemble half moons)and this trunk carries deoxygenated blood to the lungs. From the right side of the left ventricle arises a single aorta which distributes oxygenated blood through its branches to different parts of the body.

Functioning of the heart

The heart beats rhythmically by alternate contraction (systole) and relaxation (diastole), contraction is initiated by a special patch of modified heart muscles, the sinu atrial (SA) node or pace maker, which is situated in the wall of the right atrium. The node is innervated by fibers of autonomic nervous system. The pace maker is capable of initiating impulses which stimulate the heart muscles to contract. When the heart beats, the familiar lub-dub sound occurs as the valves of the heart close. The lub is caused by vibrations occurring when the atrio-ventricular valves close and the ventricles contract. The dub is heard when the semilunar valves close.



The right auricle receives deoxygenated blood from all parts of the body through a superior vena cava and inferior venacava. A small vein that enters the right atrium, the coronary sinus, returns blood that has been circulating within the heart. At the same time the left auricle expands to receive oxygenated blood from the lungs through pulmonary veins. When both the auricles are filled with blood pacemaker starts contractions in the right auricle followed by left auricle and due to this deoxygenated blood from right auricle flows into the right ventricle and the oxygenated blood from left auricle flows into the left ventricle. Mixing of the blood either in the auricles or in the ventricles does not occur due to the presence of inter auricular and inter ventricular septum.

The Atrio-ventricular node (AV node) is situated at the posterior right border of the inter auricular septum. This node consists of Purkinje fibers and Bundle of His which forms a dense network. Bundle of His spreads in the ventricle and in inter ventricular septum.

When the two ventricles are filled with blood, the muscular papillae start contractions and the two ventricles are made to contract to pump the blood. The contraction of the ventricle takes place when the wave of contraction reaches the Atrio-ventriculor node, it is stimulated to emit an impulse of contraction which spreads to the ventricular muscle, via bundle of His and purkinje fibers. Deoxygenated blood from right ventricle enter the pulmonary trunk and from there into pulmonary arteries to the lungs for oxygenation. When the left ventricle contracts, oxygenated blood enter the aorta and distributed to all parts of the body. After contraction of the ventricles, the heart rests for 0.4 of a second and this period is known as complete cardiac diastole during which atria are filled with blood.

Check Points

- Heart is covered by a two layered pericardium.
- Pericardial fluid protects the heart.
- Heart is four chambered having two auricles and two ventricles.
- Right auricle receives deoxygenated blood and left auricle receive oxygenated blood from lungs.
- Ventricular valve on the inner side forms muscular folds called columnae carnae.
- Chordae tendinae and flaps of bicuspid and tricuspid valves prevents backward flow of blood from ventricles to auricles during ventricular contraction.
- Contraction of the heart is called Systole and relaxation is called Diastole.
- Contraction of the heart is initiated by sinuatrial node or pace maker.
- Atrioventricular node is present on the posterior side of inter auricular septum.
- Atrioventricular node consists of Bundle of His and Purkinje fibers.

Additional information

1. The heart contracts or beats about 72 times a minute and each heart beat lasts about 0.85 seconds.
2. Normally, the pulse rate indicates the rate of the heart beat because the arterial walls pulse whenever the left ventricle contracts.
3. In adult human male the heart is about 0.43% of the body weight and in the female about 0.4%.
4. The heart beats are detected by an instrument called stethoscope.
5. The blood circulation in man has discovered by William Harvey.
6. The B.P. in man is measured by an instrument called sphygmomanometer. A condition of high blood pressure is called hypertension.
7. The method of detecting the abnormalities in heart is called ECG method.(Electro cardiogram)
8. The blood pressure in normal healthy man is 120/80 (systolic pressure/diastolic pressure)

Semester - III

General Biology

Unit 1: Human Physiology – I

Module No: 5 (III) Circulation: Arteries, Veins and Capillaries

The cells of higher animals are organized into tissues and organs which perform specialized functions and, therefore, transportation of materials between them is very important. Oxygen must reach the cells and Co_2 must be carried away, food must be distributed, excretory wastes removed and the hormones must be carried from the endocrine glands to the body parts which they influence. This function of distribution is served by the circulation which comprises blood vascular system.

The blood vascular system includes the heart and blood vessels. Blood vessels in animals form circulatory systems which are either open or closed.

In an open circulatory system, the blood is not completely enclosed within vessels, the hearts pump blood through arteries into large cavities or sinuses, where it mixes with interstitial fluid and bathes the cells of the body. The blood is slowly returned to the hearts through small pores, called ostia. In a closed circulatory system, the blood remains within a completely enclosed system of vessels and never comes in direct contact with the body cells. Materials move between the blood and interstitial fluid through the thin walls of capillaries.

Circulation is slower in an open system, because with some of the blood pooled in sinuses, the hearts can't build up enough pressure to make the blood flow rapidly. An open system can't achieve the high rates of oxygen transport that animals require. Animals with open systems are either quite small and sluggish or use the open system only for transport of food and wastes, and use a different system for transport of gases.

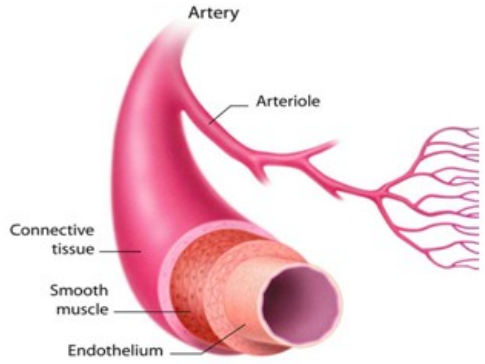
In vertebrates, the circulatory system is of closed type and consists of a heart and blood vessels (arteries, Capillaries and Veins).

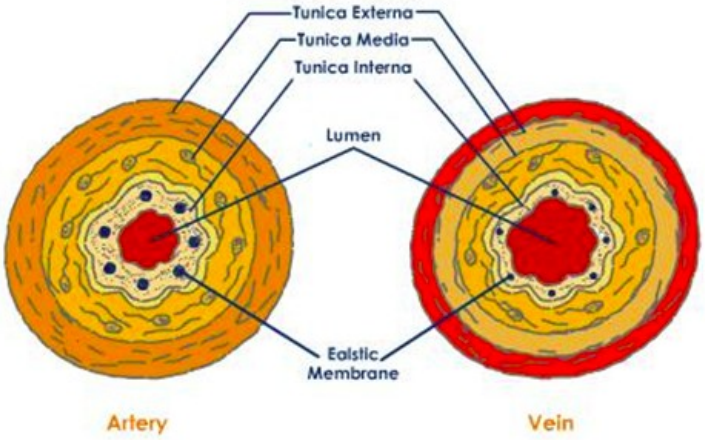
Blood vessels

Blood vessels are hollow tubes for carrying blood. They are three types – arteries, veins and capillaries. During blood circulation, the arteries carry blood away from the heart. The capillaries connect the arteries to the veins. The veins carry blood back to the heart.

Arteries

All the blood vessels leading from heart are called arteries, whether they contain oxygenated blood as in the aorta or deoxygenated blood as in the pulmonary artery. The small branches of artery are called arterioles which branch further into capillaries.





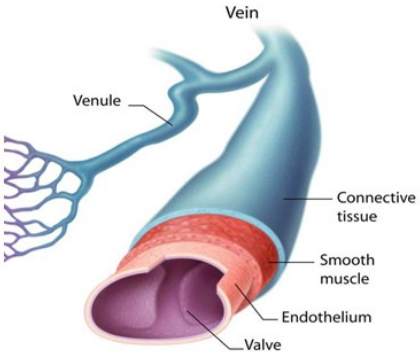
Arteries are thick walled blood vessels and made up of three layers – outer tunica externa made up of fibrous connective tissue, middle tunica media made up of smooth muscles and elastic fibers and inner layer is tunica intima made of squamous epithelium. Tunica externa in arteries is relatively thin. They are capable of withstanding high pressure and are capable of stretching and expanding. Tunica media is well developed that prevents them from collapsing. They have the property of elasticity thereby they can expand to accept a volume of blood, then contract and squeeze back to their original size after the pressure is released.

1. Capillaries

The arterioles lead into a branching series of microscopic vessels known as capillaries. The capillary walls are thin made of only a single layer of endothelium and allow an exchange of nutrients, gases and other substances between their blood and the cells through a process called diffusion or active transport. Beds of capillaries connect arterioles to venules. Venules eventually become veins, which heads back to the heart.

2. Veins

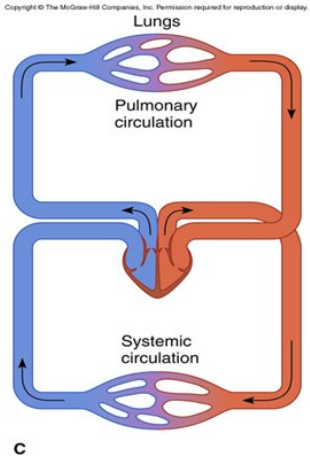
These are relatively thin walled and collapsible blood vessels carrying blood at low pressure.



The veins are blood vessels that carry blood towards heart. The wall of the vein is also made of three layers but do not have an inner layer of elastic membrane found in the arteries. The tunica media is thin, ill defined coat containing a small number of smooth muscle fibers. Tunica externa forms the thickest coat. It consists of fibrous connective tissue plus a few smooth muscle fibers.

Some of them possess internal valves along their length to prevent the back flow of blood. The diameter of the lumen is much larger than in the artery. All veins carry deoxygenated blood except the pulmonary veins.

The vertebrates have chambered hearts, having two, three or four chambers. The fish heart consists of two main chambers, auricle and ventricle. It is a single circuit heart and blood passes through it only once in each complete circuit. Amphibians and most reptiles have three chambered heart. Birds and mammals have 4-chambered heart and there are two circuits, one through the lungs (Pulmonary) and the other through the body (Systemic).



C

Double circulation

This pulmonary and systemic circulations together called as double circulation. The deoxygenated blood from the right ventricle passes through the pulmonary artery into the lungs and after aeration, the oxygenated blood is carried through the pulmonary veins into the left auricle. This is known as pulmonary circulation. The oxygenated blood from the left ventricle through systemic aorta carried by its branches to all parts of the body. The deoxygenated blood from different body parts is collected by two major veins and brought into the right auricle. This is called systemic circulation. In this complete circulation the blood passes through the heart twice.

The advantages of the 2-circuit over the 1-circuit plan are many because there is no mixing of the oxygen rich and oxygen poor bloods. The blood in the aorta contains relatively more oxygen, a higher metabolic rate is thus possible and a resulting higher temperature can be maintained by the animal.

The systemic circulation can be divided into three sub-system.

1. Coronary circulation

The heart also requires oxygenated blood like any other organ. The coronary arteries supply blood to the heart. The coronary veins return blood from the heart muscles, but instead of emptying into another larger vein, they empty directly into the right atrium.

2. Renal circulation

It supplies blood to the kidneys. The kidneys filter waste from the blood.

3. Hepatic portal circulation

Nutrients are picked up by capillaries in the small intestine and are transported to the liver. Excess nutrients are stored in the liver for future needs. The liver also receives oxygenated blood from a larger artery that branches off the aorta.

Check Points

- The function of distribution of materials in our body is served by the circulation which comprises blood vascular system.
- Double circulation is found in Birds and Mammals.
- The arteries carry blood away from the heart and veins carry blood back to the heart. Capillaries connect the arteries to the veins.
- Arteries can with stand high pressure and are capable of stretching and expanding.
- Veins don't have inner layer of elastic membrane found in the arteries.
- Capillary walls are thin and allow exchange of materials by a process called diffusion.

Semester - III

General Biology

Unit III: Human Physiology – III

Module No: 12 (III) Structure of the skeleton (Structure of Bone and Limbs)

Structure of skeleton

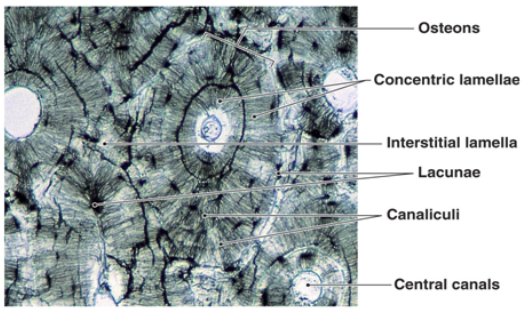
The endoskeleton or internal skeleton forms one of the most complex parts of the body. It provides the attachment to the muscles of the body and gives free mobility to the body. The skeleton mainly comprises of two types of bones, the cartilage or replacing bones and the membrane bones. Cartilage or replacing bones are formed by the ossification of cartilage. Membrane or investing bones are formed by independent ossification in connective tissue. Muscles are present around the skeleton. The average human adult skeleton consists of 206 bones.

The endoskeleton is differentiated into two main groups 1) Axial skeleton and 2) Appendicular skeleton. The axial skeleton of man consists of the skull, vertebral column, the ribs and the sternum and includes 80 bones. The Appendicular skeleton comprises limbs and limb girdles (Pelvic and pectoral girdles) and consists of 126 bones. The number of bones in the face of man is 14. The number of vertebrac in man is 33. The number of ribs in man is 12 pairs. The bones are connected at their ends by flexible joints. Muscles are attached to the bones by the tendons while ligaments attach bone to bone.

The bone is one of the hardest connective tissue in the body which give the main support to different organs and provides attachment to muscles.

The bone consists of three main regions – the innermost bone marrow, the middle circumferential lamellae consists of matrix and the outer most tough layer the periosteum.

The matrix made up of several thin layers or lamellae arranged in a concentric manner around numerous canals called Haversian canals.



The lamellae possess numerous spaces or lacunae from which delicate branching tubes, the canaliculi radiate in all directions. During life, each lacuna is provided with a bone cell or osteocyte which gives off processes into canaliculi. Each canal with lamellae is known as Haversian system. The lamellae are made up of calcified matrix. The lacunae are connected with one another and with Haversion canals by canaliculi. Thus through the canaliculi, lymph, secreted by the Haversion canals reaches all the bone cells. The bone is covered on the outer side with fibrous tissue called periosteum, beneath which are situated osteoblast cells. Periosteum is innervated by blood vessels, which are communicated with the capillaries of Haversian canals and bone marrow.

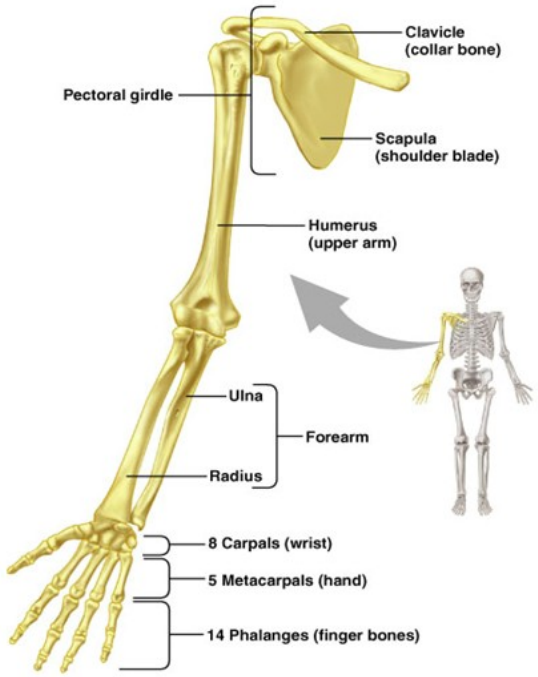
Limbs

Bones of the fore limb

Fore limb consists of 30 bones. Each fore limb consists of the following parts.

1. Upper arm

Consists of a single long bone called Humerus. At its proximal end oval head is present which articulates with the glenoid cavity of the pectoral girdle. Inner lesser and outer greater tuberosities are situated on the outer border of head. A prominent deltoid ridge occurs in proximal end which is the most diagnostic features of humerous bone.



2. Fore arm

The radius and ulna are the bones of fore arm. Radius is curved and elongated bone articulating anteriorly with ulna. Ulna is longer and stout bone forming anteriorly olecranon process for the articulation with humurus.

3. Wrist

It consists of 8 carpal bones arranged in two rows of four each.

4. Palm

There are five metacarpal bones in the palm. The first metacarpal is short.

5. Fingers

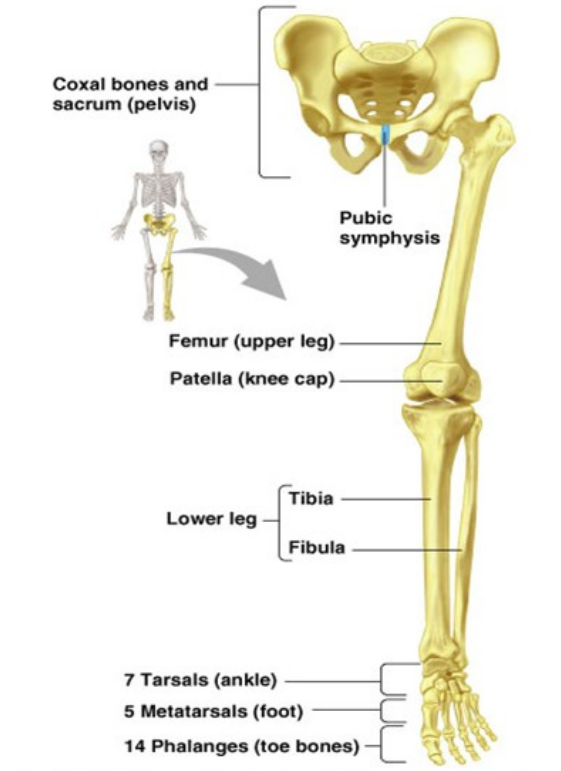
Small bones called phalanges are present in fingers. There are 14 bones in the fingers. First finger is the shortest while the third is the longest. Thumb has two phalanges while in other fingers three phalanges are present. The pharyngeal formula is 2,3,3,3,3.

Hind Limbs

The hind limb is made up of 30 bones. The hind limb consists of

1. Thigh

Femur is the bone of thigh region. Femur is the longest and heaviest bone of the body. The round head of the femur articulates with the acetabulum of the pelvic girdle to form the hip joint. The distal end of femur has two condyles which articulate with tibia fibula to form knee joint.



2. Shank

This region consists of two bones namely tibia and fibula. Tibia is the inner stoutest, straight and longest bone. Fibula is very weak long, slender leteral bone. Extending from the tibia is a sesamoid bone called patella which forms the knee cap.

3. Ankle or Tarsus

It is made up of seven bones called tarsals arranged in three rows.

4. Sole

It is made up of five metatarsal bones.

5. Toes

Man has five toes. The small bones present in the toes are called phalanges. First toe is called hallux. There are 14 bones in the toes. The pharyngeal formula is 2,3,3,3,3.

GIRDLES

1. Pectoral girdle

The pectoral girdle consists of the scapula (shoulder blade) and the clavicle (collarbone). The components of the pectoral girdle are loosely linked together by ligaments, and this allows the girdle to follow freely the movements of the arm. The claricle articulates with the acromian process of the scapula and also with the stermum. The scapula is a flat, triangular shaped bone, lying on the posterior side of the ribs. The glenoid cavity of the pectoral girdle articulates with the head of the humerous.

2. Pelvic girdle

The pelvic girdle consists of two heavy, large coxal bones (hip bones). The strong bones of the pelvic girdle bear the weight of the body, protect the organs within the pelvic cavity and serve as the place of attachment for the legs. Each coxal bone has three parts – the ilium, the ischium and the pubis. The hip socket called acetabulum occurs where these three bones meet.

Check Points

- Endoskeleton provides attachment to the muscles and give the main support to different organ of the body.
- 206 bones are present in human adult skeleton.
- Bone cells are called osteocytes.
- Haversian canals are present in mammalian bones.
- Fore limbs consists of 30 bones and hind limbs also contain 30 bones.
- Bone is covered externally by periosteum.
- Endo skeleton is differentiated into Axial skeleton and Appendicular skeleton.

Semester – III

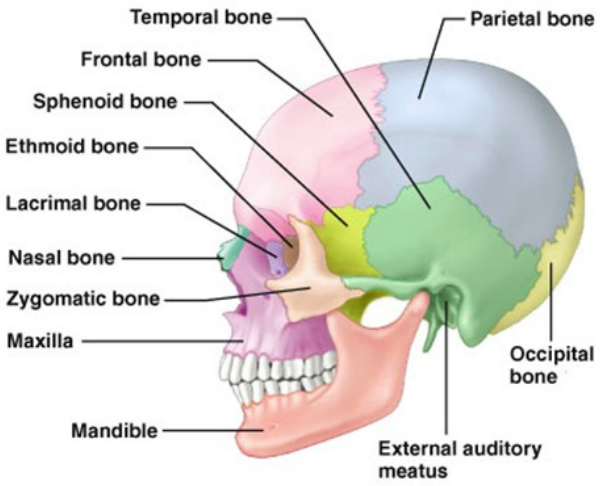
General Biology

Unit III: Human Physiology - III

Module No: 13 (III) Skull And Vertebral Column

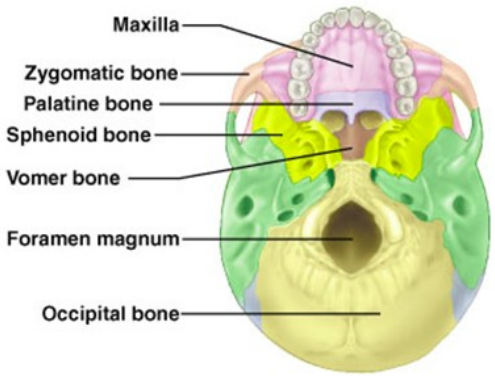
Skull

1. The human skull is made of 29 bones. The skull of man is dicondylic, having two occipital condyles at the posterior end with which it articulates with the first vertebrae called Atlas.
2. Skull is divisible into five parts namely Cranium, Sense capsules, Upper jaw, Lower jaw and Hyoid apparatus.



3. Cranium

It is a box like structure and protect the brain. It is made of 8 bones which are fused tightly by immovable joints. At the posterior end of the cranium there is a large opening called foramen magnum through which spinal cord emerges out. The facial bones are 14 in number and present in the front part of the skull. It includes the bones of the face, lower jaw, nose and the hard palate. Roof of the cranium is formed by the frontal bone and a pair of parietal bones extend to the sides where as floor of the cranium is formed by sphenoid bone. The sphenoid is considered to be the key stone bone of the cranium because all the other bones articulate with it. The sphenoid completes the sides of the skull and also contributes to forming the orbits (eye sockets). The ethmoid bone, which lies in front of the sphenoid, also helps form the orbits and the nesal septum.



4. **Sense capsules**

A. Olfactory Capsules

They enclose the organs of smell. They are covered dorsally by nasals, laterally by jaw bones and ventrally by vomers.

B. Optic Capsules

Present round the eyes an either side of cranium. Two optic capsules are separated by inter – orbital septum.

C. Auditory Capsule

These capsules enclose the organ of hearing and consists of a single bone, the periotic. There are three bones in the middle ear – the malleus, incus and stapes.(Auditory ossicles)

5. **Upper Jaw**

Upper jaw consists of two equal halves called rami. Each ramus consists of Premaxilla, Maxilla and Jugal bones. Palatine, Pterygoid and squamosal bones are also associated with upper jaw.

6. **Lower Jaw**

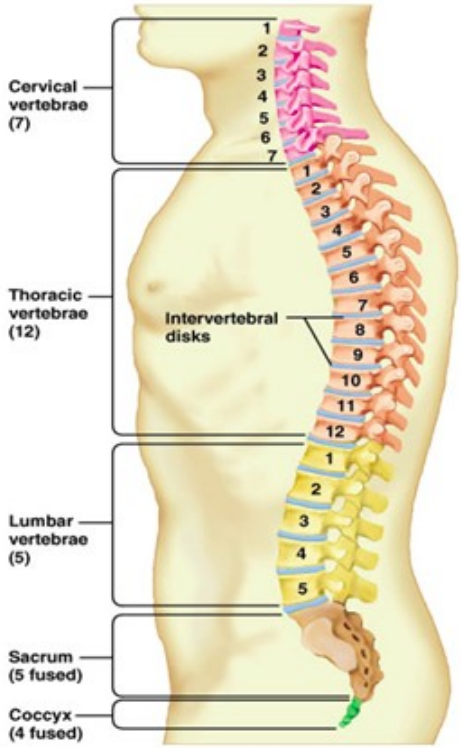
Lover jaw is the only movable portion of the skull and its action permits us to chew our food. It consists of two equal halves called rami. Each half is formed by a single bone called dentary.

7. **Hyoid apparatus**

It is a 'U' shaped bone found in the floor of the buccal cavity.

Vertebral column

The vertebral column is also known as the back bone or spine. The vertebral column of man consists of 33 vertebrae. These vertebrae are separated by inter vertebral cartilaginous discs. The presence of discs allows a certain degree of flexibility to the vertebral column and so enable the vertebral column to bend backwards and forwards or from side to side. Each vertebra has a central hollow portion called neural canal through which the spinal cord passes. The vertebral column allows human beings to stand upright and help to maintain the balance of upper body. The vertebral column protects the spinal cord, supports the head and serves as the point of attachment for the ribs and musculature of the back.



The vertebrae are of following types.

1. Cervical vertebrae

They are present in the neck region and they are 7 in number. The first cervical vertebra is called as Atlas and the second cervical vertebra is known as Axis, Atlas supports the head. Cervical vertebrae allow the widest range of motion so that we can turn our heads in many directions. Movement of the atlas permits the "yes" motion of the head. It also allows the head to tilt from side to side. The second cervical vertibra is called the axis because it allows a degree of rotation as when we shake the head "No" . The bodies of the other cervical vertebrae are small compared to the thoracic and lumbar vertebrae.

2. Thoracic vertebrae

Found in the chest region and they are 12 in number. The thoracic vertebrae have long, thin spinous processes and they have an extra articular facet for the attachment of the ribs.

3. Lumbar vertebrae

Found in the abdominal region. They are 5 in number. Lumbar vertebrae have a large body and thick processes, because they support most of the body's weight.

4. Sacral vertebrae

They are 5 in number and they supports the pelvis. They are fused to form a single bone called sacrum, which forms a wedge between the two hipbones.

5. Coccgeal vertebrae

Found in the lower abdomen below the sacrum. They are 4 in number and fused to form a coccyx or tailbone, which has no known function in humans.

Ribs

There are 12 pairs of ribs. All 12 pairs connect directly to the thoracic vertebrae in the back. In front , 10 pairs of ribs connect either directly or indirectly to the sternum. The seven pairs of ribs that attach directly to the sternum are called true ribs. The three pairs of ribs that attach to the sternum by means of a common cartilage are called false ribs. The lower two pairs of ribs are known as “floating ribs” because they donot attach to the sternum.

Check Points

- Skull of man is dicondylic having two occipital condyles.
- The skull protects the brain, eyes and ears.
- Foramen magnum is the opening present on the posterior side of the cranium through which spinal cord comes out.
- Malleus, Incus and Stapes are the bones present in the middle ear.
- Each half of the lower jaw is made up of a single bone called dentary.
- Vertebral column is made up of 33 vertebras.
- Vertebral column support the body and also protect the spinal cord.

Semester – III

General Biology

Unit III: Human Physiology - III

Module No: 14 (III) Function of the Skeleton and types of Joints

Functions of the Skeleton

The functions of the skeleton are the following

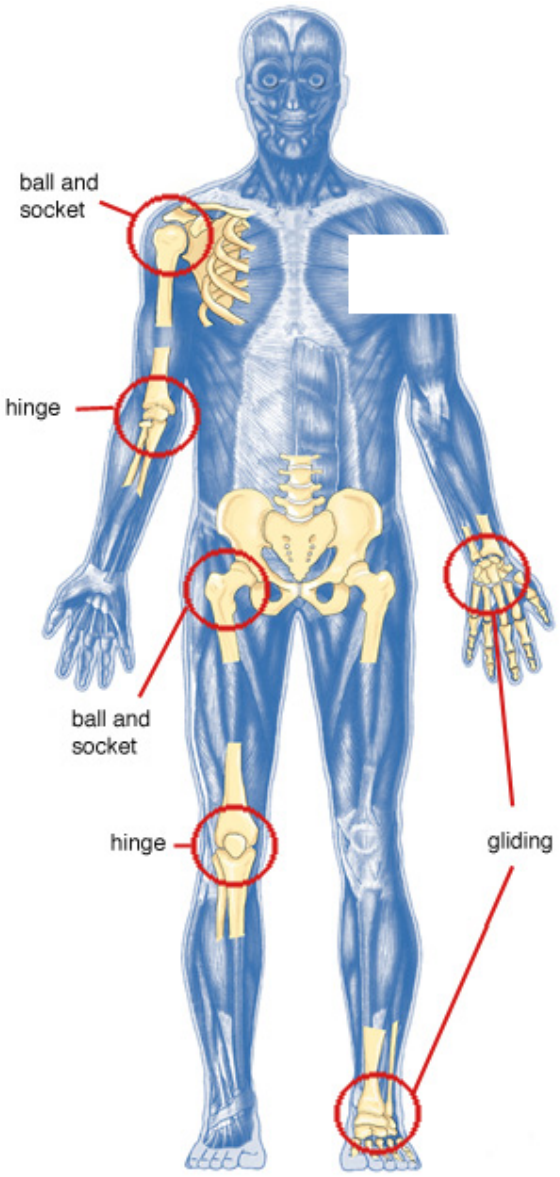
1. It provides a bony frame work, which gives a definite shape and support to the body. The bones of the leg support the entire body when we are standing. The bones of the skull protect the brain, and the rib cage, composed of the ribs, thoracic vertebrae and sternum protect the heart and lungs.
2. It provides attachment to various body muscles or their tendons.
3. It allows movement of the body as a whole and of parts of the body, by forming joints that are moved by muscles.
4. All bones in the fetus have spongy bone with red bone marrow that produces blood cells. In the adult, the flat bones of the skull, ribs, sperum, clavicles, vertebrae and pelvis produce blood cells (Haemopoiesis)
5. Hyoid cartilage gives support and basis to the tongue.
6. All bones have a matrix that contains calcium phosphate. Bone also help regulate blood calcium levels, serving as calcium sink.

Joints

The junction between the ends or edges of two bones is called joint or articulation. Joints are essential for all types of movements involving the bony parts of the body. Joints are points of contact between bones, or between bones and cartilages. Joints have been classified into three major structure forms, namely, fibrous, cartilaginous and synovial.

Fibrous Joints

These joints are present in skull. These joints do not allow any movement. The flat skull bones are fused end-to-end with the help of dense fibrous connective tissue in the form of sutures to form the cranium.



Cartilaginous Joints

The bones involved are jointed together with the help of cartilages either by hyaline cartilage or fibrous cartilage. The joint between the adjacent vertebrae in the vertebral column is of this type and it permits limited movements.

Synovial Joints

1. These are freely movable and permit the greatest degree of flexibility.
2. Joint is enclosed in a tough synovial capsule which is composed of tough and elastic ligaments.
3. Inner surface of the synovial capsule is lined by synovial membrane.
4. Synovial membrane encloses a cavity called synovial cavity filled with synovial fluid. Synovial fluid is secreted by synovial membrane.
5. Synovial fluid serves as a lubricant in the joints.

Based on the construction and types of movements, movable joints are classified into the following types.

1) Ball and Socket Joint

In this type, the head of one bone is ball like and fits into a socket or concavity of another bone. This joint allows free movement in more than one plane. Shoulder joint and hip joint are of this type.

ball and socket

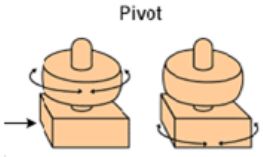
2) Hinge Joint

In this joint a small convexity of one bone fits into a shallow depression of another bone. Hinge joint allows angular movement only in one plane. The knee joint, elbow joint, ankle joint and joints between the phalanges are of this type.

hinge

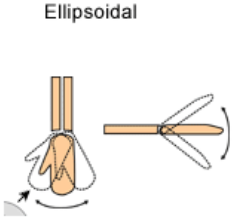
3) Pivot Joint

In this type of joint, one of the bones is fixed which acts like pivot or axis. The other bone fits over the pivot by a concavity and rotates freely around. It allows rotator movement around a central axis. The joint between the atlas and axis vertebrae in man is of this type.



4) Angular, Ellipsoid or Condyloid Joint

In this type, articular surface of one bone is oval shaped. It fits into the oval shaped depression of the other bone. This allows movement in two directions – side to side and back and forth. Wrist and meta carpo phalangeal joints are of this type.



5) Gliding Joint

In this type of joint the surface of one bone glides on the surface of another bone. Restricted movement in different planes is possible. The joints between the zygapophyses of the vertebrae, between the carpals in the wrist and tarsals in the ankle, between sternum and clavicles are of this type.

gliding

6) Saddle Joint

Articular surface of one bone is saddle shaped. Articular surface of another bone sits into the saddle. The movement is angular motion. Joint between carpal and metacarpal of thumb is of this type. Hence thumb enjoys greater freedom of movement than the other fingers.

Check Points

- Skeleton protect important organs like heart, lungs, brain and sense organs.
- Skeleton gives definite shape to the body.
- Muscles are attached to the skeleton.
- Joints are points of contact between bones.
- Three types of joints are present namely fibrous joints, cartilaginous joints and synovial joints.
- Synovial joints are 6 types they are. Ball and socket joint, Hinge joint, Pivot joint, Condyloid joint, Gliding joint and Saddle joint.

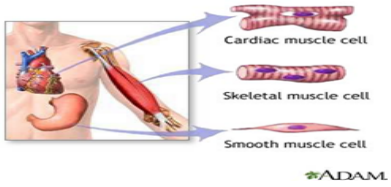
Semester – III

General Biology

Unit III: Human physiology

Module No: 15 (III) Muscles and movement: Benefits of exercise

The bones and muscles play an important role in various types of movement. Muscle is a specialized tissue of mesodermal origin.
Three different kinds of muscles are found in vertebrate animals. They are (1) Skeletal (2) Visceral and (3) Cardiac

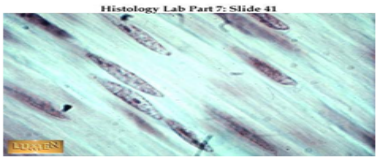


1. Skeletal Muscles

The muscles which are attached to the bones are called skeletal muscles. They have striped appearance under the microscope and hence they are called striated muscles. The contraction of skeletal muscle is under voluntary control and they are also called as voluntary muscles. The skeletal muscle is composed of a cylindrical or flat sheet of skeletal muscle fibers. Each fiber is formed from many cells, but the cells have fused together. The cell boundaries cannot be seen but the individual nuclei are still present. (syncytial state)The muscle fibers are arranged in bundles (Fasciculi) which form distinct muscles. Most of these are attached to bones and produce movement. Each muscle has a nerve supply. When a nerve impulse is sent to a muscle, it makes the muscle contract i.e., get shorter and fatter. At each end of the muscle a cylindrical tendon is present that attaches the muscle to the bone.

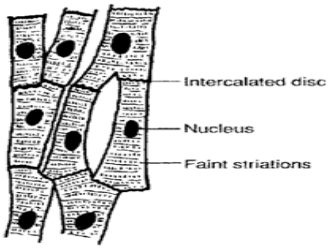
2. Visceral or smooth or Involuntary muscles

The smooth muscles are unstriated and are found in the inner walls of hollow visceral organs of the body like the alimentary canal, reproductive tract etc. The contraction of smooth muscles is generally not under voluntary control and are there fore known as involuntary muscles. These muscles regulate the flow of blood in the arteries and movement of air through the lungs. They also assist in the transportation of food through the digestive tract and gametes through the genital tract.



3. Cardiac Muscles

Cardiac muscles are found in the walls of the heart. They are functional through out the life of the individual. The cardiac muscle is made of cardiac muscle fibers. The fibers are connected by intercalated discs. They are involuntary in nature.



MOVEMENT

Human body exhibit three basic mechanisms for movement.

1. Amoeboid movement

Amoeboid movement in our body is seen in leucocytes and macrophages. It is effected by pseudopodia. Amoeboid movement involves the change in shape of the cell body, streaming movement of the cytoplasm, involvement of cytoskeletal elements like the microfilaments.

2. Ciliary movement

Ciliary movement is the movement with the help of cilia. In our body ciliary movements can be seen in internal tubular organs which are lined by ciliated epithelium such as respiratory, excretory, digestive, genital systems. Ciliary movements helps in for example, removing dust particles and foreign substances from the trachea, passage of ova through the female reproductive tract etc.

3. Muscular movement

Muscles are the organs of movement and locomotion in higher organisms. It works in association with the skeletal system to cause movement. Movement of our limbs, jaws, tongue etc require muscular movement. The contractile property of muscles are effectively used for locomotion and other movements by human beings.

The tendon at one end is attached to a non-moving part of the skeleton while the tendon at the other end is attached to the movable bone close to the joint. When the muscle contracts it pulls on the bones and makes one of them move. For example, a contraction of biceps muscle bends the arm at the elbow, while the triceps straightens the arm.

Limb muscles (biceps and triceps) are usually arranged in pairs having opposite effects. This is because muscles can only shorten or relax, they cannot elongate, so the triceps is needed to pull the relaxed biceps back to its elongated shape after it has contracted.

There are many muscular activities which bring about movements but donot result in locomotion. Chewing, breathing, swallowing and blinking are example of such movements.

BENEFITS OF EXERCISE

Regular exercise can produce the following physiological changes, which are beneficial.

1. The resting heart rate goes down

The ventricles enlarge and the heart muscle grows stronger, so that the stroke volume is increased. This means that when you take exercise, your heart can deliver more blood to the muscles without its rate of beating rising too far.

2. The muscles used in exercise grow larger

At first the muscle fibers grow thicker and then their number increases. The capillaries in the muscle develop more branches. Thus the muscle become stronger.

3. More enzymes are made in the muscle tissue

These are the enzymes needed for breaking down glucose, glycogen or fatty acids. Thus the muscle is able to take up oxygen and food more rapidly from the blood and increase the rate of energy production. The muscle can also store more glycogen.

4. Your ligaments and tendons become stronger

This reduce the chance of injury during sudden vigorous activity.

5. **Your joints become more flexible**

Giving a greater range of movement with a lower risk of spraining a joint

6. **Protection from heart attacks**.

All these changes increase your strength, and also your stamina. All these changes help to post pone the effects of old age, but if the pattern of exercise is maintained. Once regular exercise ceases, the muscles get thinner. All the improved physiological functions go back to their original level.

Check Points

- Three different kinds of muscles are found in vertebrate animals, they are skeletal, visceral and cardiac muscles.
- Skeletal muscles are attached to bones and produce movement.
- Smooth muscles are found in the visceral organs and their contraction is not under voluntary control.
- Intercalated discs are present in cardiac muscles.
- Human body exhibits three types of movements, they are amoeboid, ciliary and muscular movements.
- Exercise can have long term benefits but only if maintained throughout life.

Semester – III

General Biology

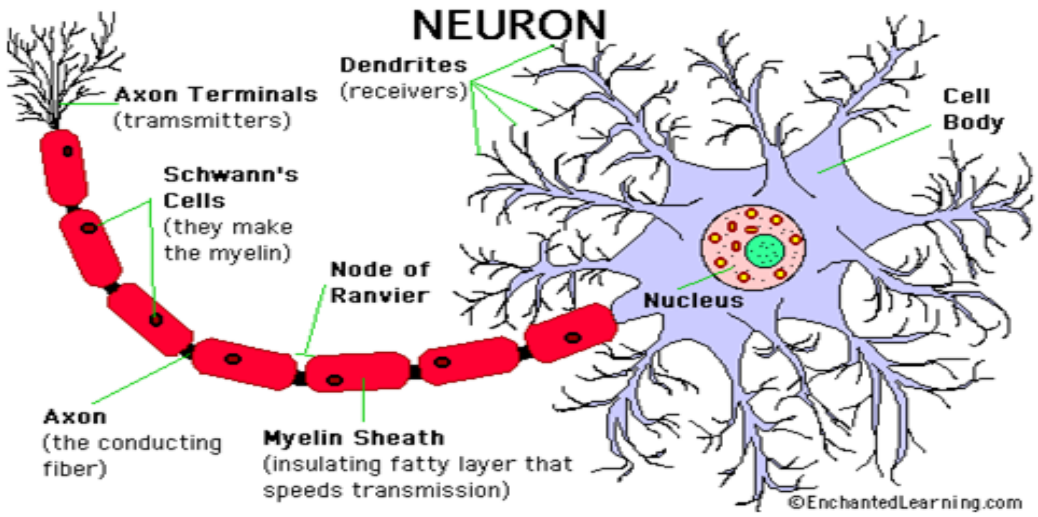
Unit IV: Co-ordination of organs

Module No: 19 (III) Nervous System: Nerve cells, Synapses

The nervous system consists of a vast number of cells called neurons, supported by a special type of connective tissue, neuroglia.

Nerve cells (Neurons)

All multi cellular animals contain elongated nerve cells called neurons. A neuron may be defined as a nerve cell consisting of a cell body which is drawn out into many processes. It is the morphological and functional unit of the nervous system. Neuron is the largest cell in the body.



A typical nerve cell consists of three parts

1. Cell body or cyton

It contains nucleus and majority of cell organells and nissil granules. The cytoplasm of cyton is called neuroplasm. There is no centrosome. For this reason, fully matured nerve cells never multiply and when damaged, are never replaced. Several protoplasmic threads called neurofibrils are present in the neuroplasm. The portion of the cell body from which the nerve fibre arises is known as axon hillock. This portion is found to be rich in neurofibrillae. Neurofibrils are fine filaments passing through the cytoplasm from the dendrite to the axon. Nissl granules probably manufacture enzymes for the synthesis of neurotransmitters.

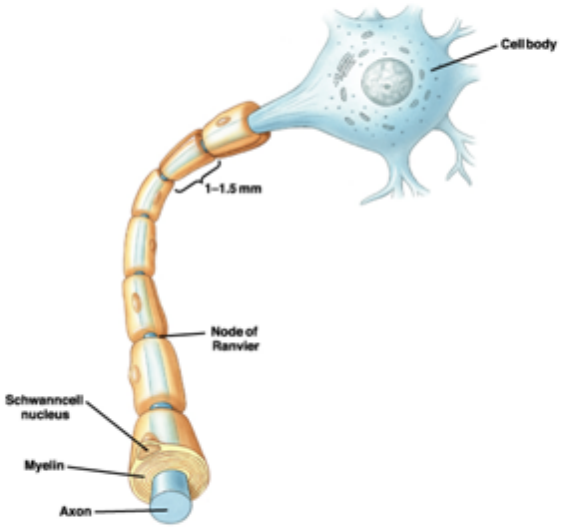
A neuron has two types of protoplasmic processes a very long cylindrical axon and a number of short tapering dendrites.

2. Dendrites

Dendrites are smaller, hair like processes present at the distal end of axon. The dendrites carry nerve signals towards the cell body. Dendrites typically contain Nissl bodies and mitochondria.

3. Axon

It is a single highly specialized long process that conduct impulses away from the cell body to another neuron or tissue. The membrane of the axon is called the axolemma and it encloses the cytoplasmic extension of the cell body. Cytoplasm of axon is the axoplasm contains mitochondria and neurofibrils but no Nissl bodies. The axon terminates in many fine filaments called telodendria. Along the course of an axon, there may be side branches called axon collaterals. The axons are usually covered by a fat containing myelin sheath which is further enveloped by a single layer of fat cells called Schwann cells. The outermost layer of Schwann cell plasma membrane is sometimes called the neurilemma. Schwann cells produce the myelin sheath around the axon. Myelin is white and made up of phospholipid. The myelin sheath provides both mechanical support and electrical insulation to the axon. The myelin sheath is not continuous on the axon but leaves small naked areas called nodes of Ranvier. At the end of the axon slight swellings called synaptic knobs or buttons are present. Buttons make contact with other cells.



TYPES OF NEURONS

1. On the basis of the number of processes emerging from the cell body, neurons can be classified into Apolar, Unipolar, Bipolar and Multipolar.

a. Apolar

Primitive neurons without cytoplasmic processes like axon or dendrites.

Eg: Embryonic neuro ectodermal cells.

b. Unipolar

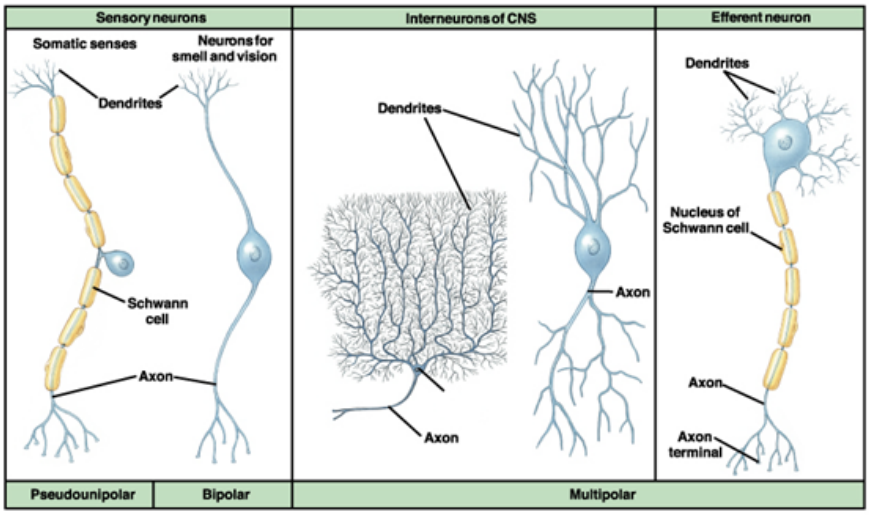
Neuron with only one cytoplasmic process, the axon. Dendrites are absent. Such type of neurons are mostly found in the roots of cranial nerves like trigeminal, gloss pharyngeal, vagus etc.

c. Bipolar

Neuron with one axon and one Dendron. Such neurons are found in retinal layer of eye.

d. Multipolar

Neuron with a long axon and many cytoplasmic processes or dendrites. Most of the neurons are of this type.



Histologically neurons are categorized into myelinated neurons (those with myelin sheath they appear to be white) and unmyelinated neurons (those without myelin sheath, such neurons appear to be grey).

On the basis of function neurons are classified into motor neurons (motor neuron conduct impulses away from the brain or spinal cord), sensory neurons (they are located within the receptor organs and transmit impulses towards the central nervous system) and internuncial neurons (mixed) (these neurons lie between sensory and motor neurons and transmit signals in several directions according to the need of the animal).

On the basis of the chemical substance released by the neurons, they are of two types

1. **Adrenergic neurons** (Those release sympathin or Adrenaline)
2. **Cholinergic neurons** (produce a substance called acetylcholine)

SYNAPSES

A Synapse is the region where two neurons are functionally connected, OR the junction between two neurons is known as a synapse. Actually synapse is a gap, (of 200A^{o}) the synaptic cleft, between the end of one nerve fibre and the beginning of the next.

The following types of synapses have been recognized depending upon the parts of neurons that come in contact.

1. **Axon dendritic**

In this type an axon terminates on a Dendron of another neuron.

2. **Axo somatic**

Here an axon terminates on the cell body or soma of another neuron.

3. **Axo-axonic**

In this type an axon terminates on another axon.

4. **Dendro-dendritic**

The synapse develops between the dendrites of different neurons.

NEUROGLIA

The neurons of the central nervous system are supported by four types of non-excitable glial cells. They are astrocytes, oligo dendrocytes, microglia and ependymal cells. Neuroglial cells service the neurons. They have supportive, nutritive and perhaps some communicative functions. Microglial cells, in addition to supporting neurons, also phagocytize bacterial and cellular debris.

Check Points

- Neuron or nerve cell is the morphological and functional unit of nervous system.
- Neuron consists of cell body called cyton, Axon and dendrites.
- Dendrites carry impulses towards cell body and axon carry impulses away from the cell body.
- Functional connection between the two neurons is the synapse.
- Nerve cells never multiply because of the absence of centrosome.
- Axon hillock is found to be rich in neurofibrils.
- Nissl bodies are present in cyton and dendrites but absent in Axon.
- Schwann cells produce myelin sheath around the axon.
- Neurons are classified into different categories 1. Based on the number of processes emerging from the cell body 2. Histologically 3. On the basis of function and 4. On the basis of chemical substances released by them.
- Neuroglia is the packing tissue present in the central nervous system.

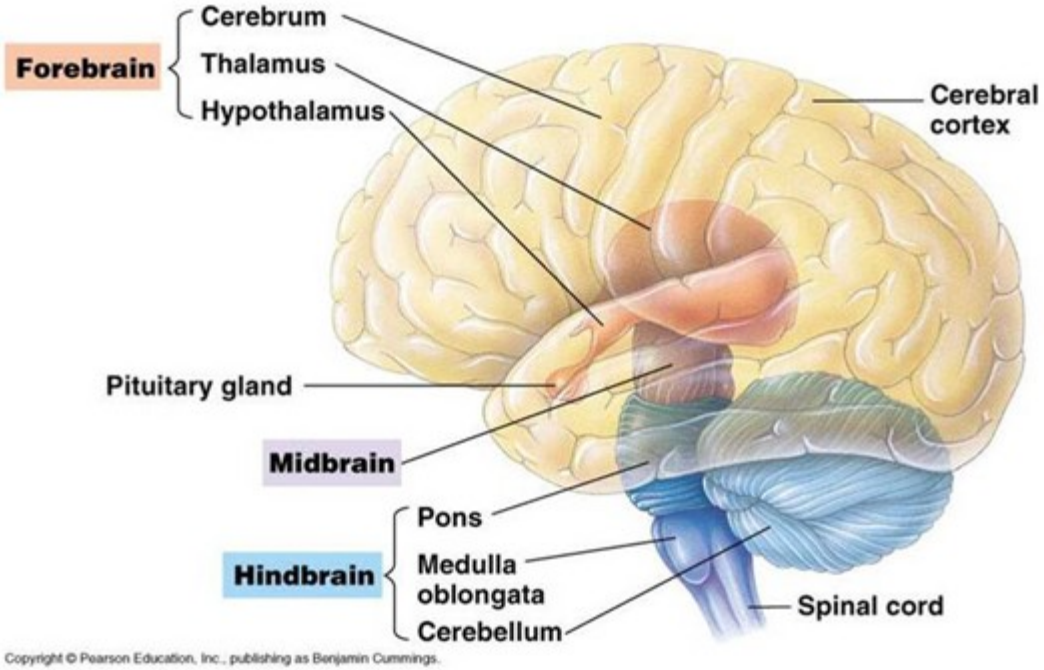
Semester – III

General Biology

Unit IV Co-ordination of organs

Module No: 20 (III) Central nervous system

The central nervous system includes Brain and Spinal cord. The Brain of man is highly evolved and enclosed in a cranial cavity. The human brain weighs a mere 3 pounds (1.36 kilograms) and looks and feels like grayish pudding. The brain is covered by three protective membranes called meninges. The outer thick layer present below the cranium is called duramater, inner highly vascularised membrane is called Piamater and Arachnoid membrane is middle layer. The cavities in between these layers are filled with cerebrospinal fluid. The brain is hollow structure having cavities called ventricles, filled with cerebrospinal fluid.



The brain can be divided into three major parts

1. Fore brain or Prosencephalon
2. Mid brain or Mesencephalon and
3. Hind brain or Rhombencephalon

Fore brain

It includes olfactory lobes, cerebrum and diencephalon. A pair of short club shaped olfactory lobes are present at anterior end of the brain. The cavity of the olfactory lobe is called rhinocoel. Olfactory lobes are the centers of smell. A pair of olfactory nerves arises from the olfactory lobes. A pair of large cerebral hemispheres constitute the cerebrum. Right and left hemispheres are connected by a thick bundle of myelinated fibres called corpus callosum. Each cerebral hemisphere is divided into four lobes by three deep fissures. The lobes are frontal, Parietal, temporal and occipital lobes.

The cavities of cerebral hemispheres are paracoels or lateral ventricles. The cerebral hemispheres receive sensory impulses from the sense organs and issue motor impulses for voluntary movements. They are also the seat of intelligence, memory, learning, perception, will and emotions. The outer layer of cerebrum is the cerebral cortex. The cerebral cortex contains sensory, motor and association areas. Sensory areas receive and interpret messages from sense organs about temperature, body movement, pain , touch, taste, smell, sight and sound. Motor areas send impulses to skeletal muscles. Association areas do not appear to be either sensory or motor, but they are the seats of learning and creativity. Diencephalon is small posterior part of the fore brain. The cavity of the diencephalon is diocoel or third ventricle. The two Paracoels communicate with the dicoel by a transverse passage called inter ventricular formina. The roof of diocoel is called thalamus and floor of diocoel is called hypothalamus. Pineal body is attached to thalamus and hypothalamus bears pituitary gland. Groups of nerve cell bodies in the hypothalamus control hunger, thirst, sexual arousal and feelings of pain, pleasure, anger and fear. The hypothalamus also regulates hormone secretion from the pituitary gland. Thus, the hypothalamus links the nervous and endocrine systems, the body's two communication systems. The thalamus is a gray, tight package of nerve cell bodies, acts as a relay station for sensory input, processing incoming information and sending it to the appropriate part of the cerebrum.

The Mid brain

It is the middle region of the brain. It consists of optic lobes. A transverse groove divides each optic lobe into two parts, thus forming four optic lobes, collectively called corpora quadrigemina. The mid brain has a thin canal called iter or cerebral aqueduct which connect diocoel with myelocoel (IV^{th} ventricle). The optic lobes are concerned with sense of sight. The mid brain receives sensory information from touch, sound, visual and other receptors and passes it to the fore brain.

Hind brain

It is the posterior region of the brain. This includes three parts – cerebellum, pons varolii and medulla oblongata. Pons varolii is a transverse band of nerve fibres connects the right and left halves of the cerebellum. In addition, gray matter in the pons controls some aspects of respiration. Cerebellum is well developed and transversely elongated. It consists of a median lobe called vermis and two lateral lobes. Cerebellum maintains equilibrium and co-ordinates the voluntary muscular movements. Medulla oblongata is broad anteriorly and tapers posteriorly into the spinal cord. It is the last part of the brain. The cavity of medulla oblongata is called myelocoel or fourth ventricle. Medulla oblongata and pons varolii control the involuntary activities in the body such as heart beat, blood pressure, breathing etc. In addition, the medulla contains reflex centres for vomiting, coughing, sneezing, urinating, defecating, swallowing etc.

Spinal cord

The medulla oblongata of the brain continues as spinal cord. It comes out through the foramen magnum of the skull. The spinal cord is a tube of neural tissue encased in the bony armor of the vertebral column, which protects the delicate nervous tissue. The spinal cord extends about 17 inches from the base of the brain to an inch or so below the last rib. It carries impulses to and from the brain. The spinal cord communicates with and receives information from the rest of the body through31 pairs of spinal nerves, numbered according to their position along the cord. The spinal cord is also made up of grey matter and white matter. White matter is external and grey matter is internal. The spinal cord encloses a central canal which is connected with myelocoel. The central canal is also filled with cerebrospinal fluid. Spinal cord is slightly dorsoventrally flattened. Grey matter is “H” shaped or butterfly shaped extend into white matter and forming dorsal horns and ventral horns. The spinal cord conducts information to and from the brain via myelinated fibers that form white matter at the periphery of the cord. The gray matter interior of the spinal cord consists of motor neuron cell bodies, un myelinated fibers, interneurons and glial cells. The spinal cord handles reflexes without interacting with the brain.

Check points

- Duramater, Pia mater, Archnoid membraines are the protective covering of the brain.
- Brain cavities are called ventricles filled with cerebrospinal fluid.
- Olfactory lobes are centres of smell.
- Both cerebral hemispheres are connected by corpus callosum.
- Inter ventricular foramina connects paracoels with the diocoel.
- Four optic lobes are collectively called as corpora quadrigemina.
- Cerebellum maintains equilibrium and co-ordinates voluntary movements.
- Medulla oblongata and pons varolii control the involuntary activities.
- Spinal cord controls reflex actions.

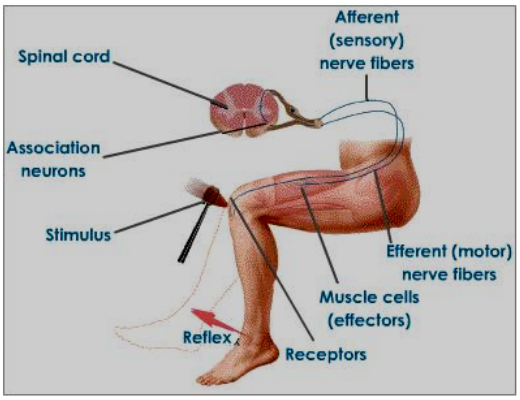
Semester – III

General Biology

Unit IV: Co-ordination of organs

Module No: 21(III) Reflexes and Reflex arc

Most of our body activities and reactions to environmental changes are automatic or involuntary. Such responses which occur outside of our awareness are immediate and rapid and are called reflexes. A reflex may be defined as an immediate and rapid response given without our awareness by an effector organ on the arrival of some external or internal stimulus.



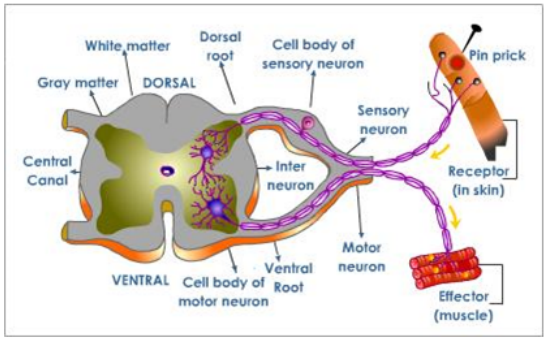
Reflexes are usually classified into two

1. Simple or un conditioned reflex and
2. Conditioned reflex or acquired reflexes

Simple Reflex

A simple reflex is an in born, inherited or unlearned response to a stimulus and do not depend upon previous experience. Most reflex actions are protective in function. There are a number of familiar examples.

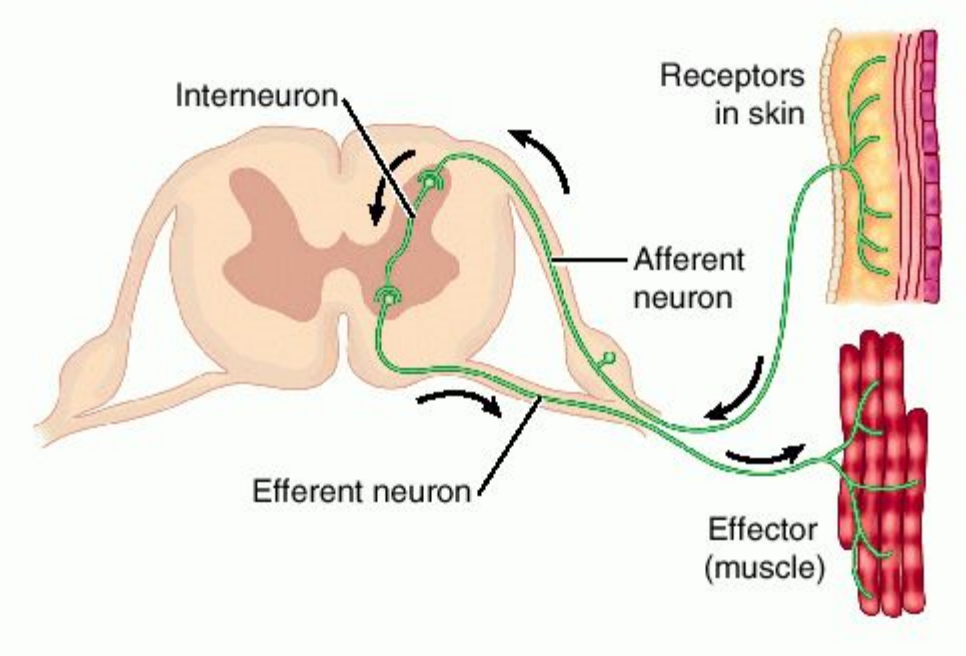
1. The quick closing of an eyelid when an object suddenly approaches the eye.
2. The quick jerk of the leg if the patella tendon is sharply tapped.
3. The rapid withdrawal of a hand when it is burned.



4. The quick recovery of the balance of the body to prevent falling, after a slip.

Many other reflex actions occur within the body which never reach consciousness, for example, glandular sanctions, movements of the stomach, intestine, breathing, rats of heart beat etc.

1. A sensory neuron which comprises the sensory nerve endings in a receptor organ, the sensory nerve, posterior (dorsal) root ganglion cells and its nerve fiber which posses to the dorsal horn of grey matter in the spinal cord.
2. A connector neuron which consists of a nerve cell, its dendrites and axon in the spinal cord.



3. A motor neuron consisting of a nerve cell and its dendrites in the ventral horn of the grey matter. The axon of this nerve cell and the motor and plated terminate in the effector organ. eg: muscles.

Check Points

- Spontaneous involuntary activities, evoked by the stimulation of receptors are called reflexes.
- Reflexes are two types – unconditioned reflexes and conditioned reflexes.
- Unconditioned reflexes are all inborn, and do not depend upon previous experience.
- Conditioned reflexes develop after birth and their appearance depends upon previous experience.
- The structural and functional basis of the simple reflex is called the reflex arc.
- Reflex action is the response to a stimulus carried over a reflex arc.

Semester – III

General Biology

Unit III: Human Physiology – III

Module No: 16 (III) Types of receptors - Eye

Our senses make us aware of changes in our surroundings and in our own bodies. We have sense cells which respond to stimuli. A stimulus is a change in light, temperature, pressure etc. which produces a reaction in a living organism. Structures which detect stimuli are called receptors.

Types of receptors

Receptors can be classified according to the kinds of stimuli received, into mechano receptors (excitable by contact, pressure etc), chemo receptors (excitable by chemical changes), Thermo receptors (excitable by changes in Temperature) and osmo receptors (excitable by changes in osmotic pressure) and so on.

Receptors can also be divided on the basis of their location into intero receptors, Proprio receptors and extero receptors.

a) Intero receptors (Visceral receptors)

These are found in internal organs and are responsive to the changes of internal environment.

b) Proprio receptors

These are present on the skeletal muscles, tendons and ligaments. They ensure a well co-ordinated contraction of so many muscles together.

c) Extero receptors

They are present close to the body surface and receive information from external environment. These are divisible into cutaneous sense organs or general receptors and special sense organs.

1. Cutaneous sense organs or General receptors:

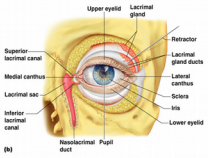
This category includes

a) **Algesi receptors:** They are pain receptors.
b) **Tango receptors:** They are tactile receptors. They are excited by touch and pressure.
c) **Thermo receptors:** These are the receptors sensitive to temperature.

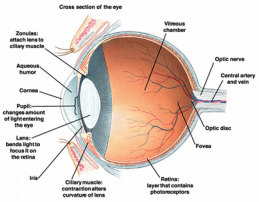
Those receptors which are localized are the special sensory receptors (eyes, ears etc).

EYE (Photo - Receptor)

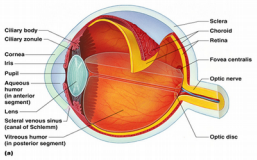
The human eye ball is almost spherical in shape. It is composed of three coats or layers.



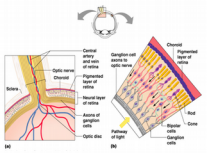
1. The white of the eye is the **outer most layer or sclera** which protect the inner structures. The front part of the sclera is clear and allows light to enter the eye. This part is called cornea. The conjunctive is a thin epithelium which lines the inside of the eye lids and the front of the sclera.



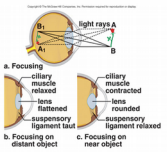
2. The middle layer of the eye ball is the **choroid coat**, is rich in blood vessels that nourish the eye. In the front of the eye the choroid thickens into a highly folded structure called the ciliary body, which houses the ciliary muscles. This muscle alters the shape of the lens to adjust focus of the image. In front of the ciliary body, the choroid becomes the thin iris, which provides eye colour. Opening present in the iris is called pupil. The pupil narrows or widens and there by regulates the amount of light admitted to the eye.



3. The third and inner most layer of the eye ball is the **retina**. The retina contains three layers of cells – from inside to outside – ganglion cells, bipolar cells and photo receptor cells. There are two types of photo receptor cells, namely rods and cones. These cells contain the light sensitive proteins called the photo pigments. The photo pigments of rods are called rhodopsin and the photo pigment of cones is called Iodopsin. **Rod cells, which are concentrated around the edges of the retina, provide black and white vision in dim light and enable us to see at night. Cone cells, which are concentrated towards the centre of the retina, detect colour.** The human eye contains about 125 million rod cells and 7 million cone cells.



4. The **iris** divide the cavity of the eye ball into anterior aqueous chamber and posterior vitreous chamber. These chambers are filled with aqueous humor and vitreous humor. Both humors help bend light rays to focus them on the retina. Behind the iris a transparent, biconvex disc like lens is present in man. The aqueous humor cleanses and nourishes the cornea and lens and presses against the sclera to maintain the shape of the eye ball.
5. The optic nerve leaves the eye and the retinal blood vessels enter it at a point, where there are no sensory cells and so no information reaches the brain about that part of the image. This point is called **Blind spot**.
6. The cone cells are concentrated in a central part of the retina called the fovea and when you study an object closely, you are making its image fall on the fovea. The centre of the fovea contains only cones; it is here that colour discrimination occurs.
7. Light from an object produces a focused image on the retina. The curved surfaces of the cornea and lens both bend the light rays which enter the eye, in such a way that each point of light from the object forms a point of light on the retina. These points of light will form an image, upside down and smaller than object.
8. The cornea and the aqueous and vitreous humours are mainly responsible for the bending (refraction) of light. The lens makes the final adjustments to the focus.
9. The pattern of sensory cells stimulated by the image will produce a pattern of nerve impulses sent to the brain. The brain interprets this pattern, using past experience and learning, and forms an impression of the size, distance and upright nature of the object.
10. **Human eyes have remarkable power of accommodation by changing the convexity of the lens.** The eye can produce a focused image of either a near object or a distant object. To do this the lens changes its shape, becoming thinner for distant objects and fatter for near objects. This change in shape is caused by contracting or relaxing the ciliary muscles present in ciliary body.



11. When both the eyes can be focused simultaneously on a common object, as in human eyes, it is called **Binocular vision.**
12. The Lacrimal glands under the top eye lid produce tears, which are composed of water, salts and an enzyme called lysozyme. The function of tears is to keep the surface moist and wash away dust particles or foreign bodies. Lysozyme destroys micro organisms in the front of the eye ball.

Check Points

- Receptors respond to stimuli by sending nerve impulses to the brain.
- Stimuli may be, for example, Light, Chemicals, Temperature, touch or pressure.
- The wall of the eye ball consists of three layers – the outer sclera, middle choroid and inner retina.
- Photo receptors cells called rods and cones are present on the retina.
- Rod cells enable us to sea at night.
- Cone cells detect various colours.
- The sensory cells of the retina are stimulated by the light and send nerve impulses to the brain.
- No image is formed in the blind spot.
- Brain interprets the nerve impulses and gives us the sense of vision.
- Ciliary muscles regulate the shape of the lens and iris regulate the amount of light entering the eye ball.
- The formation of an image on the retina requires – refraction of the light rays, accommodation of the lenses, and constriction of the pupil.
- The eye can focus on near or distant objects by changing the thickness of the lens.
- In human beings, the vision is binocular.
- Lachrymal glands produce tears.

Semester- III

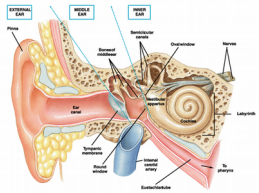
General Biology

Unit III: Human Physiology – III

Module No: 17 (III) Types of receptors – Ear and Tongue

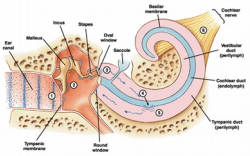
The Ear

1. The ear is a specialized receptor for detecting sound waves in the surrounding air.
2. The ear of man consists of three parts – External ear, middle ear and internal ear.
3. **External ear** consists of two parts **a)** the pinna and **b)** auditory canal. In humans, the pinna serves the functions of collecting sound waves and direct them in to auditory canal. The auditory canal extends inwards to the ear drum (Tympanic membrane). Its lining contains numerous ceruminous glands which secrete war wax (cerumen). The wax lubricate the canal and prevents foreign objects from entering the ear.

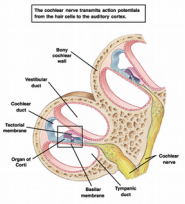


4. **The middle ear** is an air filled chamber called tympanic cavity and is separated from the external ear by tympanic membrane (ear drum). The tympanic cavity is connected with auditory capsule by two apertures- an oval fenestra ovalis and a circular fenestra rotundus.
   The middle ear contains three ossicles called malleus, incus and stapes which are attached to one another in a chain like fashion. Malleus is attached to the innerside of the tympanic membrane while the inner broader end is connected to incus. The inner end of incus is connected to stapes. The oval base of the stapes fits into the oval window (fenestra ovalis) of the cochlea.

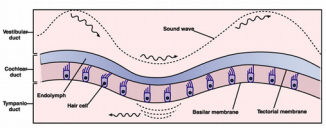
   The ear ossicles increase the efficiency of transmission of sound waves to the inner ear. An Auditory (Eustachian) tube connects the middle ear cavity with the pharynx. The Auditory tube helps in equalising the pressures on either side of the tympanic membrane.



5. **Internal ear** consists of two labyrinths, one within the other. The inner one is called the membranous labyrinth which is filled with endolymph. The membranous labyrinth is surrounded by a bony labyrinth. The space between the two labyrinths' is filled up with perilymph. The membranous labyrinth consists of three parts namely vestiblule, semicircular canals and cochlea.
6. **The cochlea,** the part involved in hearing is coiled like a snail shell. It is spirally coiled, making two to five turns connected together by supporting elastic ligaments. The cochlea is divided into three longitudinal canals that are separated from each other by two thin membranes called Reissner's membrane and Basilar membrane. One of these canals is called the scala vestibuli whose base is closed by the oval window(fenestra ovalis). The scala tympani has its base closed by the round window (fenestra rotundus) which opens to the middle ear. Between these two canals is the scala media. The scala media contains the actual organ of hearing called organ of corti, which are groups of specialized hair cells .
7. **The organ of corti** is a structure located on the basilar membrane of the scala media. The actual sensory receptors in the organ of corti are two types of hair cells. They are innervated by nerve fibres of the cochlear branch of vestibulocochlear (VIII) nerve. From the upper surface of the hair cells project tiny hair or stereo cilia which are embedded in the tectorial membrane.



8. **The vestibular apparatus** is also present in the internal ear just above the cochlea. The vestibular apparatus consists of three semi circular canals and two small membranous sacs called saccule and utricle. They are filled with endo lymph. Three bony semi circular canals project upwards and arranged approximately right angles to the other two. One end of each canal enlarges into a swelling called ampulla which contains a projecting ridge called crista ampullaris. The saccule and utricle also contain projecting ridge called macula. The crista and macula are the specific receptors responsible for maintenance of balance of the body and posture.
9. **In hearing** sound waves are received by the external ear and transmitted through the auditory canal to the tympanic membrane which is caused to vibrate. The vibrations are conducted by the chain of ear ossicles to the oval window which transmits them to the fluid in the vestibular and tympanic canals. The vibrations of the endolymph cause the basilar membrane, with its hair cells to vibrate so that the latter strike the tectorial membrane. This stimulation of hair cells causes them to initiate nerve impulses in the fibres of the cochlear nerve, with which they are connected. The impulses are carried to the brain where they are analysed and the sound is recognized.



TONGUE

1. Gustato – receptors form the organs of taste. These receptors are located in taste buds. Taste buds are found in some connective tissue elevations on the tongue called papillae. These papillae make the outer surface of tongue rough. In human being there are about 10,000 taste buds. In humans, the taste buds are also located in the mucosa of the epiglottis, palate and pharynx. In man three types of papillae are present on the tongue. They are vallate papillae, Fungi form papillae and Foliate papillae.
2. A taste bud is an oval shaped sac about 50 µm in size and opens on the surface by taste pore. It has a number of spindle shaped cells which are of two types.

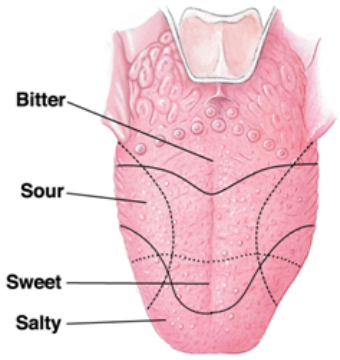
a) Gustato receptors

These are 5 – 15 in number in a taste bud. Each is long, narrow, crescentic shaped, bipolar, neurosensory cell. It has hair like microvilli on free side and a nerve fibre on the other side. The nerve fibres join to form either facial (VII) or glosso pharyngeal (IX) nerve which conduct nerve impulses to a taste area present in the parietal lobe of cerebral hemisphere where taste impulses are interpreted.

b) Supporting cells

These are about 40 in number.

3. The gustatory cells are also chemo receptors and are sensitive to specific chemicals of food in solution. The food chemicals are dissolved in mucus and saliva, enter the taste buds through taste pore and stimulate taste cells.



4. A man can perceive four basic modalities of taste namely sweet, sour, salty and bitter. Each of four tastes is due to a different response to different chemicals.
5. Although the tip of the tongue reacts to all four taste sensations, it is highly sensitive to sweet and salty substances. The posterior portion of the tongue is highly sensitive to bitter substances. The lateral edges of the tongue are more sensitive to sour substances. Except specified areas concerned with four basic tastes, rest of the tongue is insensitive to various chemicals.

Check Points

- Ear of man consists of three parts – External, middle and internal ear.
- Malleus, incus and stapes are the ear ossicles present in the middle ear.
- Bony labyrinth and membranous labyrinth are present in the internal ear.
- The part involved in hearing is cochlea.
- Organ of corti is present in the scale media.
- Vestibular apparatus is responsible for maintenance of balance of the body and posture.
- The fibres of auditory nerve innervate the internal ear.
- Taste buds are present on the tongue, epiglottis, palate and pharynx.
- In man about 10,000 taste buds are present on the tongue.
- Man can perceive only sweat, sour, salty and bitter tastes.

Semester – III

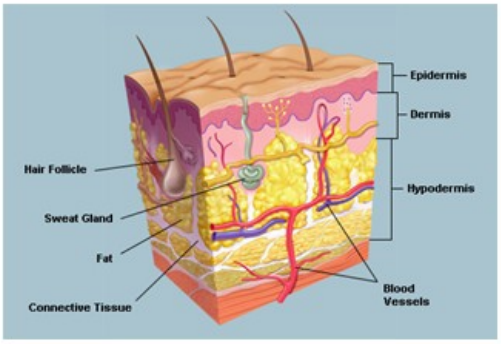
General Biology

Unit – II Human Physiology - II

Module No: 11 (III) Skin Structure

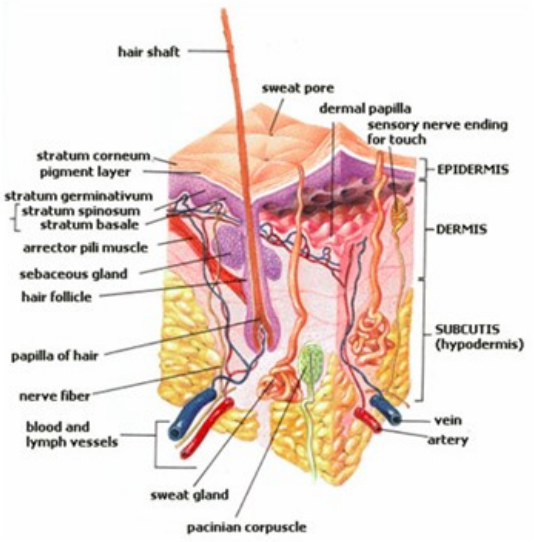
Skin structure

The body is covered by a protective layer called skin or integument.
The skin consists of two parts – an outer epidermis and an inner dermis.



Epidermis

Epidermis is derived from ectoderm. Epidermis consists of several layers of epithelial cells. The outer most layer is called stratum corneum. This layer consists of dead cells and is made up of keratin. This layer does not allow water and solutes to pass out. Just below the stratum corneum one more layer of cells is present and it is called stratum lucidum. Inner to stratum lucidum is present stratum granulosum made up of granular cells.



Inner most layer of the epidermis is called stratum malpigihii or stratum germinativum. The cells of this layer goes on dividing and producing new cells. As the new cells are formed, the older ones are pushed up and gradually the protoplasm is converted into horny substance called keratin. Some pigment cells called chromatophores are present in the basal layer of the epidermis and they are responsible for the colour of the skin.

Dermis

Dermis is present below the epidermis. It consists of connective tissue fibres, unstriped muscles, blood capillaries, nerves, fat cells and lymph vessels. Several finger like touch receptors with nerve endings are present in the dermis but projecting into the epidermis. Groups of fat cells are present in the deeper part of the dermis (adipose tissue) serving as heat insulating layer. Dermis gives firmness and flexibility to the skin and support the body.

Hair

The skin is covered with hair. Hair is ectodermal out growth derived from malpighian layer of epidermis. Hair is present in hair follicle. Hair follicles are formed by the invagination of stratum malpighii layer of the epidermis. Hair consists of two parts – basal root lying in the dermis and upper part which project out from the epidermis is called shaft. At the base of each hair follicle is present an hair papilla which is rich in nerves and blood vessels. The cells of hair papilla multiply and are responsible for the growth of the hair. The shaft of the hair is covered by cuticle. Sebaceous glands of the skin opens into the hair follicles. The oily secretion of sebaceous glands called sebum keep the hairs and skin water proof and greasy and gives hair a shiny appearance. Sebaceous glands are absent on the palms of the hand and soles of the feet. These glands are also modified to form mammary glands (producing milk) meibomian glands (lubricate the eye lids) perineal glands (perineum –give characteristic odur to the animal). Sebaceous glands are bacteriocidal in nature.

Sweat glands (Sudo rific glands)

Stratum malpighii of the epidermis invaginates to form long, tubular sweat glands. These glands are present in the dermis but opens with the help of a duct on the surface of skin – by a minute pore. The cells of the sweat glands separate sweat from the blood and is passed outside on the surface of the skin. Sweat glands play an important role in excretion. These glands remove metabolic wastes from the body in the form of sweat. The sweat consists of water, inorganic salts and excretory products. These glands also regulate the body temperature by evaporating the sweat. In man sweat glands occur all over the body except on lips and penis. Sweat glands are modified to form ceruminous glands in external ear and secrete ear wax, which protect and lubricate tympanic membrane.

Check Points

- The skin consists of an outer epidermis and inner dermis.
- Adipose tissue keeps the body warm.
- The skin is covered with hair which form the exoskeleton.
- Hair is derived from Malpighian layer of the epidermis.
- Sebaceous gland secretions help to keep the skin soft and oily.
- Sweat glands play an important role in excretion.
- Sweat glands also regulate the body temperature.
- The dermis consists of connective tissue, blood capillaries nerves, fat cells, lymph vessel etc.

Glossary

Perineum: The space present between the anus and urinogenetal aperture.

Semester – III

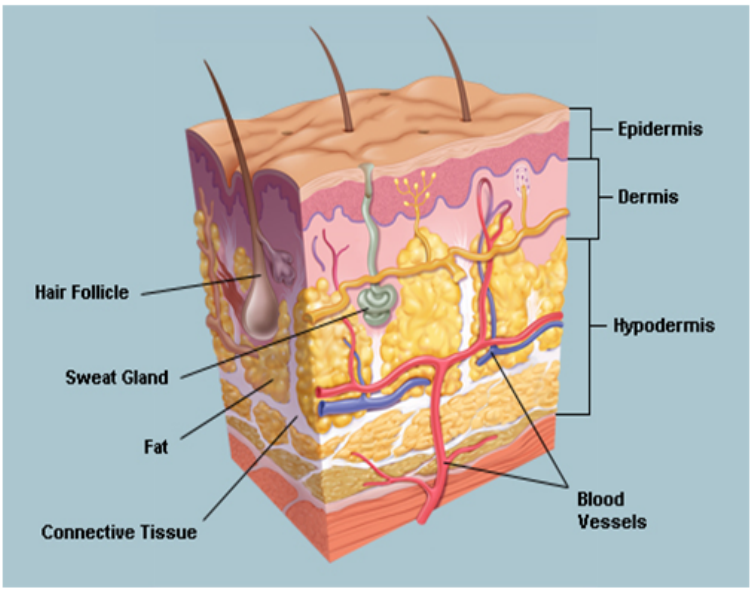
General Biology

Unit – III: Human Physiology

Module No: 18 (III) Skin Functions

Skin Function

The skin serves many useful purposes.



1. Protection

The skin provides a protective body-covering. It also gives protection to the muscles underneath. The outer most layer (Statum corneum) of dead cells of the epidermis helps to reduce water loss and provide a barrier against bacteria. The pigment cells present in the basal layer of epidermis protect the skin from damage by the ultraviolet rays in sunlight.

2. Sensitivity

In the skin there are various nerve-endings and special tactile corpuscles which receive stimuli of touch, pain, pressure, heat and cold. These make us aware of changes in our surroundings and enable us to take action to avoid damage, to recognize objects by touch and to manipulate objects with our hands.

3. Temperature Control

The skin helps to keep the body temperature more or less constant. This is done by adjusting the flow of blood near the skin surface and by sweating. Normal human body temperature varies between 35.8^{0}C and 37.7^{0}C. Temperature below 34^{0}C or above 40^{0}C if maintained for long, are considered as dangerous. Heat is lost from the body surface by conduction, convection, radiation and evaporation. Heat is gained, internally, from the process of respiration in the tissues and, externally, from the surroundings or from the sun. These two processes are normally in balance but any imbalance is corrected by the following methods.

I. **OVERHEATING:** It can be controlled by

a) **Vasodilation**

The widening of the blood vessels in the dermis allows more warm blood to flow near the skin surface and so lose more heat.

b) **Sweating**

The sweat glands secrete sweat on to the skin surface. When this layer of liquid evaporates, it takes heat from the body and cools it down.

II. **OVER COOLING:** Can be avoided by

a) **Vaso constriction**

Constriction of the blood vessels in the skin reduces the amount of warm blood flowing near the surface.

b) **Sweat production stops**

Thus the heat lost by evaporation is reduced.

c) **Shivering**

Shivering followed by muscular contraction in the limbs release heat as a result of respiration in the muscles.

In these ways, the body temperature remains at about 37^0C. we also control our temperature by adding or removing clothing or deliberately taking exercise.

4. Homeostasis and Negative feed back

Homeostasis means "Staying similar". It refers to the fact that the composition of the tissue fluid in the body is kept within narrow limits. The concentration, acidity and temperature of this fluid are being adjusted all the time to prevent any big changes.

Many systems in the body contribute to homeostasis. Temperature regulation is an example of homeostasis. Maintenance of a constant body temperature ensures that vital chemical reactions continue at a predictable rate and do not speed up or slow down when the surrounding temperature changes. The constant temperature or homoio thermic (warm blooded) animals (birds and mammals) therefore have an advantage over the variable temperature or poikilothermic (cold blooded) animals.

Poikilotherms (reptiles, insects etc) can regulate their body temperature to some extent by, for example, basking in the sun or seeking shade. If their body temperature falls, their vital chemistry slows down and their reactions become more sluggish. The homoiotherms have to take enough food to maintain their body temperature, usually above that of their surroundings.
In the hypothalamus of a homoiotherm's brain, there is a thermo regulatory centre. This centre monitors the temperature of the blood passing through it and also receives sensory nerve impulses from temperature receptors in the skin. A rise in body temperature is detected by the thermo regulatory centre and it sends nerve impulses to the skin which result in vaso dilation and sweating. Similarly, a fall in body temperature will be detected and will promote impulses which produce vaso constriction and shivering.
This system of control is called negative feedback. The outgoing impulses counteract the effects which produced the incoming impulses. For example, a rise in temperature triggers responses which counteract the rise.

Check Points

- Skin provides a protective body covering and protect the body from bacteria and drying out.
- Sensory receptors present in the skin which give us the sense of touch, pain, pressure, heat and cold.
- Skin controls the body temperature by adjusting the blood flow and by sweating.
- Heat is lost to the surroundings by conduction, convection, radiation and evaporation.
- Heat is gained by respiration.
- Over heating of the body is controlled by sweating and vasodilatation.
- It the body loses too much of heat, vasoconstriction and shivering help to keep it warm.

Semester – III

General Biology

Unit – II: Human Physiology – II

Module No- 8 (III) Excretory organs: Lungs, Kidney, Liver and Skin

Excretion may be defined as the separation and elimination of the metabolic wastes from the body. Those organs which are responsible for the excretion of waste products are called excretory organs. These include skin, gills, lungs, liver, intestine and kidneys. These organs eliminate nitrogenous wastes, adjust water balance of the body and maintain ionic composition of the extra cellular fluids. The major waste products are carbon dioxide, excess of water and salts and nitrogenous products of protein catabolism.

Degradation of proteins, amino acids, purines and pyrimidines yield various nitrogenous substances such as ammonia, urea and uric acid. Ammonia is highly toxic, in mammals, ammonia is converted into harmless urea in the liver. Urea is highly soluble in water and is excreted out of the body in the form of urine. During the oxidative metabolism of carbohydrates, carbon dioxide and water are formed as excretory products. The bile pigments bilirubin and biliverdin that are formed in the liver by the breakdown of haemoglobin are excretory substances which pass out through the intestine. Carbon dioxide along with several volatile substances like alcohol, ketone bodies, aromatic oils, water vapour etc are excreted through the lungs.

Excretion also includes the removal drugs or other foreign substances taken into the alimentary canal and absorbed by the blood.

Lungs

The lungs supply the body with oxygen, but they are also excretory organs because they get rid of Co_2. Cellular respiration occurs in every living cell in our body through which our body derives energy in the form of ATP molecule for cellular activities. As respiration occurs Co_2 is produced as a waste product. As the Co_2 accumulates in body cells, it eventually diffuses out of the cells into the blood stream and from the blood circulation it reaches the lungs. In the alveoli of the lungs Co_2 diffuses from the blood into the lung tissue and then leaves the body every time we exhale. They also lose a great deal of water vapour, but this loss is unavoidable and is not a method of controlling the water content of the body.

Liver

Liver is the largest internal organ of our bodies. Its numerous functions make it part of the circulatory, digestive and excretory system. Liver excretes bile pigments namely bilirubin and biliverdin, which are derived from the break down of haemoglobin of the worn out erythrocytes. Bile is stored in the gall bladder before it passes into the small intestine and expelled with faeces. Liver also removes cholesterol, bile salts and other salts into the intestine. Some proteins and other nitrogenous compounds are broken down in the liver by a process called deamination to form Urea which is excreted in Urine. Nucleic acids are also broken down in the liver to form Uric acid, which is excreted in the urine.

Skin

The skin is a minor excretory organ for some substances including

1. Sodium chloride in Sweat
2. Urea, especially when kidney function is impaired
3. Aromatic substances eg: Garlic and other spices

The sweat glands in the skin excrete perspiration, which is a solution of water, salt and some urea. This aids the overall process of excretion. Sweat comes out of pores in your skin. So as you sweat, your body accomplishes two things 1. Sweat has a cooling effect on the body and 2. Metabolic wasts (water, salts and urea) are excreted.

Sweat gland is a tubular structure tangled with blood capillaries. This close association of tubes allows wastes (namely water, salts and urea) to diffuse from the blood into the sweat gland. When the body temperature rises the sweat is released from the gland and reaches the skin surface through pores. However, sweating is a response to a rise in temperature and not to a change in the blood composition. In this sequence, therefore, skin is not an excretory organ like the lungs and kidneys.

Kidneys

The kidney is a compound tubular gland, adapted to filtering wastes from the blood. Three of the four major metabolic wastes produced by the body are filtered from the blood by the kidneys. They are water, salts and urea. The fourth one is Co_2 which is excreted by the lungs. Each kidney is made up of thousands of tiny filtering sub-units called Nephrons.

The kidney is the main secretary organ of the body, and the fluid separated from plasma by its activity is the urine. The kidney aids in regulating the volume and composition of body fluids by virtue of its ability to alter the nature of urine with varying metabolic and environmental circumstances. Kidneys eliminate the end products of bodily metabolism such as urea, uric acid and creatine. It also excrete many foreign compounds such as drugs, food additives, pesticides and other exogenous non-nutritive materials that have gained entrance to the body.

Ureter is the duct coming out from kidney that opens in the urinary bladder. The bladder temporarily store urine. Urethra is the tube through which urine leaves the body when you urinates.

Excretory organ	Excretory Products	Incidental losses
Lungs	Carbon dioxide	Water
Kidneys	Nitrogenous wastes, water, salts, toxins, hormones, drugs etc.	
Liver	Bile pigments, Bile salts, Cholesterol	
Skin		Water, salt, urea

Check Points

- Excretion is the separation and elimination of the metabolic wastes from the body.
- Skin, lungs, gills, liver, intestine and kidneys are the excretory organs.
- The major excretory products include nitrogenous wastes, Co_2, excess of water and salts etc.
- Co_2 is eliminated through lungs.
- Liver excretes bile pigments and bile salts through bile into the small intestine.
- Break down of Nucleic acids in the liver forms uric acid.
- Sodium chloride, urea and some aromatic substances are eliminated by the skin.
- Nitrogenous wastes, water, salts, toxins, drugs etc are eliminated through kidneys.

Semester – III

General Biology

Unit IV: Co-ordination of organs

Module No: 22 (III) Production and Propagation of a Nerve impulse

Nerve impulse can be defined as "the sum total of physical and chemical reactions which take place in the propagation of the wave of physiological activity along the nerve fiber". Its propagation along the nerve fiber is called the transmission.

Transmission of Nerve Impulse

When nerve fiber is at rest i.e., when it is not carrying an impulse, the outside of the fiber is positively charged in relation to the inside. Inside the fiber is negatively charged. In this condition Na^+ ions are present outside the membrane and K^+ and Cl^- ions are present inside the membrane. This difference is called the potential difference. This difference is mainly due to the unequal distribution of sodium and potassium ions on either side of the membrane. Potassium ion concentration inside the neuron is about 30 times greater than it is outside. Similarly, sodium ion concentration is about 10 times grater outside than inside.

A potential difference arises when a membrane is selectively permeable to either anions or cations. The potential difference across the membrane is called resting potential. Resting potential of the membrane is – 70 millivolts. The resting potential depends on a physico chemical equilibrium condition known as the Donnan Equilibrium which predicts the movements of Na^+, K^+ and Cl^- ions into and out of living cells. The membrane at this stage is said to be polarized membrane.

Stimulation of nerve changes the permeability of the nerve fiber membrane creating an action potential. This stimulus may be of mechanical, electrical or chemical nature. The action potential alters the ionic permeability of the membrane. As a result Na^+ ions quickly moves in results in a positive charge on the inside of the fiber as compared with the outside. This reversal of electric charges is called depolarization. This process ignites to create the nerve impulse. Reversal potential is + 40 millivolts. A nerve fiber will not respond unless the stimulus applied to it is of certain minimum strength called Threshold. (Stimulus can be defined as the environmental change which may disturb the steady state of living matter).

Action potential may be defined as self propagating – depolarization of the nerve membrane. The propagation of depolarization process along a nerve fiber is called nerve impulse.

The flow of current can be explained by local circuit theory. It states that current flows inwards through the depolarized membrane and outwards through the resting membrane thus completing a local circuit.

After fraction of a millisecond Na^+ conductance decreases to its normal level and K^+ ions begin to flow out faster leading to repolarization (return to the resting state)

The active transport of Na+ out of the cell and the reestablishment of K+ concentration inside it restore the cell to a resting state. This mechanism is called sodium potassium exchange pump because it transports sodium out of the cell and at the same time also moves potassium back into the cell against concentration gradient by expenditure of energy.

Propagation in Myelinated nerves

Myelin is a lipid rich wrapping of high electric resistance and functions as an effective insulator. But this insulation is broken at the nodes of Ranvier.

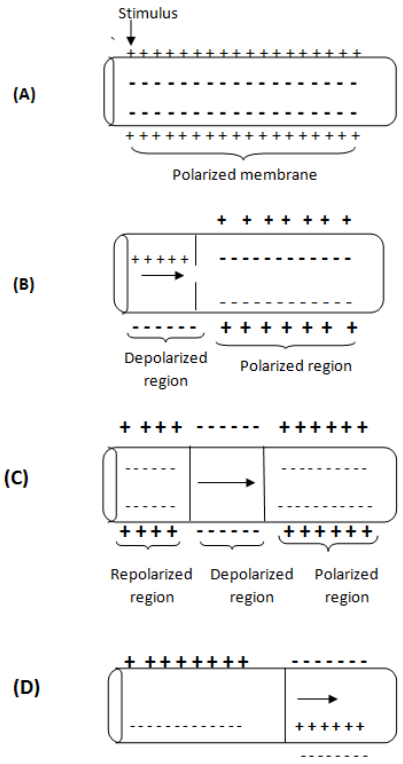
In myelinated nerve fibers depolarization takes place only at the nodes of Ranvier because myelin function as an effective insulator. Current flows from one node over the myelin to the next node by jumping, skipping or leaping instead of travelling along the nerve fiber. This is called saltatory propagation. Saltatory propagation increases the speed of the impulse, because only the membrane at the nodes of Ranvier must undergo depolarization. As a result impulse transmission is about 20 times faster in a myelinated than in an unmyelinated neurons. The nerve fiber carry impulses in only one direction due to the presence of synapse.

The synaptic transmission

The synapse is defined as the functional connection between two neurons. In synapses transmission is chemical. As soon as the impulse reaches the tip of the axon a chemical neurotransmitter substance called acetylcholine is released into the synapse.

The acetylcholine diffuse across the synoptic cleft and become attached to chemoreceptors present on the dendrites of the next neuron. The attachment triggers the depolarisation of the post synaptic membrane and initiate an impulse which now travels across the nerve fiber. The time required for the impulse to cross a synapse is about 0.5 millisecond. It is called the synaptic delay. Since dendrites do not release the chemical transmitter, synapse acts as a valve permitting only one way traffic of nerve impulses.

The acetylcholine is quickly hydrolysed by an enzyme acetyl cholinesterase present at the post synoptic membrane.



Figs: Initiation and transmission of nerve impulse

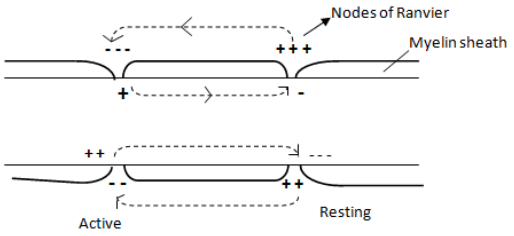


Fig: Saltatory conduction of nerve impulse in a myelinated fiber

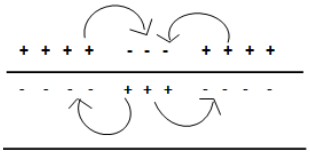


Fig: The arrows indicate a local circuit of current flow between the depolarized and the resting membrane areas.

Check points

- The nerve impulse can be defined as the sum total of mechanical, chemical or electrical disturbance created by a stimulus in a neuron
- The propagation of an impulse along the nerve fiber is termed as transmission.
- The potential difference across the membrane is called resting potential which is about -65 millivolts.
- Donnan Equilibrium predicts the movements of Na+, K+ and Cl- ions into and out of living cells
- Reversal poetential is +40 millivolts
- Local circuit theory explains the flow of current
- In myelinated nerve fibers depolarization takes place only at the nodes of Ranvier.
- Saltatory propagation takes place in myelinated nerve fibers.
- Synapse is the functional connection between the two neurons.
- Synaptic transmission is chemical takes place with the help of Acetyl Choline.
- Synaptic delay is 0.5 millisecond.

Semester – III

General Biology

Unit IV: Co-ordination of organs

Module No: 23 (III) Endocrine System

Human endocrine system is a complex collection of glands that control basic body functions such as metabolism, growth and sexual develop pment. The endocrine system communicates through hormones. Hormones are produced in very small quantities by the endocrine glands. Each hormone is responsible for specific functions in the body. The action of hormones is slow and of long duration. Chemically hormones are made up of proteins, amino acids and steroids.

The endocrine system consists of the following glands

1) Thyroid gland

It is a bilobed gland situated in the neck on either side of the trachea, below the larynx. It secretes iodine containing hormone called thyroxine. This hormone stimulate O_2 consumption, increase protein synthesis, enhances glucose absorption and it is essential for normal growth and mental development.

2) Para Thyroid glands

The Parathyroids are four small glands placed on the thyroid, two on each side. They secrete parathyroid hormone. This hormone plays an important role in regulating the calcium concentration of the blood, increases the calcium absorption by gut, regulates the excretion of inorganic phosphate in urine. This hormone mobilizes calcium from bones by stimulating bone resorption (dissolution or demineralization).

3) Thymus gland

The thymus gland is located on the ventral side of the heart and the aorta. It secretes thymosin hormone. The thymus gland is responsible for the maturation of special type of white blood cells called T-lymphocytes which provide cell mediated immunity. In addition thymosin also promote production of antibodies to provide humoral immunity.

4) Pituitary gland

It is present between the roof of the mouth and the floor of the brain in a depression of the sphenoid bone. It is regarded as the master endocrine gland as it influences many other endocrine glands. It is divided anatomically into an adeno hypophysis and a neuro hypophysis.

The hormones secreted by Adeno hypophysis includes

a) Growth Hormone (GH)

Stimulates growth of bones, cartilage, muscles, viscera and the body as a whole, promotes protein anabolism.

b) Prolactin Hormone (PRL)

It promotes the development of mammary glands and in secretion of milk immediately after child birth.

c) Thyroid Stimulating Hormone (TSH)

It controls the various aspects of thyroid gland function including development and maintenance.

d) Adreno cortico trophic Hormone (ACTH)

Stimulates the cortex of the adrenal gland to produce Gluco corticoids.

e) Luteinizing Hormone (LH)

In females it promotes final maturation of ovarian follicle, ovulation and formation of corpus luteum. In males it stimulates interstitial cells of testes to release male sex hormones.

f) Follicle Stimulating Hormone (FSH)

In females it stimulate the development and ripening of the ovarian follicle. In males it stimulates the development of seminiferous tubules and spermatogenesis.

The hormones secreted by Neuro hypophysis includes.

a) Oxytocin

It causes contraction of uterine muscles and uterus at the time of child birth and expulsion of foetus and placenta. It promotes the ejection of milk from mammary glands immediately after child birth.

b) Vasopressin or Antidiuretic Hormone (ADH)

It has an important role in regulating water re absorption by the renal tubules.

5) Adrenal Glands

The adrenal gland is located on top of each kidney. Adrenal gland has two parts – internal reddish brown medulla and outer bright yellow cortex. The adrenal medulla secretes two main hormones. They are adrenaline and noradrenaline. They are secreted in response to stress of any kind and during emergency situations like fear, anger, accident, intense pain, injury, poisoning, restless ness, anxiety, mental tension etc. and are called as emergency hormones or **hormones of Fight – Fright and Flight.**

a) Adrenaline (Epinephrine): The effects of adrenaline are

1. It intensifies cardiac contractions
2. It raises blood pressure
3. It dilates the vessels of skeletal muscles, heart, liver etc. to incr ease the flow of blood.
4. It relaxes smooth muscles of trachea – increasing the rate of breathing.
5. Accelerate breakdown of glycogen into glucose.
6. It increases oxygen consumption, body temperature and heat production.
7. It increases heart beat, inhibit peristalitic, movements of gut, dilates the pupils of the eye, increases muscular power and resistance to fatigue etc.

b) Noradrenaline (Norepinephrine)

It raises blood pressure, but it is responsible for constriction instead of dilation of the blood vessels.

Adrenal cortex also secretes several hormones.

They are

a) Gluco corticoids

Such as cortisone, cortisol and cortico sterone. They play an important role in carbohydrate, protein and fat metabolism. They increase blood glucose level at the expense of liver glycogen and enhance the conversion of protein to carbohydrates. They are anti – inflammatory hormones. Cortisone is used for suppressing allergies and rheumatoid arthritis.

b) Mineral corticoids

Such as aldosterone. Aldosterone acts mainly at the renal tubules and stimulate the reabsorption of sodium and water and excretion of potassium and phosphate ions. Thus this hormone helps in maintenance of electrolytes, body fluid volume, osmotic pressure and blood pressure.

c) Sex hormones

Sex hormones are secreted by Adrenal cortex. They are androgens and estrogens. Androgens are concerned with the development of secondary sexual characters.

6) Pancreas

Pancreas acts both as exocrine and endocrine gland. The pancreas is located with in the curve of duodenum. The endocrine portion of the gland consists of scattered, isolated groups of cells known as islets of Langerhans. The cells are three types 1) Beta cells 2) Alpha cells 3) Gamma cells. The Beta cells secretes a hormone called insulin. Insulin is the most important regulator of carbohydrate metabolism. It facilitates diffusion of glucose from blood into the cells. **The deficiency of insulin causes "Diabetes mellitus",** Alpha cells secrets Glucagon. Blood sugar levels are raised by glucagon. This hormone causes glycogenolysis in liver. Gamma cells secretes somatostatin. Somatostatin controls the rate at which the blood absorbs nutrients.

7) Testes

In between the seminiferous tubules there are interstitial cells of leydig. There Leydig cells secrete the hormone Testosterone. This hormone is responsible for the development of secondary sexual characters, promotes the growth and function of the epididymis, vas deferens, prostate, seminal vesicles and penis, influence spermatogenesis, stimulate muscular growth, growth of facial and axillary hair, aggressiveness etc.

8) Ovary

Two main types of female hormones are secreted by the ovary. They are 1) Estrogen produced by the cells of developing graafian follicle and 2) Progesterone derived from the corpus luteum that is formed in the ovary from the ruptured follicle after ovulation.

Estrogen promotes the development of female secondary sexual characters, development of mammary glands, pelvis becomes broader, the genitalia enlarge and growth of hair. It also promotes the development of fat deposits in subcutaneous tissues, growth of fallopian tube and influences behaviour and psychic patterns in female.

Progesterone hormone maintains the foetus by forming placenta and inhibits uterine muscles to contract during pregnancy. It also stimulate mammary glands. Progesterone is responsible for carrying out the growth of endometrium, implantation of the fertilized egg in the uterine wall.

9) Hormones of Gastro intestinal tract

Endocrine cells present in different parts of the gastro intestinal tract also secrets different hormones. They are

a) **Gastrin** – Secreted by the wall of the stomach. It activates the gastric glands to secrete gastric juice.
b) **Chole cystokinin -** Secreted by the wall of duodenum. It stimulates the gall bladder for the release of bile juice.
c) **Secretin -** Secreted by the duodenum. It stimulates the pancreas to release pancreatic juice.
d) **Entero gastrone -** Secreted by the wall of duodenum. It inhibit gastrin secretion in the stomach.
e) **Entero crinin** – Secreted by the wall of intestine. It activates intestinal glands to secrete intestinal juice.

10) Hypothalamus

Hypothalamus is the basal part of diencephalon of forebrain. Neuro secretary cells of the Hypothalamus secretes hormones which regulates the synthesis and secretion of pituitary hormones. Two types of hormones are secreted by hypothalamus. They are 1) Releasing factors (RF) which stimulate secretion of pituitary hormones and 2) Inhibiting factors (IF) which inhibit secretion of pituitary hormones in accordance with the type of nervous stimulation that is channeled into the hypothalamus.

11) Placenta

It secretes Chorionic Gonadotropin and relaxin hormones. Chorionic gonadotropin maintains corpus luteum during pregnancy and exerts protective influence on the unborn child. Relaxin is produced by corpus luteum and placenta. It relaxes the pelvic ligaments and facilitates child birth.

Check Points

- The endocrine system is composed of hypothalamus, Pituitary, Pineal, Thyroid, Parathyroid, Adrenal, Pancreas, Thymus, Testes and Ovary.
- Secretions of endocrine glands are called Hormones. Hormones regulates various physiological activities.
- Hormones regulate metabolism, growth and development of our organ.
- Pituitary gland is regarded as the master endocrine gland as it influences many other endocrine glands.
- Adrenaline and nor adrenaline are called as emergency hormones. They are the hormones of Fight – Fright and Flight.
- Pancreas acts both as exocrine and endocrine gland.
- Deficiency of insulin causes Diabetes mellitus.
- Testosterone and Estrogen are sex hormones promotes the development of secondary sexual characters.
- Hormones secreted by gastro intestinal tract regulate the secretion of digestive juices and help in digestion.

GLOSSARY

Hormones: Hormones are chemical substances secreted by endocrine glands in minute quantities in one part of the body and transported by blood stream to another region where it produces a definite physiological effect.

Endocrine glands: These glands have no ducts and liberate their secretions known as hormones, directory into the blood stream. For this reason the endocrine glands are also referred to as the ductless glands.

Diabetes mellitus: Disease caused by inadequate insulin secretion in which sugar is improperly metabolized, high blood sugar, weakness, frequent urination and some times death are the result.

Placenta: A temporary reproductive organ of most mammals, by which the embryo is attached to the wall of the uterus and through which homeostatic exchanges take place between the mother and embryo.

General Biology

Unit – V: Human Reproduction

Module No: 24 (III) Male Human Reproductive System

Reproductive system is concerned with the production of young ones. Man shows distinct sexual dimorphism. Male and females differ in size and external genital organs. The reproductive system of both male and female individuals consists of definite structures and produce specialized reproductive germ cells called gametes. The male gametes are called spermatozoa and the female gametes are called ova. They contain the genetic material or genes on chromosomes, which pass inherited characteristics on to the next generation.

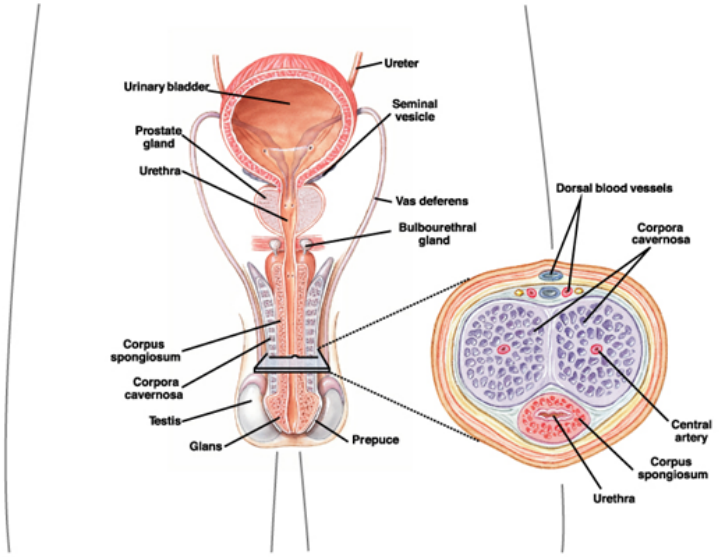
Male reproductive system

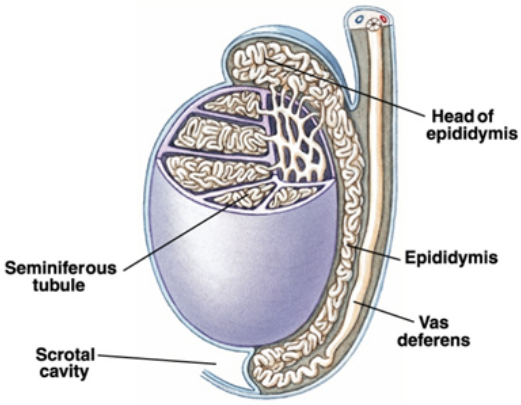
Male reproductive system consists of a pair of testes, Epididymis, vasa deferentia, seminal vesicles, prostate gland, urethra, Bulbo urethral glands and penis.

Testes

The male gonads are paired testes, which are suspended within the scrotal sacs of the scrotum by the spermatic cords, outside the abdominal cavity. Testes are surrounded by three layers of tissue. They are tunica vaginalis, tunica albuginea and tunica vasculosa. The tunica albuginea project inwards forming inter lobular septa, divide the testis into 200 to 300 lobules and within each lobule are 1 to 4 convoluted loops composed of seminiferous tubules. The seminiferous tubules are lined by germinal

epithelial cells from which spermatozoa develop by a process called spermatogenesis. Between the tubules are groups of interstitial cells or leydig cells that secrete the hormone testosterone after puberty.





Epididymis

It is also known as the main storage house of sperms. The seminiferous tubule in each testis open into a network called rete testes which open into fine ducts called vasa efferentia and then into epididymis. The epididymis is highly convoluted tubule serves to store and nourish the spermatozoa.

Vas deferens

Posterior part of epididymis leads into muscular tube called sperm duct or vas deferens. It is lined by a powerful muscle coat. Once the sperm have matured, they are propelled into the vasa deferentia by muscular contractions. At ejaculation, it propels the spermatozoa from the epididymis to ejaculatory duct in the urethra.

The Urethra

The vasa deferentia from both sides unites to form uterus masculinus above the urinary bladder. The neck of the urinary bladder and uterus masculinus join to form the urethra. It is the common passage for both urine and semen hence called urinogenital canal. Urethra passes into the penis.

The penis

Penis is a cylindrical muscular, erectile male copulatory organ present in front of the scrotum. It is formed by three cylindrical masses of erectile tissue and smooth muscle. The erectile tissue is supported by fibrous tissue. The two lateral columns are called the corpora cavernosa and the column between them, containing the urethra is corpus spongiosum. During sexual excitement in males blood spaces in corpora cavernosa filled with blood leads to erection of penis. Penis serves to transmit sperms into the vagina of female.

Seminal vesicles

The seminal vesicles are two small fibro muscular pouches lined with columnar epithelium, lying on the posterior aspect of the bladder. Each joins a vas deferens to form an ejaculatory duct that enters the urethra. As sperm pass from the vasa deferentia into the urethra, these vesicles secrete a thick, viscous fluid containing nutrients for possible use bye the sperms.

Prostate gland

The prostate gland is small, muscular, rounded organ present just below the bladder in pelvic cavity in front of the rectum. It secretes a thin, alkaline, milky fluid that makes up about 30% of semen and gives it its milky appearance. This fluid believed to activate or increase the motility of the sperm. The alkalinity assists in neutralizing the acids normally found in urethra, as well as those encountered within the vagina.

Bulbo-urethral (Cowper's) glands

The paired bulbo-urethral glands are situated at the base of the penis, slightly below the prostate gland, on either side of the urethra. They open into the urethral lumen. These glands secrete a thick, sticky, alkaline mucus that has lubricating and neutralizing properties.

Ejaculation

Sexual arousal can cause an erection, and if arousal reaches its peak, ejaculation follows. After sperm enter the ejaculatory duct, seminal vesicles, prostate gland and bulbo urethral glands release their secretions. As orgasm occurs, rhythmical contractions of the urethra expels sperms from the penis.

Puberty in the male

This occurs between the ages of 10 to 14. Luteinising harmone from the anterior lobe of the pituitary gland stimulates the interstitial cells of the testes to increase the production of testosterone. This hormone influences the development of the body to sexual maturity.

Check points

- Reproduction is the process of producing new individuals
- Testes are located in scrotal sacs outside the abdominal cavity
- The male gametes are called spermatozoa
- Seminiferous tubules are lined by germinal epithelial cells form which spermatozoa develops by a process called spermatogenesis.
- Epididymis serve to store and nourish the spermatozoa
- Penis is the copulatory organ of males
- Seminal vesicles secrete a thick, viscous fluid containing nutrients
- Bulbo urethral glands secretes alkaline mucus which has lubricating and neutralizing properties.

Semester – III

General Biology

Unit – V: Human Reproduction

Module No: 25 (III) Female Human Reproductive System

The female reproductive system includes the ovaries, the oviducts, the uterus, vagina and certain accessory glands.

Ovaries

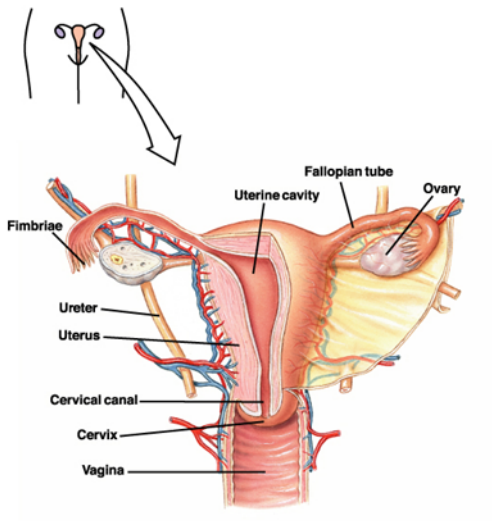
The female gonads are called ovaries. The ovaries are small, ovoid structures located one on either side of the pelvic cavity and on the sides of the kidneys. They are attached to the dorsal body wall by double folds of peritoneum called mesovarium. Blood vessels and nerves pass to the ovary through the mesovarium.

The ovaries have two layers of tissue. They are medulla and cortex. Medulla lies in the centre and consists of fibrous tissue, blood vessels and nerves. Cortex surrounds the medulla. It has a frame work of connective tissue or stroma, covered by germinal epithelium. It contains ovarian follicles (Graafian follicle) in various stages of maturity, each of which contain an ovum. When ripe, the Graafian follicle ruptures and releases its ovum into the peritoneal cavity. This is called ovulation.

After ovulation, the follicle lining cells develop into a yellow coloured endocrine body, the corpus luteum. The corpus luteum produces the hormone progesterone and some oestrogen. If the ovum is not fertilized the corpus luteum gradually disappears leaving a scar called corpus albicans.

Oviducts

The oviducts are also called uterine or fallopian tubes. These muscular tubes, which extend from the uterus to the ovaries. The tubes are not attached to the ovaries. The end of each tube has finger like projections called fimbriae that sweep over the ovary at the time of ovulation. The uterine tubes are internally lined with ciliated epithelium. The uterine tubes move the ovum from the ovary to the uterus by peristalsis and ciliary movement. The mucus secreted by the mucosa provides ideal conditions for movement of ova and spermatozoa. Fertilization of the ovum usually takes in the uterine tube, and the zygote is propelled into the uterus for implantation.



Uterus

The uterus is a hollow muscular pear shaped organ, flattened antero posteriorly. It lies in the pelvic cavity between the urinary bladder and the rectum. It is attached to the dorsal abdominal wall by ligaments. The muscular uterus has three portions – the fundus, the body and the cervix. The oviducts join the uterus just below the fundus. The uterus terminates in a muscular ring, the cervix, which projects a short distance into the vagina. The lining of the uterus is called the endometrium which participates in the formation of the placenta, which supplies nutrients needed for development. Development of the embryo takes place in the uterus.

Vagina

The two uteri extend towards the median line and unite to form the vagina. The vagina is a fibromuscular tube lined with stratified squamous epithelium. The vagina acts as the receptacle for the penis during coitus and provides an elastic passage way through which the baby passes during child birth.

Vulva

The vulva is the external portion of the genitalia of the female that extends from the vagina to the exterior and consists of the labia majora and labia minora, the clitoris, the vestibule, the hymen and the vestibular glands (Bartholin's glands). Labia majora are the two large folds forming the boundary of the vulva. Labia minora are two smaller folds of skin between the labia majora. The cleft between the labia minora is the vestibule. The opening of vagina is often covered partially by a membrane called hymen. The vagina, urethra and ducts of vestibular glands open into the vestibule. A small, rod like organ lies on the ventral side of vestibule. It is called clitoris. It is erectile and highly sensitive. It corresponds to the penis of the male, but it has no reproductive significance.

Vestibular glands (Bartholin's glands)

The vestibular glands are situated one on each side near the vaginal opening. They are about the size of a small pea and have ducts, opening into the vestibule. They secrete mucus that keeps the vulva moist and their secretion lubricates vaginal passage to facilitate copulation.

Puberty in females

Puberty age in females is between 10 and 14 years and is characterised by menstrual cycle and ovulation. Estrogen secretion maintains growth and maturation of reproductive tract and development of secondary sexual characters.

Check Points

- Female gonads are called ovaries.
- Mature ovarian follicles are called Graafian follicles.
- Liberation of ova from Graafian follicle is called ovulation.
- Corpus luteum produces the hormone progesterone and some oestrogen.
- Finger like projections found at the end of oviducts are called fimbriae.
- Fertilization of the ovum usually takes place in fallopian tube.
- Development of the embryo takes place in the uterus
- Uteri of both sides open into vagina.
- Clitoris is homologous to the penis of male.
- Vulva is the external portion of the genitalia of the female.

Semester – III

General Biology

Unit V: Human Reproduction

Module No: 26 (III) Production of Gametes

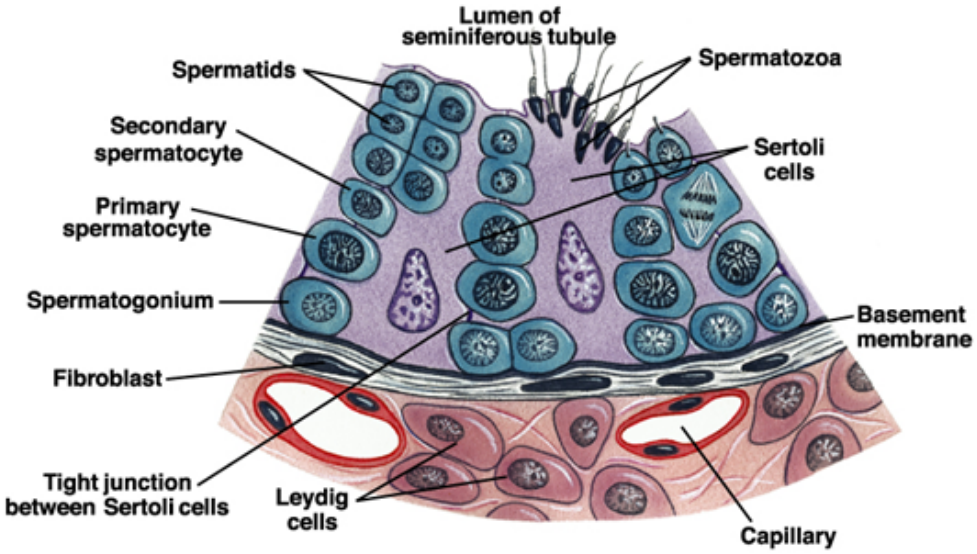
Most animals reproduce sexually. The two sexes, male and female, each produce special types of reproductive cells, called gametes. The male gametes are the sperms or spermatozoa and the female gametes are the ova or eggs.

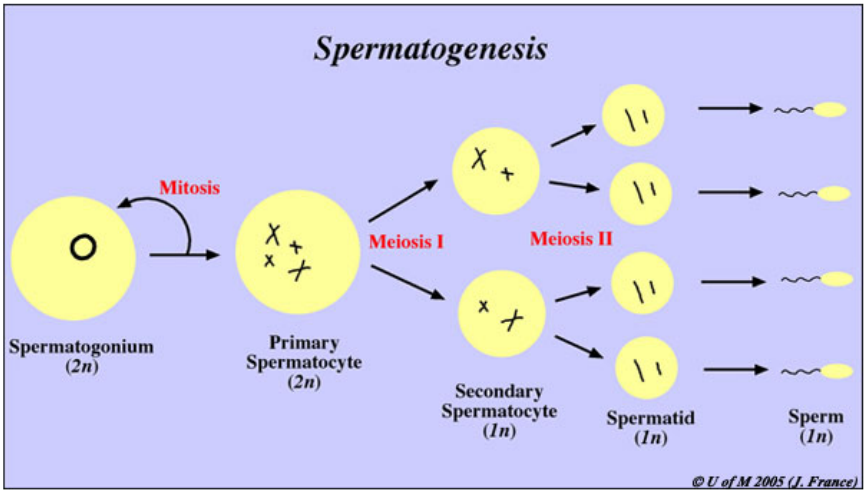
Sperm Production

Testis is composed of seminiferous tubules. The seminiferous tubules are lined by germinal epithelial cells from which spermatozoa develop by a process called spermatogenesis. The process of spermatogenesis can be studied under the following heads

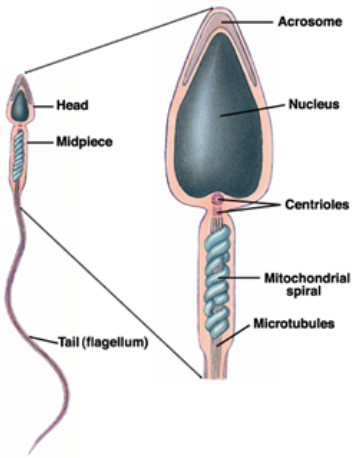
1. Phase of Multiplication
2. Phase of Growth
3. Phase of Maturation

All the germ cells do not take part in the formation of sperms. Some of them simply provide nourishment to the developing cells forming the sperms and are called the sertolicells or nutritive cells. Remaining germ cells which take part in the formation of sperms are called as primary germ cells or primordial cells. During multiplication phase the primordial cell divide by mitosis to produce large number of spermatogonia having diploid number of chromosomes.



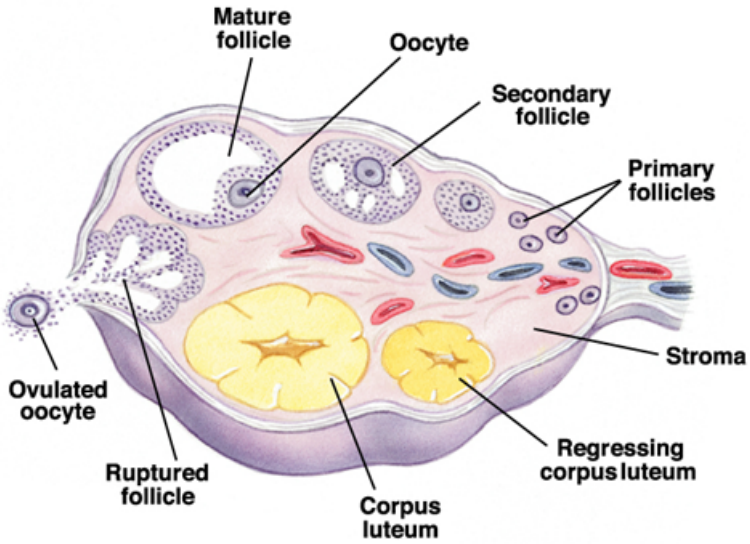


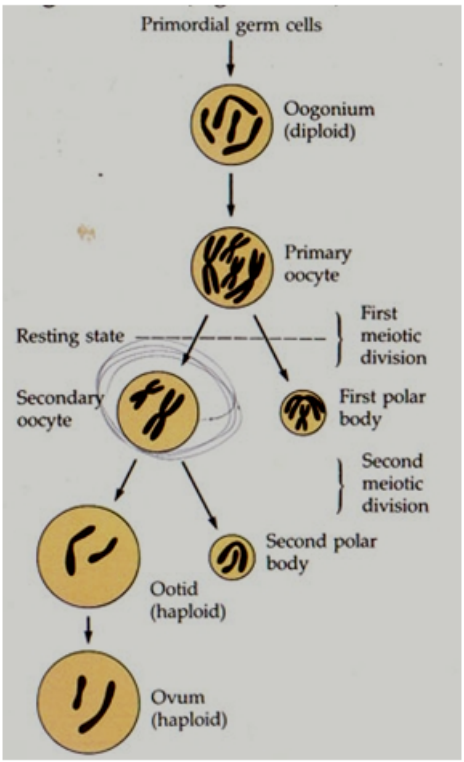
During the growth phase, the size of nucleus as well as spermatogonial cells grow in size due to absorption of nutritive material from nutritive cells and also due to the synthetic activities of nucleic acids and proteins. These enlarged cells are now called as the primary spermatocytes. The primary spermatocytes during maturation phase undergo meiotic division where chromosome number is reduced to half and become secondary spermato cytes and spermatids which are haploid. By a process called spermiogenesis haploid and motile sperms are produced from spermatids. Mature spermatozoa become free in the seminiferous tubule. Each haploid sperm consists of three parts – head, collar or middle piece and tail. Head is composed of an acrosome and a compact nucleus. Middle piece contains mitochondria that provides energy to sperm during fertilization. Tail is the longest part that develop from the centriole of spermatid.



Formation of Ovum

Formation of ovum is called as Oogenesis. The ovary is solid and covered by visceral peritoneum. Inside this layer is a layer of germinal epithelium. Within the germinal epithelium is the Stroma. Germinal epithelium by mitotic division gives rise to new cells called oogonia. The oogonia project into the stroma in the form of a cord, the egg tube, which later becomes a rounded mass, the egg nest. One cell in the egg nest grows and becomes the primary oocyte, while other cells form a regular layer round the oocyte to nourish it. The structure thus formed is called as primary follicle.





Oogenesis

This follicle slowly sink into the deeper part of the stroma and grows in size and divides to become several layered thick. The solid follicle now develops in it a small cavity the follicular cavity filled with semiviscous fluid secreted by follicular cells. The oocyte along with a few layer of follicular cells is left attached on one side by a stalk of follicular cells, the germ hill. The follicle is now mature and is called the Graafian follicle. The graafian follicle being lighter, rises to the surface of the ovary and ruptures, releasing the oocyte. Release of the oocyte is termed ovulation. Before its release, the primary oocyte changes into the secondary oocyte by first meiotic division. Some follicles fail to reach maturity and degenerate. After discharge of the oocyte, the follicle cells encroach the follicular cavity by proliferation and form yellowish endocrine body, the corpus luteum. It soon disappear if fertilization does not oocur.

Check Points

- Male gametes are called sperms and female gametes are called ova.
- The sperms are formed by a process called spermatogenesis.
- The formation of ovum takes place by a process called oogenesis.
- Spermatogenesis and oogenesis takes place in three phases called phase of multiplication, phase of growth and phase of maturation.
- Sertoli cells provide nourishment to the developing sperms.
- The process of formation of sperms from spermatids is called spermiogenesis.
- Each sperm consists of three parts – Head, middle piece and tail.
- Mature ovarian follicles are called graafian follicles.
- Release of the oocyte is called ovulation.
- Graafian follicle burst to shed the ova.

General Biology

Unit V: Human Reproduction

Module No: 28 (III) Reproductive Health – Infertility and Invitro fertilization. Methods of family planning

Reproductive Health

1. Reproductive health means a total well-being in all aspects of reproduction i.e., physical, emotional, behavioural and social. Reproductive health implies that people are able to have a responsible, satisfying and safe sex life and that they have the capability to reproduce. The term reproductive health addresses the reproductive processes, functions and systems at all stages of life of an individual.
2. The elements of reproductive health are human sexuality and sexual health, fertility control and treatment of infertility, safe motherhood and child survival, freedom from sexually transmitted diseases.
3. India is the first country in the world to initiate action plans and programmes at a national level to attain total reproductive health. These programmes are called "family planning".
4. Fertility control and family planning improves women health and reduces maternal mortality by preventing unwanted and high risk pregnancies and reduces the need for unsafe abortions.
5. Awareness should be created in people through audio-visual and print media about (1) available birth control measures (2) care of pregnant mothers (3) post-natal care of mother and child (4) un controlled population growth (5) sex abuse and sex related crimes (6) sexually transmitted diseases (7) AIDS (8) safe and hygienic sexual practices (9) abortions (10) contraception and (11) menstrual problem etc. So that people can think and take necessary steps to build up a socially responsible and healthy society.
6. Lot of improvement in quality of life and reproductive health of the people has taken place in our country which is indicated by decreased maternal and infant mortality rates, increased medical facilities and better detection and cure of sexually transmitted diseases.
7. Further, to improve the quality of life, reproductive health and to check uncontrolled growth of population the people should be educated about
    1. Various contraceptive methods to prevent unwanted pregnancies.
    2. Importance of smaller families.
    3. Practicing natural methods, barrier methods.
    4. Use of condoms.
    5. Use of intra uterine devices.
    6. Use of oral pills.
    7. Surgical methods available (Vasectomy and tubectomy).
    8. Medical termination of pregnancy.

8. Contraception includes temporary and permanent measures to prevent pregnancy. The method of contraception by men and women helps families space births, prevents unwanted pregnancy, and in case of consistent condom use prevents transmission of sexually transmitted diseases.
9. Sexually transmitted diseases are a major threat to a healthy society. Early detection facilitates better cure of these diseases. Avoiding sexual intercourse with unknown, multiple partners, use of condoms during intercourse personal hygiene, abstinence (avoidance of the act of sex), vaccines, health education, social welfare measures etc are useful to prevent sexually transmitted diseases.
10. A large number of couples all over the world are infertile due to various reasons. Several methods are currently available to help such couples and one such popular method is Test tube baby method, in which In vitro fertilization followed by transfer of embryo into female genital tract. But this method is very expensive and these facilities are available only in limited centers. In view of this only few people can avail this benefit.

Infertility

Infertility is the inability to conceive (unable to produce children). Infertility is seen in both males and females. The reasons for this could be many – physical, congenital, diseases, drugs, immunological or even psychological.

Female infertility

A woman may be infertile due to several causes. They are

1. Failure to ovulate

It is the common cause of infertility in females. This is because the pituitary gland fails to produce FSH which is required for follicle development or LH required for release of the egg from the ovary. Or may be because ovaries fails to produce oestrogen or progesterone hormones. Failure to produce ova can be treated with fertility drugs. These drugs are similar to hormones and act by increasing the levels of FSH and LH.

2. Damage to oviducts

There may be blockage or distortion of the oviducts which can often be corrected by surgery.

3. Damage to Uterus

Sometimes large non-malignant tumors called fibroids or smaller growths called polyps grow in the walls of the uterus and cause infertility. These can be removed by surgery.

4. Damage to cervix

Due to abortions or difficulty in child birth cervix gets damaged. The damaged cervix interfere with sperm movement (cervix is the neck of the uterus)

Male infertility

Male infertility is because of

1. Oligo spermia

Inadequate quantity of sperms in the semen (Low sperm count) causes infertility

2. Azoospermia

Lack of sperms in the semen is called azoospermia. This may be due to damage or injury to the testis or due to infections or may be due to hormones.

3. Abnormal sperms

May also leads to infertility in males.

4. Impotence and premature ejaculation also leads to infertility in males.

Invitro fertilization

In vitro fertilization or IVF is a technique in which egg cells are fertilized by sperms out side the women's body. After fertilization, the zygote is transferred to the patient. The transfer of the zygote is called embryo transfer. The foetus is then allowed to grow in the uterus.

'In vitro' means literally "in glass" or in other words, the fertilization is allowed to take place in laboratory glass ware. This method is popularly known as test tube baby programme. In this method ova from wife / donor (female) and sperms from the husband / donor (male) are collected and are induced to form zygote under simulated conditions in the laboratory.

One or more of the dividing zygotes are then introduced to the women's uterus by means of a tube inserted through the cervix to complete its further development.

Methods of family planning

Family planning refers to practices that help individuals to attain certain objectives such as

1. To avoid unwanted births
2. To be able to conceive as and when desired
3. To regulate the intervals between pregnancies
4. To determine the number of children in the family.

Most people do not want or cannot afford, to have as many children as possible. All human communities, therefore, practice some form of birth control to space out births and limit the size of the family.

Natural methods of family planning

If it is possible to know exactly when ovulation occurred, intercourse could be avoided for 3-4 days before and 1 day after ovulation. For the present, there is no simple, reliable way to recognize ovulation, though it is usually 12-16 days before the onset of the next menstrual period. By keeping careful records of the intervals between menstrual periods, it is possible to calculate a potentially fertile period of about 10 days in mid-cycle, when sexual intercourse should be avoided if children are not wanted.

Artificial methods of family planning

I. Contraception

1. **Condoms:** A condom is placed on the erect penis before sexual inter course which traps the sperms and prevents them from reaching the uterus.
2. **Diaphragm:** a thin rubber disc, placed in the vagina before intercourse, covers the cervix and stops sperms entering the uterus.
3. **Spermicides:** Spermicides are chemicals, though harmless to the tissues, do kill or immobilize sperms. The spermicides in the form of a cream, gel or foam is placed in the vagina.
4. **Intra-Uterine device (IUD):** A small metal or plastic strip bent into a loop or coil is inserted and retained in the uterus, where it probably prevents implantation of a fertilized ovum.
5. **The contraceptive pill:** The pill contains chemicals which have the same effect on the body as the hormones oestrogen and progesterone. When mixed in suitable proportions these hormones suppress ovulation and so prevent conception. The pills need to be taken each day for the 21 days between menstrual periods.

II. Sterilization

Vasectomy

This is a simple and safe surgical operation in which the man's sperm ducts are cut and the ends sealed. This means that his semen contains the secretions of the prostate gland and seminal vesicle but no sperms and so cannot fertilize an ovum. Sexual desire, erection, copulation and ejaculation are quite unaffected.

Laparotomy (Tubectomy)

A women may be sterilized by an operation in which her oviducts are tied, blocked or cut. The ovaries are unaffected. Sexual desire and menstruation continue as before, but sperms can no longer reach the ova. Ova are released, but break down in the upper part of the oviduct.

Check Points

- Reproductive health means a total well being in all aspects of reproduction.
- India is the first country in the world to introduce family planning programme.
- Sexually transmitted diseases are a major threat to a healthy society. Public awareness should be created to check this problem.
- Infertility is the inability to produce children.
- Female infertility is due to – failure to ovulate, damage to oviducts, damage to uterus, or damage to cervix.
- Male infertility is because of oligo spermia, Azoospermia, abnormal sperms or impotence.
- In vitro fertilization is a technique in which ovum is fertilized by sperms outside the women's body.
- In vitro fertilization is popularly known as test tube baby programme.
- There are effective natural and artificial methods for spacing births and limiting the size of a family.

Semester – III

General Biology

Unit VII - Theories and Rates of Evolution

Module No: 34(III) Theories of Evolution – Lamarckism, Darwinism, Mutation theory and Germ plasm theory.

Evolution simply means "change". It is a process of "Opening out" or "rolling out" or "unfolding". According to Darwin "Evolution is Descent with modification".

Evolution is defined as a gradual and orderly change from one condition to other. Such a kind of change in the living world is called organic evolution. The gradual development and emergence of complex organisms from simple organisms over a period of time is called organic evolution.

Evolution is a naturally occurring process. It is a slow, continuous and irreversible process of change.

Several theories have been put forward to explain the phenomenon of evolution. Most important ones are

1. Lamarckism or Lamarck's Theory of Inheritance of Acquired Characters
2. Darwin's Theory of Natural selection and
3. Devries's Theory of mutations.
4. Weisman's Germ plasm theory

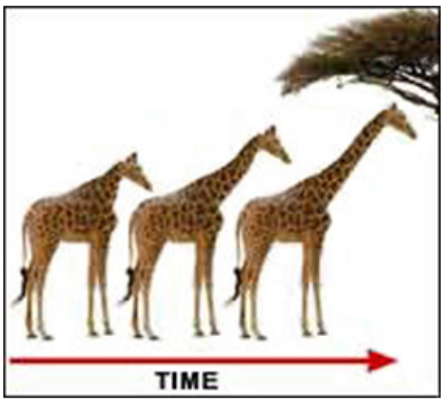
I. Lamarckism

Jean Baptiste Lamarck for the first time suggested a complete theory of evolution which is known as Theory of Inheritance of acquired characters which is also known as Lamarckism. He published his ideas of evolution in his book "Philosophie Zoologique" in 1809. According to Lamarck

a. All living things and their component parts are continuously increased due to internal vital forces.
b. Environment keeps on changing and thus influences the organisms by creating new needs. The new needs lead to the development of new structures. The changed environment put certain old organs out of use
c. When an organ is put into greater and constant use, that particular organ develops well, at the same time when an organ is not used for a long time, it decreases and in due course it degenerates and disappears completely from the organism. This is called Theory of use and Disuse.

Some Examples are

1. Aquatic birds develop webbed foot by stretching the skin between the toes.
2. The long neck of the giraffe developed due to constant stretching to reach food.



3. Snakes have elongated body accompanied by loss of limbs. The continuous creeping through holes and crevices made limbs continuously useless for locomotion with the result that limbs became completely lost in snakes. Their ancestors possess short limbs.

d. The characters developed by the animals during their life time in response to the environmental changes are called acquired characters. According to Lamarck, the acquired characters are transmitted to the offspring. This is called inheritance of acquired characters. As the process is continued, after several generations a new species will be formed.

However, Lamarck's Theory was subject to severe criticism.

Germplasm Theory

August Weismann (1890), the German Biologist performed the decaudalisation experiments on mice and disproved Lamarckism. He cut the tails of mice for more than 20 generations and observed the effect on the length of tail in the coming generations. But in all the generations he could see mice with normal tail only. With this he believed that the acquired characters are not inherited. Weismann proposed the germ plasm theory. According to this theory the protoplasm is differentiated into somatoplasm and germ plasm. Somatoplasm is present in somatic cells (Body cells). It does not play any role in heredity. Germ plasm is present in the sex cells. It plays an important role in heredity. Weismann proposed that the changes occur in somatic cells are not transmitted and the changes that occur only in the reproductive cells are transmitted to the next generation.

II. Darwinism

Darwinism or natural selection theory proposed by Charles Darwin, explains the mechanism of evolution. The mechanism is clearly stated in Darwin's book "Origin of Species". This theory is formed of five principles

1. Over Production

Reproduction is the most characteristic feature of organisms. All living organisms have enormous fertility power, to ensure continuity of their races. The multiplication of population is almost in geometrical ratio. Darwin observed that the population of each species is maintained constant over long periods even though the rate of production is enormous.

2. Struggle for existence

As a result of geometrical multiplication of individuals, the food and space become limited with the result that a struggle inevitably follows for existence. This struggle may be intra-specific

Struggle (between the individuals of the same species); inter specific struggle (between individuals of different species) or struggle with environment.

3. Survival of the fittest

Due to these various struggles for existence, only those individuals survive which are best fitted to new conditions of life and the least fit are the first to perish. These individuals in the course of time show various adaptive modifications to suit themselves in the changed conditions of life. The survival of the fittest is the result of natural selection, which enforces adaptation.

4. Variations

No two individuals are exactly alike. The differences between the organisms of same species are called variations. Variation is the inherent property of life. Darwin believed that the small continuous variations are important for evolution, because without variations, no change could occur and evolution would be impossible. Certain of these variations are useful or beneficial to the organisms and some others are of no use. Only those variations which can be inherited can take part in the evolution of species.

5. Natural selection and origin of species

The fit individuals with more adaptive variations, selected by nature will be able to reproduce. Then the offspring of fit individuals will also be fit, due to the inheritance of such variations. The progeny again face struggle for existence. In the course of long periods, those best fitted and suitable individuals survive and become adjusted to nature. Thus with each generation, the beneficial variations with a slight increase or modification are inherited to the next generation. After several generations, the progeny may appear totally different from the original ancestors due to these accumulated heritable variations. Thus, a new species is originated i.e.,

III. Mutation Theory of Devries

The theory of mutations was first formulated by Hugo Devries in 1901. The sudden, large, heritable variations in a population are called mutations. Devries postulated the mutation theory based on his observation on an ornamental plant called evening primerose *Oenothera lamarckiana*

Devries summarized his observations as follows:

1. New species arise not gradually with transitional forms, but suddenly by a single step
2. The organisms that have undergone mutations are called mutants. They transmit their mutations to progeny. So mutations are heritable and form new species.
3. Mutations may be either beneficial or harmful.
4. Mutation can take place in any direction
5. A large number of same type of mutations make their appearance at the same time
6. Mutations are subjected to natural selection
7. The tendency to mutate in species may re-occur periodically
8. Mutations may occur in different members of same species and give rise to several related new species simultaneously from the same ancestral species.

So, the mutations are the raw materials for the formation of new species. Thus, a new species is evolved suddenly but not gradually.

After studying these theories, scientists feel that no theory is the complete answer to the evolution. However natural selection is admitted today as the most probable explanation, but it is not the sole course.

The modern theory of evolution and the origin of species is a combination of mutations and natural selection constituting the synthetic theory or Neo darwinsim. It is based on natural selection and it takes into account the mendelian and post mendalian laws of Heredity, which Darwin was unable to do. Evolution is mainly a sequence of genetic changes, and variations, consequently the adaptations.

The famous NeoDarwnists like, E.Haeckel, Weismann, Haldane, Sewall wright and Muller explained the modern Synthetic Theory.

Check points

- Lamarck proposed Theory of inheritance of acquired characters
- Lamarck published his views in “Philosophie Zoologique”
- Natural selection theory was proposed by Charles Darwin
- Darwin’s book is “ Origin of Species”
- Two facts form the basis of Darwinism
  a. The first one is geometric character of population growth
  b. The second fact is that animals vary in many ways and many of these variations are inherited
- Struggle for existence was due to over growth of population and variation
- Result of struggle for existence is survival of the fittest
- Devries worked on *Oenothera lamarkiana* and formulated mutation theory
- Devries believed new species appear suddenly in a single step without intermediate forms.
- August Weismann proposed the theory of Germ plasm.

Semester – III

General Biology

Unit- VII – Theories and rates of evolution

Module: 35(III) Evidences of organic evolution

Introduction

Organic evolution is the progressive development of simple organisms to the complex organisms over a period of time. Man's life span is too short to observe the process of evolution. In order to convince all about the truth of evolution, biologist have put forward several indirect and direct evidences, which support the validity of evolution. The evidences of organic evolution includes

1) Morphological and anatomical evidences
2) Embryological evidences
3) Paleontological evidences
4) Physiological evidences
5) Zoogeographical evidences

1. Morphological and anatomical evidences

Morphology refers to the external structures: anatomy refers to the internal structures. These structures provide ample evidences for evolution. The morphological and anatomical evidences include

1. Homologous organs
2. Analogous organs
3. Vestigial organs and
4. Connecting links

A. Homologous organs

Organs which are fundamentally similar in origin and basic structure but perhaps modified for widely-different functions, can only be explained through a common ancestry. These types of organs are called homologous organs.

For Example: the arm of a man, the wings of the birds, the wings of a bat, the flippers of a seal and the fore legs of dogs, all possess the same types of skeleton. This fundamental similarity is called homology. The presence of homologies in animals indicates that they have inherited a common plan from their ancestors.

B. Analogous organs

The organs which are different in their basic structure but similar in form and function are called analogous organs.

For example: wings of insects and birds. They differ in origin and structure but looks alike and perform the same function of flying. This similarity is achieved due to their existence under similar environmental conditions. Another example is the body form of whale and fish is similar because of the same aquatic life. This process of convergence of different groups of animals into the common mode of life due to the influence of same habit is called convergent evolution.

The homologous and analogous organs indicate the nature and ability of the organisms to change without changing their basic organization, which is a proof for the concept of organic evolution.

C. Vestigial organs

The organs which are functional in the ancestors and reduced and remained functionless in the present generations are called as vestigial organs. Vestigial organs are developed due to changes in the environment and habits. Presence of vestigial organs is the most convincing evidence of organic evolution.

Examples of vestigial organs

In man	Vermiform appendix
	Nictitating membrane
	Muscles of the ear pinna
	Mammary glands of male etc.

D. Connecting links

The animals exhibiting characters of two adjacent groups are called connecting links. They afford a very good evidence for organic evolution.

Example

Peripatus (between annelida and arthropoda)
Archaeopteryx (between reptiles and birds)
Prototheria (between reptiles and mammals)
Dipnoi (between fishes and amphibians)

2. Embryological Evidences

Embryology deals with the development of an organisms form the egg to adult. It includes a series of stages of development. A comparative study of the developmental stages, organs and organ systems give evidences for organic evolution.

All multicellular animals begin their life as a single cell called zygote (represents the protozoan stage) and by repeated divisions it produces single layered blastula (represents collonial protozoan stage), which later on produces a double layered gastrula (represents the diploblastic coelenterate stage). Every multicellular animal passes through the above stages indicate their ancestors.

Similarly, the embryo of different vertebrates like fishes, amphibians, reptiles, birds and mammals are similar in their early stages and cannot be differentiated from one another. As the development progresses they can be differentiated due to the development of specialized characters of their adults. This kind of similarity of the early embryos indicates that they have evolved from a common ancestor.

On the basis of the developmental history of the animals, Haeckel proposed his Recapitulation theory or Biogenetic law which states that "Ontogeny (embryonic development of an organism) recapitulates Phylogeny (Evolutionary history of the race or phylum)". This means that embryos, in their development, repeat the evolutionary history of their ancestors.

Example

Tadpole larva of frog looks like a fish, it has gills, fins, lateral line sense organs etc as in fish. It undergoes metamorphosis to become adult frog. It shows that the frog recapitulates its immediate ancestor, fish through tadpole larva which indicates that frog was evolved from fish.

3. Physiological and Biochemical evidences

The similarities between different animals with regard to their physiology and chemical composition are considered as evidence of relationship, which show that they have descended from a common ancestor.

1. The chemical composition of protoplasm is fundamentally similar in all animals.
2. Chromosomes are common to all living cells. Each chromosome is formed of proteins and nucleic acids. Chromosomes of all the animals have same chemical compositions this is because of a common ancestry.
3. In all animals DNA functions as the genetic material. It is present in the chromosomes.
   The structure, composition and function nucleic acids is similar in all animals. All organisms utilize the same DNA triplet base code and the same 20 amino acids in their proteins. These similarities can be explained by descent from a common ancestor.
4. Enzymes are proteins of high molecular weight, used to digest the food materials. Trypsin is a protein splitting enzyme, it has the same structure and function form protozoa to man. Similarly, amylase splits starch and occurs form sponge to man. The similarity of enzymes is due to a common ancestry.
5. Hormones are 'chemical messengers' secreted by the endocrine glands or ductless glands, their structure and function are similar in all vertebrates.
6. Composition of blood and lymph is almost similar in most vertebrates; similarly nitrogenous wastes are similar in organisms.
7. The process of glycolysis, the muscle contraction and the chemical processes involved in it are similar in all vertebrates. With the above examples it is clear that physiological evidences support the concept of evolution.

4. Palaeontological evidences

Paleontology deals with the study of fossils, (fossils are defined as the remnants of the previously existing animals and plants preserved in the earth crust). The fossils are regarded as the written documents of evolution. They explain the mechanism of evolution of ancient animals. They reveal the characteristics of the organisms of past and the changes of these characteristics from time to time. Various fossils are found in different strata of the earth.

Examples

Archaeopteryx and Archaeornis were the first fossil birds which are quite different from the modern birds. They show few reptilian characters such as long tail, Jawed teeth, solid bones and few avian characters such as feathers, three digits in fore limbs etc. It shows that modern birds evolved from reptiles.

5. Zoo Geographical evidences

The study of the distribution of animals on the earth is called zoogeography. The different kinds of animals living in a given area form the fauna. The geographical distribution of animals provides a good evidence of organic evolution.

The distribution of animals is not uniform on the earth due to the difference in climatic conditions of different regions. Certain zones have their own characteristic fauna but even the places with the same climatic conditions in different regions of the world don't have the same fauna i.e., have discontinuous distribution. For example, Elephant's are found in America and India but not in other places like Brazil etc. Although the climates of these places are alike, yet the common animals found are diverse in nature. Again, representatives of a group of animals may occur in widely-separated places not in the interconnecting zones. For Example lung fishes are found in South America, Australia and Africa but not in other places.

The hypothesis of evolution explains, in better way, the process of geographical distribution.

Example 1

Australian fauna differs from South American fauna even though the climatic conditions are the same. The fauna of south America consists of Sloths, Armadillos, bears, Lamas etc, where as prototherians and metatherians are found in Australia. This is because Australia was separated from the mainland when the prototherians and metatherians were present on the earth. As these prototherians and metatherains are unable to migrate into new regions, they are confined to Australian regions only. Whereas these animals in the mainland migrated into new areas with different climatic conditions and evolved into eutherian mammals. Prototherians and metatherians could not survive in other parts of the world due to the competition with the higher mammals and become extinct.

Example 2

Lung fishes are present in Australia, Africa and South America only. It can be said that these fishes might have present continuously. If there is environmental changes within a given range, these forms are either driven out or destroyed.

Check points

- Organs of different animals which carry different functions but with a fundamental basic plan are called homologous organs
- Organs of different animals which carry same function with different structure and origin are called analogous organs
- Homologous organs indicate common ancestry
- Organs which are functional in the ancestors and reduced and functionless in the present generation are called as vestigeal organs
- The animals which show common features of two phyla are called connecting links
- The theory of recapitulation or Biogenetic law was proposed by Earnest Haeckel. Which states " ontogeny repeats phylogeny"
- Fossils are the written documents of organic evolution
- Archaeopteryx is the connecting link between reptiles and birds
- The study of the distribution of animals on the earth is called zoogeography

Semester – III

General Biology

Unit VII: Theories and Rates of Evolution

Module No: 36 (III) Mechanism of Evolution (Hardy-Weinberg principle)

The raw material of evolution is inherited variation. Genes influence evolution at all levels above that of the individual. Population is a general term for any group of organisms sharing a geographic area and able to interbreed. All the genes in a population constitute its gene pool. The movement of alleles between populations is called gene flow. The proportion of a gene in a gene pool or population is called gene frequency. The proportion of different alleles for each gene determines the characteristics of that population. Micro evolution occurs when the frequency of an allele in a population changes.

Mathematics can describe the theoretical state when gene frequencies do not change from one generation to the next. This state is called Hardy-Weinberg equilibrium. It serves as a basis of comparison for more realistic situations in populations, and there is no migration, mutation or natural selection,- conditions that in actuality do not occur together.

Hardy-Weinberg Law

Hardy-Weinberg law was developed in 1908 by the independent contributions of two scientists namely Hardy in England and Weinberg in Germany.

This law states that "in a large population, the gene frequencies of various kinds of genes remain constant generation after generation when mating is at random and in the absence of mutation, selection and migration". It is also called Hardy-Weinberg equilibrium because the gene frequencies in a population are maintained in a certain equilibrium.

Hardy-Weinberg equilibrium is only possible if a population is large, its members mate at random and in the absence of evolutionary forces like mutation, natural selection, migration etc. when the gene frequency is maintained constant generation after generation genetic changes can not occur. When there is no genetic changes in a population evolution cannot occur. Hence when a population follows the Hardy-Weinberg equilibrium, the rate of evolution is zero, so evolution occurs only when the Hardy-Weinberg equilibrium is upset or altered.

In a stable population for a gene with two alleles where 'A' is dominant allele and 'a' is a recessive allele, three possible genotypes are AA, Aa, and aa. If the frequency of occurrence of 'A' is 'p' and 'a' is 'q' then the frequency of occurrence of AA, Aa and aa can be expressed by equation $p^2+2pq+q^2=1$ or $(p+q)^2=1$.

Its major application is the calculation of dominant allelelic frequency 'p' and the recessive allelic frequency 'q'.

If the allele "A" has a frequency of 'p' in a population and allele 'a' has a frequency of 'q' and there are no other alleles for they were

$$P + q = 1$$

The probability that allele 'A' occurs also its frequency 'p', the probability that 'a' will occur is 'q'. Thus the probability of occurrence of homozygous dominants AA or its frequency in a population is $p \times p = p^2$

Since there are two ways of forming hetero zygotes 'Aa, (i.e., 'A' allele from mother and 'a' from father or vice versa). The frequency of 'Aa in the population is 2 pq.

The sum of all these frequencies is $p^2 + 2pq + q^2 = 1$ or $(p + q)^2 = 1$.

This is binominal expression.

This formula is referred to as the Hardy – Weinberg formula.

p = dominant allelic frequency

q= recessive allelic frequency

p^2 = homozygous dominant genotype frequency

2pq= heterozygous dominant genotype frequency

q^2= recessive genotype frequency

Algebraic Expression	What it means
$p + q = 1$ (allele frequencies)	All dominant alleles plus all recessive alleles add up to all of the alleles for a particular gene in a population.
$P^2 + 2pq + q^2 = 1$ (genotype frequencies)	For a particular gene, all homozygous dominant individuals (p^2) plus all hetero zygotes (2pq) plus all homozygous recessives (q^2) add up to all of the individuals in the population.

This formula can be applied to any population to find out the frequency of genes. The natural populations will not contain the genes in equal numbers always. Most of the populations have different proportion of genes. The above formula can be applied to any population containing any proportion of genes.

Hardy – Weinberg Law and Evolution

Evolution can be defined as changes in frequencies in the gene pool of a population. Evolution progresses only when the population deviates or upsets the Hardy-Weinberg equilibrium. This deviation of the equilibrium is brought about by the evolutionary forces. The evolutionary forces are those that change the gene pool of the populations. These include 1) Mutations 2) Natural Selection 3) Non-random mating 4) Genetic drift 5) Migration and gene flow that bring the changes in allelic frequencies, and genotypic frequencies.

1. Mutations

Many evolutionary changes occur due to the appearance of new alleles through mutation. Only large and discrete mutations were important in evolution. Mutations occur at random. When there is mutation in a population, it tends to alter the gene frequencies in the gene pool and hence the equilibrium is upset or deviated. This paves way for evolutionary change.

2. Natural Selection

Natural selection plays an important role to upset Hardy Weinberg equilibrium and hence it brings about evolution. Mutation produces favourable or unfavorable changes in the population from generation to generation. Environment favours such animals which are provided with favourable characters. These animals have ample opportunity for mating and they produce more off spring. Hence the genes controlling favourable characters spread more rapidly than other genes. This leads to the differential reproduction of genes by which some genes are favoured over others. This differential reproduction of genes upsets the Hardy-Weinberg equilibrium and helps evolution to progress.

3. Non-Random mating

The Hardy-Weinberg equilibrium is maintained only when the mating in a population is at random. But in most of the natural populations mating does not occur at random; mating is a selective process. Hence when mating is on a non-random basis, the Hardy-Weinberg equilibrium is deviated. A departure from randomness may also lead to change in gene frequencies. Due to this selective, non-random mating the frequency of hetero zygotes in the population will decrease generation after generation. Hence, non-random mating results in the abundance of certain genotypes at the expense of other genotypes.

4. Genetic Drift

Genetic drift (Sewall Wright effect) is an evolutionary force operating in small populations. Genetic drift refers to “Changes in gene frequency brought about purely by chance in small populations”.

According to Hardy Weinberg Law, in a large population the gene frequency remain constant generation after generation when mating is at random and when there is no mutation and selection. But in small populations, the gene frequencies are found to fluctuate purely by chance. As a result of this, in small populations, some genes may be reduced in frequency or even lost by chance and other may be increased in frequency by chance. It upsets Hardy-Weinberg equilibrium. In small populations, genetic drift fixes or preserves certain genes and eliminates other genes completely. A new mutation arising in a small population is either lost or fixed as a result of genetic drift. Thus the gene pool of the population is changed without involving the question of the usefulness of the traits. In small populations heterozygous gene pairs tend to become homozygous by chance. It produces variation. It helps in the origin of new species.

5. Migration and Gene Flow

Animals are not static, they migrate to different places and come into contact with another population, it mates with the inmates of the population. Thus the genes of one population are transferred into another population. This movement of alleles from one population to another because of the interbreeding between members of the two populations is called gene flow. Gene flow brings about addition or loss of genes in the gene pool. Thus the gene frequency is altered and the Hardy-Weinberg law is upset.

Check Points

- The total number of alleles of every gene in a population is gene pool.
- The conditions required for Hardy-Weinberg law are large population, random mating, no mutations, selection and migration.
- Hardy-Weinberg formula is $p^2 + 2pq + q^2 = 1$.
- Evolution progresses only when the population deviates from Hardy-Weinberg equilibrium.
- Evolutionary forces change the gene pool of the populations, which includes-Mutations, Natural selection, Non-random mating, Genetic drift and migration.
- Mutations alter the gene frequencies in the gene pool.
- The variation in gene frequency is brought about by natural selection and genetic drift.

Semester – III

General Biology

Unit VII: Theories and Rates of Evolution

Module No: 37 (III) Micro evolution and Macro evolution

Evolution is a continuing process that explains the history of life on earth, as well as the diversity of life to day. Biological evolution includes large-scale vents, such as speciation, the appearance of new species. Such large changes constitute macro evolution. Evolution also includes changes in individual allele (gene variant) frequencies within a population, termed microevolution. Macro evolutionary events tend to span very long periods of time where as micro evolutionary changes can happen rapidly. Simpson (1953) has proposed the additional term Mega evolution for really large scale evolution, such as that of families, orders, classes and phyla.

Micro evolution

Evolution leading to small changes in populations is called micro evolution (evolution of sub-species or geographic races). These small changes are produced by the interaction of the elemental forces of evolution such as mutations, recombinations, natural selection and genetic drift. **The said evolutionary forces are discussed in detail in earlier module No.41.** Micro evolution occurs when the frequency of an allele in a population changes. A gene frequency may be altered when

- Mutation introduces new alleles into a population.
- Individuals migrate between populations.
- Individuals remain in closed groups, mating among themselves within a larger population.
- Natural selection acts differently on variant phenotypes.
- Genes are eliminated because individuals with certain genotypes do not produce fertile offspring.

Because these situations are common, evolution is not only possible but unavoidable. When the microevolutionary forces are operating for a shorter period, but when the effects are continued generation after generation, new populations will be resulted from the existing one. The new populations originate by two ways:- one is by successional manner, by which successional replacement of the pre-existing population by a new one will occur. The other is by divergent manner which results in the splitting of parental population with the appearance of genetic divergence.

A very good example for micro evolution is provided by the varieties of races of the golden whistler *Pachycephala pectoralis* (bird) found in the soloman islands. The different races develop different patterns of plumage.

Macro evolution

Macro evolution or adaptive radiation is defined as the development of new adaptive types by a population leading to the formation of new groups like species, genera, family and order.

Macro evolution operates at the species level and above the species level. It splits the population into two or more adaptive types, each of which evolves in different directions. Macro evolution results in the development of new modes of existence or adaptive zones. It is a broader adaptation developed by groups of animals rather than a single animal. Macro evolution splits single population into two or more major groups, and each group is developing a particular mode of adaptation or adaptive zone. Macro evolution is brought about by large, sudden, rapid mutations.

The basic patterns of evolution above species level involves the migration of a group of animals into a new adaptive zone. As the original population increases in size it spreads out from its centre of origin to exploit new habitats and food sources. In order to survive in the new adaptive zone, two conditions are essential. First of all, the new zone should be free from strong enemies or competitors. Secondly, the group must already have some characteristics adaptive to the new zone. As the new zone is free from enemies, the newly entered group comes to occupy all the sub-zones. The animals of the different subzones develop adaptations in different directions. Thus a single group, entering into a new adaptive zone, is developed into many groups, diverging in different directions. Natural selection operates in each group in a different way leading to the formation of genera or family or order. A good example of this process is the evolution of the Australian marsupials into species adapted as carnivores, herbivores, burrowers, fliers etc.

Evolution of horse family, Equidae is a classical example of evolutionary trends in macro evolution. The earliest known genus, Hyracotherium (now reclassified as palaeothere), was a herbivore animal resembling a dog with padded feet that lived in the early coenozoic. As its habitat transformed into an open arid grass land, selective pressure required that the animal become a fast grazer. Thus elongation of legs and head as well as reduction of toes gradually occurred, producing the only extant genus Equidae, Equus.

Macroevolution ultimately leads to extinction. Some groups acquired special adaptations for a narrow adaptive sub-zones and due to these specialized adaptations they could not move into new major zones. Because all adaptive zones finally change and disappear, so all groups restricted to a narrow zone also disappeared. Hence, the groups which could change the adaptive zones by acquiring general adaptation survived and others became extinct.

Check Points

- Evolution leading to small changes in populations is called micro evolution.
- Micro evolution occurs when the frequency of an allele in a population changes.
- Mutations introduces new alleles into a population.
- Evolution leading to large changes such as speciation, appearance of new species etc constitutes macro evolutionn.
- Macro evolution is otherwise called adaptive radiation.
- Macro evolution operates at the species level and above the species level.

Semester – III

General Biology

Unit VII: Theories and Rates of Evolution

Module No: 38 (III) Rates of Evolution

Evolution means change. Evolution is a continuing process that explains the history of life on earth, as well as the diversity of life today. Biological evolution includes large scale events, such as speciation, the appearance of new species. It is abundantly evident that rates of evolution vary. They vary greatly from group to group, and even among closely related lineages there may be strikingly different rates. Differences in rates of evolution, and not only divergent evolution at comparable rates, are among the reasons for the great diversity of organisms on the earth.

The rate of evolution is a measurement of the change in an evolutionary lineage over time. The speed of evolution may be average or slow or rapid. Based on this, it is divided into three types namely

(1) Horotelic (2) Bradytelic (3) Tachytelic

1. Horotelic

Horotelic refers to average rate of evolution. Horotely represents a sort of normal or average turnover or metabolism in the evolution of a group of organisms.

2. Bradytelic

It is a slow rate of evolution where the rate is below the average eg: Cockroaches have undergone little changes since Pennsylvanian period. Similarly oysters of 200 million years ago were exactly like that of present day. Opossums have changed little from the end of Mesozoic era. Bradytely is essentially a statistical effect produced by the prevalence in some groups of organisms of lines with extremely low rates of evolution or with changes fluctuating on a small scale and not appreciably cumulative. Certain genetic and other factors in organisms set limits to rates of evolution. Low mutation rate is one such factor often suggested. Factors that reduce genetic variability, self fertilization and reduction of crossing over, certainly limit the possibilities for change and therefore may characterize groups that change but little. In the longer run, however, such groups generally do finally change or become unusually liable to extinction.

3. Tachytelic

Here the rate of evolution is rapid and it is above the average eg: evolution of bats.

Evolution at exceptionally high rates cannot long endure. A tachytelic line must soon become horotelic, bradytelic or extinct. It occurs at exceptionally fast rates but also that it occurs while populations are shifting from one major adaptive zone to another, and especially when a threshold is crossed. They include the forms that are forced into rapid change by changes in their adaptive zones. Their adaptive evolution tends to be the opposite of that seen in bradytely, and the factors involved tend to be inverse.

One of the most remarkable known examples is that of the snail-*Valenciennesia* formerly classified in another sub-order than the notably different *Limnaea*, but shown to have evolved from the latter so rapidly that the whole process occurred while a horse, *Hipparion gracile*, on adjacent lands showed no appreciable change. Here, too, change to a distinctly different adaptive zone is involved from clear and fresh to muddy and brackish water.

However no evolutionary line is confined to any one type of rate. At one time the rate of evolution may be tachytelic and at another time, it will be horotelic. The rate of evolution is determined by mutation and environmental changes, of these changes, environment is a primary factor in altering the rate of evolution. The change in environment is brought about by the entering of the animals into a new environment (adaptive zone) or by the change in the environment in which the animals live.

Check Points

- The rate of evolution is a measurement of the change in an evolutionary linease over time.
- The rate of evolution vary greatly from group to group.
- Rate of evolution may be Horotelic, Bradytelic or Tachytelic.
- Average rate of evolution is called Horotelic.
- Bradytelic is a slow rate of evolution and is below the average.
- In Tachytelic the rate of evolution is rapid and is above average.
- The rate of evolution is determined by mutation and environmental changes.

Semester – III

General Biology

Unit VII: Theories and Rates of Evolution

Module No: 39 (III) Role of Hybridization in Evolution

Hybridization is the process of interbreeding between individuals of different species (inter specific hybridization) or genetically divergent individuals from the same species (intra specific hybridization). The resulting offspring are called hybrids.

From evolutionary point of view STEBBINS (1979) defined hybridization as "Crossing between populations having different adaptive gene complexes such populations are either different races or sub species or species which are separated by isolating mechanisms".

Hybridization is considered to be a potent evolutionary force that contributes to adaptive evolution and speciation. In this view, the new gene combinations generated by hybridization promote the development and acquisition of novel adaptations.

Salient features of hybridization

1. Off spring produced by hybridization may be fertile, partially fertile or sterile.
2. The hybrids share the genetic materials from two different species, i.e. it brings about new gene combinations.
3. It increases the size of the gene pool.
4. It produces new mutations
5. It establishes variations in the populations.
6. New varieties and species are formed by hybridization.
7. Only a small number of the progeny of hybrids prove to be better adapted to certain environments
8. Even though a great majority of the progeny of hybrids is poorer in every respect than their parents, the forces of natural selection pick out that small number of individuals which may be better adapted to an available environment and to increase greatly the frequency of such gene combinations in the environment to which they are better adapted.

Limitations of hybridizations to evolution

Hybridization has certain limitations. It can bring about evolution only when it satisfies three important conditions. They are as follows:

1. In the progeny of hybrids fertility should be restored
2. There should be a variety of environmental niches. This enables the progeny of the hybrids to fit into any of the suitable environmental niches and
3. New combinations of genes should be stabilized so that they can maintain them selves under natural conditions.

Plants hybridize much more frequently and successfully than animals do. Pollen from flowering plants disperses widely and may land on flowers of other species. Chromosomal doubling (polyploidy) occurs more frequently in plants and facilitates the fertility of the hybrid offspring. Finally, plant forms are less stringently controlled than animal forms, and so the intermediate form of a plant hybrid is more likely to be physiologically successful.

Examples for Hybridization

There are two species of red-eyed towhees (bird) in Mexico. One species collared towhee *Pipilo ocai* lives in coniferous weed lands of Southern Mexico. The other species spotted towhee *Pipzilo erythrophthalmus* lives in oak forests of Northern Mexico. In the mountains of south eastern Mexico the two species are found together, living in the same area without any inter breeding; each species maintains its own integrity in this area. But in many parts of western Mexico, the two species interbreed resulting in the formation of swarms of hybrids. These hybrids are intermediate in their appearance. In these places the original oak forest is completely cleared for human purposes. This disturbance of the habitat has favored the hybrids. The hybrid populations vary from locality to locality. In some localities the hybrids are unusually high. This suggests that the hybrids are successful groups. This example shows how hybridization can produce variability among populations.

Introgressive hybridization

"Hybridization that introduces some genes of one species into the genotype of another species is called introgressive hybridization". If refers to the crossing of the hybrid to its parent species (Back crossing).

Back crossing, which is the inter breeding between hybrids and their parental species, can transfer alleles from one parent to the other using the inter specific hybrids as a genetic bridge in a process called introgression. Introgression increases the genetic variation of one or both of the parents.

Example: One good example of introgressive hybridization involves hybridization between two species of Spiderwort (plants).

One species *Tradescantia canaliculata* grows in full sunlight on the top of the cliffs. The other species *Tradescantia subaspera* grows in the woodland shade of the base of the cliff. In some places where there is a gradual slope connecting the top of a cliff with its base, the forest dwelling species has extended its range upwards and the cliff top species has extended its range downwards. In the meeting place hybrid are produced. The hybrids contain characters of both parents and they are successful because the environment is intermediate between the cliff top and the forest.

The hybrids contain some genes derived from the forest dwelling species and some genes derived from the Cliff-top species. When the hybrids breed with cliff top species some genes of the forest dwelling species are introduced into the Cliff-top species. The reverse also occurs. Thus hybrids function as go between the parental species. Introgressive hybridization brings about gene flow between two different gene pools. As a result genetic variability is increased. Genetic variability provides the raw materials upon which natural selection operates. Introgressive hybridization is a potent force in introducing genetic variability into a species as in the occurrence of new mutations.

Origin of New Characters by Hybridization

Hybridization promotes the origin of new characters and variability. New characters can be established and fixed by placing mutations derived from one species on a new genetic background. The new genetic background is formed by a combination of genes derived from both parental species.

A mutant gene which is harmful in one population may be neutral or beneficial in another. Similarly certain advantageous genes may exist in one population and different beneficial genes in another. If interbreading takes place between these populations, individuals may arise in which the two beneficial genes recombine, so conferring a selective, advantage on the new phenotype. For example the genes in a wild grass which renders it resistant to fungus disease have been combined by cross breading with the genes for large grain size in cultivated wheat thus producing a variety with high yield and good resistance to disease. Their combined selective advantage could cause them to maintain a constant frequency in a population. In such instances the hybrids can become new species with characteristics different from either of the parents. Humans have used intra specific hybridization, hybridization between strains of a single species, to develop high yielding crops. Thus hybridization may influence evolution in a variety of ways.

Check Points

- Hybridization is the process of inter breading between individuals of different species.
- Off springs produced by hybridization are called hybrids.
- Hybridization increases the size of the gene pool, produce new mutations and establishes variations in the populations.
- Plants hybridize much more frequently and successfully than animals do.
- Hybridization can produce variability among populations.
- Hybridization that introduces some genes of one species into the gene type of another species is called introgressive hybridization.
- Hybridization may influence evolution in a variety of ways.

Semester – III

General Biology

Unit-VII: Theories and Rates of Evolution

Module No: 40 (III) Origin and Evolution of Man

Many kinds of evidence indicate that man is a product of evolution. The order primates have two sub-orders:

Sub-order: Prosimii (tree shrews, Lemurs, tarsiers) and sub-order: Anthropoidea (monkeys, apes, man). Sub-order Anthropoidea is divided into groups (1) New world monkeys and (2) old world monkeys, apes and men. Man resembles old world monkeys and apes as compared with new world monkeys. Man in many respects, is similar in structure to the great apes, particularly to the chimpanzee and the gorilla. None of these forms are the ancestors of any of the others, because they are all contemporaries.

Man shares many physical features with the modern primates. The chemical composition of blood of humans, apes and monkeys is quite similar. Man and other primates particularly apes (gorilla and chimpanzee) share similarities in blood groups. Man and the primates are subject to the same diseases. The chromosomes in chimpanzee and gorilla are much more like ours. These things suggest that man and primates are closely related and probably descended from a common ancestor. Modern humans are hominids (family Hominidae) as are their immediate ancestors.

Ancestry of Man

The *Parapithecus*, a monkey – ape was ancestral to man. It possessed very primitive characters of primates and hence it represents a stage in evolution in which old world monkeys, apes and ancestors of man were not clearly separated. Man shared common ancestory with monkeys and apes and hence it was ancestral to all three.

In Miocene and Pliocene evolved *Dryopithecus*. *Dryopithecus* had forelimbs shorter than hind limbs. In this respect, it is resembling man. So it is believed that *Dryopithecus* is the distant ancestor of man, chimpanzee and gorilla.

Oreopithecus, a fossil primate lived in late Miocene or early Pliocene times, some thirteen million years ago. *Oreopithecus* resembled man, and differed from apes and monkeys in so many characters. In the structure of teeth, in the possession of broad pelvis, in shortness of face and in erect walking it resembles man,

The earliest primate, which was truly man – like creature and different from the apes is *Ramapithecus*. It lived during late Miocene and early Pliocene. It was contemporeary to *Oreopithecus*. The fossil of this animal contains only jaws and dentition. The dentition is more identical to man. It was directly ancestral to man.

In evolution, the next primate that followed *Ramapithecus* was *Australopithecus*. It is supposed to be the most immediate ancestor of man among the primates. The hominid line of descent begins with *Australopithecus*. It was an ape – man. It combined many characters of ape and man. It is 2 to 5 million years old. The human characters of *Australopithecus* includes – erect posture with four feet height, Bipedal locomotion, vertebral column has a distinct lumbar curve, Broad pelvic girdle, Dentition, forward position of foramen magnum etc. The ape-characters of *Australopithecus* includes – small cranial case and brain, teeth were larger than modern man, no chin, eye brow ridges projected over the eyes.

In view of this it can be considered as the connecting link between ape and man.

Two million years ago, *Australopithecines* coexisted with *Homo habilis* (handy man) – a more human like primate who lived communally in caves and cared intensely for young. The name means handy man and is the first human known to have manufactured stone tools. *Homo habilis* was small but the brain capacity was 700 CC. *Homo habilis* coexisted with and eventually was replaced by *Homo erectus*.

Homo erectus (upright walking man) evolved around 1.5 million years ago. The brain capacity increased to 1000 CC. The pace of man's evolution increased with the newly acquired tool of change, i.e., culture. *Homo erectus* learned to use fire, cook food and use animal hide to keep his body warm. Fossilized teeth and jaws suggest that *Homo erectus* ate meat. They were the first primates to have an angled skull base that permitted a greater range of sounds, making speech possible. *Homo erectus* had more pronounced brow ridges, a flatter face and a nose that projects like ours. It is believed that *Homo erectus* first appeared in Africa and then migrated into Asia and Europe. The distribution of fossils suggests that *Homo erectus* lived in families of male-female pairs. They left fossil evidence of co-operation, social organization and tool use including the use of fire.

Homo sapiens (Thinking man) were descended from *Homo erectus*. They were more or less identical to modern man. A number of fossils of *Homo sapiens* are known. The grade of sapiens contains at least two contrastingly different anatomical types – Neanderthal and Cro-magnons.

1. *Homo sapiens neanderthalensis* (Neanderthal man)

The skeleton of Neanderthal man was first unearthed in 1856 in Neander valley in Germany. The Neanderthals were 1.5 lakh years old cave dwellers, short (about 5 feet) but powerfully built, with prominent facial brow ridges, and the nose, the jaws and the teeth protruded forward. They had large brains with an average capacity of 1450 CC. the fore head was low and sloping, and the lower jaw sloped back without a chin.

The Neanderthals were heavily muscled, especially in the shoulders and the neck. The bones of the limbs were shorter and thicker than those of modern humans. Neanderthals made complex stone tools, were accomplished hunters of large game, used animal hides as clothing and with stood the rigors of the bitter cold climate of the last glaciation. They give evidence of being culturally advanced. They used and could control fire, and they even buried their dead with flowers and tools, indicating that they may have had a religion.

2. *Homo sapiens sapiens* (Cro-Magnon man)

The fossil remains of Cro-magnons, a representative of our species, *Homo sapiens*, were unearthed from a French rock-shelter in the village of Les Ezgies. They were about 35,000 years old. Cro-magnons had a thoroughly modern appearance. They possessed almost all the characteristics of modern man. Techniques of manufacturing stone weapons and tools improved as time went on. They made coloured paintings on the walls in Spain and France. They carved tools and ornaments from ivory and manufactured finely chipped stone arrow and spear points. Cro-magnons hunted cooperatively and most likely lived in small groups, with the men hunting by day while the women remained at home with the children. We do not know about the birth place of modern *Homo sapiens*. Modern humans may have been cradled in Asia or Africa. The over all pattern of human evolution extended over a period of about 5 million years during which *Australopithecus africanus* evolved into *Homo erectus* which eventually give rise to *Homo sapiens*. The earliest *Homo sapiens* evolved into many varieties and eventually into modern man.

Evolution continued, taking on a cultural aspect as social and communication skills improved. Cave art from about 14,000 years ago indicates that our ancestors had developed fine hand coordination and could use symbols. By 10,000 years ago, people had migrated from the Middle East across Europe. They brought agriculture and may have replaced hunter-gatherers.

Check Points

- Man and primates are closely related and are descended from a common ancestors.
- *Parapithecus*, a monkey-ape was ancestral to man.
- *Dryopithecus* is the distant ancestor of man, chimpanzee and gorilla.
- *Ramapithecus* was the earliest primate which was truly man like creature.
- *Australopithecus* is supposed to be the most immediate ancestor of man among the primates.
- *Homo habilis* was a more human like primate, manufactured stone tools for the first time.
- *Homo erectus* learned to use fire.
- *Homo sapiens* were more or less identical to modern man.