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Department of Zoology

Study material

Paper IV

Animal physiology, Cellular metabolism and Embryology

PHYSIOLOGY

UNIT I

EQ1: Explain the process of chemical digestion of food materials like Carbohydrates, fats and lipids:

Definition: Digestion is a process that involves physical and chemical breakdown of insoluble complex materials into soluble simple food materials. During digestion, carbohydrate is converted into glucose. Proteins are converted into Amino acids. Lipids are converted into Fatty acids and Glycerol

Carbohydrates --------->Glucose

Proteins----------> Amino Acids

Lipids--------> Fatty acids +Glycerol

Carbohydrates digestion:

Carbohydrate is an important component of diet. Human diet contains 60to 83% carbohydrates.

Carbohydrates -----> Disaccharide ----> Monosaccharide

Places of carbohydrate digestion: Buccal cavity, Stomach, Intestine**.**

Glands involved in carbohydrate digestion:Salivary glands, Pancreas, Gastric glands, Intestinal glands.

Enzymes involved in carbohydrate digestion: Amylase, Maltase, Lactase, Sucrose, Cellulase.

Digestion of Starch: Starch is digested by Ptyalin. It is secreted by salivary gland.

Starch ---> Soluble starch ---> Erythrodextrin --->Achrodextrin -→ Maltase.

Digestion of Glycogen: Amylase hydrolyzes glycogen into Maltose.

Digestion of Maltose: Maltose is digested by Maltase.

Maltose -Maltase--> Glucose+ Glucose

Digestion of Sucrose: Sucrose is digested by sucrose.

Sucrose ---Sucrase--→Glucose+ Fructose

Digestion of Lactose: Lactose is digested by Lactase enzyme.

Lactose -Lactase-------→Glucose + Galactose.

Protein digestion:

Places of protein digestion:

Adult human diet contains 25 to 40 gramsof protein. In the process of digestion, proteins are split into Amino acids.

Places of protein digestion: Stomach, Intestine

Glands involved in proteindigestion: Pancreas, Gastric glands, Intestinal glands.

Enzymes involved in protein digestion:

Pepsin, Trypsin, Chymotrypsin, Carboxypeptidase, Aminopeptidase, Dipeptidase, Renin.

Proteins----Proteoses ----Peptones ----Polypeptides ----Dipeptide ----Amino acid

Role of pepsin:

Pepsin is secreted by gastric glands. Proteins acts in native proteins and milk and convert them into proteoses, peptones and polypeptides.

Native protein —pepsin---------- Proteoses+ Peptones+ Polypeptides

Calcium+ Casein(milk)-- pepsin-----Calcium Para casein(curd)+ proteose
Calcium Para casein — pepsin---proteoses, Peptones, polypeptides

Role of trypsin:

Trypsin is secreted by Pancreas.
Native protein ---- Trypsin --------proteoses+ Peptones+ polypeptides
Proteose ------ Trypsin ----peptones
Peptones------- Trypsin ---- Polypeptide
Polypeptide---- Trypsin -----Dipeptide

Role of chymotrypsin: Action similar to trypsin

Role of carboxypeptidase: This enzyme is secreted by pancreas.

Proteose ------ carboxypeptidase----peptones
Peptones----- carboxypeptidase-- ---- Polypeptide
Polypeptide--- carboxypeptidase- -----Dipeptide + Amino acid

Role of Amino peptidase: This enzyme is secreted by pancreas. Its action is similar to carboxypeptidase.

Role of Dipeptidase:

Dipeptide---- Dipeptidase -------Amino acid + Amino acid

Lipid digestion: Lipids are second major source of energy. Lipids are split into Fatty acids and Glycerol.

Places of lipid digestion: Stomach, Intestine.

Glands involved in lipid digestion: Pancreas, Gastric glands, Pancreas

Enzymes involved in lipid digestion: Gastric lipase, Pancreatic lipase, Phospholipase, Phospho diesterase, Phosphatase, Cholesterol esterase.

Digestion of neutral fats:

Neutral fats –gastric lipase---------- Diglyceride + Glycerol

Diglyceride ----------Monoglyceride + Fatty acid

Monoglyceride ---------Glycerol + Fatty acid

Digestion of Lecithin and cephalin:

Lecithin --Phospholipase---------- Lysolecithin + Fatty acid

Cephalin --- Phospholipase ----------Lysocephalin + Fatty acid

Lipid digestion is completed in the intestine by Intestinal lipase enzyme.

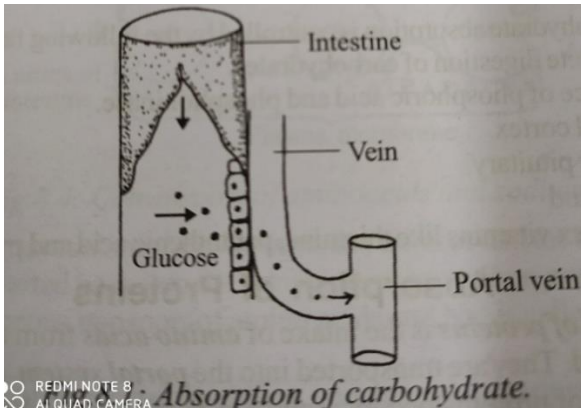
EQ2: Define Absorption. Explain the process of absorption Carbohydrates, Proteins and Lipids

Definition: It is a process by which the end products of digestion are transported from lumen of alimentary canal to the bloodstream through the intestinal wall.

Places of absorption: Small intestine.

Absorption of carbohydrates:

- Absorption of monosaccharides from the lumen of intestine into the blood.
- They enter the portal system of blood.
- Absorption mainly occurs in the intestine.
- The maximum rate of glucose absorption is 120 g/hr.
- Carbohydrate is absorbed in the form of glucose, galactose, fructose, mannose, and pantose.
- Glucose and galactose are absorbed much more rapidly than fructose, mannose and pentoses.
- Glucose and galactose are absorbed by active transport.
- Monosaccharides are present in the lumen of intestine. They are transported through the plasma membrane of intestinal cells into the cytoplasm. From the cytoplasm, they diffuse into the Venous blood of portal system.



Absorption of carbohydrate.

- The plasma membrane of intestinal cell has carrier protein called **SGLT** (Sodium dependent glucose transporters).
- The carrier protein has two binding sites one for glucose and another for Sodium.
- It binds with sodium and glucose.

- Then the carrier protein moves towards the cytoplasm of the cell which brings both Na+ and glucose facing the cytoplasm. Then the carrier protein moves towards the cytoplasm of the cell which brings both Na+ and glucose facing the cytoplasm here both glucose and Na+ are released.Glucose moves along the cytoplasm and diffuses into the blood. The Na+ is transported back into the lumen of gut through sodium potassium pump.

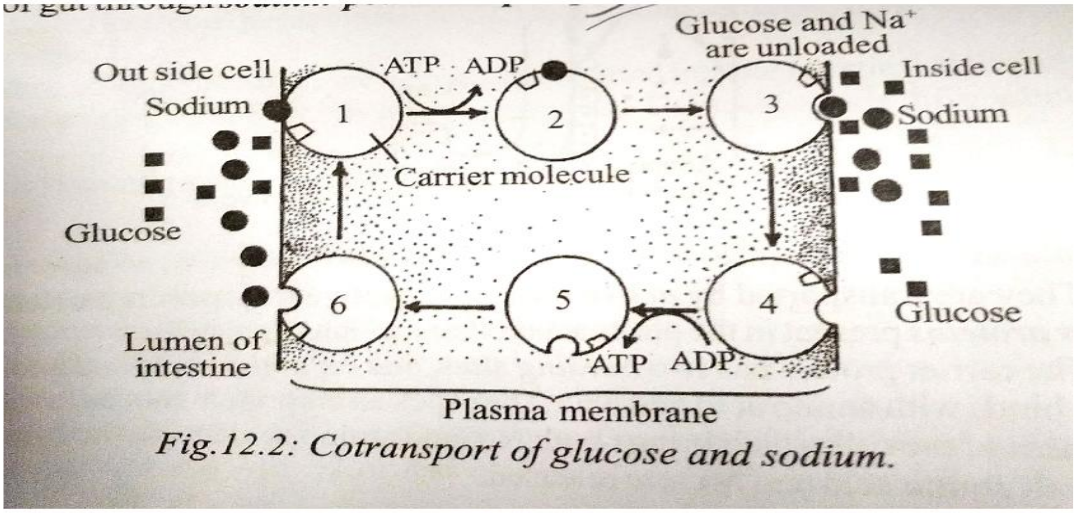


Fig.12.2: Cotransport of glucose and sodium.

- Na+ is transported into the cell along the concentration gradient glucose moves against the concentration gradient
- The simultaneous transport of Na+ and glucose is called co- transport
- Since Na+ and glucose are transported simultaneously in the same direction it is called symport.
- SGLT also transports galactose
- Fructose is transported by the career protein GLUT(glucose transporters). The carrier for fructose is independent of Na+. The transport of fructose is much slower.

The carbohydrate absorption is controlled by the following factors:

- Complete digestion of carbohydrates.
- Presence of phosphoric acid and phospokinase.
- Adrenal cortex
- Anterior pituitary
- Insulin and
- B complex vitamins like thiamine, pantothenic acid and pyridoxine.

ABSORPTION OF PROTEINS

Absorption of proteins is the intake of amino acids from the lumen of intestine into the blood they are transported into the portal system of blood.
Absorption of proteins occurs mainly in the intestine.
Amino acids are transported from the lumen of intestine into the cytoplasm of intestinal cells through the plasma membrane. From the cytoplasm they diffuse into the Venus blood of portal system.

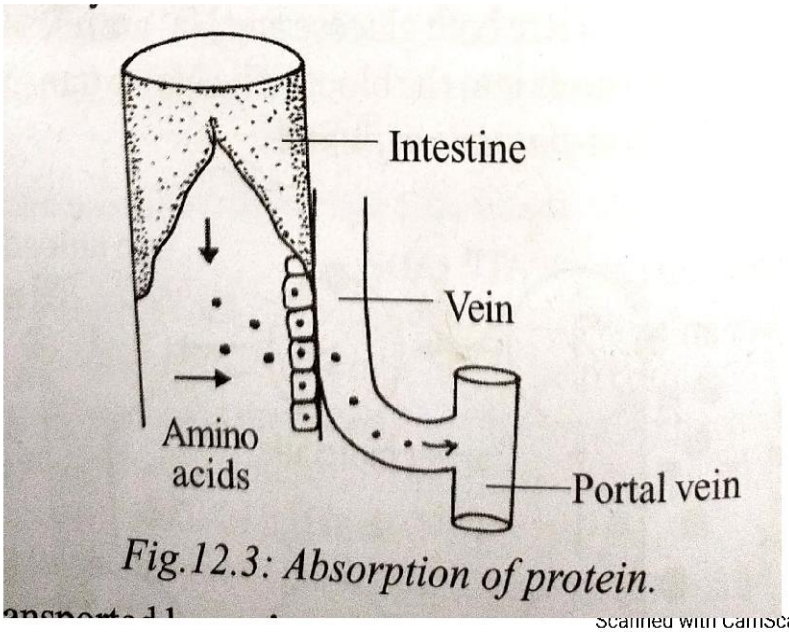
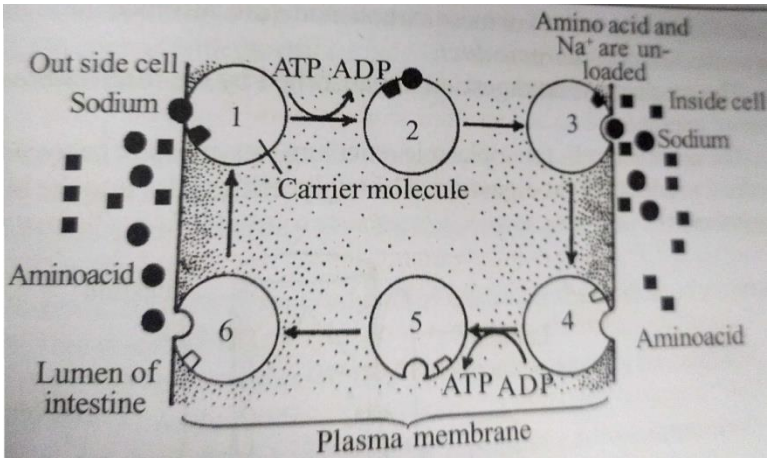


Fig.12.3: Absorption of protein.

- They are transported by active transport. Active transport is carried out by career proteins present in the plasma membrane of intestinal cells.
- The career protein has two binding sites one for amino acid and other for Na+. It binds with amino acid and Na+. Then the carrier protein moves towards the cytoplasm of the cell which brings both Na+ and amino acid facing the cytoplasm. Here both amino acid and Na+are released.



Amino acid moves along the cytoplasm and diffuses into the blood.
Na+ is transported back into the lumen of gut by sodium potassium pump.
The simultaneous transport of amino acids and Na+ is called co transport.
The transport of amino acid is against concentration gradient and the transport of Na+ is along the concentration gradient.
The L form of amino acids are rapidly and activate transported the d forms are transported very slowly and passively.
About 7 careers systems are observed for the transport of proteins of these five transport systems need Na+ for co transport and the two are not co transported with Na+.

Absorption of lipids:

Absorption of lipids is the intake of fatty acids and glaze from the lumen of intestine into the blood.
Absorption of lipids mainly occurs in the intestine.
The fat is digested into fatty acids, glycerol, triglycerides, di glycerides, monoglycerides, phospho lipids, cholesterol, cholesterol estarage etc.
Lipids are transported through two routes namely ***Venus blood*** and ***lacteals.***
Free fatty acids with 12 or less carbon atoms are absorbed into the portal blood.
Fatty acids with 14 or more carbon atoms are absorbed through the lacteals and passed into the ***thoracic duct.***
The products of fat digestion are absorbed by the intestinal cells from the lumen of intestine.
The intestinal cells Rey synthesize triglycerides from the absorbed product of fat digestion they triglycerides pass into the blood from the intestinal cells.

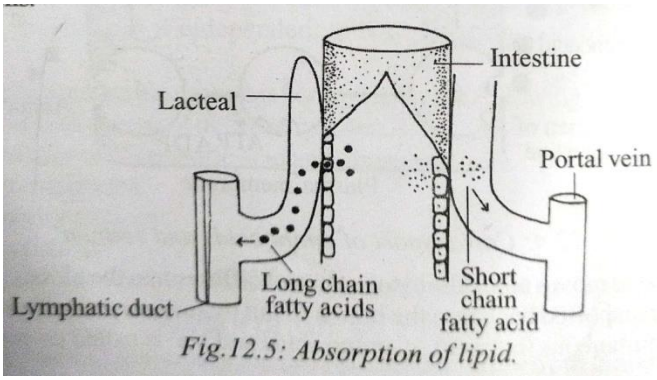
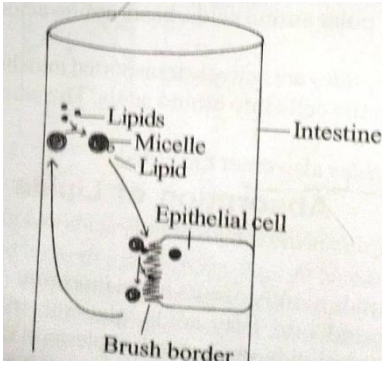


Fig.12.5: Absorption of lipid.



Lipid absorption is facilitated by bile salts of bile the Bible sounds perform a pairing function is transported lipids from the lumen of intestine to the surface of intestinal cells the bile cells function as careers of lipids.
Bile saults have a polar hydrophilic portion and nonpolar hydrophobic portion. Thus they have affinity for both water and lipids. Bile salts in the presence of

lesithin, interact with fatty acids and monoglycerides to form minute complexes called micelles. They are water soluble.
The missile make the lipid soluble and transport them to the brush border of the intestinal cells and contact with the cell surface, the bile saults separate from the lipid portion .The lipid portion passively diffuses through the plasma membrane and enter the cytoplasm.
The separated bile salts move into the lumen and transported more fatty acids and monoglycerides to the brush border.
The micelles move down along the concentration gradient to the mucosal surface.
Free cholesterol, formed from cholesterol esters by the action of esterases, enters the cell and are re-esterified.
The lipids reach the Venus blood through two routes, namely through the portal blood and through the lacteals.
Most of the shorts and fatty acids having 12 or less carbon atoms and glycerol of the mucosal cells diffuse into portal blood.
Long chain fatty acids having more than 12 carbon atoms of the mucosal cells are resynthesized into triglycerides.This synthesis occurs in the smooth endoplasmic reticulum.

EQ3:Explain about the process of oxygen transport in Mammals:

The lungs contain atmospheric air.

From the lungs, oxygen diffuses into the blood. The blood transport oxygen from the lungs to the cells. This is called Oxygen transport.

The oxygen is transported by Haemoglobin (Hb) present in the RBC of blood.

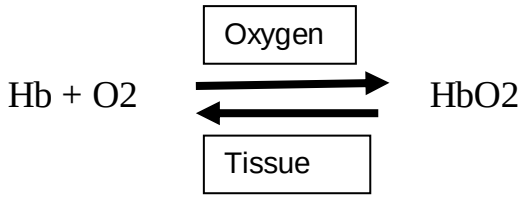
The arterial blood contains 20ml of o2 /100 ml

The venous blood contains 15ml of o2 /100 ml

The oxygen carrying capacity of blood will be higher when the blood contains more Hb.

Hb is loosely attaches with oxygen to form oxyhaemoglobin (Hb O2) when oxygen pressure in the blood is high.

Similarly, it dissociates (separate) readily with oxygen when the oxygen pressure is lesser in the blood.



In alveolar capillaries of lungs, the oxygen pressure is higher. Hence, Hb combines with oxygen to form Oxyhemoglobin (HbO2).

Each Hb molecule combines with 4 moles of O2

The blood leaving the lungs has 99% of Hb is fully loaded with oxygen.

The oxygen rich blood enters the heart and is then pumped to various organs.

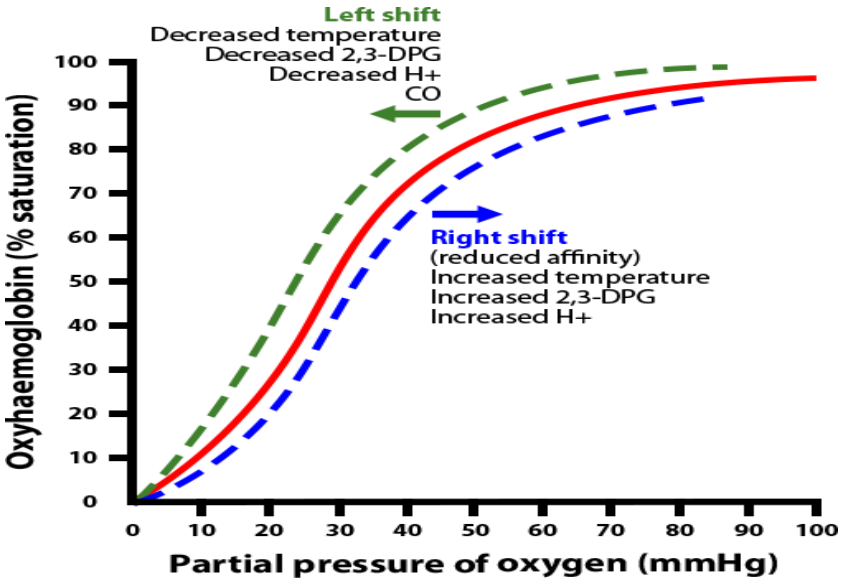
The cells present in the tissue of various organs consume oxygen continuously. Hence, the oxygen pressure in the tissues and organs will be lesser. Hence, when the oxygen rich blood passes through the tissues, Hb dissociates from oxygen. The oxygen diffuses out from the blood through the capillary wall and enters the tissues. The Hb returns to the lungs and again transports new oxygen molecules.

Oxygen dissociation curve: The capacity of Hb to combine with oxygen to form HbO2 is conditioned by many factors like oxygen pressure, Co2, Ph, temperature etc.

When Oxygen pressure is low, the percentage of HbO2 formed will be also lesser ie. at low oxygen pressure, the affinity of Hb for O2 will be lesser.

When O2 pressure is high, the percentage of HbO2 formed will be higher. The proportion between HbO2 and oxygen pressure can be represented in the form of a curve called O2 dissociation curve. It is “S” shaped curve.

The curve for blood clearly shows that at 0mm Hg of O2 Pressure that % of HbO2 formed is also 0.



At 30 mm Hg of O2 pressure, the % of HbO2 -- 55

At 70 mm Hg of O2 pressure, the % of HbO2 -- 90

At 90 mm Hg of O2 pressure, the % of HbO2 -- 98

At 100 mm Hg of O2 pressure, the % of HbO2 -- slightly increased.

Formation of Oxyhemoglobin: The formation of oxyhemoglobin in the lungs is due to the following three factors.

- High O2 tension and low CO2 tension.
- Normal pH of blood that is 7.4
- Low temperature.

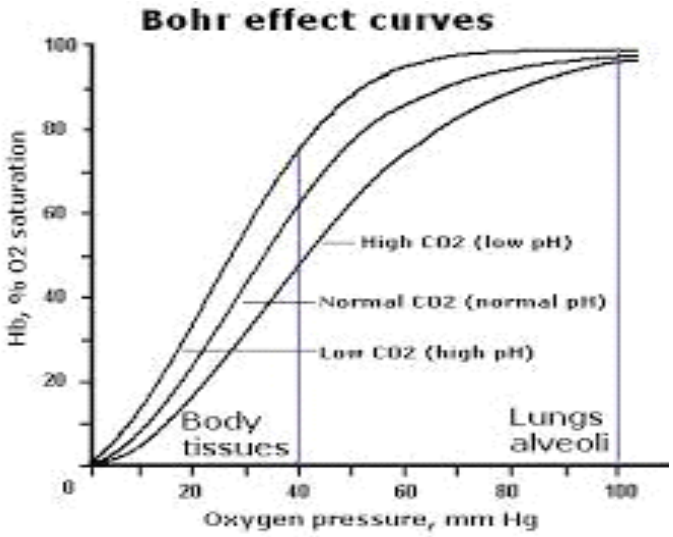
Dissociation of Oxyhemoglobin: The dissociation is caused by three factors.

- High CO2 tension.
- Slightly acidic Ph in venous blood.
- Rise in temperature in the tissues.

Bohr effect: The dissociation curve is much affected by CO2. When the CO2 concentration increases in the blood, the affinity of Hb for O2 is reduces.

As cells are continuously using O2 and releasing of CO2, CO2 concentration is higher in the tissues.

When blood containing HbO2 passes through the tissues, the affinity of Hb for O2 is reduced because of higher concentration of CO2 in the tissues. Hence Hb separates from O2 and O2 is released for the utilization of tissues. Thus increasing concentration of CO2 helps to unload O2 from Hb. This phenomenon is called Bohr effect. The dissociation curves move towards right.



EQ 4: **Structure of Mammalian Heart:**

Mammalian heart is mesodermal in origin.

The heart is conical, muscular organ, reddish Colour.

It is 4 chambered and lies between two lungs or mediastinal space.

In mammals, the heart is myogenic. The rhythmic activity of the heart is under control of muscles.

Pericardium: The heart is enclosed in a transparent, double layered sac, is called pericardium.

The inner layer of the pericardium is called Visceral layer and outer layer is called parietal layer. The narrow space in between these two layers is called pericardial space, filled with **pericardial fluid**. This fluid protects the heart from external shock and keep the heart always moist.

External structure: Mammalian heart has four chambers, 2 Auricles & 2 ventricles.

The anterior 2 chambers are called Auricles and posterior 2 chambers are called Ventricles.

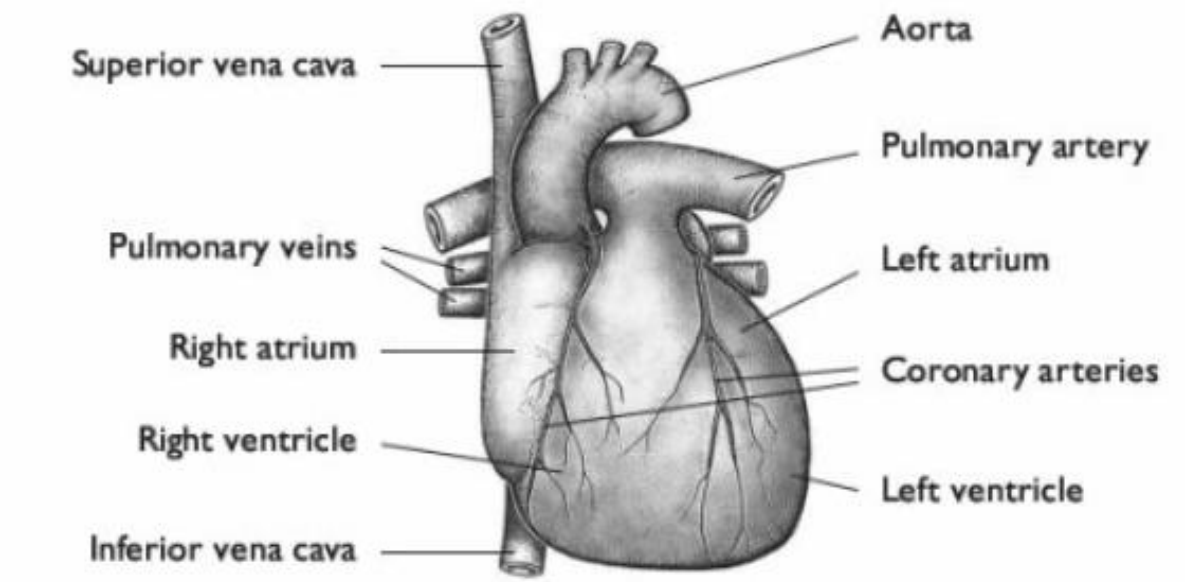
Sinus venosus and conus arteriosus are absent.

Auricles: Two auricles are dark in colour and forms a smaller anterior part of the heart.

Two auricles are separated from ventricles by Auriculo ventricular septum.

The right auricle is extended ventrally into a flap called **Auricular appendix.**

Ventricles: These are posterior chambers of the heart. Two ventricles are demarcated externally by a groove. In this groove, coronary blood vessels are present.



External view of a mammalian heart

Internal structure:

Heart is enveloped by three membranes.

Outer epicardium, Middle mesocardium, Inner endocardium.

Auricles: Two auricles completely separated by a septum, inter auricular septum.

In the embryonic development, **foramen ovale** is present in this septum, but, during development, it is closed and represented by **Fossa ovalis.**

Right Auricle: The right auricle is smaller than the left.

Right auricle receives deoxygenated blood from various parts of the body through three veins, two precaval and one post caval vein.

The opening of the post caval is guarded by a valve, **Eustachian.**

Near eustachian valve, a small node of specialized tissue, Sinoatrial node**(SA node)** is present. This is pace maker.

Left precaval opens into right atrium, which is guarded by **Thebesius** valve.

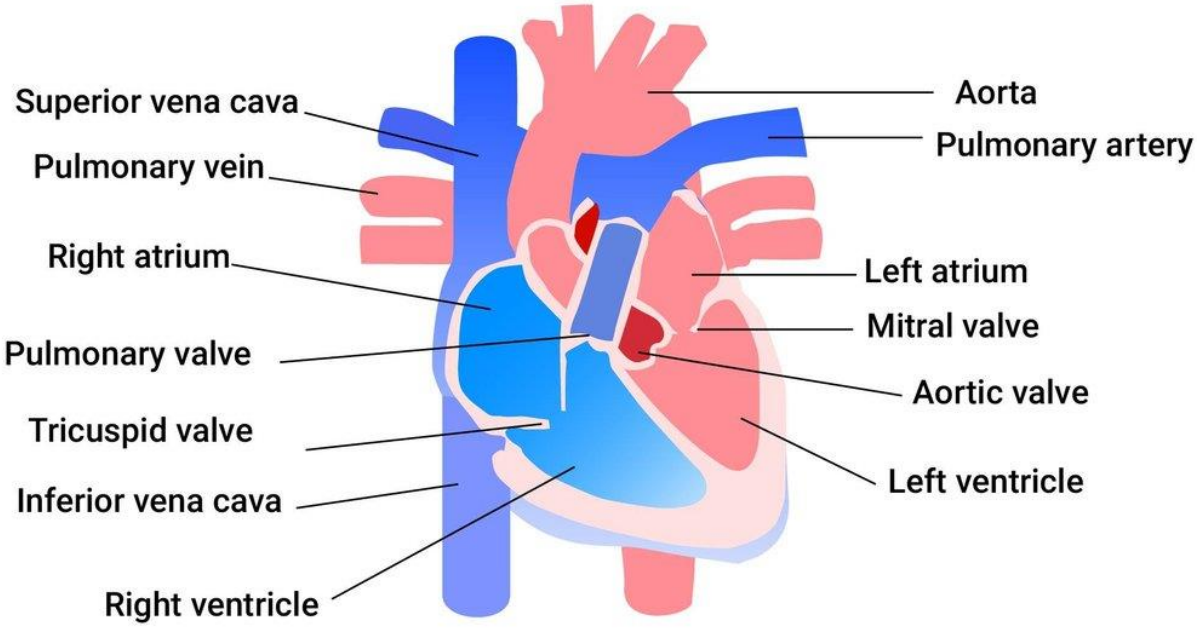
Right precaval opens into right atrium through a opening, which is not guarded by valve.

Left Auricle: Left auricle is larger in size.

It receives oxygenated blood from lungs through a pair of puln=monary veins, which is not guarded by any valve.

Atria and ventricles are separated by an auriculo-ventricular septum which possesses left and right auriculo ventricular apertures.

Right aperture is guarded by **tricuspid** valve and left aperture is guarded by **bicuspid** or mitral valve.



Ventricles: These are two, which forms the posterior part of the heart. They are separated by interventricular septum.

Left ventricle is larger than the right.

The walls are highly muscular.

The inner surface of ventricle is raised into muscular ridges called **Columnae corneae**.

Some of these ridges are large and conical, and are called papillary muscles. Extending between auriculo ventricular valves and papillary muscles are tendon like chords, called **chordae tendinae.**

EQ 5:Working of mammalian Heart:

The right auricle receives deoxygenated blood from various parts of the body through a pair of precaval and one postcaval veins.

At the same time, the left auricle expands to receive oxygenated blood from the lungs through common pulmonary vein opening.

The contraction of heart is called as systole and relaxation is called diastole.

The sinus venosus is represented as Sino-auricular node(SA node) or pace maker.

The pace maker initiates the rhythmic contraction carried by Bundle of his and spread over the heart walls through Purkinji fibres.

When auricles are filled with blood, auricled contract.

When right auricle contract, the Eustachian valve and thebesean valves are closed preventing the back flow of deoxygenated blood.

At the same time, Tricuspid valve at the right auriculo ventricular aperture is open and impure blood flows into right ventricle.

When left auricle contract, the paired valves present inside the pulmonary vein, prevent the entry of blood into the pulmonary vein but, bicuspid valve present at the left auriculo-ventricular aperture is open the oxygenated blood from left auricle flows into the left ventricle.

When two ventricles are filled with blood, the muscular papillae start contractions and the two ventricles contract simultaneously, auricles relax. The

semi lunar valves present at the base of the systemic aorta are open and the oxygenated blood enter the systemic aorta and distributed to all parts of the body.

At the same time, semi lunar valves at the base of pulmonary aorta are open, and deoxygenated blood enter into pulmonary aorta and from there, into the lungs for oxygenation.

The first sound LUB is produced when the atrioventricular valves i.e. tricuspid and bicuspid valves close at the start of ventricular systole. The second sound DUP is produced at the beginning of ventricular diastole when the pulmonary and aortic semi lunar valves close.

Cardiac cycle:

The sequence of events that takes during a single heart beat constitutes cardiac cycle.

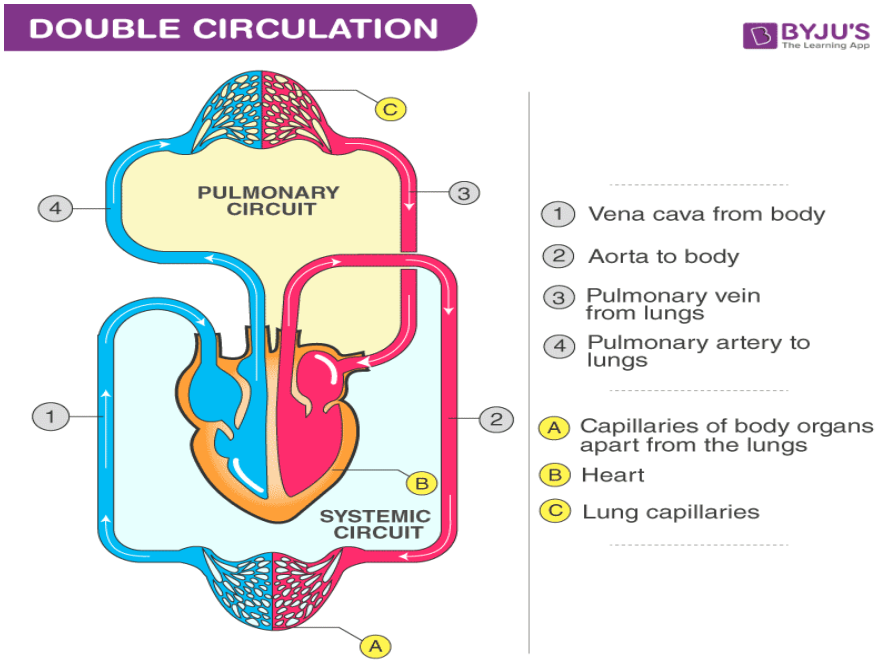
A cardiac cycle lasts 0.8 Seconds. It may be divided into three phases. Atrial systole, Ventricular systole and Atrio- Ventricular diastole.

Atrial systole: It lasts about 0.1 seconds. During this phase, atria contract.

Ventricular systole: It lasts about 0.3 seconds. During this phase, ventricles contract.

Ventricular diastole: It lasts about 0.4 seconds. During this phase, ventricles relax. Semilunar valves are closed.

Double circulation:



In double circulation, there are two pathways in which blood flows. They are:

- ✓ Pulmonary pathway
- ✓ Systemic pathway.

The pulmonary circulation or pathway carries the deoxygenated blood from the right side of the heart to the lungs. Exchange of oxygen and carbon dioxide takes place in the lungs and the blood is now oxygenated (with oxygen).

Through the systemic circulation, oxygenated blood travels from the left side of the heart to the other areas of the body. At various organ sites, exchange of gases, nutrients, and waste through lymph occurs. This deoxygenated blood again goes back to the right side of the heart.

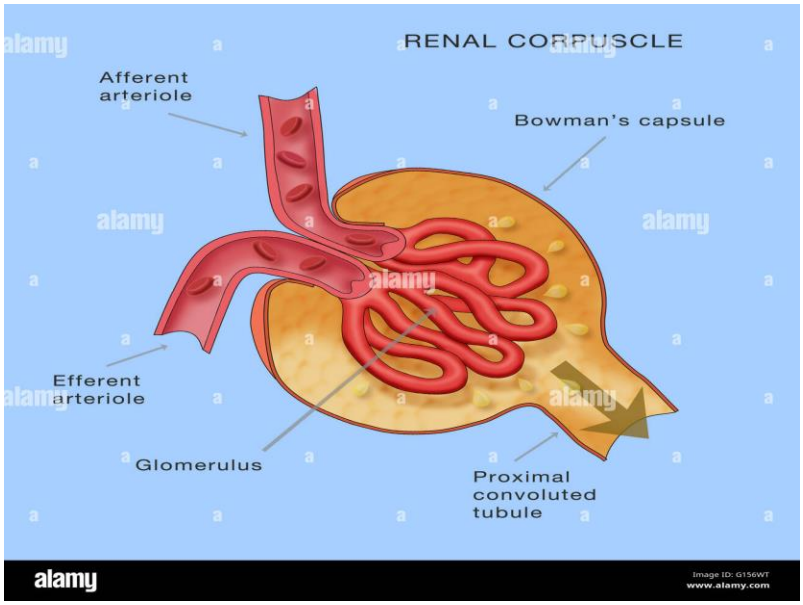
The pulmonary circuit and the systemic circuit work together. This ensures that deoxygenated blood goes to the lungs through the pulmonary artery while the oxygenated blood from the aorta reaches the different organs and tissues.

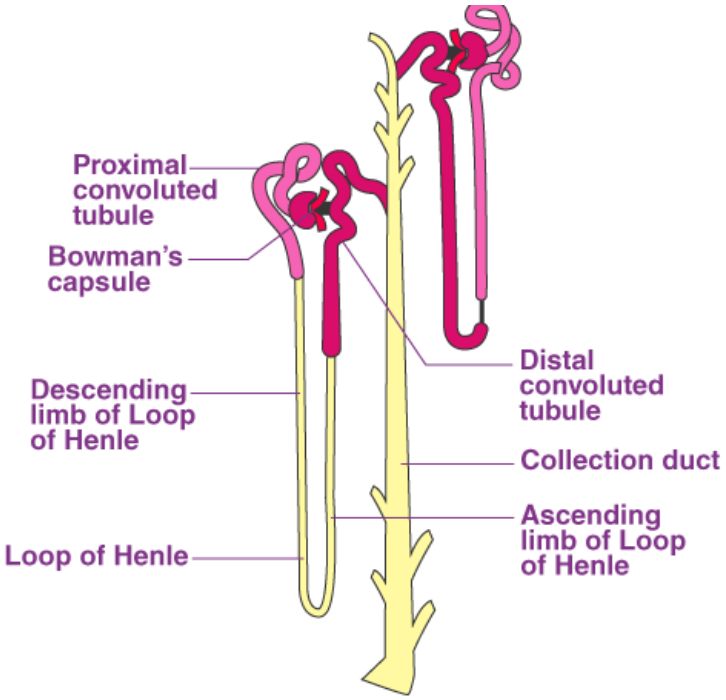
EQ 6: Explain about Urine formation

Formation of urine involves three steps. They are:

1. Ultrafiltration
2. Reabsorption
3. Secretion

Ultrafiltration: Ultrafiltration involves filtration of the blood which takes place in the glomerulus. The blood containing urea from the afferent arteriole enters the glomerulus under high pressure. The high pressure is created because the efferent arteriole is narrower than the afferent arteriole. The high pressure causes the liquid part of the blood to filter out from the glomerulus into the renal tubule. This filtrate is known as 'glomerular filtrate'. Glomerular filtrate consists of water, urea, salts, glucose, and other plasma solutes. Blood corpuscles, proteins, and other large molecules remain behind in the glomerulus. Therefore, the blood which is carried away by the efferent arteriole is relatively thick.





Selective reabsorption:

The glomerular filtrate is an extremely dilute solution containing a lot of usable materials like water, urea, salts, glucose, and other plasma solutes. When the filtrate reaches the proximal convoluted tubule, sodium ions and chloride ions, glucose, amino acids, water, and some vitamins move back into the blood. But their re-absorption is only to the extent that the normal concentration of the blond is not disturbed. This is called selective absorption.

Secretion:

Tubular secretion involves the removal of toxic substances from the blood capillaries and tissue and their active secretion into the nephron. Metabolic wastes such as urea, uric acid, ammonia and hydrogen ions are secreted into the fluid within the nephron.

The secretion mainly occurs in the convoluted tubules

Amino hippuric acid, an excretory product is secreted into the proximal convoluted tubule.

K+ and H+ ions are secreted by the distal convoluted tubule.

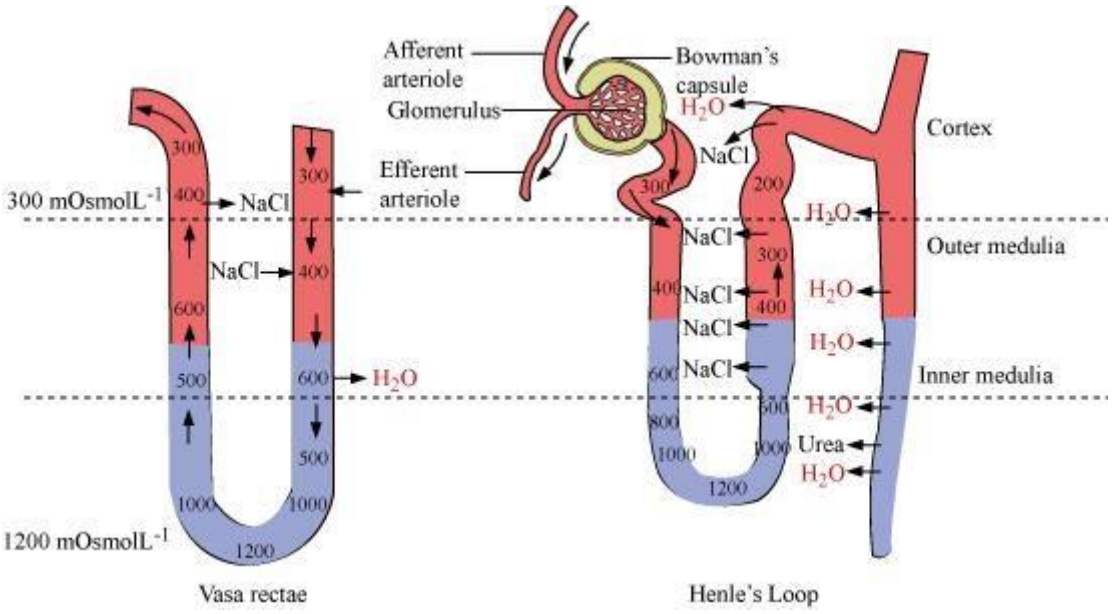
Potassium, Ammonia, Urea are also secreted into the tubule.

Creatinine and phosphates are other substances secreted.

- Significance of tubular secretion
- To maintain the ionic balance
- To maintain the hypotonic condition with the plasma
- To maintain the air pressure
- To maintain the hypertonic condition with the plasma

Counter current theory:

"The mechanism that the kidneys use to concentrate urine is called the countercurrent mechanism."



- Ascending limb actively transports na+ into the medullary tissue.
- As medullary tissue is concentrated, water diffuses out from the descending limb until the fluids in the descending limb and medullary tissue are isotonic. The maximum concentration is 1400 million moles/ liter at hair pin curve of Henley's loop.
- Descending limb is impermeable to water. A certain amount of Na+ions enter into the descending limb by diffusion.
- A certain amount of Na+ions enter into the descending limb by diffusion.

- The renal fluid is progressively concentrated as it flows down the descending limb and then is progressively diluted as it passes up the descending limb. The dilution is brought about by the diffusion os sodium from the renal fluid to the outside. Hence, here the urine becomes hypotonic.
- The distal convoluted tubule is permeable to water.

In the collecting duct, the water diffuses out and the renal fluidbecomes concentrated to form the urine. The diffusion of water is controlled by ADH hormone.

The urine then passes into ureter through calyces and pelvis.

UNIT-II

EQ1: Conduction of Impulse through Non-myelinated Neuron:

A nerve fibre is in the form of a long tube filled with axoplasm and is covered by a plasma membrane. In the resting nerve fibre, the axoplasm contains more K^+ and large number of negatively charged organic ions. On the outside of the nerve fibre, the intercellular fluid contains more Na^+ ion and K^+ ions. Again, in the resting nerve fibre, the plasma membrane is more permeable to K^+ than to $Na^{+\cdot}$ Hence K^+ leave the nerve fibre faster than Na^+ enters it. Hence the outside of the fibre is positively charged and the inside is negatively charged, Hence the plasma membrane of the resting nerve fibre is polarised with the outside being positively charged with respect to the inside, This difference in electrical potential on the two sides of the plasma membrane of nerve fibre is termed membrane potential or resting potential The resting potential is about 70 mill volt to -90 mill volt. The nerve fibre membrane at this state is said to be polarised.

The polarised state of the nerve fibre has the following salienfeatures:

1. It is the resting state of the nerve fibre.

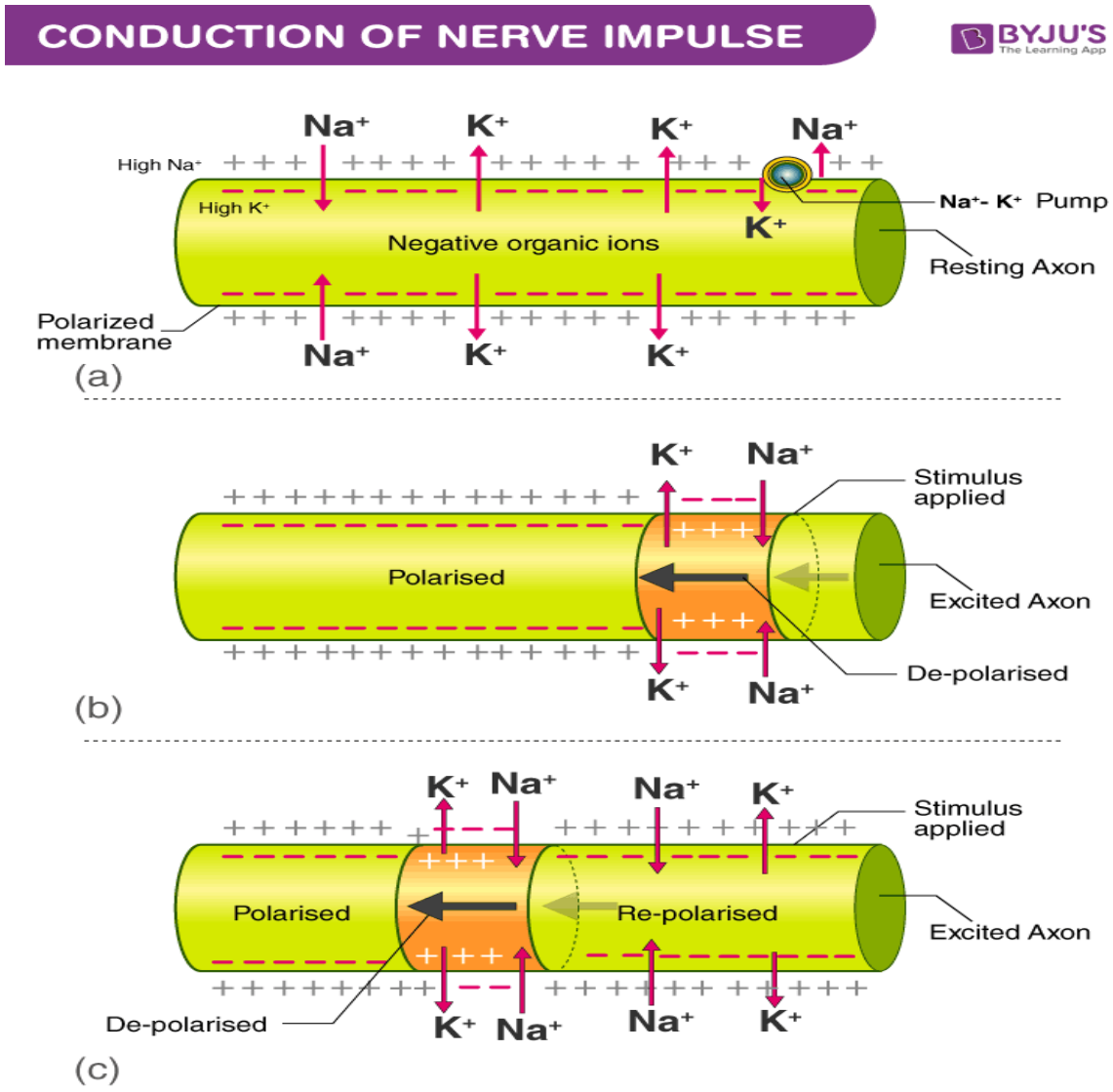
2. The axoplasm is negatively charged and the extracellular fluid is positively charged

3. The plasma membrane is more permeable to K^+ than to Na^+.

4. More K^+ move out and less Na^+ move in. When a nerve fibre is stimulated, the plasma membrane becomes more permeable to Na than to K^+. As a result more Na^+ quickly to the outside is move into the axoplasm and the rate of flow of K^+ lowered. As a result the axoplasm becomes positively charged and the outside becomes negatively charged. This reversal of electrical charge is called depolarization.

The depolarization, i.e. the transport of Na^+ into the fibre starts from a single point. The outside of the fibre at this point becomes negatively charged briefly. Adjacent to this the outside remains positively charged. This difference in potential between the two areas is called action potential. This is a temporary change between a stimulated and resting portion of a nerve fibre. The flowing in of Na^+ proceeds from this point. This is the depolarization wave. This wave is nothing but the impulse. It moves bit by bit down the fibre till it cover the whole length of the fibre.

As the depolarization wave passes away, the nerve fibre returns to the resting state called repolarised state. During the repolarised state, the membrane becomes more permeable to K^+ than to Na^+. Hence more K^+ move out and less Na^+ move in. This is called Repolarisation.



EQ2: Chemical changes during muscle contraction

4. Chemical Changes

The energy required for the muscular contraction is derived from certain chemical changes. The chemical processes which accompany the muscular contraction are summarised below:

1. Conversion of ATP into ADP

The initial step in the contraction phase is the break down of ATP with the sudden release of energy. ATP is usually described as the ***energy coinage of the cell.*** ATP break down is the only reaction going on with the liberation of energy available for the process of contraction ***(Needham).*** The break down of ATP is taking place in the presence of the enzyme ***ATPase*** and ***Ca*** $^{++}$.

$$\text{ATP} \xrightarrow[ATPase]{Ca^{++}} \text{ADP} + \text{Pi (inorganic phosphate)}$$

2. Break Down of Creatine Phosphate

For further contraction to take place, ADP should be regenerated to ATP. The energy for this conversion is derived by the breaking down of creatine phosphate present in the muscle into creatine and phosphoric acid in the presence of the enzyme ***creatine phosphatase***.

$$\text{Creatine phosphate} \xrightarrow[phosphatase]{Creatine} \text{Creatine} + \text{Phosphoric acid}$$

The phosphoric acid thus formed is transferred to the ADP which is converted to ATP.

$$\text{Phosphoric acid} + \text{ADP} \longrightarrow \text{ATP}$$

3. Breakdown of Muscle Glycogen

The muscle glycogen is broken down to glucose phosphate.

$$\text{Glycogen} + \text{Phosphoric acid} \longrightarrow \text{Glucose phosphate}$$

4. Formation of Fructose Diphosphate

The glucose phosphate is converted into ***fructose diphosphate.***

$$\text{Glucose phosphate} \longrightarrow \text{Fructose diphosphate}$$

5. Glycolysis

The fructose diphosphate is converted into pyruvic acid through glycolysis.

$$\text{Fructose diphosphate} \longrightarrow \text{Pyruvic acid} + 3\text{ATP}$$

6. Conversion of Pyruvic Acid into Lactic Acid

The pyruvic acid is then converted into ***lactic acid.*** This reaction never involves the use of oxygen.

Pyruvic acid ⟶ **Lactic acid**

7. Resynthesis of Creatine Phosphate

Creatine phosphate is resynthesized by the combination of creatine with ATP. This reaction is catalysed by ***ATP creatine phosphorylase.*** This process occurs during recovery phase.

$$\text{Creatine} + \text{ATP} \xrightarrow[\text{phosphorylase}]{\text{ATP Creatine}} \text{Creatine phosphate} + \text{ADP}$$

8. Conversion of Lactic Acid to Glycogen

80% of the lactic acid diffuses out from the muscle and is carried to the liver where it is converted into glycogen.

Lactic acid ⟶ **Glycogen unit**

This conversion takes place in the liver because the muscles lack the enzymes required for the synthesis of glycogen from lactic acid.

9. Cori Cycle

The conversion of liver glycogen into muscle glycogen and vice versa is called ***Cori cycle.*** As glycogen is a large molecule, it cannot diffuse out of liver.

Hence part of liver glycogen is converted into glucose. This glucose diffuses into the blood and is carried to the muscles. In the muscles, it is converted into glycogen.

10. Krebs Cycle

The energy for the resynthesis of glycogen is obtained from the oxidation of the remaining 20% of lactic acid. This 20% of lactic acid is oxidised to pyruvic acid which enters the ***Krebs cycle*** to produce CO_2 and H_2O.

Pyruvic acid ⟶ $\mathbf{CO_2 + H_2O}$

11. Myokinase

When a muscle is induced to contract over a prolonged period, fatigue develops owing to which ATP, glycogen and phosphocreatine levels decline. But ADP, AMP and lactic acid levels rise.

Under such conditions ATP is regenerated by the transfer of high-energy phosphate from one molecule of ADP to another ADP. This reaction is catalysed by the muscle enzyme ***myokinase.***

$$\text{ADP} + \text{ADP} \xrightarrow[\text{kinase}]{\text{Myo-}} \text{ATP} + \text{AMP}$$

12. Actin

Before contraction ***actin*** (muscle protein) remains in the globular form called ***G-actin.*** During contraction, ***G-actin*** is converted into fibrous protein called ***F-actin.*** F-actin represents the polymerised form of G-actin. After the contraction is over F-actin is converted into G-actin. The energy for the conversion of G-actin into F-actin is provided by ATP.

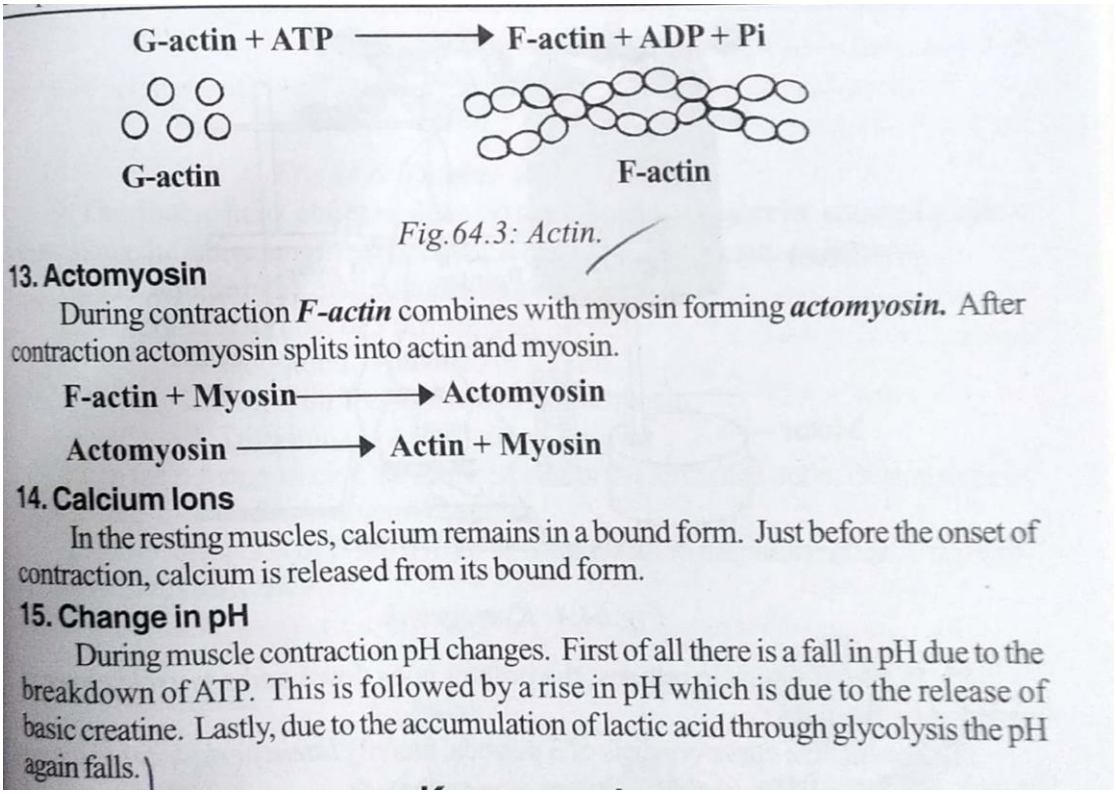


Fig.64.3: Actin.

13. Actomyosin

During contraction ***F-actin*** combines with myosin forming ***actomyosin.*** After contraction actomyosin splits into actin and myosin.

F-actin + Myosin → Actomyosin

Actomyosin → Actin + Myosin

14. Calcium Ions

In the resting muscles, calcium remains in a bound form. Just before the onset of contraction, calcium is released from its bound form.

15. Change in pH

During muscle contraction pH changes. First of all there is a fall in pH due to the breakdown of ATP. This is followed by a rise in pH which is due to the release of basic creatine. Lastly, due to the accumulation of lactic acid through glycolysis the pH again falls.

EQ 3:List out the hormones from Anterior Pituitary

Pituitary gland secretes the following hormones:

1. Growth hormone (STH)

2. Adreno corticotropic hormone (ACTH)

3. Thyroid stimulating hormone (TSH)

4. Follicle stimulating hormone (FSH)

5. Luteinizing hormone (LH)

6. Luteotrophic hormone (LTH)

7. Melanocyte stimulating hormone (MSH)

1. Growth Hormone or somatotrophic Hormone (GH or STH)

1. Growth hormone is secreted by the acidophil cells of adeno hypophysis.

2. It is protein in nature and is formed of a straight polypeptide chain- having about 200 amino acids

3. It stimulates the multiplication

4. It increases the body growth.

6. It stimulates the growth of muscles.

7. It stimulates the growth of thymus.

8. It increases the secretion of milk during lactation.

9. STH has a remarkable effect on metabolism.

10. It increases protein synthesis.

11. Administration of STH produces hyperglycemia and glycosuriainsulin by Islets of Langer Hans and finally to their exhaustion and atrophy. high sugar level). The high blood glucose level leads to overproduction of So the growth hormone is diabetogenic.

Gigantism: Gigantism is a disorder caused by the over activity of Pituitary gland in the child.

Acromegaly: Caused by hyper activity of pituitary gland

2.Adreno Corticotrophic Hormone or (ACTH)

It stimulates the activity of the adrenal cortex, inducing the secretion of glucocorticoids. Deficiency causes rheumatoid fever, Addison's disease etc.

3. Thyrotrophin or Thyroid stimulating Hormone or TSH:

It stimulates thyroid gland there by increasing the thyroxine secretion.

4. Follicle Stimulating Hormone or FSH:

In females it increases the number and size of Graffian follicles.

In males, it stimulates the testis for spermatogenesis

5. Luteinising Hormone (LH) or Interstitial Cell Stimulating Hormone (ICSH)

1. LH is a gonadotrophic hormone secreted by the anterior lobe of pituitary.

2. It is a glycoprotein with a molecular weight of about 3000.

3. It makes the Graffian follicles grow and mature.

4. It causes the Graffian follicles to secrete another sex hormone called oestrogen.

5. In co-operation with FSH, it causes the rupture of the follicle and ovulation.

6. Lactogenic Hormone or Prolactin or Luteotrophic Hormone (LTH)

1. LTH is secreted by the anterior lobe of the pituitary gland.

2. It is a protein with several disulphide bridges.

3. It helps in initiating milk secretion in the breast.

4. It helps the corpus luteum in the secretion of progesterone, in co-operation with LH.

7. Melanocyte Stimulating Hormone

MSH stimulates the production of new pigment.

EQ:4 Write an essay on Adrenal gland:

Man contains two adrenal glands.

They are situated on the top of each kidney.

The right gland is smaller and the left one is larger.

Each gland is about 5 to 9 gms in the adult.

The adrenal cortex consists of three layers of cells. They are:

1. Zona glomerulosa

2. Zona fasciculata

3. Zona reticularis

1. **Zona Glomerulosa**: It is the outer layer formed of columnar cells. The cells are small and thickly set with their long axis parallel to the surface. They secrete mainly aldosterone and small amount of glucocorticoids and sex hormones.

2. **Zona Fasciculata** : It is the middle layer and is the widest layer. The cells are polyhedral, larger and are arranged in radiating columns perpen- dicular to the surface. They secrete glucocorticoids.

3. Zona Reticularis: It is the inner layer Zona reticularis secrets sex hormones and small amount of glucocorticoids.

Hormones of Adrenal Cortex

The hormones secreted by the adrenal cortex are called corticosteroids.

The corticosteroids can be classified into three groups. They are:

1. Glucocorticoids

2. Mineralocorticoids

3. Sex steroids

1. Glucocorticoids

1. The main role of glucocorticoids is concerned with carbohydrate metabolism and hence the name glucocorticoid.

2. It stimulates the formation of glycogen in the liver (similar to insulin)

3. It helps in the absorption of glucose from intestine and nephron.

2. Mineralocorticoids

1.Secreted by adrenal cortex

2.The main function is concerned with the metabolism of minerals

3.They provide resistance against various stress

4.Help in reabsorption of NaCl and H_2O

3. Sex steroids

Sex steroids include androgens, estrogens, and progesteron

ADRENAL MEDULLA

This is the central part the adrenal gland it secretes two hormones

1.Adrenaline

2.Noradrenalin

1.Adrenaline

This hormone is produced under emergency conditions it is secreted at the time of stress emotion.

It promotes glycogenolysis resulting in increase blood glucose level.

The blood pressure rises shortly

2.Noradrenalin

It is also secreted under emergency condition.

It increase blood pressure

Blood sugar level is raised

Eq5: Explain about Thyroid and Parathyroid glands

Thyroid gland

Thyroid gland is situated in the neck region near the trachea. The thyroid gland consists of two lobes connected by a narrow band called isthmus. Each lobe is formed of numerous spherical masses called follicles. Each follicle covered by a basement membrane. In the centre, each follicle contains cavity filled with a is colloidal material. The cavity is lined by a layer of cuboidal epithelial cells.

Hormones of the thyroid gland ;The thyroid gland secretes 3 types of hormones. They are:

1. Thyroxine

2. Tri-iodo thyronine

3. Calcitonin

Thyroxine: It ia an iodine containing thyroid hormone .

It has the following functions:

1. In amphibians thyroxin brings about metamorphosis.

2.In the case of reptiles thyroxin induces moulting.

3. In mammals thyroxin improves growth. . It increases basal metabolic rate (BMR). Hence it stimulates the production of more energy.

4. It improves growth.

5. It stimulates protein synthesis.

6. Deficiency of this hormone in children causes cretinism,

Thyrocalcitonin:

Thyrocalcitonin is secreted by the thyroid gland. Formerly it was thought that this hormone was secreted by parathyroid gland.

It is secreted by the para follicular cells (C-cells) of the thyroid gland. It is a protein hormone containing 32 amino acids. It does not contain iodine.

Physiology: Calcitonin decreases blood calcium ion concentration. It reduces plasma calcium concentration in three ways:

1. It increases osteoblastic effect.

2. It prevents the formation of new osteoclasts.

3. It decreases the activity of osteoclasts.

Cretinism: Cretinism is a disease produced in children as a result of hypothyroidism.

Myxoadema is a disease produced in adults as a result of hypo thyroidism.

Exophathalmic goiter is a disease caused by hyperthyroidism

2**. Parathyroid gland**

The parathyroid glands are situated in the thyroidgland in the form of four patches. Each parathyroid gland is surrounded by a connective tissue capsule. The hormone secreted parathormone or PTH

Functions of PTH

1. PTH increases serum calcium level by acting on osteoclasts of bone.

2. It increases renal tubular reabsorption calcium.

3. It may increase the rate of Ca absorption in the gut.

4. It reduces the secretion of Ca** by themammary gland

Removal of parathyroid the hyposecretion of the gland causes tetany.

It has the following symptoms:

1.Locking of jaws

2.Twitching of muscle

3.Respiration becomes rapid and noisy

4. It increases salivation and body temperature. The ultimate result is death owing to asphyxia.

Hyper secretion has the following characteristics:

Weakness, loss of muscular tone, vomiting, thirst, mental symptoms, formation of bone-cysts. renal disorder.

Eq6:Hormonal control on Reproduction in females.

Reproduction and sexual cycles are regulated by hormones. There are three main steps in reproduction, namely

Ovulation,

Pregnancy

Birth.

Each step is regulated by hormones.

Hormonal regulation of ovulation:

The process of sexual cycle is initiated by the master gland of the endocrine system the pituitary gland. The pituitary land itself is signalled by another part of the brain called hypothalamus. It is situated immediately above the pituitary gland. It produces a number of chemical substances called releasing factors. They stimulate the pituitary gland to secrete its hormones. The hypothalamus itself is getting the signal from various centres of the brain. These centres in turn receive the stimulus from the external environment or from inside the body. For example, sheep are stimulated by decreasing photoperiod; rabbit can be stimulated by copulation; olfaction (smell) is another stimulus.

The sexual hormones secreted by the pituitary gland are called gonadotropic hormones. The pituitary gland secretes five important gonadotropic hormones which are involved in sexual cycles. They are as follows:

1. Follicle-stimulating hormone (FSH)

2. Luteinizing hormone (LH)

3. Luteotrophic hormone (LH)

4. Oxytocin and

5. Relaxin.

FSH: The follicle stimulating hormone causes the growth of Graafian follicle in the ovary.

LH: The luteinizing horinunes does the following functions:

1. It causes the ripening of the Graafian follicle.

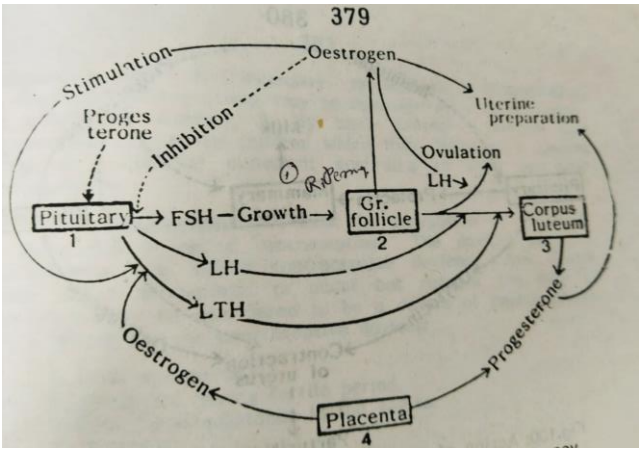
2. It stimulates ovary to secrete another hormone called oestrogen.

3. It brings about ovulation in assistance with another hormone called oestrogen. When the egg is fertilized, it enters the uterus where it is implanted. throughout the entire period of pregnancy. The continuous existence of corpus luteum

4. It stimulates the formation of corpus luteum from the ruptured follicle.

5. It stimulates the corpus luteum to secrete oestrogen and progesterone.

Oestrogen: The oestrogen, secreted by the follicle, has four functions. They are



1. It increases blood supply to the uterine epithelium. As a result, the uterus becomes hypertrophic.

2. The sexual behavior of the female is changed; it begins to seek the male and is ready to accept the male for mating.

3. It stimulates the pituitary gland to secrete LH and another hormone called luteotrophic hormone (LTH).

4. It inhibits further secretion of FSH

Hormonal regulation of pregnancy: After ovulation the ruptured follicle is transformed into an yellow body called corpus luteum. It is formed by the influence of luteinizing hormone (LH). This hormone induces only the morphological growth of the corpus luteum. The functional activity of the corpus luteum is influenced by another hormone called luteotrophic hormone (LTH) secreted by the pituitary gland. Corpus luteum functions as an endocrine gland. It secretes two hormones, namely progesterone and relaxin.

Progesterone: It has the following functions:

1. Along with oestrogen, it causes the increase of blood supply to the uterine epithelium. As a result the uterus becomes hypertrophic.

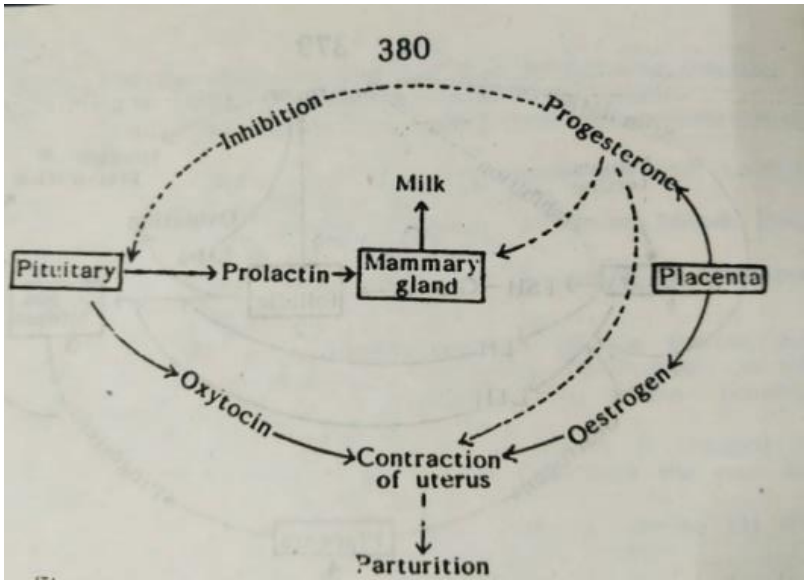
2. It make the breast sensitive to lactogenic hormone

3. It inhibits the secretion of FSH and thus prevents the formation of new follicles and eggs.

If the egg is not fertilized, the corpus luteum degenerates and is converted into a connective tissue-mass called corpus albicans. The degeneration of corpus luteum is due to the stoppage of oestrogen from ruptured follicle.

When the egg is fertilized, it enters the uterus where it is implanted. Now the trophoblast of the implanted embryo secretes luteotrophic hormone (LTH). This hormone prevents the degeneration of corpus luteum. When the placenta develops, it secretes & large amount of oestrogen. Now the oestrogen acts on the pituitary gland to secrete more and more LTH to maintain the life of corpus luteum throughout the entire period of pregnancy. The continuous existence of corpus luteum

Hormonal regulation of birth: After ovulation the ruptured follicle is transformed into a yellow body called corpus luteum. It is formed by the influence of luteinizing hormone (LH). This hormone induces only the morphological growth of the corpus luteum. The functional activity of the corpus luteum is influenced by another hormone called luteotrophic hormone (LTH) secreted by the pituitary gland. Corpus luteum functions as an endocrine gland. It secretes two hormones, namely progesterone and relaxin.



SHORT ANSWER QUESTION

SQ1 : Liver

Location: The liver is located in the upper right portion of the abdomen. It is the largest gland in the human body that performs several important functions. It is the only organ that has the ability to regenerate efficiently.

STRUCTURE OF LIVER

The liver is a triangular, bilobed structure consisting of a larger right lobe and a smaller left lobe. The falciform ligament separates the two lobes.

A layer of fibrous tissue called Glisson's capsule covers the liver. This capsule is covered by the peritoneum. This protects the liver from physical damage.

It has two main sources of blood:

- **Hepatic Portal Vein** carries nutrient-rich blood from the digestive system.
- **Hepatic Artery** carries oxygenated blood from the heart.

FUNCTIONS OF LIVER

1.PRODUCTION OF BILE

Bile, which helps in the digestion and absorption of fats, vitamins and cholesterol is produced in the liver.

2.ABSORPTION OF BILIRUBIN

Bilirubin is formed by the breakdown of haemoglobin. The iron released is stored in the liver to make next-generation blood cells.

3.SUPPORTING BLOOD CLOTS

Bile is responsible for the absorption of vitamin K. If bile is not produced, clotting factors will not be produced.

4.METABOLIZATION OF FATS

Bile helps in the breakdown and digestion of fats.

5.CARBOHYDRATE METABOLIZATION

The carbohydrates stored in the liver as glycogen are broken down into glucose and released into the blood to maintain glucose levels.

6.STORAGE OF VITAMINS AND MINERALS

Vitamins A, D, E, K, and B12 are stored in the liver. It also stores iron in the form of ferritin to form new red blood cells.

7.METABOLIZATION OF PROTEINS

Bile helps in the digestion of proteins.

8.FILTERING BLOOD

The compounds such as hormones, alcohol, etc are filtered by the liver from the blood.

9.IMMUNOLOGICAL FUNCTION

The liver contains Kuffer cells involved in immune activity. These destroy any disease-causing agents.

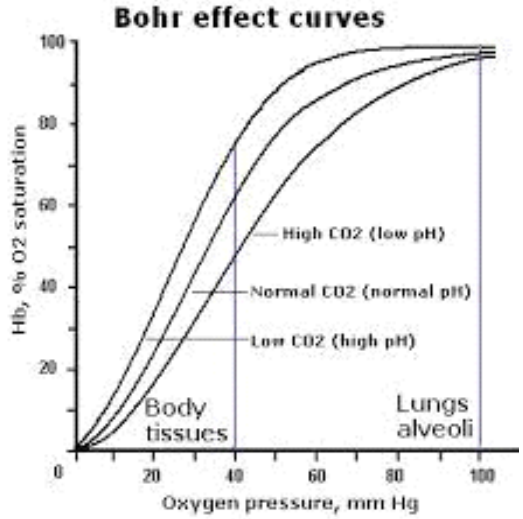
10.ALBUMIN PRODUCTION

Albumin transports fatty acids and steroids to maintain correct pressure and prevent leakage of blood vessels.

SQ 2 :Bohr effect: The dissociation curve is much affected by CO_2. When the CO_2 concentration increases in the blood, the affinity of Hb for O2 is reduces.

As cells are continuously using O_2 and releasing of CO_2, CO_2 concentration is higher in the tissues.

When blood containing HbO_2 passes through the tissues, the affinity of Hb for O_2 is reduced because of higher concentration of CO_2 in the tissues. Hence Hb separates from O_2 and O_2 is released for the utilization of tissues. Thus increasing concentration of CO_2 helps to unload O_2 from Hb. This phenomenon is called Bohr effect. The dissociation curves move towards right.



SQ3: TRANSPORT OF CO2

CO_2 transport

CO_2 is continously produced in the cells. Adult man produces about 200 ml. CO_2 per minute. It is toxic and the cells cannot tolerate the accumulation of CO_2. Hence CO_2 must be eliminated and it is done by lungs. The CO_2 formed in the cells and tissues is carried to the lungs by the blood. This is called **CO_2 transport.**

The CO_2 is transported both by plasma and RBC. About 67% of the CO_2 is carried by plasma and the remaining 33% is carried by RBC. CO_2 is carried in three forms, namely

1. Carbonic acid.
2. Carbamino compounds and
3. Bicarbonates.

1. As Carbonic Acid

About 5% of CO_2 dissolves in plasma to form carbonic acid (H_2CO_3) and it is carried to the lungs. In the lungs the reaction is reversed to release CO_2.

$$CO_2 + H_2O \underset{\text{Lungs}}{\overset{\text{Tissues}}{\rightleftharpoons}} H_2CO_3$$

2. As Carbamino compounds

About 10% of CO_2 is carried as carbamino compound. It combines with the amino group of plasma proteins to form carbamino compounds. These compounds are carried to the lungs where the reaction is reversible.

$$R-NH_2 + CO_2 \underset{\text{Lungs}}{\overset{\text{Tissues}}{\rightleftharpoons}} R-NHCOOH$$

3. As Bicarbonates

About 85% of CO_2 is transported as bicarbonates in RBC as well as in plasma. Most of the CO_2 entering the blood from the tissues, diffuses into the RBC. In the RBC, CO_2 combines with water to form carbonic acid (H_2CO_3). In the RBC this reaction is accelerated by an enzyme called **carbonic anhydrase.** The carbonic acid is unstable and immediately it dissociates into H^+ ions and bicarbonate ions (HCO_3^-)

$$CO_2 + H_2O \underset{\text{Lungs}}{\overset{\text{Tissues}}{\rightleftharpoons}} H_2CO_3 \underset{\text{Lungs}}{\overset{\text{Tissues}}{\rightleftharpoons}} H^+ + HCO_3^-).$$

The hydrogen ions released from the carbonic acid cannot be retained as such in the RBC. It readily combines with HbO_2.

SQ 4: Cardiac cycle:

The sequence of events that takes during a single heart beat constitutes cardiac cycle.

A cardiac cycle lasts 0.8 Seconds. It may be divided into three phases. Atrial systole, Ventricular systole and Atrio- Ventricular diastole.

Atrial systole: It lasts about 0.1 seconds. During this phase, atria contract.

Ventricular systole: It lasts about 0.3 seconds. During this phase, ventricles contract.

Ventricular diastole: It lasts about 0.4 seconds. During this phase, ventricles relax. Semi lunar valves are closed.

Sq5: Structure of mammalian kidney

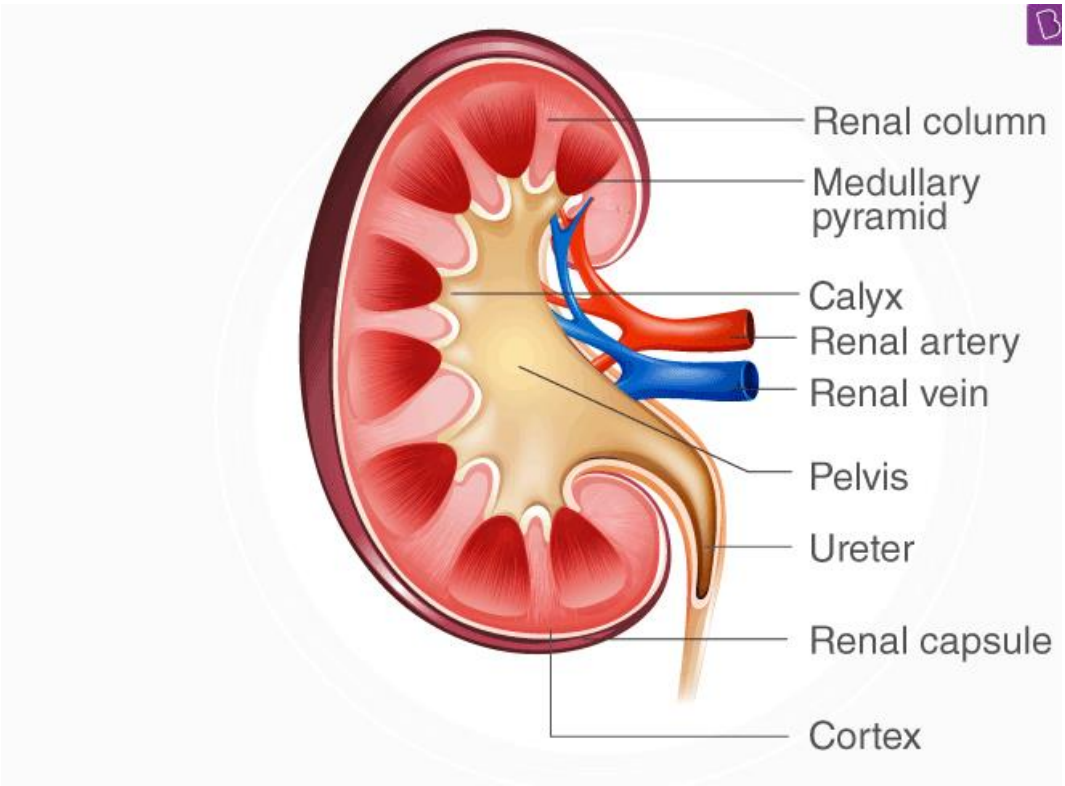
- Kidneys are bean-shaped organs, about 11 cm long, 6 cm wide, 3 cm thick and weigh 150 g. They are embedded in, and held in position by, a mass of adipose tissue.
- Each kidney is enclosed by a thin tough fibrous connective tissue called renal capsule that protects it from infections and injuries. Around the capsule there is a layer of fat (adipose tissue) which is further enclosed by another layer of fibrous membrane known as **renal fascia**. The bean shaped kidney has outer convex surface and inner concave surface.
- **Location:** The kidneys lie on the posterior abdominal wall, one on each side of the vertebral column, behind the peritoneum and below the diaphragm.

ANATOMY OF KIDNEY

- Longitudinal section of the kidney shows following parts.

1. **Capsule**: It is an outermost covering composed of fibrous tissue surrounding the kidney.

2. **Cortex**: It is a reddish-brown layer of tissue immediately below the capsule and outside the renal It consists of renal corpuscles and convoluted tubules.
3. **Medulla**: It is the innermost layer, consisting of conical areas called the renal pyramids separated by renal columns. There are 8-18 renal pyramids in each kidney. The apex of each pyramid is called a **renal papilla,** and each papilla projects into a small depression, called a **minor calyx** (plural calyces). Several minor calyces unite to form a **major calyx.** In turn, the major calyces join to form a funnel shaped structure called **renal pelvis** that collects urine and leads to ureter.



Sq 6:Counter current mechanism: In essay Urine formation

UNIT II

Sq 1: Saltatory conduction:

Myelin is a fatty white substance, made mainly up of cholesterol, acts as an insulation around a wire. The myelin sheath is wrapped around an axon in such a fashion, that there are a few gaps in between, these are called the *Nodes of*

Ranvier. Simply put the impulse jumps from one node to the other node, hence called **Saltatory Conduction**. Even though strictly speaking, the signal doesn't *jump* from one node to another, there is some moderately complex stuff going on in the background, during this type of conduction.

Unlike the wiring in outer world, which conducts electricity by the shifting of electrons, within these *biological wires* the impulses are conducted through hyperpolarizing or depolarizing the membrane. It is slightly tricky, but I will try to explain it as easily I can. Now, there are alot of ion channels on the cell membrane (*neurilemma*) of the nerve cells. These ion channels selectively allow some ions to pass through them, and prevent some of the ions. Now, because of these ion channels, there will be a difference in the net charge(either positive or negative) on either side of this membrane.

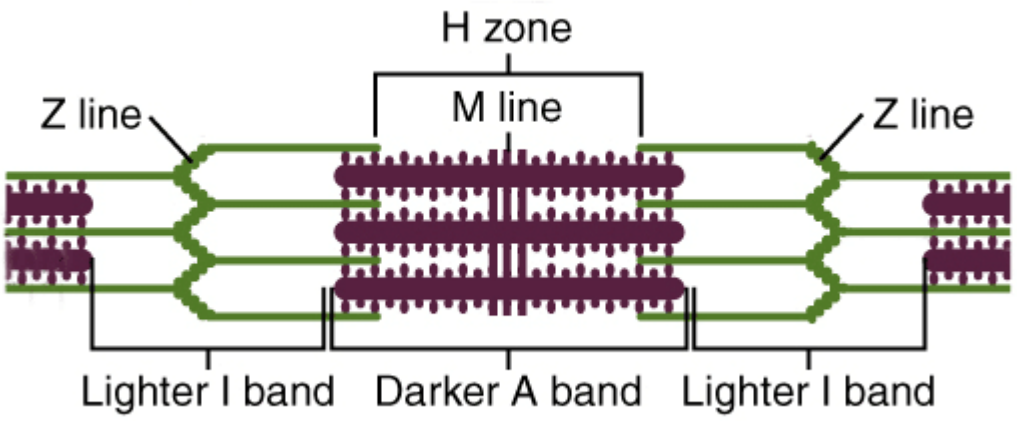
Nervous transmission: If the membrane is preventing certain positively charged ions to come inside the cell, there will be more positive charge outside the cell, or there will be more negative charge inside the cell. In other words, there is a net negative charge inside the cell. This is the **Membrane Potential**. Now when a signal reaches the cell body through its dendrites, this potential is disturbed. This disturbance travels across the axon and then either end up in an effector organ(a muscle or a gland) or send this impulse to another cell.

This disturbance goes in a linear fashion in an unmyelinated neuron, so should traverse the entire neuron. In a myelinated neuron, the disturbance does not have to pass along the entire length, instead the membrane potential is disturbed only where there is no insulator(i.e., at the nodes of Ranvier). So put in other words, the signal ***jumps*** from one node to another. Hence myelinated neurons are much much faster than unmyelinated neurons in terms of conduction.

Sq2 : Ultra structure of muscle

The ultrastructural appearance of skeletal muscle reveals the intricate organization of its contractile proteins and the functional units responsible for muscle contraction.

At the microscopic level, skeletal muscle fibers exhibit a striated appearance due to the arrangement of two main contractile proteins: actin and myosin. These proteins are organized within the functional unit of muscle contraction called the sarcomere.



The sarcomere extends from one Z line to another Z line and is composed of several distinct sections. Let's explore these sections:

1. Z line: The Z line serves as an anchor for actin filaments. It marks the boundary between adjacent sarcomeres.
2. M line: The M line is located in the center of the sarcomere and serves as an anchor for myosin filaments.
3. I band: The I band is a light-colored region within the sarcomere that contains only actin filaments. It extends from the Z line to the edge of the overlapping myosin filaments.
4. A band: The A band is a dark-colored region that represents the length of a myosin filament. It may contain overlapping actin filaments within its boundaries.
5. H zone: The H zone is a region within the A band that contains only myosin filaments. It appears lighter due to the absence of overlapping actin filaments.

Sq3 : Sodium potassium pump

Sodium-Potassium Pump The nerve fibre is a long tube filled with axoplasm and covered by plasma membrane. In the resting nerve fibre (when it is not conducting irapulses), the axoplasm contains more K and outside the nerve there are more Na. The resting nerve fibre membrane is more permeable to Kions. So more K are transported from inside to the out side. At the same time Na" are also transported from outside to the inside but at a slower rate. Again, the axoplasm contains large amount of negatively charged ions. Hence the outside of the nerve fibre is positively charged and the inside is negatively charged.

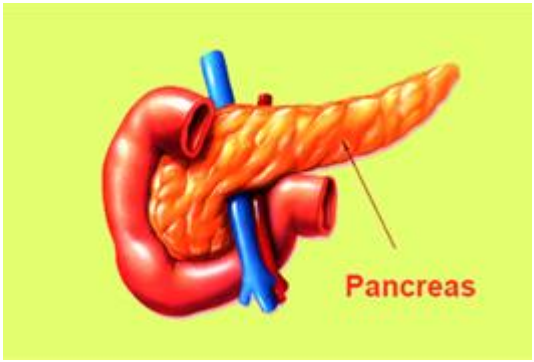
When the nerve is stimulated, the membrane of the nerve fibre becomes more permeable to Na than to K Hence more Na" move in and less K move out. As a result the inside of nerve fibre becomes positively charged and the outside becomes negatively charged.

After the transmission of impulse the membrane of the nerve fibre again becomes more permeable to K than to Na". Hence more K pass out and less Na move in. Thus once again the outside becomes

positively charged and the inside becomes negatively charged. The active transport of Na* and K across the membrane is called sodium pump or sodiumpotassium pump

Sq4 : Pancreas

Location: Pancreas is an abdominal organ located behind the stomach and surrounded by spleen, liver and small intestine. It is a vital part of the digestive system and is responsible for regulating blood sugar levels.



Pancreas releases the following enzymes:

- **Lipase:** Works with bile (a fluid produced by the liver) to break down fats.
- **Amylase:** Breaks down carbohydrates for energy.
- **Protease:** Breaks down proteins.

Functions:

A)EXOCRINE FUNCTION

- The pancreas consists of exocrine glands that produce enzymes trypsin and chymotrypsin that are essential for digestion. These enzymes contain chymotrypsin and trypsin to digest proteins, amylase for the digestion of

carbohydrates and lipase to break down fats. These pancreatic juices are liberated into the system of ducts and culminated in the pancreatic duct when the food enters the stomach.

B) ENDOCRINE FUNCTION

- The endocrine part of the pancreas comprises Islets of Langerhans that release insulin and glucagon directly into the bloodstream. They help in regulating the blood sugar levels of the body.

Sq5: Progesterone

1.Progesterone is a female sex hormone

2. It is secreted by corpus luteum of ovary, placenta and adrenal cortex

3. It is a derivative of sterol.

4. It appears in the urine one or two days after ovulation and becomes maximum about a week before the onset of menstruation and ceases 2-3 days before the period comes.

During pregnancy much larger quantities are excreted, the amount being maximum (about 8 fold) during the eighth and ninth months. It falls before parturition. Its presence in the urine is regarded as an index of progesterone secretion

5. Progesterone is responsible for the premenstrual changes of the uterus. Following oestrogen-primed uterus, progesterone stimulates development,

growth and activity of the endometrial secretary glands causing a thickening

of the mucosa.

6 It helps Progesteron plays a major role for the maintenance of pregnancy.

7. It helps in the implantation of the fertilized ovum.

8. It is essential for the formation of placenta.

9. Progesterone desensitises the uterine muscles to the action of oxytocin

10. Progesterone completes the development of breasts, and it makes the

breast, a milk-producing apparatus. Glandular elements of the breast are proliferated.

11. Progesterone inhibits oestrous or menstrual cycles and ovulation. Thisis brought about by inhibiting the secretion of LH and FSH by the pituitary.

12. It causes the growth of vagina and the relaxation of pelvic ligaments resulting in the enlargement of birth canal.

13. It helps in the retention of salts and water

Sq6 : Posterior Pituitary

The hormones released from posterior pituitary gland are Vasopressin and Oxytocin

Vasopressin or Anti diuretic hormone (ADH)

1. Vasopressin is secreted by the posterior lobe of the pituitary gland.

2. Chemically, vasopressin is a protein formed of eight amino acids with a di-sulphide (S-S) bond. Hence vasopressin is an octopeptide.

3. It has a molecular weight of 1100.

4. Vasopressin is released in response to stress dehydration.

5. It constricts arterioles and capillaries, causing the raise of blood pressure.

6. The rate of heart beat is reflexly reduced owing to high blood pressure.

7. It stimulates the nephron to reabsorb water from the urine and thus it reduces the volume of urine formed. Hence this hormone is commonly called antidiuretic hormone (ADH).

8. It reduces chloride absorption and thus chloride loss.

9. It causes the contraction of the plain muscles of urinary bladder, stomach and intestine. It cannot cause the contraction of the muscles of heart and uterus.

10. It produces glycogenolysis, hyper glycaemia and glycosuria Sugar tolerance is reduced.

11. Deficiency of this hormone produces large volume of urine that is about 40 litres in a day. This defect is called diabetes insipidus.

Oxytocin or Pitocin

1. Oxytocin is secreted by the neuro hypophysis.

2. Chemically, oxytocin is a protein formed of eight aminoacids with adisulphide (S-S) bond. Hence oxytocin is an octopeptide.

3. It has a molecular weight of 1000.

4. The term oxytocin is derived from Greek, meaning Quick child birth (oxys swift. tokos = child birth). It causes contraction of the pregnant = uterus. Oxytocin takes part in the onset of parturition, expulsion of the foetus and placenta.

5. It causes the contraction of the mammary glands resulting in the ejection of milk.

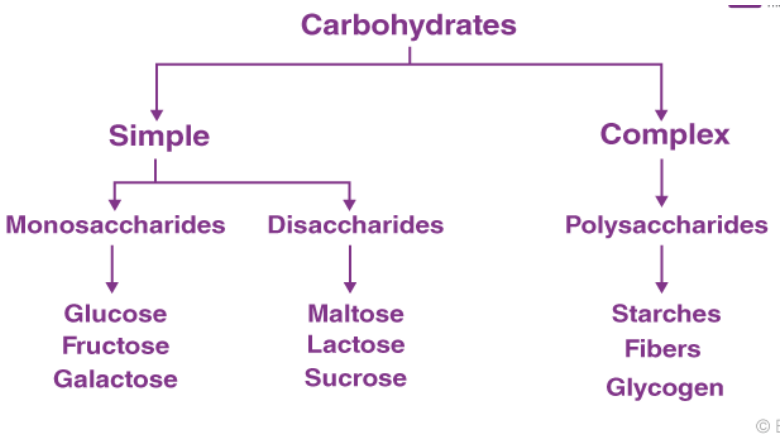
6. Sexual stimulation of the female during intercourse increases the. secretion of oxytocin and the increased oxytocin is responsible for uterine contractions that occur during the female orgasm. It has been proposed oxytocin promotes fertilization of the ovum by causing uterine propulsion of male semen upward through fallopian tubes.

CELLULAR METABOLISM

UNIT III

EQ1: Describe the classification of carbohydrates:

Carbohydrates Formula: Carbohydrates are large macromolecules consisting of carbon (C), hydrogen (H) and oxygen (O) and have the general Cx(H2O)y formula. The hydrate of carbon is known as carbohydrates. They contain hydrogen and oxygen in the same proportion as in water.



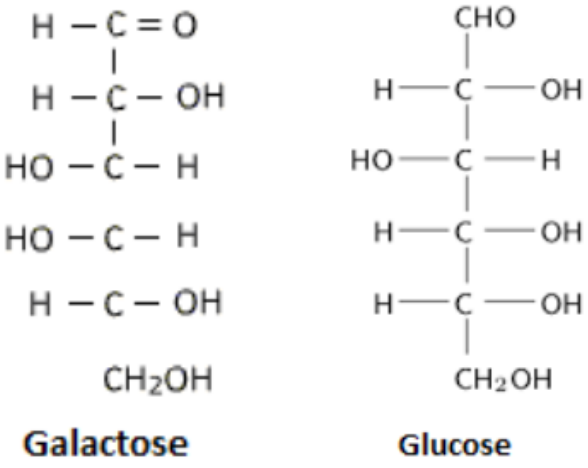
The carbohydrates are further classified into simple and complex which is mainly based on their chemical structure and degree of polymerization.

Simple Carbohydrates (Monosaccharides, and Disaccharides)

Simple carbohydrates have one or two sugar molecules. In simple carbohydrates, molecules are digested and converted quickly resulting in a rise in the blood sugar levels. They are abundantly found in milk products, beer, fruits, refined sugars, candies, etc. These carbohydrates are called empty calories, as they do not possess fiber, vitamins and minerals.

1. MONOSACCHARIDES:

Glucose is an example of a carbohydrate monomer or monosaccharide. Other examples of monosaccharides include mannose, galactose, fructose, etc. The structural organization of monosaccharides is as follows:



Monosaccharides may be further classified depending on the number of carbon atoms:

(i)Trioses (C3H6O3): These have three carbon atoms per molecule. Example: Glyceraldehyde

(ii)Tetroses (C4H6O4): These monosaccharides have four carbon atoms per molecule. Example: Erythrose.

Similarly, we have-

(iii) Pentoses,

(iv) Hexoses, and

(v) Heptoses

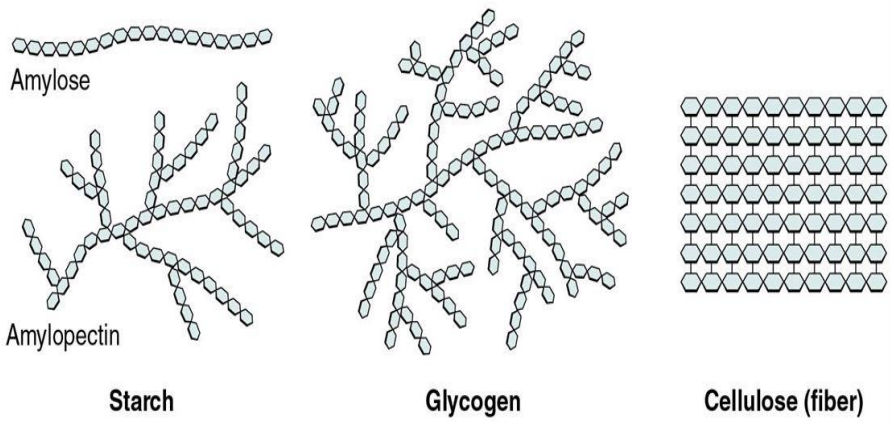
2. DISACCHARIDES:

Two monosaccharides combine to form a disaccharide. Examples of carbohydrates having two monomers include- Sucrose, Lactose, Maltose, etc.

Polysaccharides :(COMPLEX Carbohydrates)

Complex carbohydrates have two or more sugar molecules, hence they are referred to as starchy foods. In complex carbohydrates, molecules are digested and converted slowly compared to simple carbohydrates. They are abundantly found in lentils, beans, peanuts, potatoes, peas, corn, whole-grain bread, cereals, etc.

Polysaccharides are complex carbohydrates formed by the polymerization of a large number of monomers. Examples of polysaccharides include starch, glycogen, cellulose, etc. which exhibit extensive branching and are homopolymers – made up of only glucose units.

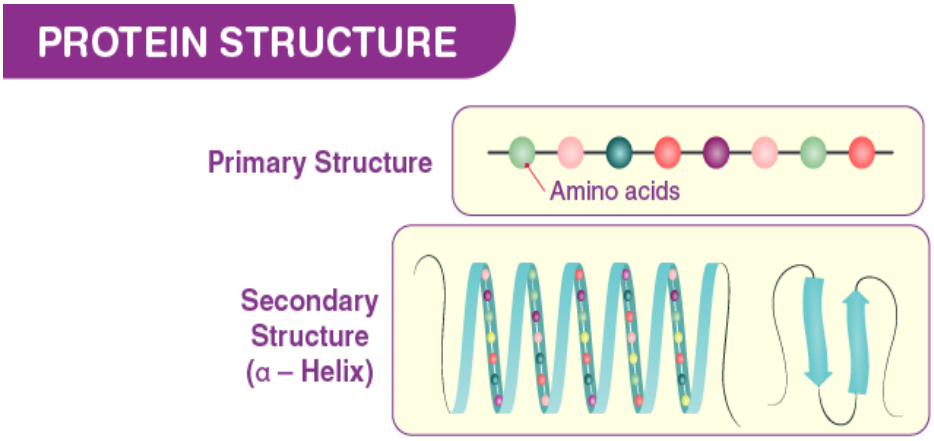


1. Starch is composed of two components- amylose and amylopectin. Amylose forms the linear chain and amylopectin is a much-branched chain.
2. Glycogen is called animal starch. It has a structure similar to starch, but has more extensive branching.
3. Cellulose is a structural carbohydrate and is the main structural component of the plant cell wall. It is a fibrous polysaccharide with high

tensile strength. In contrast to starch and glycogen, cellulose forms a linear polymer.

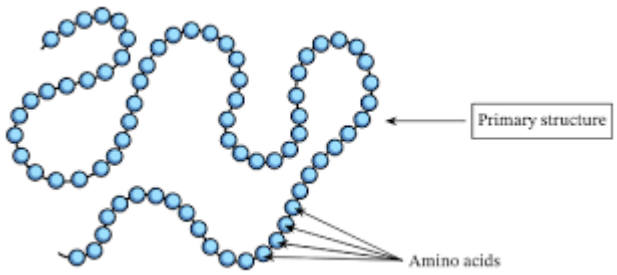
EQ 2: Write a detailed note on Primary, Secondary structure of proteins.

Protein structures are made by condensation of amino acids forming peptide bonds. The sequence of amino acids in a protein is called its primary structure. The secondary structure is determined by the dihedral angles of the peptide bonds.



1. PRIMARY STRUCTURE OF PROTEIN

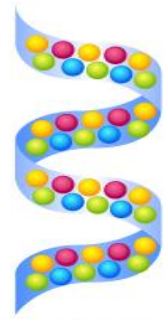
- The Primary structure of proteins is the exact ordering of amino acids forming their chains.
- The exact sequence of the proteins is very important as it determines the final fold and therefore the function of the protein.
- The number of polypeptide chains together form proteins. These chains have amino acids arranged in a particular sequence which is characteristic of the specific protein. Any change in the sequence changes the entire protein.



The above picture represents the primary protein structure (an amino acid chain). As you might expect, the amino acid sequence within the polypeptide chain is crucial for the protein's proper functioning. This sequence is encrypted in the DNA genetic code. If mutation is present in the DNA and the amino acid sequence is changed, the protein function may be affected.

2. SECONDARY STRUCTURE OF PROTEIN

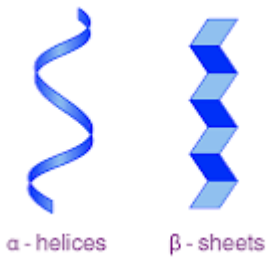
- **Secondary structure** is the next level up from the primary structure, and is the regular folding of regions into specific structural patterns within one polypeptide chain. Hydrogen bonds between the carbonyl oxygen and the peptide bond amide hydrogen are normally held together by secondary structures.



(α – Helix)

(A) A – HELIX:

α – Helix is one of the most common ways in which a polypeptide chain forms all possible hydrogen bonds by twisting into a right-handed screw with the -NH group of each amino acid residue hydrogen-bonded to the -CO of the adjacent turn of the helix. The polypeptide chains twisted into a right-handed screw.



α - helices β - sheets

(B) B – PLEATED SHEET:

The second essential type of secondary structure of a protein is the Beta-Pleated Sheets of Protein. It consists of various beta strands linked by hydrogen bonds between adjacent strands. Three to ten amino acids are combined to create a beta-strand polypeptide.

Beta sheets are involved in forming the fibrils and protein aggregates observed in amyloidosis.

Alike alpha-helix, the residue hydrogen bond between the adjacent strands is separate from each other.

EQ3: CLASSIFY PROTEINS BASED ON THEIR FUNCTIONS:

1**. Catalytic proteins**

The most striking characteristic feature of these proteins is their ability to function within the living cells as biocatalysts. These biocatalysts are called as enzymes. Enzymes represent the largest class. Nearly 2000 different kinds of enzymes are known, each catalyzing a different kind of reaction. They enhance the reaction rates a million fold

2**. Regulatory proteins:**

These are polypeptides and small proteins found in relatively lower concentrations in animal kingdom but play highly important regulatory role in maintaining order in complex metabolic reactions. e.g., growth hormone, insulin etc.

3.Protective proteins Antibodies

These proteins have protective defense function. These proteins combine with foreign protein and other substances and fight against certain diseases.e.g., immunoglobulin. These proteins are produced in the spleen and lymphatic cells in response to foreign substances called antigen. The newly formed protein is called antibody which specifically combines with the antigen which triggered its synthesis thereby prevents the development of diseases. Fibrin present in the blood is also a protective protein

4.Storage proteins

It is a major class of proteins which has the function of storing amino acids as nutrients and as building blocks for the growing embryo. Storage proteins are source of essential amino acids, which cannot be synthesized by human beings. The major storage protein in pulses is globulins and prolamins in cereals. In rice the major storage protein is glutelins. Albumin of egg and casein of milk are also storage proteins.

5.Transport proteins

Some proteins are capable of binding and transporting specific types of molecules through blood. Haemoglobin is a conjugated protein composed of colourless basic protein, the globin and ferroprotoporphyrin or haem. It has the capacity to bind with oxygen and transport through blood to various tissues. Myoglobin, a related protein, transports oxygen in muscle. Lipids bind to serum proteins like albumin and transported as lipoproteins in the blood

6.Toxic proteins

Some of the proteins are toxic in nature. Ricin present in castor bean is extremely toxic to higher animals in very small amounts. Enzyme inhibitors such as trypsin inhibitor bind to digestive enzyme and prevent the availability of the protein. Lectin, a toxic protein present in legumes, agglutinates red blood cells. A bacterial toxin causes cholera, which is a protein. Snake venom is protein in nature.

7.Structural proteins

These proteins serve as structural materials or as important components of extra cellular fluid. Examples of structural proteins are myosin of muscles, keratin of skin and hair and collagen of connective tissue. Carbohydrates, fats, minerals and other cellular components are organized around such structural proteins that form the molecular framework of living material

8.Contractile proteins

Proteins like actin and myosin function as essential elements in contractile system of skeletal muscle

EQ 4: Give an account on properties of Amino Acids:

PHYSICAL PROPERTIES OF AMINO ACIDS:

1. **Solubility:** The majority of amino acids are soluble in water, but insoluble in organic solvents.

2.**Taste:** Amino acids can be sweet(Gly, Ala, Val), tasteless (Leu) or bitter (Arg, Ile). Monosodium glutamate, or ajinomoto, is used in the food industry as a flavoring agent. It can also be used to enhance taste and flavor of Chinese foods. Chinese restaurant syndrome is a short-term flulike condition that can be seen in some people who are not sensitive to MSG.

3.**Optical properties:** All amino acids, except glycine, have optical isomers because of the presence of an asymmetric carbon. Some amino acids also contain a second asymmetrical carbon, e.g. isoleucine, threonine. It has been shown that the structure of L-and D-amino acid is different from glyceraldehyde.

CHEMICAL PROPERTIES:

1. Zwitterionic property

A zwitterion molecule is one that has functional groups. At least one of these groups has a positive electrical charge and at most one has one with a negative. The molecule's net charge is zero. The most well-known examples are amino acids. They have an amine (basic) as well as a carboxylic (acidic) group. The -NH2 is the stronger base. It picks up H+ form the -COOH to create a zwitterion. The neutral zwitter ion refers to the most common form of amino acids found in the solution.

2. Amphoteric property

Amino acids can be amphoteric, meaning they can act as both an acid and a base because of the presence of two amine or carboxylic groups.

3. NINHYDRIN TEST

If 1 ml Ninhydrin solution is mixed with 1 ml protein and heated, the violet color will indicate the presence of a-amino acid.

4. Xanthoproteic test

The xanthoproteic is used to detect aromatic amino acids (tryptophan, tyrosine and phenylalanine in a protein solution). A reaction with nitric acids results in the yellowing of the solution. This causes the nitration and formation of benzoid radicals within the amino acid chain.

5. Reaction with Sanger's reagent

Sanger's reagent (1,fluoro-2 and 4-dinitrobenzene), reacts with an amino group free in the peptide chains in mild alkaline media under cold conditions.

6. Reaction with nitrous acid

The amino group reacts with nitrogen acid to release nitrogen and create the corresponding hydroxyl.

Q 5: Write a detailed note on Lipids classification:

Lipids can be classified into two main classes:

- Nonsaponifiable lipids
- Saponifiable lipids

NONSAPONIFIABLE LIPIDS

A nonsaponifiable lipid cannot be disintegrated into smaller molecules through hydrolysis. Nonsaponifiable lipids include cholesterol, prostaglandins, etc

SAPONIFIABLE LIPIDS

A saponifiable lipid comprises one or more ester groups, enabling it to undergo hydrolysis in the presence of a base, acid, or enzymes**,** including waxes, triglycerides, sphingolipids and phospholipids.

Further, these categories can be divided into non-polar and polar lipids.

Nonpolar lipids, namely triglycerides, are utilized as fuel and to store energy.

Polar lipids, that could form a barrier with an external water environment, are utilized in membranes. Polar lipids comprise sphingolipids and glycerophospholipids.

Fatty acids are pivotal components of all these lipids.

Types of Lipids

Within these two major classes of lipids, there are numerous specific types of lipids, which are important to life, including fatty acids, triglycerides, glycerophospholipids, sphingolipids and steroids. These are broadly classified as simple lipids and complex lipids.

Simple Lipids

Esters of fatty acids with various alcohols.

1. **Fats:** Esters of fatty acids with glycerol. Oils are fats in the liquid state
2. **Waxes**: Esters of fatty acids with higher molecular weight monohydric alcohols

COMPLEX LIPIDS

Esters of fatty acids containing groups in addition to alcohol and fatty acid.

1. **Phospholipids**: These are lipids containing, in addition to fatty acids and alcohol, phosphate group. They frequently have nitrogen-containing bases and other substituents, eg, in glycerophospholipids the alcohol is glycerol and in sphingophospholipids the alcohol is sphingosine.
2. **Glycolipids (glycosphingolipids)**: Lipids containing a fatty acid, sphingosine and carbohydrate.
3. **Other complex lipids**: Lipids such as sulfolipids and amino lipids. Lipoproteins may also be placed in this category.

EQ 6: Give an account on classification of enzymes:

On the basis of International Union of Biochemistry (IUB) system, enzymes are six types.

1. **Oxidoreductase**
2. **Transferase**
3. **Hydrolase**
4. **Lyase**
5. **Isomerase**
6. **Ligase**

1. **OXIDOREDUCTASE ENZYME*:***

- The enzyme that catalyze transfer of H+ atom, or electron pair from one substrate to another is called oxidoreductase.
- According to International union of biochemistry and molecular biology (IUBMB), this enzyme belongs to class 1 and it is designated by E.C.1. e.g. E.C.1.1 – CHOH group containing donor E.C.1.1.1.- If NAD+ in NADP+ acts as electron acceptor.
- Examples of oxidoreductase enzyme:
  - Dehydrogenase, reductase, catalase etc.

2. TRANSFERASE ENZYME*:*

- The enzyme that catalyze transfer of any group except H-atom such as methyl group, acetyl group, phosphate group etc. among substrate is called transferase.
- E.g. Acetyltransferase, kinase, methylase, polymerase, etc.
- This enzyme belongs to E.C.2
- Nomenclature:
  - E.C.2- transferase
  - E.C.2.1- enzyme that transfer one carbon group
  - E.C.2.1.1- if the group transfer is accepted by nicotinamide.

3. HYDROLASE ENZYME*:*

- The enzyme that catalyzes the break down of bond of substrate by using water is called hydrolase.
- The bond may be ester, glycosidic, peptide etc.
- E.g. digestive enzymes- pepsin, lipase, urease, proteinase, glycosidase
- This enzyme belongs to E.C.3
- Nomenclature:
  - E.C.3- Hydrolase
  - E.C.3.1.1- carboxylic ester hydrolase
  - E.C.3.1.1.3- Lipase (Glycerol ester hydrolase)

4. LYASE ENZYME*:*

- The enzyme that catalyze the addition of removal of group from one substrate to another by mechanism other than hydrolysis and oxidation creating double bond is called lyases.
- E.g. aldolase, fumarase, histidase, carboxylase, ketolase etc.
- Nomenclature:
  - E.C.4 – lyase
  - E.C.4.1 – C-C lyase
  - E.C.4.1.1.1- Pyruvate decarboxylase

- E.C.4.2.1.2- Fumarase

5. ISOMERASE ENZYME:

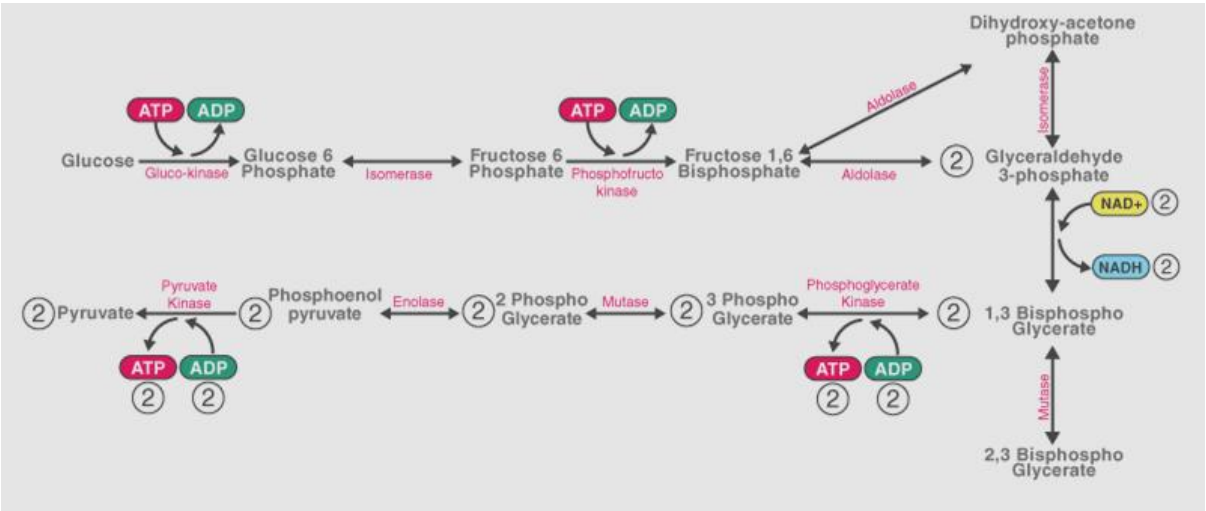
- The enzyme that catalyze the interconversion of optical, geometrical, positional isomers by intermolecular re-arrangement of atom or group within substrate is called isomerase.
- It belongs to enzyme class E.C.5 e.g. Isomerase, Epimerase, Racemase
- Nomenclature:
  - E.C.5- Isomerase
  - E.C.5.1 – Epimerase and Racemase
  - E.C.5.1.1.1 – Alanine racemase
  - Glyceraldehyde-3-phosphate —-***triosphosphate isomerase***———-> Dihydroxyacetone phosphate

6. LIGASE ENZYME*:*

- The enzyme that catalyze the formation of bond such as C-C, C-N, C-S, C-O etc. utilizing the energy due to simultaneous breaking of pyrophosphate bond of ATP molecule or similar compound. E.g. ligase, synthetase
- Nomenclature:
  - E.C 6- ligase
  - E.C.6.1- form C-O bond
  - E.C.6.1.1 – aminoacyl tRNA synthase

UNIT IV

Eq 1: Various steps involves in Glycolysis



STAGE 1

- A phosphate group is added to glucose in the cell cytoplasm, by the action of enzyme hexokinase.
- In this, a phosphate group is transferred from ATP to glucose forming glucose,6-phosphate.

STAGE 2

Glucose-6-phosphate is isomerised into fructose, 6-phosphate by the enzyme phosphor glucomutase.

STAGE 3

The other ATP molecule transfers a phosphate group to fructose 6-phosphate and converts it into fructose 1,6-bisphosphate by the action of the enzyme phosphofructokinase.

Stage 4

The enzyme aldolase converts fructose 1,6-bisphosphate into glyceraldehyde 3-phosphate and dihydroxy acetone phosphate, which are isomers of each other.

STEP 5

Triose-phosphate isomerase converts dihydroxyacetone phosphate into glyceraldehyde 3-phosphate which is the substrate in the successive step of glycolysis.

STEP 6

This step undergoes two reactions:

- The enzyme glyceraldehyde 3-phosphate dehydrogenase transfers 1 hydrogen molecule from glyceraldehyde phosphate to nicotinamide adenine dinucleotide to form NADH + H^+.
- Glyceraldehyde 3-phosphate dehydrogenase adds a phosphate to the oxidised glyceraldehyde phosphate to form 1,3-bisphosphoglycerate.

STEP 7

Phosphate is transferred from 1,3-bisphosphoglycerate to ADP to form ATP with the help of phosphor glycerokinase. Thus two molecules of phospho glycerate and ATP are obtained at the end of this reaction.

STEP 8

The phosphate of both the phosphor glycerate molecules is relocated from the third to the second carbon to yield two molecules of 2-phosphoglycerate by the enzyme phosphor glyceromutase.

STEP 9

The enzyme enolase removes a water molecule from 2-phosphoglycerate to form phosphoenol pyruvate.

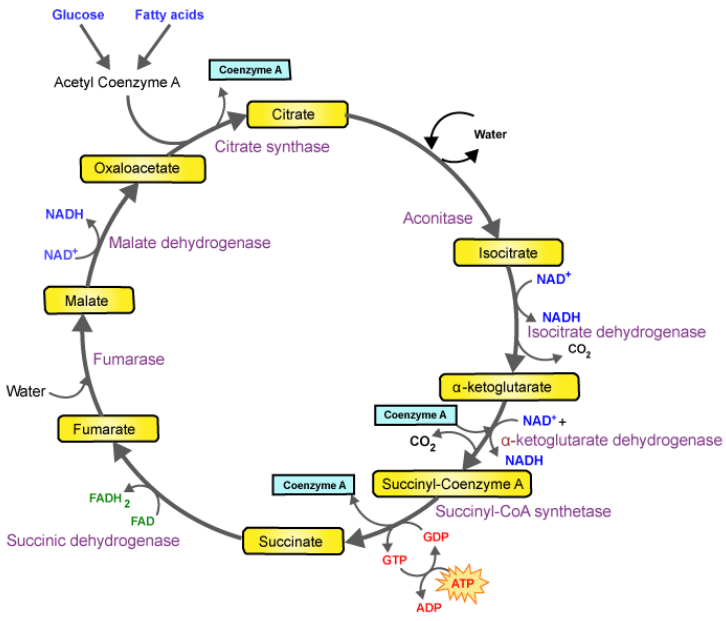
STEP 10

A phosphate from phospho enolpyruvate is transferred to ADP to form pyruvate and ATP by the action of pyruvate kinase. Two molecules of pyruvate and ATP are obtained as the end products.

KEY POINTS OF GLYCOLYSIS

- It is the process in which a glucose molecule is broken down into two molecules of pyruvate.
- The process takes place in the cytoplasm of plant and animal cells.
- Six enzymes are involved in the process.
- The end products of the reaction include 2 pyruvate, 2 ATP and 2 NADH molecules.

Eq2 : Explain about process of Krebs Cycle



It is an eight-step process. Krebs cycle or TCA cycle takes place in the matrix of mitochondria under aerobic condition.

Step 1: The first step is the condensation of acetyl CoA with 4-carbon compound oxaloacetate to form 6C citrate, coenzyme A is released. The reaction is catalysed by ***citrate synthase***.

Step 2: Citrate is converted to its isomer, isocitrate. The enzyme ***aconitase*** catalyses this reaction.

Step 3: Isocitrate undergoes dehydrogenation and decarboxylation to form 5C **α**-ketoglutarate. A molecular form of CO_2 is released. ***Isocitrate dehydrogenase*** catalyses the reaction. It is an NAD^+ dependent enzyme. NAD^+ is converted to NADH.

Step 4: α-ketoglutarate undergoes oxidative decarboxylation to form succinyl CoA, a 4C compound. The reaction is catalyzed by the ***α-ketoglutarate dehydrogenase*** enzyme complex. One molecule of CO_2 is released and NAD^+ is converted to NADH.

Step 5: Succinyl CoA forms succinate. The enzyme ***succinyl CoA synthetase*** catalyses the reaction. This is coupled with substrate-level phosphorylation of GDP to get GTP. GTP transfers its phosphate to ADP forming ATP.

Step 6: Succinate is oxidised by the enzyme ***succinate dehydrogenase*** to fumarate. In the process, FAD is converted to $FADH_2$.

Step 7: Fumarate gets converted to malate by the addition of one H_2O. The enzyme catalysing this reaction is ***fumarase***.

Step 8: Malate is dehydrogenated to form oxaloacetate, which combines with another molecule of acetyl CoA and starts the new cycle. Hydrogens removed, get transferred to NAD^+ forming NADH. ***Malate dehydrogenase*** catalyses the reaction.

EQ3 : ELECTRON TRANSPORT CHAIN

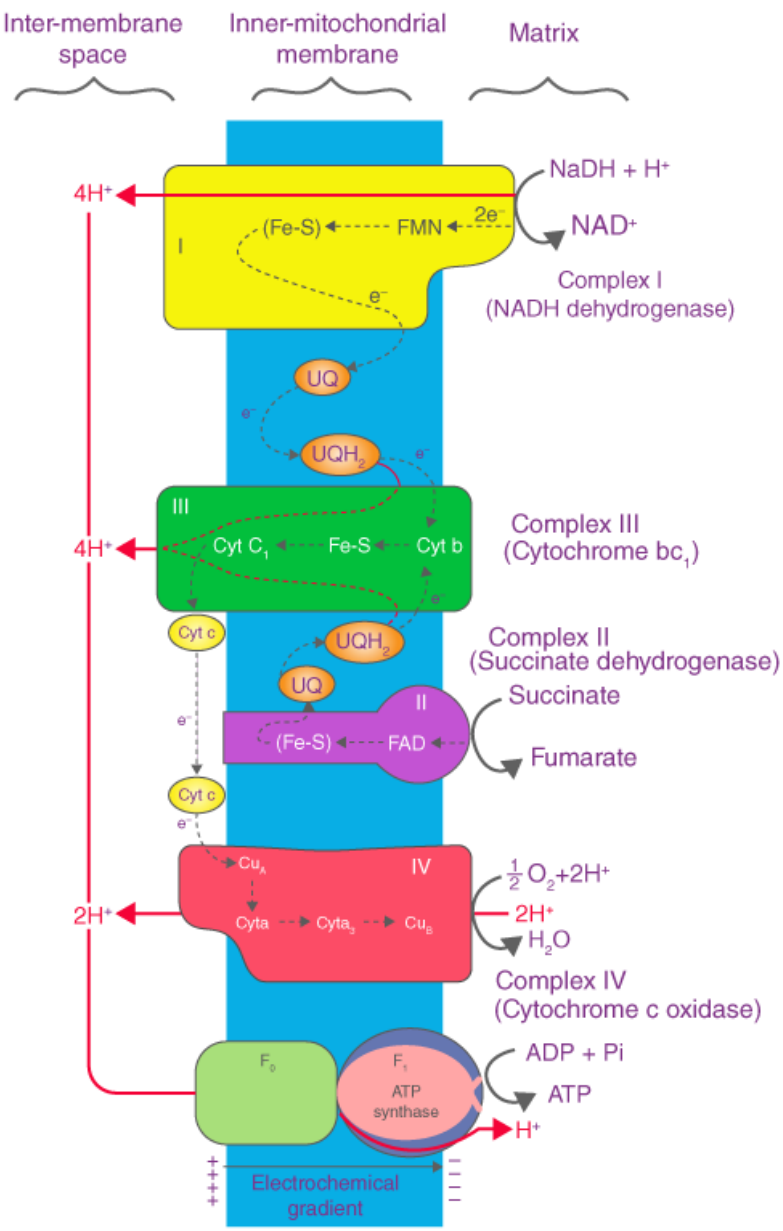
A complex could be defined as a structure that comprises a weak protein, molecule or atom that is weakly connected to a protein. The plasma membrane of prokaryotes comprises multi copies of the electron transport chain.

Complex 1- NADH-Q oxidoreductase: It comprises enzymes consisting of iron-sulfur and FMN. Here two electrons are carried out to the first complex aboard NADH. FMN is derived from vitamin B2.

Q and Complex 2- Succinate-Q reductase: FADH2 that is not passed through complex 1 is received directly from complex 2. The first and the second complexes are connected to a third complex through compound ubiquinone (Q). The Q molecule is soluble in water and moves freely in the hydrophobic core of the membrane. In this phase, an electron is delivered directly to the electron protein chain. The number of ATP obtained at this stage is directly proportional to the number of protons that are pumped across the inner membrane of the mitochondria.

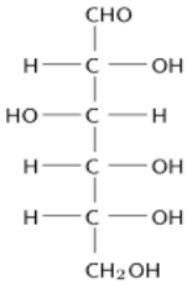
Complex 3- Cytochrome c reductase: The third complex is comprised of Fe-S protein, Cytochrome b, and Cytochrome c proteins. Cytochrome proteins consist of the heme group. Complex 3 is responsible for pumping protons across the membrane. It also passes electrons to the cytochrome c where it is transported to the 4th complex of enzymes and proteins. Here, Q is the electron donor and Cytochrome C is the electron acceptor.

Complex 4- Cytochrome c oxidase: The 4th complex is comprised of cytochrome c, a and a3. There are two heme groups where each of them is present in cytochromes c and a3. The cytochromes are responsible for holding oxygen molecule between copper and iron until the oxygen content is reduced completely. In this phase, the reduced oxygen picks two hydrogen ions from the surrounding environment to make water.


Inter-membrane space
Inner-mitochondrial membrane
Matrix
4H+
NaDH + H+
NAD+
2e−
I
(Fe-S)
FMN
e−
Complex I
(NADH dehydrogenase)
UQ
UQH2
III
Cyt C1
Fe-S
Cyt b
Complex III
(Cytochrome bc1)
Cyt c
Complex II
(Succinate dehydrogenase)
Succinate
II
(Fe-S)
FAD
Fumarate
IV
CuA
Cyta
Cyta3
CuB
½ O2+2H+
2H+
H2O
Complex IV
(Cytochrome c oxidase)
2H+
Fo
F1
ATP synthase
ADP + Pi
ATP
H+
Electrochemical gradient

SQ 1: Glucose structure:

- Glucose is a monosaccharide, meaning it has only one monomer unit of sugar molecule.
- It is a 6-carbon compound.
- The chemical molecular formula of the glucose molecule is C6H12O6.
- It contains an aldehyde (-CHO) group present on the first carbon.



- Glucose is a sugar-containing six carbon atoms and an aldehyde as its functional group.
- When the carbohydrate holds a ketone group (-CO) as a functional group, it is called a ketose.
- For example, the hexose monosaccharide fructose is a ketose containing a ketone functional group at the second carbon of the 6-carbon chain.
- The aldehyde containing glucose can convert into a ketone containing fructose because they are isomers. They have equal molecular formulas but differ in their structures and configurations.
- The carbons in the glucose molecules are linked by covalent bonds, which, on breaking, yield energy to an organism.
- The glucose molecule comprises 12 hydrogen and six oxygen atoms bound to the parent carbon chain.
- Generally, the glucose molecule is drawn as a linear chain of 6 carbon atoms for easy understanding.
- But there are different structural forms of glucose. This means that the glucose changes the nature of its chain, its optical rotation, and its confirmations under different conditions.
- Glucose mostly exists as a ring form mimicking a hexagon in the human body.

SQ 2: General properties of Amino Acids: In essay

SQ 3: Factors affecting enzymatic activity

1. Substrate concentration:

The activity of an enzyme also increases with the increase in substrate concentration. If the substrate concentration increases, then the availability of the active site would decrease. This will affect the activity of an enzyme and limit the reaction rate.

2. pH

Each enzyme has its optimal pH in which they work. For example pepsin and trypsin work on acidic pH. The enzymes are globular proteinaceous structure, form by the interaction of the hydrogen bond between the side chains of the protein. Any change in the cause deionization of side chain which results in the denaturation of the enzyme.

3. Temperature:

Each enzyme works on its optimal temperature. Any alteration in temperature affects the activity of an enzyme, and it also leads to denaturation of an enzyme.

4. Enzyme cofactor and coenzyme:

Each enzyme requires cofactors (inorganic ion or protein organic molecules) for their work. The non-availability of these cofactors decreases the activity of an enzyme.

5. Enzyme inhibitors:

The inhibitors of an enzyme bind to the active site which affects the activity of an enzyme.

UNIT-4

SQ 4: Gluconeogenesis:

1. Gluconeogenesis originates in the liver or kidney's cytoplasm or mitochondria. To make oxaloacetate, two pyruvate molecules are required to carboxylate first. This requires one ATP (energy) molecule.
2. NADH converts oxaloacetate to malate, which can then be transported out of the mitochondria.
3. Once malate leaves the mitochondria, it is oxidised back to oxaloacetate.
4. The enzyme Phosphoenolpyruvate carboxykinase (PEPCK) converts oxaloacetate to phosphoenolpyruvate.
5. By reversing glycolytic processes, phosphoenolpyruvate is converted into fructose 1,6-bisphosphate.
6. Fructose-1, 6-bisphosphate is converted to fructose-6-phosphate in the reaction releasing inorganic phosphate and is catalysed by fructose-1,6-bisphosphatase.
7. The enzyme phosphoglucoisomerase converts fructose-6-phosphate to glucose-6-phosphate.

8. Glucose-6-phosphate generates inorganic phosphate that yields free glucose, which enters the blood. Glucose 6-phosphatase is the enzyme involved.

In the Mitochondria

Pyruvate + ATP → Oxaloacetate + ADP + Pi

Oxaloacetate + NADH → Malate + NAD+

The conversion to malate enables the molecule to be transferred out of mitochondria. It is converted back to oxaloacetate in the cytoplasm.

In the Cytoplasm

Malate + NAD+ → Oxaloacetate + NADH

Oxaloacetate + GTP → PEP + GDP

It then passes through the same intermediates that glycolysis does. The endoplasmic reticulum is the location of the final reaction.

In the Endoplasmic Reticulum

G6P → glucose (catalyst: glucose-6-phosphatase)

Glucose is transported out of the cell into the extracellular environment by a glucose transporter.

SQ 5: Electron transport system:

Complex 1- NADH-Q oxidoreductase: It comprises enzymes consisting of iron-sulfur and FMN. Here two electrons are carried out to the first complex aboard NADH. FMN is derived from vitamin B2.

Q and Complex 2- Succinate-Q reductase: FADH2 that is not passed through complex 1 is received directly from complex 2. The first and the second complexes are connected to a third complex through compound ubiquinone (Q). The Q molecule is soluble in water and moves freely in the hydrophobic core of the membrane. In this phase, an electron is delivered directly to the electron protein chain. The number of ATP obtained at this stage is directly proportional to the number of protons that are pumped across the inner membrane of the mitochondria.

Complex 3- Cytochrome c reductase: The third complex is comprised of Fe-S protein, Cytochrome b, and Cytochrome c proteins. Cytochrome proteins consist of the heme group. Complex 3 is responsible for pumping protons across the membrane. It also passes electrons to the cytochrome c where it is transported to the 4th complex of enzymes and proteins. Here, Q is the electron donor and Cytochrome C is the electron acceptor.

Complex 4- Cytochrome c oxidase: The 4th complex is comprised of cytochrome c, a and a3. There are two heme groups where each of them is present in cytochromes c and a3. The cytochromes are responsible for holding oxygen molecule between copper and iron until the oxygen content is reduced completely. In this phase, the reduced oxygen picks two hydrogen ions from the surrounding environment to make water.

Sq6 : Trans amination

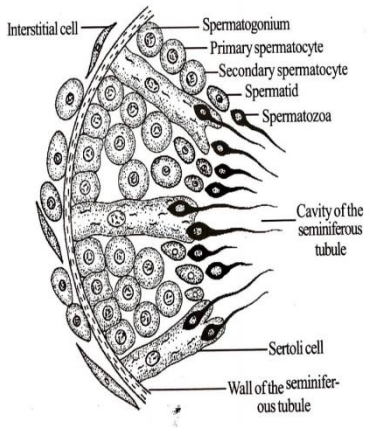
- Transamination is the process by which amino groups are removed from amino acids and transferred to acceptor keto-acids to generate the amino acid version of the keto-acid and the keto-acid version of the original amino acid.
- It involves the transfer of amino groups from one amino acid to keto groups of a keto acid.
- Transamination in biochemistry is accomplished by enzymes called transaminases or aminotransferases.
- α-ketoglutarate acts as the predominant amino-group acceptor and produces glutamate as the new amino acid.
- A specific example is the transamination of alanine to make pyruvic acid and glutamic acid.

- -The α-amino group present in an amino acid is transferred to an α -keto acid to yield a new amino acid and the -keto acid of the original amino acid.

UNIT-5
EMBRYOLOGY

Eq1: Write an essay on Spermatogenesis

It refers to the formation of spermatozoa. Spermatozoa are formed in the testis. In each vertebrate, a pair of testes is found. Each testis is attached to the dorsal



body wall by a connective tissue membrane called mesorchium. The testis is formed of thousands of minute tubules called seminiferous tubules. They lead into vasa deferentia. The seminiferous tubules are separated by interstitial cells.

Each seminiferous tubule is covered by a basement membrane and lined with germinal epithelium. The germinal epithelial cells are separated by giant cells called Sertoli cells. The germinal epithelial cells develop into spermatozoa and the Sertoli cells nourish the developing spermatozoa. The entire process of spermatogenesis has two stages, namely

1. The formation of spermatid and

2. Spermiogenesis.

1. Formation of Spermatid

The spermatid is formed from the epithelial cells of seminiferous tubules. The germinal cells which develop into spermatids are called primordial germ cells. There are three phases in the conversion of primordial germ cells into spermatids. They are

a. Multiplication phase

b. Growth phase and

c. Maturation phase.

a. **Multiplication Phase:** The primordial germ cells are larger in size and their nuclei are distinct. They undergo repeated mitotic divisions. The resulting cells are called spermatogonia or sperm mother cells. Each spermatogonium has a diploid number (2n) of chromosomes.

b**. Growth Phase:** During this phase, the spermatogonium grows. The volume increases. Now the cell is called primary spermatocyte. It is also a diploid (2n) cell.

c**. Maturation Phase:** The primary spermatocyte, then enters the maturation phase where each cell divides by meiosis. Meiosis consists of two divisions. The first meiotic division produces two cells which are having haploid (n) number of chromosomes. These cells are called secondary spermatocytes. In the second meiotic division, each secondary spermatocyte divides into two cells called spermatids. The spermatid has only haploid number of chromo- somes. Thus by meiosis each primary spermatocyte is converted into four spermatids. The sper- matids differentiate into spermatozoa.

2. Spermiogenesis The transformation of the spermatid into spermatozoon is called spermiogenesis. The spermatid is in the form of a typical cell containing the nucleus, Golgi bodies, mitochondria, centriole, etc. but it contains only haploid number of chromosomes. During the differentiation of the sperm, all these organelles undergo changes.

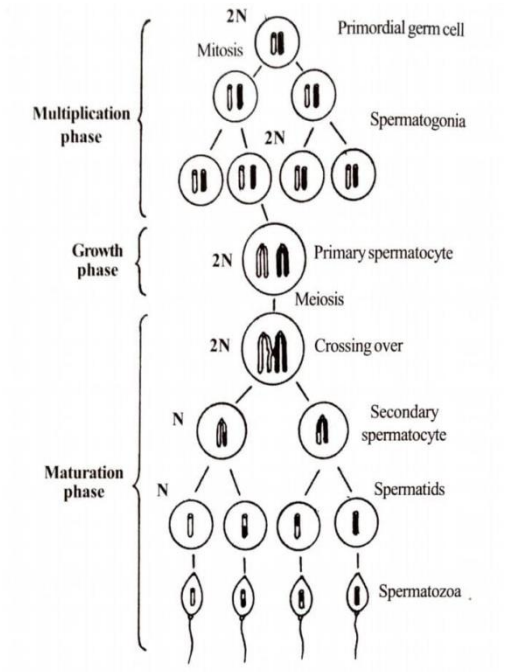
1. The nucleus gradually diminishes in its size by losing water.

2. The chromosomes become concentrated and are closely packed.

3. All the achromatic substances, nucleolus and RNA disappear.

4. The nucleus becomes elongated.

5. The Golgi bodies develop into the acrosome. In an early spermatid, the Golgi bodies are in the form of membranous vesicles, arranged around a group of vacuoles. The small vacuoles gradually fuse together to form large vacuoles. It is now called acroblast. Inside the acroblast, a dense body called proacrosomal granule is developed. The whole of the acroblast spreads over the front part of the nucleus. The proacrosomal granule enlarges to form the acrosomal granule. The acroblast is now called acrosome which forms the cap of the sperm. The acrosome and the nucleus together constitute the head. The remnants of the



Golgi body degenerate and eventually get discarded.

6. The centrosome of the spermatid contains two centrioles. They move towards the nucleus and occupy a position behind it. A depression is formed in the posterior surface of the nucleus and one of the two centrioles becomes placed in this depression. This is the proximal centriole. The other centriole is called the distal centriole takes up a position behind the proximal centriole.

7. The distal centriole develops a filament-like structure called axial filament. It gradually elongates and forms the tail by developing a cytoplasmic sheath. The distal end of the axial filament is free from the cytoplasmic sheath and it is named end piece.

8. The mitochondria of the spermatid are aggregated together to form a large mass in the region of the centrioles. This is called mitochondrial cloud. In mammals, the mitochondrial cloud becomes twisted spirally around the proximal part of the axial filament. However, in other animals the spiral arrangement of the mitochondria is not found and they may be arranged in two bands on either side of the proximal part of the axial filament or clumped together in a compact mass. This region forms the middle piece.

9. Around the surface of the middle piece the cytoplasm forms a condensed

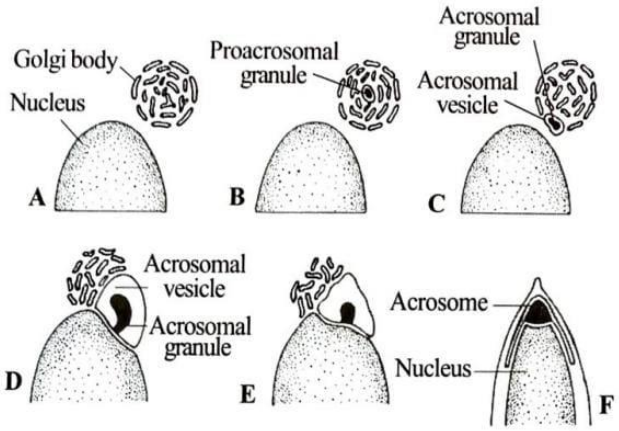


Fig.2.3: Spermiogenesis: Formation of acrosome and head.

sheath called manchette.

10. The cytoplasm flows backwards and forms a thin layer around the nucleus, middle piece and tail.

11. When the spermatozoa are developing, their heads are embedded in the

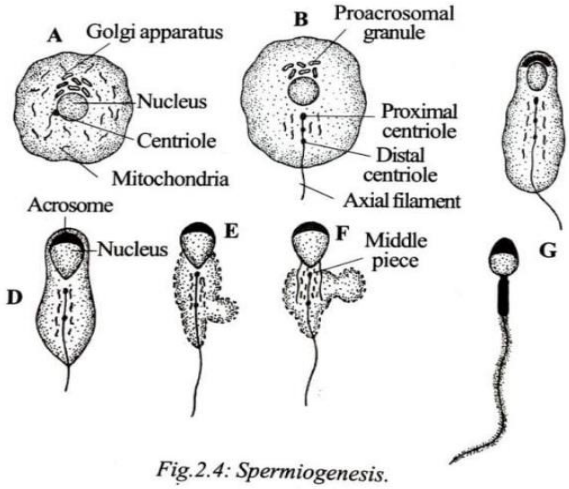


Fig.2.4: Spermiogenesis.

cytoplasm of the Sertoli cells and their tails protrude into the lumen of the seminiferous tubules. When they are fully matured, they are released and are

carried away by the ciliary movement of the lining of the vasa efferentia to the vas deferens. They are stored in the seminal vesicles to be released when required.

12. The sperms undergo morphological differentiation in the seminiferous tubules of the testis. By this change they attain the typical structure of a sperm. But they do not possess the ability to fertilize the egg. They attain the ability to fertilize the egg by a process called physiological ripening. In mammals, the physiological ripening of the sperms takes place in the epididymis while they pass through it. In frogs, the sperms undergo physiological ripening in the seminiferous tubules itself.

Eq2: Explain the mechanism of Oogenesis

The process by which the eggs or ova develop from the primordial germ cells of the ovary is called oogenesis.It can be divided into three phasea.They are multiplication phase, growth phase and maturation phase

1.Multiplication phase:

The germinal epithelial cells of the ovary detach themselves from the surface and enter the cortex of the ovary. These cells are called primordial germ cells. They divide repeatedly by mitosis and the resultant cells are called oogonia or egg mother cells. The oogonia again divide repeatedly by mitosis. When the division stops, the cells are named as primary oocytes. The nucleus of primary oocyte is diploid.

2. Growth Phase

During growth phase, the oocyte increases in size. .The growth phase of oocyte is divided into two stages, namely previtellogenesis and vitellogenesis.

1. Previtellogenesis

During previtellogenesis the cytoplasm and nuclear materials of primary oocyte grow and increase considerably in volume. The yolk and other food materials are not synthesized during this phase.

The following changes occur during previtellogenesis:

1. The nuclear sap is produced in large amount. As a result, the nucleus increases in size. The large nucleus of the oocyte is called germinal vesicle.

2. Homologous chromosomes pair together.

3. In amphibians, the chromosomes of primary oocytes acquire a characteristic shape; thin loops or threads appear on the sides of the chromosomes. These loops give a brush-like appearance to the chromosomes. Hence the chromosomes are called lamp-brush chromo- somes. The loops of these chromosomes are actively involved in the synthesis of mRNA.

4. The ribosomal RNAs are produced in a remarkable amount. They are produced by the nucleolus. As a result the nucleolus increases greatly in size

5. The genes producing the rDNA are multiplied several times to facilitate the rapid synthe- sis of rDNA. This increase in the number of genes is called amplification.

6. In many cases, the production of RNA is increased further,…

8. The amount of mitochondrial DNA increases. It exceeds even the amount of nuclear DNA

9. Cortical granules are manufactured by the cisternae of Golgi complex.

10. The growing oocytes are surrounded by special kinds of nutritive cells. These cell immensely assist the growth of oocytes in various ways. There are two types of nutritive cell namely follicle calls and nurse cells.

11. In the ovary of chordates, the developing oocyte is surrounded by follicle cells.

12 In mammals, the follicle cells and the developing ovum together constitute a Graafian follicle. Each Graafian follicle consists of a cavity called antrum filled with a fluid called liquor folliculi. The cavity is surrounded by three layers, namely an outer theca externa, a middle theca interna and an inner membrana granulosa which lines the cavity. The oocyte lies inside the antrum. It is surrounded by a few layers of follicle cells called corona radiata. The oocyte oo attached to the membrana granulosa on the side by a stalk of cells called discus proligerus . The oocyte is surrounded by a transparent membrane called zona peliucida.

3. Maturation Phase

The primary oocyte contains a diploid number of chromosomes. The diploid chromo- some number is reduced to haploid number by meiosis or reduction division and the primary oocyte is changed into the ovum or egg. This is called maturation.

The meiotic divisions are unequal in oogenesis. As a result of the first meiotic division the primary oocyte divides into a very small and a large cell each with a haploid number of chromosomes. The smaller cell is always formed at the animal pole and is called the first polar body polocyte. It contains only a negligible amount of cytoplasm. The other cell contains the main bulk of the primary oocyte and is called the secondary oocyte. In the second meiotic division also, the secondary oocyte divides unequally into a small cell and a large cell. This small cell is called the second polar body or second polocne. The larger cell is the ovum. As the second ary oocyte is dividing the first polar body divides into two polar bodies

Thus in oogenesis only one egg is produced along with the three polar bodies.

Eq: write an essay on Fertilization

Fertilization is the union of spermatozoon and egg resulting in the formation of zygote.

Significance of Fertilization

1. Fertilization maintains the diploid number of chromosomes in the race.

2. Fertilization produces genetic variation by bringing together chromosomes from two different parents.

3. Fertilization activates the egg and thus development is initiated.

Physical Factors Involved in Fertilization

1. External Fertilization

In majority of aquatic animals, sperms and ova are released into the water where fertilization takes place. It is called external fertilization. It is the primitive type of fertilization.

E.g.Fishes, Frog, etc.

2. Internal Fertilization

In amniotes, sperms are introduced into the female's genital tract, where fusion takes place. It is called internal fertilization. It is the advanced type.

E.g., Man.

3. Life-span of the Gametes

Generally, the eggs fertilized externally, have shorter life-span than those which are fertilized internally. For example, the human egg can live for more than twenty-four hours after ovulation. Spermatozoa have a comparatively long-life span. For example, the spermatozoa of bat can live for 135 days in the female reproductive tract. The cock spermatozoon can live for two weeks in theoviduct. The life time of the human spermatozoon in the female genital tract is about 24 hours.

4.Production of Enormous Number of Sperms

The meeting of gametes is enhanced by the production of enormous number of sperms.

5. Random Collision

The egg and sperm are brought together by random collision. This is favoured by the large size of the egg and the enormous number of sperms. 6. Mechanical Juxtaposition of Gametes Animals provide a number of mechanical agencies to bring together the eggs and spermatozoa. In mammals, the spermatozoa are injected deep into the female genital duct by copula In birds, the spermatozoa are introduced into the cloaca of female by a process called 'cloacal kiss'.In cephalopods (Sepia, Loligo, etc.), one of the arms in the male modified to transfer the spermatozoa into the female genital duct. This arm is said to be hectocotylus. During courtship,the male carries a bundle of spermatophores from the genital duct in his hectocotylus arm and places it either in the mantle cavity or in the seminal receptacle of the female.

7. Synchrony in Production and Release of Gametes

The male and female gametes are produced at a particular time. In certain animals, eggs are released only after ovulation. This prevents wastage of sperms.

8. Capacitation

Capacitation is a process where the spermatozoa acquire the capacity to fertilize the eggs. After capacitation, the spermatozoa develop the ability to penetrate the membranes surrounding the egg. The spermatozoa obtain capacitation by the following methods:

1.The spermatozoa gets capacitation by remaining in the female genital tract for some timeThe duration is six hours in man and one hour in mouse.

2. In some animals, sperms obtain capacitation by passing through epididymis.

3. During capacitation the coating substances on the surface of the sperm are removed.

This helps the receptor sites on the sperm to recognize signals coming from the egg.

9.Entry of Sperm into the Egg

In some animals, such as nemertines, mollusks, echinoderms, insects and fishes, the egg is surrounded by a tough membrane called chorion. This membrane cannot be easily penetrated by the spermatozoa. Hence, the eggs are provided with one or more-minute openings called micropyles. The spermatozoa enter the eggs only through these openings.

10.Time of Fertilization

The sperm fertilizes the egg at different stages of maturation in different species. It may occur after maturation or at the time of maturation or before maturation. In sea urchin, fertilization occurs after maturation divisions. In all vertebrates, the egg is fertilized after maturation division. In ascidians, some molluses and some annelids the egg is fertilized at the time of first maturation division. In nematodes and annelids, the egg is fertilized before the commencement of maturation division.

Chemical Factors Involved in Fertilization

1. Fertilizin-Antifertilizin Reaction The sperm identifies the egg by the reaction between fertilizin and antifertilizin Fertilizin: The egg contains on its surface a chemical substance called fertilizin. It is a glycoprotein. It has a molecular weight of 3,00,000. The fertilizin molecule has many receptor or binding sites for antifertilizin, Fertilizin’s are species specific and there may be different fertilizin’s for different species. The main source of the fertilizin is

jelly coat or plasma membrane. The fertilizin present inthe jelly coat and vitelline membrane is called jelly coat fertilizin. The fertilizin present in the plasma membrane is called cytofertilizin.Antifertilizin: The surface of the sperm contains a chemical substance called antifertilizin It is an acid protein. It is

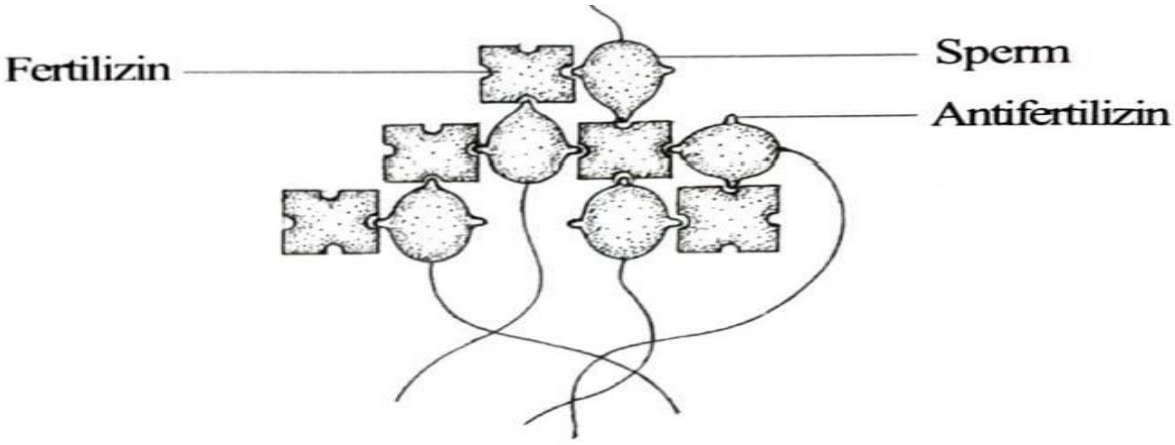


Fig.6.2: Fertilizin-antifertilizin reaction.

smaller than fertilizin. It has a molecular weight of 10,000. There may be different antifertilizins in the different species.

Reaction: Fertilizin reacts with the antifertilizin in a manner comparable to the reaction between antigen and antibody. This reaction can also be compared to the lock and key system.

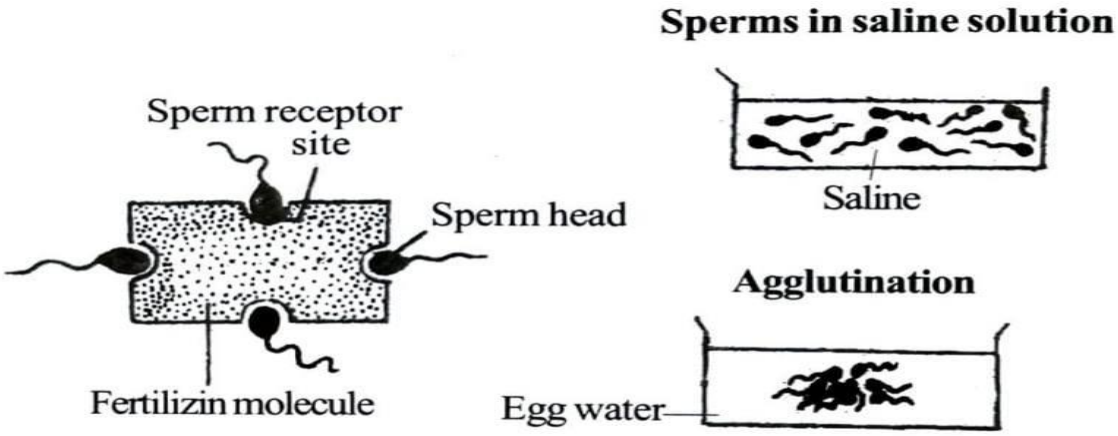


Fig.6.3: Fertilizin and Antifertilizin reaction.

complementary to the antifertilizin molecules. When eggs and sperms are released in the water, the fertilizin particles embrace the antifertilizinparticles. As a result, the sperms agglutinate or clump together. This reaction is strictly species specific.

2. Acrosome Reaction

When the spermatozoon comes in contact with the egg, tremendous changes occur in the acrosome of sperm. All these changes constitute the acrosome reaction.

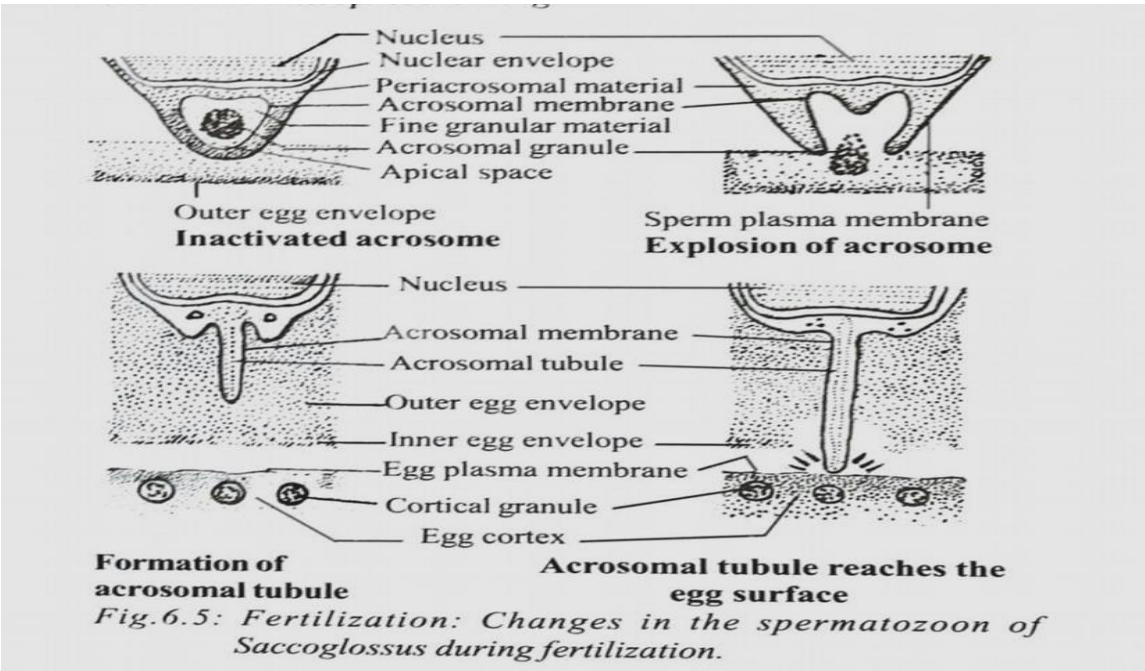


Fig.6.5: Fertilization: Changes in the spermatozoon of Saccoglossus during fertilization.

1. When the spermatozoon's tip makes contact with the egg envelope, the sperm-plasma membrane and the acrosomal membrane rupture at the point of contact.

2. The acrosomal membrane then joins with the plasma membrane around the margin of the opening.

3. The acrosomal granule is released on the egg-envelope.

4. The acrosomal Thus the egg surface is exposed at this spot.

granule contains the sperm lysin which dissolves the egg envelope.

5. Now, the centre of acrosomal membrane, nearer to the nucleus, grows towards the egg surface as a thin tube called acrosomal tubule.

3. Cortical Reaction

As the sperm enters the egg, the egg becomes activated. First of all, changes occur in the cortex (surface) of the egg. These changes constitute the cortical reaction. The cortical reaction in the egg of sea urchin can be summarized as follows:

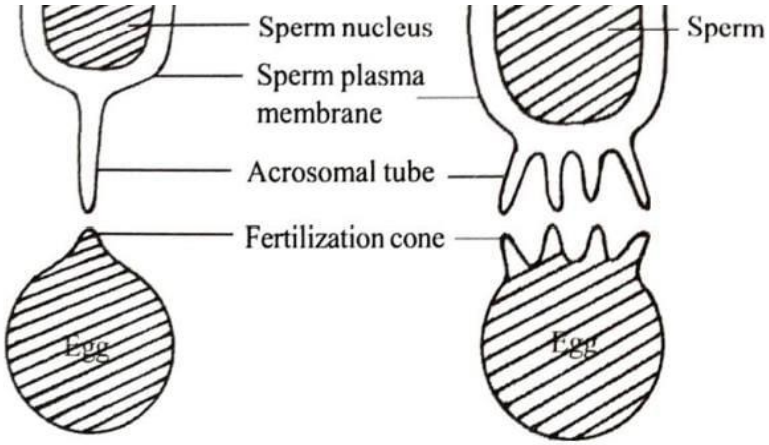


Fig.6.7: An acrosomal tube and a fertilization cone.

Fig.6.8: Many acrosomal tubes and fertilization cones devel oping during fertilization in Hydroides, a Coelenterate.

1.The colour of the egg-surface gradually changes from yellow to white. The change starts from the point of attachment of the sperm and gradually spreads over the surface of the egg..

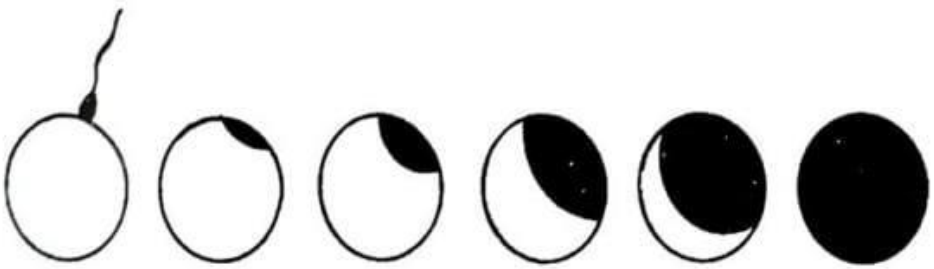


Fig.6.9: Colour changes in the egg of sea urchin after fertilization.

2. The vitelline membrane gets lifted off. This membrane is then called fertilization membrane. The space between it and the surface of the egg is called perivitelline space. It is filled with a fluid called peri vitelline fluid.

3. The cortical granules swell rapidly and explode. The cortical granules release three important components. They are,

a. Lamellar Folded Bodies: These are dark and dense bodies. On release, they unfold and fuse with the inner surface of the fertilization membrane. Thus the fertilization membrane is strengthened by the lamellar bodies.

b. Globules: The globular structures fuse together and form a new surface layer just out- side the plasma membrane. This layer is called hyaline layer. It helps to keep the blastomeres intact during cleavage.

c. Liquid Component: The cortical granules contain muco-polysaccharides. They absorb water and become liquified. This liquid is released into the perivitelline space, and it is called perivitelline fluid. By imbibing more and more water, it assists in lifting the fertilization membrane still further.

Eq4: Write about different types of Eggs

I.On the basis of the amount of Yolk - Depending on the quantity of yolks, eggs can be

- **Alecithal / Microlecithal / oligolecithal** - The amount of yolk present in an organism's egg is of a very small amount or absent.
  Example - Sea urchin, Amphioxus, Tunicates, Eutherian egg

- **Mesolecithal** - In this type of egg, the yolk amount is medium or moderate & concentrated towards one pole of the egg.
  Example - Amphibian, Dipnoi fishes, lungfishes, Petromyzon

- **Polylecithal / macrolecithal / megalecithal** - The amount of yolk content is very large. Example - Prototherian mammals, Insects, Annelids, Reptiles

II. On the basis of the distribution of yolk - Depending on how they are distributed, eggs fall into one of the following categories:

- **Isolecithal / homolecithal Egg** - The yolk is equally distributed in the whole egg.Since the amount of yolk is relatively small, these eggs undergo holoblastic cleavage, resulting in the formation of cells of similar size during early embryonic development.
  Example - Alecithal , micro, oligolecithal egg.

- **Teloleithal Egg** - Here the yolk is found on the one pole of the egg. Usually, the egg has two opposite poles, one is the animal pole and the

other one is the vegetal pole. Telolecithal types of the egg are those in which yolk is present on the vegetal pole while the other pole is free.
Example - Amphibian egg.

- **Centrolecithal Egg** - Centrolecithal eggs have a centrally located yolk, surrounded by a thin layer of cytoplasm and a large central nucleus. This type of egg is found in insects, such as flies and beetles. The yolk acts as a nutrient reserve for the developing embryo. Centrolecithal eggs undergo superficial cleavage, where cell division occurs only in the outermost layer of the cytoplasm, while the yolk remains intact.

III. On the Basis of Shell - on the basis of a shell, there are two types of eggs –

- **Cleidoic Eggs** - The egg is surrounded by a hard covering or shell. These types of eggs are generally seen in terrestrial animals.
- Example - Reptile, Bird
- **Non - Cleidoic Eggs** - The egg which is not surrounded by any hard covering.

Example - All viviparous animals.

Eq 5: Different types of cleavages:

Type of cleavage or the plane of cleavage depends mostly on the amount of yolk in the egg. This may be holoblastic (total or entire cleavage) or meroblastic (partial cleavage). The daughter cells derived are the blastomeres.

I. Holoblastic: Entire egg divides. Here, the cleavage planes pass all the way from animal pole to the vegetal pole of the zygotes during cytokinesis of cell division..

Holoblastic may be further classified into four types depending upon the nature and arrangement of blastomeres

Bilateral: The first cleavage results in bisection of the zygote into left and right halves. The following cleavage planes are centered on this axis resulting in the formation of two halves. These two are the mirror images of one another.

Radial: Radial cleavage is characteristic of the deuterostomes such as some vertebrates and echinoderms. Here the spindle axes are parallel or at right angles to the polar axis of the zygote. Hence the resultant blastomeres are arranged in linier hers i.e. exactly one above the other. This type of arrangement is seen in amphioxus and frog.

Rotational: Mammals display rotational cleavage because of the isolecithal distribution of yolk. Because the cells have only a small amount of yolk, they require immediate implantation onto the uterine wall in order to receive nutrients. Here cleavage involves a normal first division along the meridional axis, giving rise to two daughter cells. The way in which the next cleavage differs is that one of the daughter cells divides meridionally, whilst the other divides equatorially. This type of arrangement is seen in almost all eutherian mammals including man.

Spiral: In spiral cleavage, the cleavage planes are oriented obliquely to the polar axis of the oocyte from third cleavage onwards. At the third cleavage, the plane of cleavage is oblique to the polar axis of the cell. Hence the daughter cells produced are arranged as an upper quartet of smaller cells at the junctional places of the lower quartette. All protostomian groups such as annelids and molluscs show spiral cleavage.

II.Meroblastic : Only a portion of egg is divided. In the presence of a large amount of yolk in the fertilized egg cell, the cell can undergo partial or meroblastic cleavage. Two major types of meroblastic cleavages are discoidal and superficial.

a) Discoidal: Here, the cleavage furrows can not penetrate through the entire yolk mass. The embryo forms a disc of cells, called a blastodisc, on top of the yolk. Discoidal cleavage is commonly found in birds, reptiles, and fish having telolecithal egg cells (egg cells with the yolk concentrated at one end).

b) Superficial: In superficial cleavage, mitosis occurs without cytokinesis, resulting in a poly-nuclear cell. With the yolk positioned in the center of the egg cell, the nuclei migrate to the periphery of the egg. Plasma membrane grows inward, partitioning the nuclei only into individual cells but not the yolk. Superficial cleavage occurs in arthropods which have centrolecithal egg cells (egg cells with the yolk located in the center of the cell).

This is further divided into two types.

a)Determinate Cleavage

Each blastomere has a predetermined developmental fate and is not qualitatively equal. Many protostomes exhibit this type of cleavage.

Each blastomere, formed during early embryonic cleavage, has an early developmental fate that prevents it from developing into a complete organism.

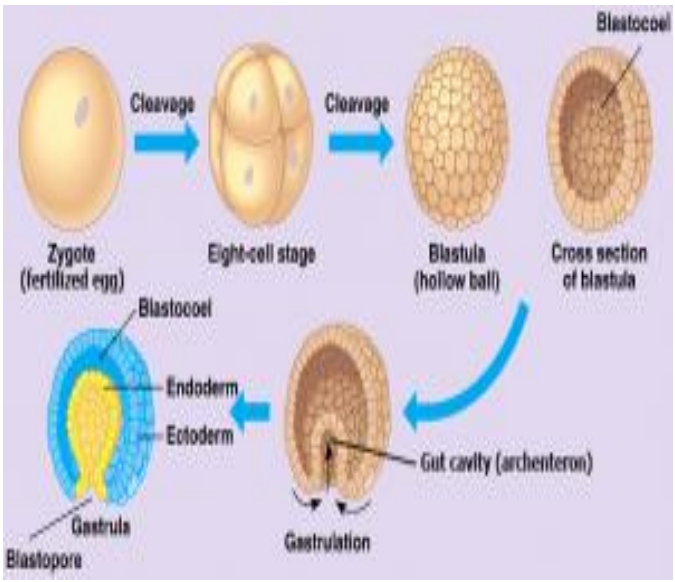
B) INDETERMINATE CLEAVAGE

The term "indeterminate cleavage" refers to a type of cleavage based on the potency of blastomeres where the blastomeres are qualitatively equal, and each can develop into an entire embryo when isolated. Deuterostomes usually possess this type of cleavage.

Eq6 : Process of gastrulation in Frog

- Gastrula is the two layered embryo stage formed by migration and rearrangement of cells of blastula. The process of formation of gastrula is called **gastrulation.**
- Gastrulation involves some critical changes in the blastula such as- differentiation of cells, transformation from monoblastic to **diploblastic layer**, formation of **three primary germ layers.**

Gastrulation completes in following steps.



1. EPIBOLY:

- In this step, micromeres at animal pole dives more repeatedly and rapidly enclosing the megameres except in the region of yolk plug. This overgrowth or spreading of micromere cells is known as Epibloy.

2. Emboly or Intucking (Invagination):

- In this step, small groove appears due to invagination of megameres near grey crescent region. The invagination gradually grows inward causing migration of cells.
- This stage is also known as Yolk plug stage.
- The narrowing of blastopore exerts pressure on underlying yolk laden megameres, result in protruding of some megameres cells as yolk plug.
- Contraction of lips of blastopore: contraction of lips from all side occurs so that blastopore become smaller and narrower.
- As invagination progresses archenteron increases in size and the blastocoel become reduced and finally obliterated.
- This groove is the beginning of archenteron and its anterior opening is called blastopore. The blastopore is guided by anterior margin called dorsal lip and backward projecting lateral lip.

3. Involution:

- due to increase in size of archenteron as well as formation of yolk plug, there is rapid migration of presumptive areas within the embryo occurs. This movement of the presumptive areas is known as involution.
- Rotation of gastrula: gastrulation causes shift in the center of gravity of the embryo. In the blastula stage, embryo floats with animal pole upward. But formation of archenteron causes the embryo to rotate within the vitelline membrane so that blastopore comes near the vegetal pole.
- Gastrulation causes following changes-
- i) blastopore is presumptive gut
- ii) roof of archenteron is chordamesoderm
- iii) floor of archenteron is endoderm

4. Formation of three germ layer:

- The three layers are ectoderm, mesoderm and endoderm are known as primary germ layer. They are also called as germinal layers because entire organs and body are derived from these layers.

Sq 1 :Spermiogenesis

The transformation of the spermatid into spermatozoon is called spermiogenesis. The spermatid is in the form of a typical cell containing the nucleus, Golgi bodies, mitochondria, centriole, etc. but it contains only haploid number of chromosomes. During the differentiation of the sperm, all these organelles undergo changes.

1. The nucleus gradually diminishes in its size by losing water.

2. The chromosomes become concentrated and are closely packed

3. All the achromatic substances, nucleolus and RNA disappear.

4. The nucleus becomes elongated.

5. The Golgi bodies develop into the acrosome. In an early spermatid, the Golgi bodies are in the form of membranous vesicles, arranged around a group of vacuoles. The small vacuoles gradually fuse together to form large vacuoles. It is now called acroblast. Inside the acroblast. a dense body called proacrosomal granule is developed. The whole of the acroblast spreads over the front part of the nucleus. The proacrosomal granule enlarges to form the acrosomal granule. The acroblast is now called acrosome which forms the cap of the sperm. The acrosome and the nucleus together constitute the head. The remnants of the Golgi body degenerate and eventually get discarded.6. The centrosome of the spermatid contains two centrioles. They move towards the nucleus and occupy a

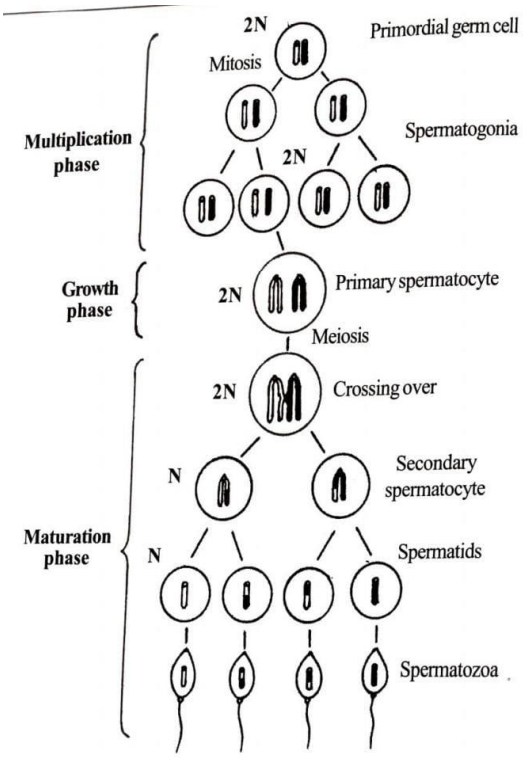


Fig.2.2: Spermatogenesis.

position behind it. A depression is formed in the posterior surface of the nucleus and one of the two centrioles becomes placed in this depression. This is the proximal centriole. The other centriole is called the distal centriole takes up a position behind the proximal centriole.

7. The distal centriole develops a filament-like structure called axial filament. It gradually elongates and forms the tail by developing a cytoplasmic sheath. The

distal end of the axial filament is free from the cytoplasmic sheath and it is named end piece.

8. The mitochondria of the spermatid are aggregated together to form a large mass in the region of the centrioles. This is called mitochondrial cloud. In mammals, the mitochondrial cloud becomes twisted spirally around the proximal part of the axial filament. However, in other nimals the spiral arrangement of the mitochondria is not found and they may be arranged in two bands on either side of the proximal part of the axial filament or clumped together in a compact mass. This region forms the middle piece.

9. Around the surface of the middle piece the cytoplasm forms a condensed sheath called manchette.

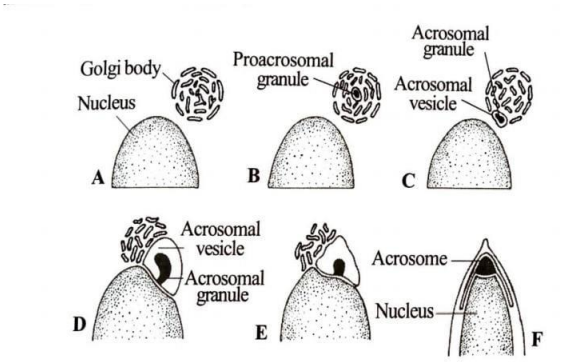


Fig.2.3: Spermiogenesis: Formation of acrosome and head.

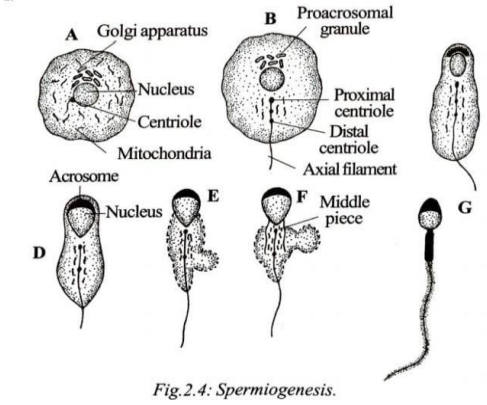


Fig.2.4: Spermiogenesis.

10. The cytoplasm flows backwards and forms a thin layer around the nucleus, middle piece and tail.

11. When the spermatozoa are developing, their heads are embedded in the cytoplasm of the Sertoli cells and their tails protrude into the lumen of the seminiferous tubules. When they are fully matured, they are released and are carried away by the ciliary movement of the lining of the vasa efferentia to the vas deferens. They are stored in the seminal vesicles to be released when required.

12. The sperms undergo morphological differentiation in the seminiferous tubules of the testis. By this change they attain the typical structure of a sperm. But they do not possess the ability to fertilize the egg. They attain the ability to fertilize the egg by a process called physiological ripening. In mammals, the physiological ripening of the sperms takes place in the epididymis while they pass through it. In frogs, the sperms undergo physiological ripening in the seminiferous tubules itself.

Sq2 Pre vitellogenesis: In essay

Sq3: Cortical reaction: in essay

Sq4: classification of egg based on amount of yolk: In essay

Sq5: Characteristics of cleavage:

1. cleavage, is a series of repeated, rapid (mitotic) cell divisions without cell growth occuring in early Embryogenes.

2. Cleavge partaitions the cytoplasm of one large cell (Hygoto into many Smaller Cells called blastomeres. So it progressively reduces the ale size.

3. The total cellular volume of the Embryo remains the same.but the number will within the embryo incereases

4. Shape of the Embryo does not change during cleavage because there is no movement of blastomeres Except for the apperance of a cavity in the interior (blastocoel) and there is no change even in the size of the Embryo because Embryo doesn't grow during cleavage..

5. The repeated and successive mitotic divisions transform Zygote into a multicellular structure called morula ,which by further divisions and arrangement of cells is ultimately. Transformed into blastula possessing a single layer of blastoderm and a Central Cavity called blastocoel.

6. Ratio of nucleus to cytoplam is very low at the beginning of cleavage but at the end it is brought to the level found in ordinary somatic cells.

7. Chemical Conversion of reserve food into active cytoplasm and active cytoplasmic material and then in molecules of nuclear substances like DNA, RNA and nucloproteins takes.

8. Internal & organization of ooplasm of zygote remains the same in a cleaved Egg.

9. The rate of cleavage varies with the species, amount and distribution of yolk in this Egg and temperature of the Environment.

10. Consumption of oxygen greatly increases during cleavages to provide Energy for activities in cell divisions.

Sq6: Cleavages in Frog

- 2-3 hours after fertilization, the zygote begins to divide. The repeated division in the successive fashion is known as **cleavage or segmentation.**
- Division is mitotic
- The cleavage begins as a small depression at animal pole and gradually extends surrounding the zygote, dividing into two cell.
- The divisions are **holoblastic** and complete
- First cleavage is vertical; two celled stage
- Second cleavage is also vertical but right angle to the first one; forms 4 celled stage
- The cells are known as blastomere
- Third cleavage is horizontal but above the equatorial line forming unequal size cells. The upper 4 cells toward animal pole are small and pigmented known as micromeres or epiblast. The lower 4 large yolk laden cells are known as megameres or hypoblat.
- Fourth and fifth cleavage are also vertical forming 16 celled zygote. These division is followed by two horizontal cleacage, one toward animal pole and other toward vegetal pole, resulting in 32 celled stage.