

7. ANIMAL PHYSIOLOGY

NUTRITION

Nutrition is the procurement of substances necessary for growth, maintenance and activities of the body. Energy is required for running life process. Green plants can directly utilise sunlight energy and they prepare their own food material. It is called Autotrophic mode of nutrition. In green plants, their energy is in the form of stored energy of organic molecules synthesized by Autotrophic mode of nutrition. Ultimately all animals get their energy from sunlight through plants.

Heterotrophic nutrition is of 2 types

Holozoic - eating whole animals or their parts.

Saprophytic - Living organisms feed on decaying organic materials of plants and animals.

DIGESTION :

The complex and large organic molecules have to be converted into simpler molecules in order to enter into the protoplasm of each and every cell for its metabolic activities.

Digestion is carried out by breaking the bonds of nutrient molecules by using a molecule of water for cleavage. This digestion is carried out by enzymes called Hydrolases

For unicellular protists like Amoeba, the digestion is carried out within the animal (intracellular digestion) but in multicellular animals, the digestion takes place outside the cell (extracellular digestion).

The multicellular animals have a cavity called 'Alimentary canal'. In that, enzymes are poured in by the cell. There, the food is digested and it is absorbed by the cells.

DIGESTIVE SYSTEM (MAN)

Food is taken into the Alimentary canal through the mouth and is propelled along by the movements of the muscles on its wall. Glands located in its wall (gastric glands) and in associated organs like liver and pancreas secrete enzymes into the lumen of the canal.

Alimentary system consists of a muscular tongue in the floor of the buccal cavity which helps in ingestion and teeth help in mastication of food. The chewed food is mixed with saliva in the mouth secreted by 3 pairs of salivary glands.

Saliva contains a starch digesting enzyme and mucus which lubricate the food for swallowing.

Mouth leads to the pharynx which communicates with the long oesophagus which opens into the stomach. The stomach is a large muscular sac which secretes hydrochloric acid and protein digesting enzyme Pepsin.

After digesting the proteins the food goes into the small intestine.

Ruminant animals like cattle have a compound stomach. Some parts of the stomach give shelter to numerous bacteria and protozoa which carry out fermentation of cellulose.

The small intestine of mammals is a long, coiled, narrow tube. The inner walls project into finger-like structures called "Villi" which increase the surface area for absorption of digested material.

The first part of the small intestine called Duodenum is very important because bile duct opens into it. Small intestine opens into large intestine. At the point of junction, a small finger-like projection called appendix is present. It is a vestigial organ. The undigested waste material is sent out through anus after absorbing water in the large intestine.

Liver, the largest gland of the body secretes bile juice containing bile salts which help in digesting and absorbing fat. Pancreas secretes pancreatic juice rich in enzymes for digesting starch, lipids, proteins.

DIGESTION OF CARBOHYDRATES

For herbivorous (plant-eating) animals, cellulose of plant food is the principal source of carbohydrates but vertebrates have no enzymes to digest cellulose. So, they have to depend on microorganisms like bacteria (symbiotic digestion) which live in their digestive tracts. Man subsisting on cereal grains, tubers etc. consumes carbohydrates mainly in the form of starch and also some disaccharides like sucrose and lactose.

Man secretes a starch-hydrolysing enzyme in saliva called salivary amylase or ptyalin. If we chew a piece of bread, it will taste sweeter after some time because starch is broken down into maltose (which is sweet) by ptyalin.

The gastric juice contains no carbohydrate-digesting enzyme. The pancreatic and intestinal juice digest carbohydrates in the small intestine. The pancreatic juice contains pancreatic Amylase, which hydrolyses the remaining starch into maltose. The enzyme Maltase hydrolyses maltose into glucose. Besides Maltase, intestinal juice contains sucrase and lactase, which convert sucrose and lactose into glucose.

Main Carbohydrates →

Starch (Polysaccharides)

Sucrose (Disaccharide)

Lactose (Disaccharide)

ptyalin or

Starch (30%) → Maltose (in mouth about 30%)

salivary amylase

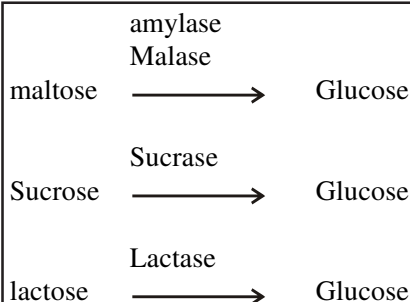
pancreatic

Starch → Maltose (in intestine)



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Note : Maltase, Sucrase, Lactase - secreted by Intestinal wall.

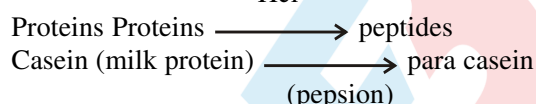
DIGESTION OF PROTEINS

Food proteins are ultimately broken down into amino acids by gastro-intestinal enzymes. Protein digestion starts in stomach. Gastric juice contains Hydrochloric acid (HCl) and pepsinogens. The inactive pepsinogen is converted into active pepsin by HCl. HCl provides Acidic pH in stomach for the action of pepsin on proteins. Pepsin hydrolyses proteins into peptones. Pepsin also hydrolyses casein (milk protein) into para casein.

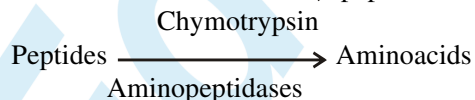
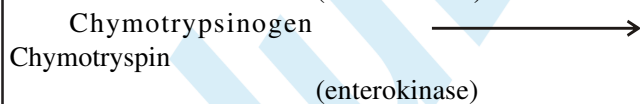
Pancreas secretes Trypsinogen and Chymotrypsinogen which are activated by enterokinase an intestinal juice and transformed them into active trypsin and chymotrypsin.

Trypsin acts best at alkaline pH- It is provided by Bile juice. Trypsin hydrolyses proteins into peptides. Amino peptidases of intestinal juice hydrolyse the peptides into amino acids.

The following reactions take place in stomach (acidic medium)



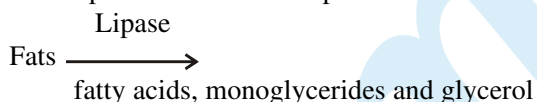
The following reactions take place in intestine (Alkaline Medium)



DIGESTION OF FATS

Lipases are enzymes for hydrolysing fats and oils. Lipases are soluble in water. Fats are largely digested in small intestine. Bile salts emulsify the fatty acids and these

emulsified fats are converted into monoglycerides by pancreatic lipase and intestinal lipase.



Absorption of digested food is taken up in villi of intestine either by simple digestion (passive absorption) or energy dependent (active absorption).

NOTE

End products of Carbohydrate — Glucose

End products of Proteins — Amino acid

End products of Fats — Fatty acids, glycerol monoglycerides.

NOTE

1 gram of Carbohydrate will yield 4k.cal of energy

1 gram of Protein will yield 5.65 to 4 k.cal of energy

1 gram of Fat will yield 9.45 k.cal of energy. NOTE

The excess glucose is converted into glycogen by liver. It is reconverted into glucose whenever the body needs.

VITAMINS

Vitamins are organic substances which are supplied through diet. A deficiency in the food produces deficiency symptoms.

There are 2 types of Vitamins

Water soluble vitamin - Vitamin 'B' complex and Vitamin 'C'

Fat soluble vitamin - A, D, E, K

RESPIRATION

Oxidation of nutrients releases their bond energy utilisation in the body. The released energy is temporarily stored in ATP.

In some lower organisms like bacteria, yeast, nutrients are oxidised without using oxygen. This process is called Anaerobic metabolism or fermentation.

In most of the animal tissue, oxidation is carried out by Aerobic Respiration. It is carried out in two phases.

(a) External respiration - uptake of oxygen and release of carbon dioxide into surrounding medium.

(b) Internal respiration - Oxygen uptake by tissues and tissue oxidation by enzymes and carbon dioxide elimination from tissue cells:

The mammalian respiratory system (Man) consists of the external nostrils, nasal cavity, Nasopharynx, larynx, Trachea, bronchi, bronchioles, and lungs.

Nasopharynx communicates with larynx through a long wide cartilaginous tube called trachea. Trachea runs through the neck in front of the oesophagus, enters the thorax and divides into right and left bronchi. They enter into elastic lungs and divide repeatedly into small bronchioles. This bronchiole opens into thin walled sac called "Alveoli". Each alveolus is supplied with blood capillaries. The pulmonary artery which is poor in



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oxygen and rich in carbondioxide supplies blood to the alveoli. The oxygenated blood (after exchange of gases) is returned to pulmonary veins.

Lateral walls of thorax (ribs and intercostal muscles), diaphragm (which separates thorax from abdomen) help in respiration by contracting and relaxing.

GAS TRANSPORT IN BLOOD

Most of the oxygen that enters into the blood is carried in chemical combinations in the erythrocytes or Red Blood Corpuscles (RBC). Oxygen combines loosely with Fe^{+2} (Iron). Ions of Haemoglobin thus form oxyhaemoglobin. This oxyhaemoglobin is carried to tissues and there molecular oxygen is released out. The carbondioxide (CO_2) produced in the tissues enters the RBC by diffusion, reacts with water to form carbonic acid (H_2CO_3). On reaching the lungs, blood is oxygenated. Here H_2CO_3 cleaved into water and CO_2 and this CO_2 is removed from the lungs during expiration.

CIRCULATORY SYSTEM

All parts of the body require nourishment and oxygen and metabolic wastes need to be removed from the body. This is carried out by blood through circulatory system.

HEART

It is a pumping organ of the blood vascular system. It is a hollow muscular organ made of cardiac muscles. It consists of chambers, the chamber which receives blood is called Auricle and from there it goes to ventricle and it gives out blood to the lungs and body parts.

The Human heart is situated in the thorax between the lungs. It consists of two auricles and two ventricles. The deoxygenated blood from body parts is received in right auricle. The left atrium or auricle receives oxygenated blood from lungs. The two auricles open into the respective ventricles. The right ventricle which receives deoxygenated blood pumps into the pulmonary arteries, from there it goes to lungs for purification. The left ventricle which receives oxygenated blood from left Auricle pumps to all body parts.

The contraction and relaxation of cardiac Chambers are respectively known as systole and diastole. The systolic and diastolic pressure of a normal human being is 120/80. The difference between systolic and diastolic pressure is called the "Pulse Pressure"

The Human heart beats at the rate of 70 per minute in the resting condition. Heart beat results from a wave of electrical potential called cardiac impulse spreading over the cardiac chambers. The impulse is myogenic in origin. It originates from cardiac muscle tissue that is from the "Sinoatrial Node". In mammals it is called "Pace Maker" of the heart because it determines the rate of heartbeats.

Circulations of blood from the left ventricle to the tissues and back to the right atrium is called the

"systematic circulation", the circulation from the right ventricle to the lungs and back to the left atrium is called "Pulmonary Circulation". Some times a vein returning blood from capillaries breaks again into second set of capillaries in a tissue to form a "Portal systems". For example a hepatic portal vein returns blood from the intestine and; breaks into a portal system of capillaries in the liver. This enables the liver cells to take up from the portal blood, nutrients brought by it from the small intestine.

Blood flow is maintained in the veins largely, by the compression of veins by contracting muscles. The valves located in veins allow blood to flow in a single direction to the heart, and block any reverse flow.

LYMPH

In the spaces between the cells of a tissue there occurs a fluid called the Interstitial fluid. Under the pressure of blood, in the capillaries, some of the water and dissolved solutes are filtered out from blood plasma into tissue spaces to form the tissue fluid. The composition of the fluid is similar to plasma except proteins. This is because the plasma wall is impermeable to plasma proteins. This fluid enters into tiny channels called lymph channels; and the fluid collected in them is called Lymph. They ultimately drain into two large lymph vessels open into veins. Thus, it combines with general circulatory system.

BLOOD

Blood is a fluid connective tissue composed of blood cells, blood platelets and an extra cellular fluid called plasma. Blood is slightly alkaline and the volume of blood in an adult person is about 5 litres.

Plasma

It is a viscous aqueous solution containing many organic and inorganic substances. Plasma contains 92% water and 8% solids. The solutes include glucose, amino acids, fatty acids, vitamins, enzymes, hormones, antibodies, oxygen, carbondioxide, and waste products such as urea, uric acid and creatinine.

Plasma contains 3 types of proteins namely albumin, globulin, and fibrinogens. Albumin and globulins retain water with their osmotic effects. Also they transport substances like thyroxine and iron ions.

Immunoglobulins, a class of globulins act as Antibodies which inactivate invading microorganisms.

Erythrocytes (Red Blood Corpuscles)

They are numerous in blood. They contain haemoglobin. [The red, oxygen carrying pigment] Mature RBC are dead cells. The entire volume of RBC is filled with Haemoglobin. In the foetus, RBC are mainly formed in the liver and spleen but in adults, RBC are formed from bone marrow. RBC have an average life span of 120 days.

Old and damaged RBC are phagocytosed (eaten away by macrophages). The haemoglobin is catabolised



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into the yellow pigment called Bilirubin which, is excreted in bile. The skin and mucous membranes of eyes assume a yellowish colour, if all the bilirubin cannot be excreted from the body. This condition is called Jaundice.

LEUCOCYTES OR WHITE BLOOD CORPUSCLES (W.B.C)

These are nucleated, colourless. Some of them possess cytoplasmic granules (called as granulocytes) and some do not possess granules (Agranulocytes)

Neutrophils and monocytes, of W.B.C protect the body against microbes by phagocytosing them. Lymphocytes of W.B.C secrete antibodies in the blood.

BLOOD PLATELETS OR THROMBOCYTES

They are non-nucleated, biconvex disc like bodies. Their life span is about a week. When any blood vessel ruptures, platelets get clumped at the injured spot and release certain chemicals called platelet factors. It promotes blood coagulation.

BLOOD COAGULATION

When a blood vessel ruptures a gel sets in within minutes. It is called coagulation. It is brought about by hydrolysis of soluble fibrinogen into insoluble fibrin. It is catalysed by Thrombin enzyme.

The network of fibrin traps blood cells particularly RBC to form a red solid mass called the blood clot. The clot stops bleeding. The straw coloured fluid left after clotting is called Serum.

Blood normally contains an anti coagulant 'Heparin' which prevents the activation of prothrombin which is an inactive globulin of thrombin.

EXCRETION

Excretion is the elimination of waste products from the body. Large volume of carbon dioxide (CO_2) and water are produced by the metabolism of carbohydrates, fats, and proteins. CO_2 is easily eliminated as a gas by respiration. The by products of metabolism have to be eliminated from the body in aqueous solution. Principles among them, are Nitrogenous substances like Ammonia, Urea, Uric Acid. All these are end products of protein metabolism.

KIDNEY

The mammalian urinary system consists of two kidneys which form the Urine, two ureters which conduct the urine from kidneys to the urinary bladder (for storage of urine) and urethra, through which the urine is sent out by urinary bladder. The kidney contains many minute tubular Nephrons which form urine.

Accessory excretory organs include skin which excretes water and sodium chloride in the Sweat and small amounts of lipids and sterols in the sebum (secreted by sebaceous glands located in the skin in order to soften the skin).

Note : Basic unit of Kidney - Nephron

LOCOMOTION

Movement is an important characteristic feature of living organisms. It distinguishes the plants from animals. Most animals have developed contractile muscle fibres for carrying out the movements and this muscle contraction moves bones of the skeleton like levers to produce body movements.

Skeleton also forms the supporting framework for the body and protects its softer internal organs. It is made up of calcium and phosphorus and houses the red bone marrow where the blood cells are formed.

Joints are the structures where two bones are fitted to each other. According to the mobility, joints are of three types

- (a) Fixed or fibrous joints where dense bands of fibrous tissue held firmly together Eg: Skull bones.
- (b) Slightly movable or cartilaginous joints which are seen in vertebral column. Here limited movement is possible.
- (c) Movable or Synovial joints where articulating bones move upon each other. Here articulating surface is covered with hyaline cartilage and a viscous slippery synovial fluid fills the space between these cartilages and lubricates the joints. These synovial joints are of two types
 - i) Ball and socket joints - Shoulder and Hip Joints.
 - ii) Hinge Joints - Elbow joint, ankle, knee joint.

Each muscle fibre requires a specific minimum intensity of nerve impulse or stimulus for stimulation. This is called muscle twitch. If a muscle is in a continued state of contractions caused by many repeated stimuli, then it is called 'Tetanus'.

Note : Fatigue occurs on repeated contraction of muscle due to the accumulation of lactic acid

NERVOUS SYSTEM

With the evolution of multicellularity, it is necessary to develop some system for coordinating the activities of numerous cells in the body. For such co-ordination information has to be exchanged between cells situated at a distance from each other. For co-ordination of all systems, nervous system has been developed.

In mammals, the nervous system consists of central nervous system (comprises brain & spinal cord) peripheral nervous system (course between the central nervous system & different parts of the body) and the 3rd one is, autonomous, nervous system (has connections with central nervous system). It works independently to regulate involuntary activities like heart beat etc.

Both brain & spinal cord are covered by connective tissue membrane called as Meninges. An extra cellular fluid called cerebro spinal fluid is present in the meninges-



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it affords some protection to the central nervous system, against injury & shock.

Brain is situated inside the cranium. The Brain is divided into Forebrain, Midbrain & Hind brain. The Hind brain continues into spinal cord.

Brain is easily differentiated into two regions. Grey matter containing nerve cells is situated on the surface and white matter containing nerve fibres located deep inside the brain.

The fore brain consists of CEREBRUM, the largest part of the human brain. The cerebrum consists of two central hemispheres joined by thick band of nerve fibres called "Corpus callosum". The surface of cerebrum shows many convulsions called "GYRI" separated by depression called "sulci".

At the base of the brain, Hypothalamus is present. It contains nerve centres for temperature regulation, hunger, thirst & emotional reactions.

Mid brain consists of many groups of nerve cells. Some of these are involved in controlling muscle tone etc. The Hind brain consists of a cerebellum which is concerned with maintenance of posture & equilibrium of the body and for the muscle tone.

The brain stem consists of pons, medulla oblongata. It is the centre for controlling respiratory centers, vaso motor centers, salivary centers etc. Medulla oblongata continues into spinal cord.

Spinal cord is a cylindrical cord like structure situated in vertebral column. From the lateral sides spinal nerves emerge & go to supply the peripheral tissue. The nerves coming out from different parts of the brain are called 'cranial' nerves.

The peripheral nervous system includes the nerves running outside the central nervous system. Each nerve is composed of many fibres enclosed in a connective tissue sheath.

Neuron is the basic unit of nervous system. Nerve fibres carry nerve impulses in a relay. The junction between two neurons is called "SYNAPSE". Basically a neuron consists of a cell body, long axon and a short, profusely branched dendrites. The axon is covered with myelin sheath. The axon of one neuron attaches with dendrites of other neuron.

The axon terminal contains membrane bound vesicles called synaptic vesicle in its cytoplasm. In this chemical substances like adrenaline & acetyl choline remain stored. When a nerve impulse passes the axon terminal, the synaptic vesicle releases stored chemicals. The chemicals diffuse through synaptic cleft & reach the membrane of next neurons. This causes the nerve impulse to be transmitted along the next neuron.

EYES

Eyes are the sense organs of vision. They contain 2 types of photoreceptors called rods & cones. These cells,

convert the energy of specific wave lengths of light into action potentials of nerve fibres.

Eye ball is spherical & is located in ORBIT. It is capable of movement with the help of recti & oblique muscles. Wall of the eye ball consists of 3 layers, the outer opaque sclerotic coat but in front side of the eye it becomes transparent CORNEA. It is covered externally in a thin membrane called CONJUNCTIVA.

The middle choroid coat supplied with blood vessels in the front side it is continuous with a muscular curtain called 'IRIS'. In the center of the Iris there is "small opening called PUPIL.

Retina is the innermost layer which is specialised for receiving the image. It consists of rods and cones named according to their shapes. Optic nerve is formed by the union of all the sensory cells of the retina.

Lens is behind the Iris. It divides the eye ball into two chambers anterior aqueous chamber & posterior vitreous chamber. Former is filled with water fluid & the latter is filled with jelly like fluid called vitreous humor.

Blind spot is a spot on the retina where optic nerve enters the eye ball and slightly, above it, an acute vision spot is present called Fovea centralis. There is presence of Lacrimal glands which secrete watery substance in order to lubricate the eye.

Light rays from an object pass through cornea & aqueous humor. The intensity of light is regulated by pupil. It contracts in strong light and vice versa. Light rays passing through the lens fall on Retina. The sensory cells of Retina (Rods & Cones) are stimulated and the light impulses are converted into nervous impulses which are received by the brain through optic nerve.

Comparison of eye with a Camera :

Eye ball	Camera
Retina	Photographic film
Convex Lens	convex lens.
Pupil	diaphragm.

ENDOCRINE SYSTEM

Endocrine glands are ductless glands which secrete hormones. This is secreted into the blood which distributes all over the body. Hormones are secreted in response to changes, in the environment inside and outside the body. There is a co-ordination between nerves & hormones. The synthesis and release of hormones is regulated by nerves.

PITUITARY GLAND

There are several Endocrine glands spread over the body. Among them the most important one is pituitary gland. It is termed as a master gland because it controls the remaining Endocrine glands. Pituitary is situated in Hypothalamus of the Brain.

The anterior Pituitary secretes growth hormone Thyrotropin which stimulates body growth.



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Corticotropins secreted by pituitary gland stimulates the Adrenal cortex (Present in Kidney) to secrete glucocorticoid hormones. Follicle stimulating hormone, & Luteinising hormones of pituitary regulate the gonads and finally Prolactin increases milk secretion.

The posterior Pituitary, releases vasopressin which increases renal reabsorption of water from the urine to make it hypertonic (high concentrated) & also increases the Blood pressure by constricting arterioles.

Oxytocin, another hormone contracts the smooth muscles of uterus. (useful in Pregnancy)

THYROID

Gland situated in the neck close to the trachea secretes thyroxine. It enhances metabolic rate and promotes body growth. Failure of thyroid secretion, produces cretinism in young age and Myxedema in adults. The excess of thyroid hormone leads to Graves disease. (Bulging of eye balls)

PARATHYROID

Parathyroids are 4 small glands situated very close to thyroid, secrete Parathormone which increases blood calcium level by increasing the mobilisation of bone calcium and renal reabsorption of calcium from the urine. The deficiency of parathormone leads to muscle cramps or tetanus.

ADRENALS

Adrenals are two conical pyramid shaped glands. Each adrenal is made up of outer layer called Adrenal cortex and a central portion called Adrenal Medulla. Adrenal cortex secretes:

- (a) Mineralo Corticoids which increase the retention of Na⁺ ions in the body & elimination of K⁺ ions from the body.
- (b) Glucocorticoids regulate Metabolism of Carbohydrates, Proteins & Fats.
- (c) Sex Corticoids develop external male sex characters. Adrenal medulla secretes Adrenalin and nor-adrenalin. They act on heart beat, blood pressure etc.

PANCREAS

Pancreas is situated along with the liver at duodenum it also secretes hormones in addition to the enzymes for digestion. The hormones Insulin and glucagon are secreted by Islets of Langerhans. Insulin lowers the blood sugar by increasing the utilization of glucose in the tissues. Its deficiency produces a disease called DIABETES MELLITUS with high blood sugar, usually excreted in the Urine. On the contrary glucagon increases the blood sugar level. Whenever the blood sugar level drops glucagon is produced & released which converts the glucagon into glucose.

GONADS

The GONADS, testes in males and ovaries in females secrete hormones which control reproductive organs. The hormones are collectively called sex hormones. Male sex hormone Testosterone is secreted by testis. It stimulates growth and secondary male sex organs. Failure of testosterone results in undeveloped external sex hormones.

Female sex hormones are of two types Estrogens and Progesterone. The ovary contains numerous sacs called ovarian follicles each with a mature ovum. Cells of a mature ovarian follicle, called Granulosa follicle, secrete estrogen. This is activated by follicle stimulating hormone of anterior Pituitary

These estrogens are responsible for development of sex organs & external sex characters and another hormone progesterone is responsible for pregnancy changes in female sex organs.

REPRODUCTION

Reproduction is an important characteristic of living Organisms in order to propagate its species, (ie) maintains continuity of the species.

The male reproductive system of human beings consists of 2 testes, suspended in the pouch of 'scrotum', a paired duct system consisting of epididymis, vas deferens, ejaculatory duct, and male urethra and secondary sex organs including prostate, two seminal vesicles, two Cowper's glands and a penis.

Testes form sperms and secrete testosterone. Prostate, Cowper's glands secrete fluid which mixes with sperms to form the semen.

The female reproductive system consists of 2 ovaries and a duct system of two fallopian tubes, a uterus and a vagina. Ovaries produce ova and secrete estrogens & progesterones. The fallopian tubes conduct the ova towards the uterus. The uterus lodges the growing foetus and opens to the exterior through the VAGINA.

The menstrual cycle consists of cyclic changes in the reproductive tract of primate female culminating into a menstrual flow of blood from the vagina. It consists of two phases.

In the first phase, growth and proliferation of tissues on the walls of uterus, fallopian tubes and vagina.

The ovum ejected from the follicle near the end of the 1st phase (proliferative phase). The ruptured follicle changes into a corpus luteum which secretes progesterone in the second phase, the uterine walls grow further and the glands secrete a fluid in the uterus. If the ovum is fertilized with a sperm, it leads to pregnancy. If fertilisation of eggs does not take place, uterus simply degenerates, progesterone secretion stops. The uterus breaks down and menstruation takes place.

