Human Body Systems

Digestion and Absorption

(i) Process of conversion of complex food substances to simple absorbable forms is called digestion.

(ii) Intracellular: When the process of digestion occurs within the cell in the food vacuole.
Examples:

Protozoa, Porifera, Coelenterata and free living Platyhelminthes

(iii) Extracellular: When the process of digestion occurs outside the cell, **Examples:** Coelenterates and phylum Platyhelminthes to phylum Chordata.

(iv) Digestion in vertebrates occurs in the digestive tract or alimentary canal. The various parts involved in digestion can be broadly grouped in two groups –

(1) Digestive tract or alimentary canal

(2) Digestive glands

On the basis of the embryonic origin, the alimentary canal of vertebrates can be divided into three parts–

(1) Fore gut / Stomodaeum: Ectodermal. It includes buccal cavity / oral cavity, pharynx, oesophagus, stomach and small part of duodenum.
(2) Mid gut/Mesodaeum: Endodermal. It includes small intestine, and large intestine.
(3) Hind gut/Proctodaeum: Ectodermal. It includes anal canal and anus.

Human Digestive System

The human digestive system is a complex series of organs and glands that processes food. It converts ingested food so that it can be assimilated by the organism. The human digestive system consists of following parts:-

Mouth

Mouth is also known as the oral cavity or buccal cavity. It is the first portion of the alimentary canal. Food and saliva are received by mouth. Mouth has inner lining of mucous membrane epithelium.

Digestive Glands: -

(A) Salivary glands:-

(i) These are the exocrine glands that produce saliva.

(ii) These are the glands with ducts which also secrete amylase.

(iii) Amylase is an enzyme that breaks down starch into maltose.

(iv) **Three types of salivary glands are: -**

1) Parotid gland
2) Submandibular gland
3) Sublingual gland

(B) Gastric glands:-

(i) The gastric glands (fundic gland) secrete acids and digestive enzymes.

(ii) Secretion of gastric gland is called gastric juice.

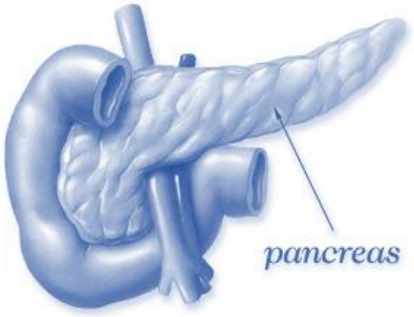
(iii) There are approximately 35 million gastric glands present in human stomach.

(C) Intestinal glands:-

(i) Intestinal glands in maamals is a collective name for **crypts of Liberkuhn** (secretes alkaline enzymatic juice) and **Brunner's glands** (secrete mucous).

(ii) Intestinal glands secrete **intestinal juice** or **sucus entericus.**

(D) Pancreas:-



(i) Pancreas has two different kind of tissue- exocrine and endocrine.

(ii) Pancreatic secretion is stimulated by **cholecystokinin** and **secret in** both.

(iii) Complete digestive juice is pancreatic juice as it contains amylolytic, lipolytic and proteolytic enzymes.

(iv) It produces several important hormones like insulin, glucagon, somatostatin and pancreatic polypeptide.

(E) Liver:-

(i) Liver is the **largest digestive gland of the body,** weighing about 1.2 to 1.5 Kg in an adult human.

(ii) It is situated in the abdominal cavity, just below the diaphragm and has two lobes (small left and large right lobe).

(iii) The liver has a wide range of functions to perform in the body:

a) It detoxifies various metabolites

b) It helps in protein synthesis.

c) Various biochemical necessary for digestion are produced by liver.

Pharynx: -

It is the opening of oral and nasal cavities. **It is classified as: -**

1) Nasopharynx
2) Oropharynx
3) Laryngopharynx

Oesophagus: -

Oesophagus connects pharynx with stomach.

Opening of oesophagus is regulated by **gastro-oesophageal sphincter.**

Stomach: –

It is a J-shaped, muscular, hollow and dilated part of the digestive system. It is located between the oesophagus and the small intestine. It has 1 liter capacity. It secretes protein-digesting enzymes (proteases) and strong acids which aid in food digestion.

The stomach has three parts:

Cardiac: The part of the stomach into which oesophagus opens.
Fundus: It is the air filled portion of stomach.
Pyloric: The portion of the stomach that opens into the small intestine

Breathing and exchange of gases

Pulmonary Volumes and Capacities

There are following respiratory volumes and capacity:

(i) **Tidal volume (TV)**: It is volume of air normally inspired or expired in one breath (i.e. inspiration and expiration) without any extra effort. It is about 500 ml in normal healthy adult. In infants it is 15 ml and in fetus it is 0 ml.

(ii) **Inspiratory reserve volume (IRV) :** By taking a very deep breath, you can inspire a good deal more than 500 ml. This additional inhaled air, called IRV is about 3000 ml.

(iii) **Expiratory reserve volume (ERV) :** If you inhale normally & then exhale as forcibly as possible, you should be able to push out 1200 ml of air in addition to 500ml. of T.V. The extra 1200 ml is called ERV.

(iv) **Residual volume (RV):** Even after expiratory reserve volume is expelled, considerable air remains in the lung, this volume, which cannot be measured by spirometry, and it is called residual volume is about 1200 ml.

(v) **Dead space**: Portion of tracheobronchial tree where gaseous exchange does not occur is called dead space. It is also called conductive zone. Dead space is 150 ml.

(vi) **Functional residual capacity (FRC):** It is the amount of air that remains in the lungs after a normal expiration. It is about 2300 ml.

FRC = ERV + RV

= 1100 + 1200 = 2300 ml.

(vii) **Vital capacity (VC):** This is the maximum amount of air that can be expired forcefully from his lungs after first filling these with a maximum deep inspiration. It is about 4600 ml.

VC = IRV + TV + ERV

= 3000+500+1100 = 4600 ml.

(viii) **Total lung capacity (TLC):** TLC is the sum of vital capacity (VC) and residual volume (RV). It is about 5800ml.

TLC = VC + RV

= 4600 + 1200 = 5800 ml.

(ix) **Inspiratory capacity (IC):** It is the total amount of air a person can inspire by maximum distension of his lungs.

I.C. = TV + IRV

= 500 + 3000 = 3500 ml.

Process of Respiration

The process of respiration is completed in 4 steps:

(i) Breathing or ventilation

(ii) Exchange of gases or External respiration

(iii) Transport of gases

(iv) Cellular respiration

(i) Ventilation or breathing:

Breathing is movement of thorax, expansion (inflation) and deflation of lungs and flow of air into the lungs and from the lungs. It is extracellular, energy consuming and physical process. Sum of inspiration and expiration is called respiratory movement. There are two steps of breathing:

(a) **Inspiration:** Intake of fresh air in lungs from outside. It is an active process. Blood pressure increases during later part of respiration.

(b) **Expiration:** Out flow of the air from the lungs is called expiration. When expiration occurs, the inspiratory muscles relax. As the external intercostal relax, ribs move inferiorly and as the diaphragm relaxes, its dome moves superiorly owing to its elasticity.

(c) **Mechanism of ventilation/breathing:**

(ii) **Exchange of gases:**

(a) **Exchange of gases in lungs:** It is also called external respiration. In this gaseous exchange oxygen passes from alveoli to pulmonary capillary blood and CO_2. Comes to alveoli from pulmonary capillary.

(b) **Release of CO_2 by the blood:** The PCO_2 (partial pressure of carbon dioxide) of blood reaching the alveolar capillaries is higher than the PCO_2 of alveolar air. Therefore, carbon dioxide diffuses from the blood of alveolar capillaries into the alveolar air.

(c) **Exchange of gases in tissues:** In the tissues, exchange of gases occurs between the blood and the tissue cells. This exchange occurs via tissue fluid that bathes the tissue cells. The blood reaching the tissue capillaries has PO_2 higher than that in the tissue cells and PCO_2 lower than that in the tissue cells.

(iii) **Transport of gases:** Blood carries O_2 from respiratory organs to the tissue cells for oxidation and CO_2 from tissue cells to respiratory organs for elimination. Blood should be slightly alkaline to help the transport of O_2 and CO_2 properly.

Difference between breathing and respiration

Breathing (Ventilation)	Respiration
It is a physical process.	It is a biochemical process.
It is simply an intake of fresh air and removal of foul air.	It involves exchange of gases and oxidation of food.
No energy is released rather used.	Energy is released that is stored in ATP.
It occurs outside the cells, hence it is an extra-cellular process.	It occurs inside the cells, hence it is an intra-cellular process.
No enzymes are involved in the process.	A large number of enzymes are involved in the process.
Breathing mechanism varies in different animals.	Respiratory mechanism is similar in all animals.
It is confined to certain organs only.	It occurs in all living cells of the body.

Composition of three samples of air

For the control of respiration following respiratory centres are found in hind brain

Type of centre	Location	Function
Inspiratory centre	Medulla oblongata	Inspiration (2 second active condition)
Respiratory centre	Medulla oblongata	Expiration (3 second inactive condition)
Apneustic centre	Pons	Slow and deep inspiration
Pneumotaxic centre	Pons	Control other centres and produce normal quite breathing
Gasping centre	Pons	Sudden and shallow respiration

Oxygen content: Total volume of O_2 in 100 *ml*. of whole blood *i.e.* volume of O_2 in physical solution form and oxyhaemoglobin form. It is equal to 19.7 + 0.3 = 20 *ml* of oxygen.

Oxygen capacity: Maximal amount of O_2 that can be held by the blood at 760 *mm Hg* pressure and 37^0C. Oxygen capacity is about 20 *ml*/100 *ml.*

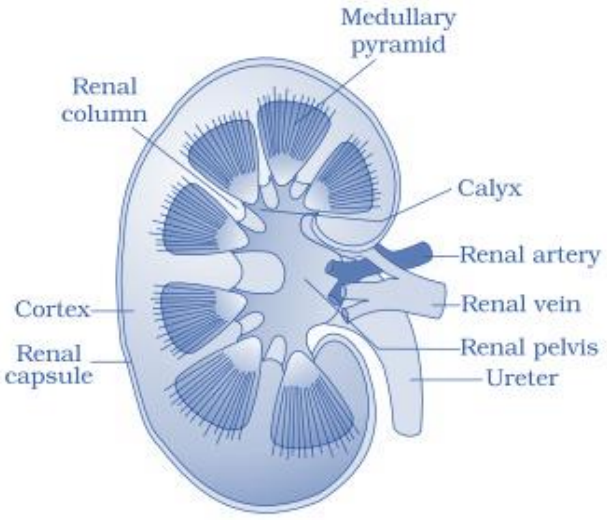
Excretory products and their Elimination

Excretion is the process by which waste products of metabolism and other non-useful materials are eliminated from an organism

Excretory system of man

Mammalian (human) urinary system consists of a pair of kidneys, a pair of ureter, a urinary bladder and a urethra.

(i) Kidneys : The kidneys are dark-red, bean-shaped organs about 11 *cm* long, 5 *cm* wide and 3 *cm* thick, each weight about 150 *gm* in an adult male and about 135 *gm* in adult female.



Differences between cortical and Juxtamedullary nephrons

Cortical Nephrons	Juxtamedullary Nephron
1. Form 80% of total nephrons.	1. Form only 20% of total nephrons.
2. Are small in size.	2. Are large in size.
3. Lie mainly in the renal cortex.	3. Have Bowman's capsules in the cortex near its junction with the medulla.
4. Henle's loops are very short and extend only a little into the medulla	4. Henle's loop are very long and extend deep into the medulla.
5. Control plasma volume when water supply is normal.	5. Control plasma volume when water supply is short.

(ii) **Ureters:** From the hilum of each kidney emerges a whitish tube the ureter. The ureters are about 28 *cm* long. Their wall consists of transitional epithelium surrounded by a layer of muscle fibres. Openings of the two ureters in the bladder are separate, but closely placed. These are oblique, so that the urine cannot regurgitate into the ureters when the bladder contracts. Peristalsis of ureters also cheeks regurgitation of urine.

(iii) **Urinary bladder and Urethra:** The urinary bladder is pear-shaped which is made up of smooth and involuntary muscles. The muscles are also known as detrusor muscles (muscles that has the action of expelling a substance). The lower part or neck of the bladder leads into the urethra.

Differences between male and female urethra

Male urethra	Female urethra
1. It is about 20 cm long.	1. It is just 3 – 5 cm long.
2. It has 3 regions : prostatic urethra (3–4 cm), membranous (1 cm) and penial (15 cm)	2. It is not differentiated into regions.
3. It opens out at the tip of the penis by urinogenital aperture.	3. It opens into the vulva by urinary aperture.
4. It carries urine as well as semen to the exterior.	4. It carries only urine to the exterior.
5. It has 2 sphincters.	5. It has a single sphincter.

Physiology of Excretion

Major nitrogenous excretory substance in frog, rabbit and human is urea, i.e. these are ureotelic animals. The excretory physiology in these animals may be considered under two phases, viz urea synthesis and formation and excretion of urine.

(i) **Synthesis of urea in liver:** Urea is formed in liver by two processes.

(a) Deamination

(b) Ornithine cycle

(ii) **Urine formation:** Urine formation occurs in the kidneys. It involves three processes glomerular filtration, reabsorption and tubular secretion.

(iii) **Mechanism of urine concentration (Counter current mechanism of urine concentration) :** Mammals form hypertonic urine. The urine is made hypertonic with the help of counter current multiplier system. This process takes place in the Henle's loop and vasa recta and it involves mainly Na^+ and Cl^-. In P.C.T. urine is isotonic. The descending limb of loop of Henle is permeable to water. Its surrounding tissue fluid is hypertonic. Hence, the water moves out and the Na^+ and Cl^- move in the descending limb by passive transport. Therefore, the filtrate in the descending limb finally becomes hypertonic.

Summary of events occurring in a nephron

Materials transferred	Nephron region	Process involved	Mechanism
1. Glucose, Amino acids, Vitamins, Hormones, Na^+, K^+, Mg^{2+}, Ca^{+2}, H_2O, Urea, Uric Acid, Creatinine, Ketone Bodies.	Bowman's capsule	Glomerular filtration	Ultrafiltration
2. Glucose, Amino Acids, Hormones, Vitamins, Na^+, K^+, Mg^{2+}, Ca^{+2}	Proximal convoluted tubule	Reabsorption	Active transport
3. Cl^-	Proximal convoluted tubule	Reabsorption	Passive transport
4. Water	Proximal convoluted tubule	Reabsorption	Osmosis
5. Urea	Proximal convoluted tubule	Reabsorption	Diffusion
6. H_2O	Narrow region of descending limb of Henle's loop	Reabsorption	Omosis
7. Na^+,K^+,Mg^{+2},Ca^{+2},Cl^-	Narrow region of ascending limb of Henle's loop	Reabsorption	Diffusion

8.Inorganic ions as above	Wide part of ascending limb of Henle's loop	Reabsorption	Active transport
9.H_2O	Distal convoluted tubule, collecting tubule, collecting duct	Reabsorption with ADH Help	Osmosis
10. Na^+	Distal convoluted tubule, collecting tubule, collecting duct	Reabsorption with aldosterone help reabsorption secretion	Active transport
11. Urea	Last part of collecting duct	Reabsorption with aldosterone help reabsorption secretion	Diffusion
12. Creatinine, Hippuric Acid, Foreign substances	Proximal convoluted tubule	Reabsorption with aldosterone help reabsorption secretion	Active transport
13. K^+, H^+	Distal convoluted tubule	Reabsorption with aldosterone help reabsorption secretion	Active transport
14. NH_3	Distal convoluted tubule	Reabsorption with aldosterone help reabsorption secretion	Diffusion
15. Urea	Ascending limb of Henle's loop (Thin part)	Reabsorption with aldosterone help reabsorption secretion	Diffusion

Differences between Rennin and Renin

S.No.	Rennin	Renin
1.	It is secreted by peptic (zymogen) cells of gastric glands into the stomach.	It is secreted by specialised cells in the afferent arterioles of the kidney cortex.
2.	Its secretion is stimulated by food.	Its secretion is stimulated by a reduction of Na^+level in tissue fluid
3.	It is secreted as an inactive form prorennin which is activated to rennin by *HCl*.	It is secreted as renin.
4.	It is a proteolytic enzyme.	It is a hormone that acts as an enzyme
5.	It helps in the digestion of milk protein casein.	It converts the protein angiotensinogen into angiotensin.

Renin

(i) Waste products of protein metabolism

(a) **Amino acids:** These are end products of protein digestion absorbed into the blood from small intestine. Certain invertebrates, like some molluscs (*eg Unio, Limnae, etc.*) and some echinoderms (*eg* Asterias) excrete excess amino acids as such. This is called aminotelic excretion or aminotelism.

(b) **Ammonia:** In most animals, excess amino acids are deaminated, i.e. degraded into their keto and ammonia groups. The keto groups are used in catabolism for producing ATP, whereas ammonia is excreted as such or in other forms.

(c) **Urea:** This is less toxic and less soluble in water than ammonia. Hence, it can stay for some time in the body.

(d) **Uric acid:** Animals living in dry (arid) conditions, such as land gastropods, most insects, land reptiles (snakes and lizards), birds *etc* have to conserve water in their bodies.

(f) **Guanine:** Spiders typically excrete their ammonia in the form of guanine. Some guanine is also formed in amphibians, reptiles, birds and earthworms. It is insoluble in water. Hence, no water is required for its excretion.

Differences between ammonotelism, ureotelism and uricotelism

S.No.	Ammonotelism	Ureotelism	Uricotelism
1.	Means excretion of nitrogenous waste mainly as ammonia.	Means excretion of nitrogenous waste mainly as urea.	Means excretion of nitrogenous waste mainly as uric acid.
2.	Uses very little energy in forming ammonia.	Uses more energy in producing urea.	Uses far more energy in producing uric acid.
3.	Its product is very toxic.	Its product is less toxic.	Its product is least toxic.
4.	Causes considerable loss of body's water.	Causes less loss of body's water.	Causes least loss of body's water
5.	Occurs in aquatic animals.	Occurs in aquatic as well as land animals.	Occurs in land animals.
6.	Examples: *Amoeba, Scypha, Hydra, Earthworm, Unio, Prawn, Salamander, Tadpole or frog, bonyfish*.	Examples: Earthworm, Cartilaginous fishes, frog, turtles, alligators, mammals (man).	Examples: Insects, land crustaceans, land snails, land reptiles birds.
7.	Animals excreting NH_3 are called ammoniotelic.	Animals excreting urea are termed uroetelic.	Animals excreting uric acid are called uricotelic.

Body movements and Locomotion

Types of Bones and their Description

Name	No.	Description
Frontal	1	Forms the forehead (anterior or front part of the top of cranium) and some upper parts (roofs) of eye orbits or sockets and nasal cavities. A newborn infant displays a faint suture in midline of frontal, indication that adult frontal is actually formed of two completely fused frontal.
Parietals	2	Articulated to and situated just behind frontal. Form the main parts of bulging top and sides of cranium.
Occipital	1	Articulated to and situated just behind parietals. Forms posterior (back) and lower (base) parts of cranium. Foramen magnum is a large perforation in this bone. On each side of the foramen, the occipital bears a prominent elevation called occipital condyle. The condyles articulate the skull with first vertebra (atlas). Thus, human skull is dicondylic.

Temporals	2	Form lower parts of right and left sides of cranium, as well as, the floor of cranial cavity. These house structures of internal and middle ears and form a part of external auditory meatuses. The middle ear of each side encloses the three small ear ossicles – malleus, incus and stapes.
Sphenoid	1	A typically butterfly-shaped bone that forms the middle and anterior parts of base of cranium in front of occipital in the middle and temporals on the sides. It articulates with all skull bones, keeping these firmly together. It also forms parts of lateral walls and floors of eye orbits.
Ethmoid	1	A small, irregular bone in front of sphenoid and behind nasal bones. It fashions the front (anterior) extremity and closer of cranial cavity. It also contributes to the architecture of eye orbits and proximal parts of nasal chambers.
Nasals	2	Small, oblong bones in middle of upper part of face, forming proximal part of the bridge of our nose. The remaining, lower part of our nose is formed of cartilage.
Inferior nasal conchae (Turbinales)	2	Two highly coiled, scroll-like processes of ethmoid bone, called conchae project into each nasal cavity from lateral wall of the proximal bony part of concerned nasal chamber. One ethmoidal concha is superior (uppermost). The other one is called middle concha, because it is followed by a thin, separate scroll-like bone which is named inferior nasal concha or turbinate.
Vomer	1	A thin, elongated, platelike bone, forming a part of the septum which separates the two nasal cavities.
Lacrimals	2	Small and thin, finger-shaped bones, each located in front part of the medial (inner) side of corresponding eye orbit. these form a part of the passages of corresponding tear ducts.
Zygomatics (Malars)	2	Cheek-bones; form the prominences of our cheeks and parts of the floor and side walls of eye orbits.
Palatines	2	L-shaped bones that form the back (posterior) part of our hard palate (roof of mouth). Also contribute to the framework of nasal cavities and floor of eye orbits.
Maxillae	2	Large, upper jaw bones that form the major part of our face and upper jaw. Comprise entire front (anterior) part of our hard palate. Also contribute to the architecture of eye orbits and nose. Bear the teeth of upper jaw.
Mandible	1	Largest bone of our face, and strongest of all bones of the body. Forms entire lower jaw and bears all lower jaw teeth. Articulated with temporal bones of skull.

Difference between Thoracic and Lumbar vertebra

S.No.	Characters	Thoracic vertebra	Lumbar vertebra
1.	Neural spine	Long undivided and downward directed.	Short, flat and upward directed.
2.	Facet for ribs	Present on transverse process and centrum.	Absent.
3.	Transverse process	Club-shaped.	Thin and elongated.

Difference between Male and Female pelvis

S.No.	Characters	Male pelvis	Female pelvis
1.	Nature of bones of pelvic girdles	Heavier and longer	Lighter and smaller
2.	Sacrum	Less concave	More concave anteriorly
3.	Pelvis	Shallow, narrow and round	Deep, wide and funnel-shaped

Muscle Contraction

From excitation to contraction to relaxation, following occurs within a skeletal muscle:

(1) An electrical signal (action potential) travels down a nerve cell. This in turn causes to release a chemical message (neurotransmitter). This chemical message is released into a small gap between the nerve cell and muscle cell. This gap is called synapse.

(2) The neurotransmitter then crosses the gap. It binds to a protein (receptor) on the muscle-cell membrane which causes an action potential in the muscle cell.

(3) The action potential spreads along the muscle cell.

(4) The action potential enters the cell through T-tubule.

(5) The action potential opens gate in the muscle's calcium store.

(6) Calcium ions flow into the cytoplasm.

(7) Calcium ions bind to troponin-tropomyosin molecules. These are located in the grooves of the actin filaments.

(8) The sites on actin where myosin can form crossbridges are covered by the rod-like tropomyosin molecule.

(9) On binding calcium ions, troponin changes shape. It then slides tropomyosin out of the groove, exposing the actin-myosin binding sites.

(10) Myosin interacts with actin by cycling crossbridges. The muscle thereby creates force, and shortens.

(11) After the action potential has passed, the calcium gates close automatically.

(12)Calcium pumps remove calcium from the cytoplasm. These pumps are located on the sarcoplasmic reticulum.

(13)As the calcium gets pumped back into the sarcoplasmic reticulum, calcium ions come off the troponin.

(14)The troponin returns to its normal shape.

(15)Troponin allows tropomyosin to cover the actin-myosin binding sites on the actin filament.

(16)As no binding sites are available now, hence no crossbridges can form, and the muscle relaxes.

Note:-

(1) The activities of muscle contraction and relaxation require energy.

(2) Muscles use energy in the form of ATP. The energy from ATP is used to reset the myosin crossbridge head and release the actin filament.

(3) In order to make ATP, the muscles do the following:

(a) Breaks down creatine phosphate.

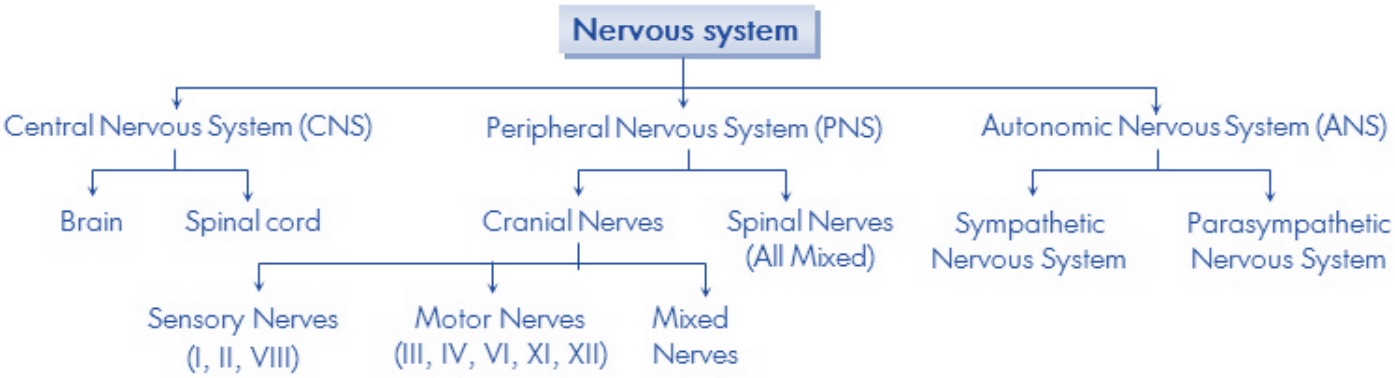
(b) Add phosphate to ADP to create ATP.

(c) Carry out anaerobic respiration, by which glucose is broken down to lactic acid and ATP is formed.

(d) Carry out aerobic respiration. Due to which glucose, glycogen, fats and amino acids are broken down in the presence of oxygen to produce ATP.

Neural Control and Cordination

Parts of nervous system



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Central nervous system:

(1) Central nervous system is made up of brain and spinal cord. CNS is covered by 3 meninges and its wall has two type of matter.

(2) Types of matter: CNS of vertebrates is formed of two types of matter –

(a) Grey matter: It is formed of cell-bodies and non-medullated nerve fibres.

(b) White matter: It is formed of only medullated nerve fibres which appear white due to presence of medullary sheath.

Brain (Encephalon): It is soft, whitish, large sized and slightly flattened structure present inside cranial cavity of cranium of the skull. In man, it is about 1200-1400 *gm* in weight and has about 10,000 million neurons. Brain is made up of 3 parts

(1) **Fore brain (Prosencephalon)**

(i) Olfactory lobe – Rhinencephalon

(ii) Cerebrum – Telencephalon

(iii) Diencephalon – Diencephalon

(2) **Mid brain (Mesencephalon)**

(i) Optic lobes – Mesencephalon

(3) **Hind brain (Rhambencephalon)**

(i) Cerebellum – Metencephalon

(ii) Medulla oblongata – Myelencephalon

Important areas in the human brain

Area	Location	Function
Premotor area	Frontal lobe	The highest centre for involuntary movements of muscles and ANS.
Motor area	Frontal lobe	Controls voluntary movements of the muscle
Broca's area	Frontal lobe	Motor speech area
Somesthetic area	Parietal lobe	Perception of general sensation like pain, touch and temperature
Auditory area	Temporal lobe	Hearing
Olfactory area	Temporal lobe	Sense of smell
Wernicke's area	Temporal lobe	Understanding speech written and spoken
Gustatory area	Parietal lobe	Sense of taste
Visual area	Occipital lobe	Sensation of light

Differences between Cerebrum and Cerebellum

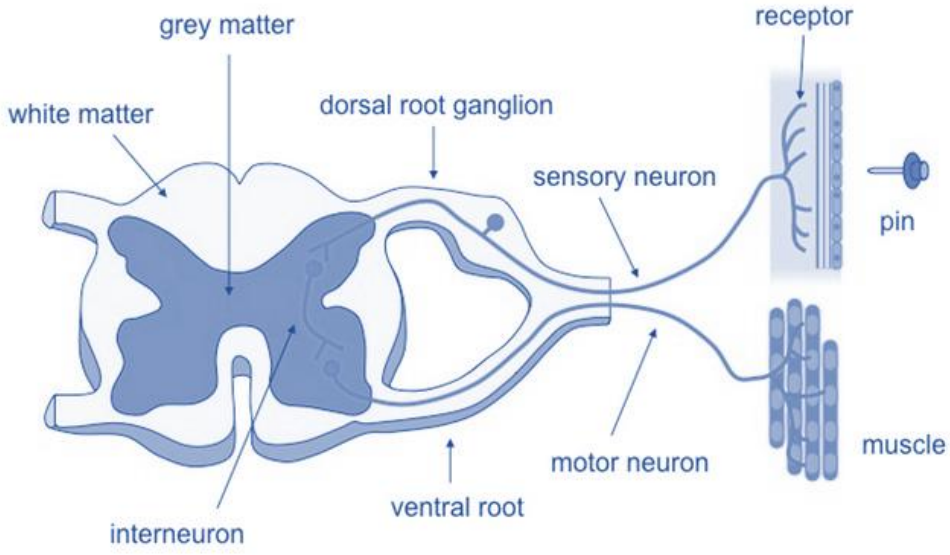
Cerebrum	Cerebellum
(1) It is the largest part of the brain, forming four-fifths of its weight.	(1) It is the second largest part of the brain, forming one-eighth of its mass.
(2) It covers the rest of the brain.	(2) It covers the medulla oblongata only.
(3) It is a part of the forebrain.	(3) It is a part of the hindbrain.
(4) It consists of 2 cerebral hemispheres each comprising 4 lobes : frontal, occipital, parietal, temporal.	(4) It consists of two cerebellar hemispheres and a median vermis.
(5) It encloses 2 lateral ventricles.	(5) It is solid.
(6) White matter does not form arbor vitae.	(6) White matter form arbor vitae.
(7) It initiates voluntary movements, and is a seat of will, intelligence, memory *etc*.	(7) It maintains posture and equilibrium.

Subdivisions, parts and associated structures of a vertebrate brain

Divisions	Subdivisions	Parts	Cavity	Associated strcutures
(I) Prosencephalon (Forebrain)	(1) Telencephalon	Rhinencephalon	I Ventricle (*Rhinocoel*)	Olfactory bulbs Olfactory tracts Olfactory lobes Palaeocortex on pallium
		Cerebral hemispheres	II or Lateral Ventricles	Corpora striata or basal ganglia Corpus callosum Neocortex on pallium Paraphysis
	(2) Diencephalon	Epithalamus (roof)		Habenulae Pineal apparatus Parapineal or parietal
		Thalamus (sides)		

		Hypothalamus (floor)		Hypothalamic nuclei Optic chiasma Median eminence Infundibular stalk Pituitary Saccus vasculosus Mamillary bodies Anterior choroid plexus
(II) Mesencephalon (Midbrain)	–	Crura cerebri (floor)	*Iter* or *cerebral aqueduct*	Cerebral peduncles
(III) Rhombencephalon (Hind brain)	(1) Metencephalon	Cerebellum		Trapezoid body Pons
	(2) Myelencephalon	Medulla oblongata	IV Ventricle (*Metacoel*)	Restiform bodies Pyramids

Reflex action



(1) The reflex actions are involuntary actions because these are not under the conscious control of the brain.

(2) The spinal cord and brain stem are responsible for most of the reflex movements.

(3) A few examples of the reflex actions are withdrawal of hand or leg if pricked by a pin, secretion of saliva as soon as one thinks of delicious food or mere its sight causes salivation, if the body

part is touched with acid or hot object it is automatically, without thinking and planning is withdrawn, cycling, motor driving etc.

(4) Component of reflex action: The whole of the reflex are includes six parts –

(a) Receptor organs: Receptors are windows of the body or guards of the body. These are situated on all, important organs, for example – eyes, nose, ear, tongue, integument etc. These perceive the stimuli from outside the body.

(b) Sensory neurons: These are also termed afferent neurons. These carry the stimuli from receptors to spinal cord. These neurons are situated in the ganglion on the dorsal side of spinal cord.

(c) Nerve centre: Spinal cord is termed as nerve centre. Synaptic connections are formed in it.

(d) Association neurons: These are also called intermediate neurons or interstitial neurons. These are found in spinal cord. They transfer the impulses from sensory neurons to motor neurons.

(e) Motor neurons: These are situated in the ventral horn of spinal cord. These carry the impulses to effector organs.

(f) Effector organs: These are the organs, which react and behave in response to various stimuli, for example – muscles and glands.

(5) Type of reflexes: The reflexes are of following types –

(a) Monosynaptic reflex

(b) Polysynaptic Spinal Reflex

(c) Polysynaptic Spinal/Brain Reflexes

(d) Unconditioned or Simple reflex

(e) Conditioned or Acquired reflex

Cranial nerves of mammal at a glance

Olfactory – sensory
Optic-sensory

Occulomotor (smallest nerve)-motor

Trochlear(pathetic)-motor

Trigeminal(dentists nerve) –mixed (a) Opthalmic-sensory (b)maxillary-sensory (c) mandibular-mixed

Abducens(shortest nerve)-motor

Facial-mixed

Auditory(vestibulocochlear)-sensory

Glossopharyngeal-mixed

Vagus(longest nerve)-mixed

Spinal accessory nerve-motor

Hypoglossal-motor

Chemical control and Coordination

Properties of hormones

(a) These are secreted by endocrine gland (biogenic in origin).

(b) Their secretions is released directly into blood (except local hormones *e.g.* gastrin).

(c) These are carried to distantly locate specific organs, called target organ.

(d) These have specific physiological action (excitatory or inhibatory). These co-ordinate different physical, mental and metabolic activities and maintain homeostasis.

(e) The hormones have low molecular weight *e.g.* ADH has a molecular weight of 600–2000 daltons.

(f) These act in very low concentration *e.g.* around10^{-10} molar.

(g) Hormones are non antigenic.

(h) These are mostly short-lived. So have a no camulative effect.

(i) Some hormones are quick acting *e.g.* adrenalin, while some acting slowly *e.g.* ostrogen of ovary.

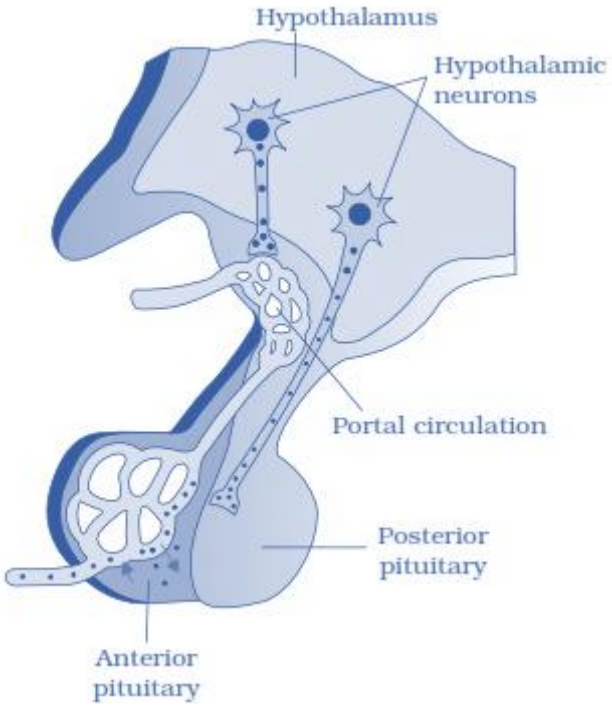
(j) Some hormones secreted in inactive form called Prohormone *e.g.* Pro-insulin.

(k) Hormones are specific. They are carriers of specific information to their specific target organ. Only those target cell respond to a particular hormone for which they have receptors.

Pituitary Gland (Hypophysis)

(1) Pituitory is known as hypophysis cerebri, its name pituitary was given by vesalius.

(2) Muller's gland of amphioxus and subneural gland of hardmania is homologous to pituitary of vertebrates.



Parts and component

(1) **Adenohypophysis (Anterior lobe)**

(i) Pars distalis

(ii) Pars tuberalis

(iii) Pars intermedia

(2) **Neurohypophysis (Posterior lobe)**

(i) Pars nervosa

(ii) Infundibulum

Hypothalamus

(i) **Position and Structure:** Hypothalamus is the floor of diencephalon. It is formed of masses of grey matter, called hypothalmic nuclei, containing neurosecretory cells. It is connected with anterior pituitary lobe by blood capillaries of hypophyseal portal system and with the posterior pituitary lobe by axons of its neurons, both passing through the pituitary stalk.

(ii) **Hormones of hypothalamus:** Neurosecretory cells of hypothalamus secrete neurohormones called releasing factors (RF) or inhibiting factors (IF). These neurohormones are carried by hypophyseal portal system to adenohypophysis (primary target organ) and stimulate or inhibit the release of trophic hormones from adenohypophysis. These neurohormones are proteinous in nature and formed of 3 – 20 amino acids.

Neurohormones of Adenohypophysis

Neurohormones	Physiological effects
(1) TSH-RF	
(Thyroid Stimulating Hormone – Releasing Factor)	Increased ACTH secretion from adenohypophysis.
(2) ACTH-RF	
(Adrenocorticotrophic Hormone-Releasing Factor)	Increased ACTH secretion from adenohypophysis.
(3) STH-RF	
(Somatotrophic Hormone-Releasing Factor)	Increased STH secretion from adenohypophysis
(4) SOMATOSTATIN (GROWTH INHIBITING HORMONE)	Decreased STH secretion from adenohypophysis.
(5) GTH-RF	
(Gonadotrophic Hormone-Releasing Factor)	
(i) FSH-RF	
(Follicular Stimulating Hormone-Releasing Factor)	Increased FSH secretion from adenohypophysis.
(ii) LH-RH (In female)	
(Luteinising Hormone – Releasing Factor)	Increased LH secretion from adenohypophysis.
or ICSH-RF (In male)	
(Interstitial Cells stimulating Hormone-Releasing Factor)	
(6) Prolactin-Releasing hormone (P-RH)	Increased secretion of prolactin or leutotrophic hormone.
(7) Prolactin-Inhibiting hormone (P-IH)	Increased secretion of prolactin or leutotrophic

	hormone.
(8) MSH-RF	
(Melanophore Stimulating Hormone-Releasing Factor)	Increased MSH secretion from intermediate pituitary lobe.
(9) MIF	
(Melanophore Inhibiting Factor)	Decreased MSH secretion from intermediate pituitary lobe.

List of hormones their chemical nature and functions

Name of endocrine gland	Name of hormone and its chemical nature	Functions
(1) Neurosecretory cells of Hypothalamus (Supraoptic Nucleus and Paraventricular Nucleus)	(1) Oxytocin and vasopressin nanopeptide.	(1) Milk ejection and parturition (oxytocic effect). (2) Vasoconstriction and antidiuretic (vasotocin) effects.
	(2) Gonadotropin releasing hormones	Stimulates FSH and LH sysnthesis.
	(3) Other releasing hormones *e.g.*TSHRH, MSHRH, ACTHRH, GHRH etc. Proteinaceous	Stimulate TSH, MSH, ACTH GH secretions from pituitary.
(2) Pituitary **(a) Neurohypophysis (Pass Nervosa)** **(b) Adenohypehypsis (contains diverse cell types)**	Store and release Oxytocin and Vasopressin.	Hormone release is related to physiological state and requirements.
	Proteincaceous or glycoprotein	Affect growth, development differential pubertal changes and other metabolic mechanism.
(3) Pineal	Melatonin-derived from the amino acid tyrosine	(1) Antagonist to FSH / LH (2) Regulates biological / circadian rhythms.
(4) Thyroid gland (amine	(a) Thyroxine, iodinated	(a) Controls basal metabolic rate (BMR). All organ /

hormone) having – NH_2 group)	amino acid called tyrosine (T_2, T_3, T_4).	system of body respond to thyroxine.
	(b) Thyrocalcitonin (Peptide)	(b) Facilitates Ca^{+2} absorption
(5) Parathyroid gland	Parathormane, Peptide	Ca^{+2} and PO^{-4} metabolism.
(6) Thymus	Thymosine (polypeptide)	Anti-FSH and LH; delays puberty
(7) Islets of lengerhans **(= Endocrine pancrease)** **(i) a-cells** **(ii) b-cells** **(iii) d-cells**	(i) Glucagon (ii) Insulin (iii) Secretin Isolated by banting polypeptide	(i) Gluconeogenesis / Glycogenolys (ii) Glycogenesis (iii) Gastric functions
(8) Adrenal gland **(a) Adrenal medulla** **(Amine hormone have – NH_2)**	(a) Catecholamines (epinephrine = adrenaline, and norepinephrine = noradrenaline (derived from tyrosine)	(a) Stresses = emergency = Fright, Fight and Flight Hormone (3F) acclerates cardiac functions muscle activity etc.
(b) Adrenal cortex	(b) Mineralcorticoids and glucocorticoids and traces of androgen and estrogen steroids derived from cholesterol	(b) Electrolyte and carbohydrate metabolism.
(9) Ovary **(a) Ganulosa cells steroid, fat soluble have sterol group derived from cholesterol**	Estrogen (Steroid) Estrone, estradiol	(a) Secondary sex character primary action on uterine endometrium mitogenic.
(b) Corpus luteum	Estrogen and Progesterone (Steroid)	(a) Secreted during luetal phase of menstrual cycle in human female and oestrous cycle of other mammals. Prepares uterine endometrium for receiving blastocytes for implantation. Progesterone is also called pregnancy hormone and is anti-FSH and anti-LH/anti-LTH.
(c) Placenta temporary endocrine gland formed	(a) Steroid secreted are estrogen and progesterone	(a) Maintenance of pregnant state prevents lactogenesis folliculogenesis, and Ovulation.

during pregnancy	(b) Relaxin-Polypeptide	(b) Act on pubic symphysis and enlarges the birth canal to facilitate birth. Acts synergestically with oxytocin during this process (parturition)
(10) Testis **(i) Sertoli cells** **(=sustentacular cells)**	Inhibin – Polypeptide	Inhibits FHS action and attenuates spermatogenesis decrementally
(ii) Leydig cells **(=Interstitial cells)**	(ii) Estradiol-Steroid Androgens (e.g. Testosterone) Steroid androstenedione)	(i) Pubertal changes in male (ii) Secy. sex characters in male (iii) Sex drives (iv) Spermatogenesis
(11) Gastro-intestinal hormones (secreted by cells of mucosa of stomach and intestine) also called hormones		Stimulates gastric juices secretion from gastric gland, movement of sphincters of stomach and increased movement of stomach
(a) Pyloric stomach (Argentophil cells) Intestine	Gastrin (i) Secreten (ii) Cholecystokinin (CCK) (iii) Enterogastrone (iv) Duedocrinin (v) Enterokinin (vi) Villikrinin	(i) Stimulates secretion of succus entericus (ii) Bile released from gall bladder (iii) Inhibits gastric secretin (iv) Stimulates secretion of mucous from Brunner's gland (v) Stimulate intestinal gland (vi) Stimulate villi movement

Circulation

Circulatory System

Functions of Circulatory System

(1) Transport of various substances such as nutrients, waste products, respiratory gases, metabolic intermediates (Such as lactic acid from muscle to liver), and vitamins hormones etc.

(2) Regulation of body pH by means of buffer, body temperature homeostasis, water balance etc.

(3) Prevention of disease by means of antibodies and antitoxins.

(4) Support or turgidity to certain organs like penis and nipples.

Heart of vertebrates

Class of vertebrates	Characteristics	Example
(1) Pisces (= Branchial heart)	Thick, muscular, made of cardiac muscles, has two chambers (i) auricle and (ii) ventricle. The heart is called venous heart since it pumps deoxygenated blood to gills for oxygenation. This blood goes directly from gills to visceral organs (single circuit circulation). A sinus venosus and conus arteriosus is present. Lung fishes have 2 auricles and 1 ventricle.	Labeo Scoliodon Neoceratodus
(2) Amphibians	**Heart consists of** (a) Two auricles (b) Undivided ventricle (c) Sinus venosus (d) Truncus arteriosus (conus + proximal part of aorta) Right auricle receives blood from all the visceral organs (deoxygenated) via precaval and post caval. Pulmonary artery carries deoxygenated blood to lungs for oxygenation. This blood returns to left auricle via pulmonary vein (Double circuit circulation)	Frog Toad
(3) Reptiles	**Heart consists of :** (a) Left and right auricle (b) Incompletely divided ventricle (Ventricle in crocodiles gavialis and alligator is completely divided) (c) Sinus venosus (d) Conus arteriosus divided into right systemic, left systemic and pulmonary arch.	Lizards Snakes Turtles
(4) Aves	**Heart consists of** (a) Left and right auricle (b) Left and right ventricle (c) Complete separation of arterial and venous circulation (d) Only right systemic arch is present (e) Sinus venosus and truncus arterisious absent	Pigeon
(5) Mammals	Same as bird except that mammals have left systemic arch.	Rabbit, man

Human Heart

Circulation of Blood through Heart

(1) The heart pumps blood to all parts of the body.

(2) The deoxygenated blood is drained into right auricle through superior and inferior vena cava and coronary sinus whereas the pulmonary veins carry oxygenated blood from lungs to the left auricle. This is called as Auricular circulation.

(3) About 70% of the auricular blood passes into the ventricles during diastole. This phase is called diastasis.

(4) The rest of 30% of blood passes into the ventricles due to auricular systole (contraction).

(5) In this way, blood reaches the ventricles and is called ventricular filling.

(6) During ventricular systole (which starts first in left ventricle than in right ventricle), the pressure increases in the ventricles, thus, forcing the oxygenated blood from left ventricle into systemic aorta and deoxygenated blood from right ventricle into pulmonary aorta.

(7) The systemic arch distributes the oxygenated blood to all the body parts except lungs while pulmonary aorta carries the deoxygenated blood to lungs for oxygenation.

Differences between Neurogenic heart and Myogenic heart

Neurogenic heart	Myogenic heart
(1) The heart beat is initiated by a ganglion situated near the heart.	(1) The heart beat is initiated by a patch of modified heart muscle.
(2) The impulse of contraction originates from nervous system.	(2) The impulse of contraction originates itself in the heart.
(3) The heart normally stops beating immediately after removal from the body. Therefore, heart transplantation is not possible.	(3) The heart removed from the body continues to beat for some time. Therefore, heart transplantation is possible.
(4) Examples: Hearts of some annelids and most arthropods.	(4) Examples: Hearts of molluscs and vertebrates.

Fractions of cardiac output :

Amount of pure blood going to an organ per minute is called as fraction of the organ.

(i) Cardiac fraction – 200 ml/min.

(ii) Hepatic fraction – 1500 ml/min. (28% of blood as liver is the busiest organ of body and has maximum power of regeneration).

(iii) Renal fraction – 1300 ml/min (25% of blood)

(iv) Myofraction – 600-900 ml/min.

(v) Cephalic organs – 700-800 ml/min.

Differences between first and seconds heart sounds

First heart sound (Lubb)	Second heart sound (Dup)
(1) It is produced by closure of bicuspid and tricuspid valves at the start of ventricular systole.	(1) It is produced by closure of semilunar valves at the start of ventricular diastole.
(2) It is low pitched, less loud and of long duration.	(2) It is higher pitched, louder, sharper and of short duration.
(3) It lasts for 0.15 seconds.	(3) It lasts for 0.1 second.
(4) Its principal frequencies are 25 to 45 cycles per second.	(4) Its principal frequency is 50 cycles per second.

Electrocardiogram (ECG)

(1) A graphic record of electrical events occurring during a cardiac cycle is called Electrocardiogram.

(i) Depolarisation waves: They represent the generation of the potential difference. These waves appear only when both electrodes of galvanometer are in different fields. When both the electrodes are in same field, there are no deflection and wave drops down to base line.

(ii) Repolarisation waves: They appear when depolarisation is over and the muscle fibre is returning to its original polarity. When both electrodes are in same polarity (means 100% repolarisation and 100% depolarisation), there is no deflection.

(a) ***P*** **wave:** Indicates impulse of contraction generated by S.A. node and its spread in atria causing atrial depolarisation. The interval *PQ* represents atrial contraction and takes 0.1 second.

(b) QRS complex: Indicates spread of impulse of contraction from A.V node to the wall of ventricles through bundle of His and pukinje fibres causing ventricular depolarisation. This complex also represents repolarization of S.A. node.

The RS of *QRS* wave and *ST* interval show ventricular contraction (0.3 seconds). QRS is related to ventricular systole.

- ***T*** **wave:** Indicates repolarisation during ventricular relaxation

Types of Blood Circulation in Human

(i) Coronary circulation: It involves blood supply to the heart wall and also drainage of the heart wall.

- **(a) Coronary arteries:** One pair, arising from the aortic arch just above the semilunar valves. They break up into capillaries to supply oxygenated blood to the heart wall.
- **(b) Coronary veins:** Numerous, collecting deoxygenated blood from the heart wall and drains it into right auricle through coronary sinus which is formed by joining of most of the coronary veins.

(ii) Pulmonary circulation: It includes circulation between heart and lungs. The right ventricle pumps deoxygenated blood into a single, thick vessel called pulmonary aorta which ascends upward and outside heart gets divided into longer, right and shorter, left pulmonary arteries running to the respective lungs where oxygenation of blood takes place.

(iii) Systemic circulation: In this, circulation of blood occurs between heart and body organs. The left ventricle pumps the oxygenated blood into systemic arch which supplies it to the body organs other than lungs through a number of arteries.

Lympahtic System

The lymphatic system is an extension of the circulatory system. It consists of a fluid known as lymph, lymph capillaries and lymph ducts.

(a) **Lymph:** It can be defined as blood minus RBC's. In addition to the blood vascular system all vertebrate possess a lymphatic system. It is colourless or yellowish fluid present in the lymph vessels. It is a mobile connective tissue like blood and is formed by the filtration of blood.

(b) **Lymph capillaries:** Small, thin, lined by endothelium resting on a basement membrane and fine whose one end is blind and other end unites to form lymphatic ducts.

(c) **Lymphatic ducts or vessels:** Numerous, present in various parts of body. These vessels are like veins as they have all the three layers – tunica externa, tunica media and tunica interna, and are provided with watch pocket or semilunar valves but valves are more in number than veins.