Body Fluids And Circulation

⇒ In it we use to discuss about the heart and circulatory system. The heart is actually two separates pumps:- a right heart that pumps blood through the lungs, and a left heart that pumps blood through the peripheral organs.

Right and left ⇒ Heart is a pulsatile two-chamber pump composed of an atrium and a ventricle. Each atrium is a weak primer pump for the ventricle, helping to move blood into the ventricle.

⇒ The ventricles then supply the main pumping force that propels the blood either:- 1) through the pulmonary circulation by the right ventricle or (2) through the peripheral circulation by L.V. (left ventricle).

⇒ Special mechanisms in the heart causes a continuing succession of heart contractions called cardiac rhythmicity, transmitting action potentials throughout the heart muscle to cause the heart's rhythmical beat.

⇒ An essential requirement of animals is the transport of materials from the parts of the body where they are formed to the others. This function is achieved by the fluid that circulate through the body. The materials transported in the body includes nutrients, waste products, respiratory gases, metabolic intermediates, informational molecules, infection fighting cells, H^+ ions, water, heat etc.

Compartment of Body fluids :-

→ The total body fluid is mainly distributed between two compartments (i) the intracellular fluid and (ii) the extracellular fluid.

(A) Intracellular fluid Compartment (ICF) :→

→ About 28 to 42 Ltr. of fluids in the body is inside the 75 trillion cells. This fluid is called intracellular fluid (ICF). The fluid of each cell contains its individual mixture of different constituents but the concentration of these substances are similar from one cell to another.

⇒ The intracellular fluids contains large amount of potassium and phosphate ions and proteins, moderate quantities of magnesium and sulphate ions, only small quantities of sodium and chloride ions and almost no calcium ions.

(B) Extracellular fluid Compartment (ECF) :-

⇒ All the fluids outside the cells are collectively called the extracellular fluid. It is about 14 Litre in a normal 70kg adult.

⇒ The ECF is mainly present as interstitial fluid and plasma.

⇒ The interstitial fluid (= tissue fluid) is about 11 Litres and plasma contributes about 3 Litres in a normal 70kg adult. plasma includes:- blood plasma and lymph plasma.

⇒ The interstitial fluid surrounds each cell. The plasma is the non-cellular part of the blood and communicates continuously with the interstitial fluid through the pores of the capillary membranes.

⇒ Thus, the ECF are constantly mixing, so that the plasma and interstitial fluids have more or less the same composition except for proteins, which have a higher concentration in the plasma.

⇒ Transcellular fluid is a specialized type of ECF, although in some cases, its composition may differ markedly from that of the plasma or interstitial fluid. It is present relatively small amounts. All the transcellular fluids together constitute about 1 to 2 litres.

⇒ Transcellular fluid includes the following :→

1> **Cerebrospinal fluid (CSF)** :→ It is present inside the ventricles of the brain, the central canal of the spinal cord and in the subarachnoid space around the brain and spinal cord.

2> **Intraocular fluid** :→ This fluid is found in the eyeball, e.g. aqueous humour and vitreous humour.

3> **Serous fluid** :→ Intrapleural fluid, pericardial fluid and peritoneal fluid are examples of serous fluid.

4> **Synovial fluid** :→ It is present in the joints.

5> **Digestive fluid** :→ Digestive juices are the examples of digestive fluid.

6> **Fluid in urinary tract** :→ This fluid is present in the tract of excretory system.

⇒ The ECF contains large amounts of sodium and chloride ions, reasonably large amounts of bicarbonate ions but small quantities of potassium, calcium, magnesium, phosphate and organic acid ions.

Significance of body fluids :→

1> **Homeostasis** :→ The maintenance of internal environment is called homeostasis. Water forms not only the essential constituent of internal environment but also plays important role in homeostasis.

2> **Transport mechanism** :→ Body water forms the transport medium by which nutrients and other essential substances enter the cells and unwanted substances comes out of the cells.

3> **Metabolic reactions** :→ Water inside the cells is necessary for the growth and functional activities of the cells.

4> **Texture of tissues** :→ Water inside the cells is necessary for the characteristic form and texture of various tissues.

5> **Temperature regulation** :→ Water plays an essential role in the maintenance of normal body temp.

Circulation of body fluids are of two types :- **Intracellular** and **extracellular**.

Intracellular circulation occurs inside the cell through cyclosis in practically all living cells and unicellular organisms e.g. Amoeba which lack circulatory system. In them the cytoplasm show regular streaming movement (called cyclosis) which helps in the distribution as well as the exit of metabolic by products from the cell by the process of diffusion.

Extracellular circulation occurs outside the body cell i.e. extracellular fluid that circulates in the body for transport of materials.

⇒ It can be extra-organismic circulation (e.g. water circulatory system in which outside water circulates in the body of and organism).

⇒ Intra-organismic circulation which involves circulation of body fluids e.g. Parenchymal circulation (flatworms), Coelomic circulations (round worms) blood vascular system (vertebrates and higher invertebrates from annelida onwards).

Blood Vascular System :→

It is a circulatory system containing a special body fluid (blood) and a pumping organ (Heart) for moving it.

⇒ Blood vascular system occurs in vertebrates and higher invertebrates.

⇒ The blood may contain carrier molecules (haemoglobin, hemocyanin, plasma proteins) that can transport much larger amounts of nutrients and gases than water.

⇒ Moreover, the blood is a safe circulating fluid than the environmental water because it is not affected by external changes such as temperature variation, pollution etc.

⇒ Some animals lack heart, among them are sandworm, Nereis (an annelid) and lancelet, Branchiostoma (a lower chordate). Heart is a modified blood vessel.

⇒ Open and closed circulation are two types of blood vascular system where blood is the medium of transportation in association with pumping organ (Heart).

(A) Open Circulatory System:→ It occurs in arthropods and molluscs.

⇒ The blood is not completely enclosed within vessels, the heart pumps blood through arteries into large cavities or sinuses, where it mixes with interstitial fluid and bathes the cells of the body.

⇒ Blood is a combination of blood and interstitial fluid called haemolymph, while the spaces and lacunae are together called haemocoel.

⇒ The blood is slowly returned to the heart through small pores called ostia e.g. arthropods (Cockroach).

⇒ Circulation is slower in an open system because with some of the blood pooled in sinuses the heart cannot build up enough pressure to make the blood flow rapidly.

⇒ Open system cannot achieve that high rates of O_2 transport that active animals require.

⇒ Animals with open systems are either quite small and sluggish or use open ~~syt~~ system only for transport of food and wastes and use a different system for the transport of gases.

⇒ Respiratory pigement, if present is dissolved in the plasma no red corpuscles are present.

(B) Closed Circulatory System:→ It was discovered by William Harvey (1628), he is regarded the father of modern physiology.

⇒ It occurs in annelids (earth worms), some molluscs and all vertebrates.

⇒ In closed circulatory system, materials move between the blood and interstitial fluid through thin walls of capillaries.

⇒ The closed circulatory system considerably enhances the speed and efficiency of circulation.

⇒ In this blood is pumped through a close system of heart, arteries, veins and capillaries, without coming in direct contact of body tissues or body cavity.

⇒ Blood flows at high pressure in a closed circulatory system.

⇒ Respiratory pigment is present and may be dissolved in the plasma but is usually held in red blood corpuscles.

⇒ The human circulatory system is a closed type with a muscular heart, blood (fluid plasma and blood corpuscles) and blood vessels (arteries, veins and capillaries).

Advantage of Closed Circulatory System:→ It has a double advantage over the open circulatory system.

(A) Increased efficiency of circulation:→ It generates sufficient blood pressure to maintain far more rapid flow of blood than the open circulatory system. The blood completes its circulation round the body in a much shorter time. This quickens the supply of useful materials to the tissues and removal of waste products from them.

(B) Regulation of blood flow :→ Arterial musculature and precapillary sphincters in the closed circulatory system regulate the flow of blood to the organs according to their needs. Such regulation is not possible in the open circulatory system because the blood flows in open sinuses.

Blood vessels :→

Blood vessels are intricate networks of hollow tubes that transport blood throughout the entire body. The study of blood vessels is called angiology. There are three types of blood vessels :- arteries, veins and capillaries.

⇒ Blood vessels (except capillaries) are made up of 3 layers:- tunica externa, tunica media and tunica interna surrounding the central blood carrying canal (known as lumen).

⇒ The tunica adventitia strong outer covering of arteries and veins is composed of connective tissue as well as collagen and elastic fibres. These fibres allow the arteries and veins to stretch to prevent over expansion due to the pressure that is exerted on the walls by blood flow.

⇒ The tunica media is the middle layer of the walls of arteries and veins. It is composed of smooth muscle and elastic fibres. This layer is thicker in arteries than in veins.

⇒ The tunica ~~[illegible]~~ intima is the inner layer of arteries and veins. In arteries this layer is composed of an elastic membrane lining and smooth endothelium that is covered by elastic tissues.

⇒ Capillaries are extremely small vessels located within the tissues of the body that transport blood from the arteries to vein.

⇒ Arteries are elastic vessels that transport blood away from the heart.

⇒ The largest artery of the body is aorta, which originates from the heart and branches out into smaller arteries.

⇒ The smallest arteries are called arterioles which branch into capillaries

⇒ Veins are elastic vessels that transport blood to the heart. Vein do not contain the elastic membrane lining that is found in arteries. In some veins the tunica intima layer also contains valves.

⇒ The smallest veins in the body is called Venules. they receive blood from the arteries via the arterioles and capillaries. The only vein that does not have valves is the Vena Cava.

⇒ Capillary walls are thin and are composed of endothelium, O_2, CO_2, nutrients and wastes are exchanged through the thin walls of the capillaries.

Special types of blood vessels :→

1) Arteriovenous anastomoses :→ In some part of the body such as distal phalanges of finger and toes, tip of the nose, pinnae, eyelids, lips, the arterioles are connected with the venules by direct vessels called the arterio-venous anastomoses

⇒ The latter open at too low temperatures, enabling the blood to by-pass the capillary network in the skin. This enables the blood to carry heat back to the internal organs without loss in the skin.

(2) Sinusoids :→ In certain organs, such as liver, spleen, adrenals and bone marrow the arteries and veins are connected by way of irregular, anastomosing vessels which are lined with discontinuous endothelium having phagocytic cells these are called sinusoids.

(3) Retia mirabilla :→ In some organs, arteries or veins divide into vessels which are as fine as the capillaries and reunite to reform arteries and veins. Such vessels are known as the retia mirabilla. Glomeruli in the kidneys are examples of retia mirabilla in the course of arteries.

Differences between arteries and veins

Arteries	Veins.
1> Arteries carry blood away from the heart for distribution to the body.	1> Veins bring blood from the body back to the heart.
2> They contain Oxygenated (aerated) blood except the pulmonary arteries.	2> They contain deoxygenated (nonaerated) blood, except the pulmonary vein.
3> The flow of the blood is intermittent and fast due to the heart beat.	3> The flow of blood is slow and steady.
4> Their blood has considerable pressure.	4> Their blood has low pressure.
5> They have thick, elastic walls, and narrow lumen.	5> They have thinner, scarcely elastic walls and wide lumen
6> They are deep-seated.	6> They are superficial.
7> They have no values in them.	7> They have valves to prevent back flow of blood and counteract gravity.
8> They become empty after the death of the animal.	8> They contain blood even after the death of the animal.
9> when they are empty or cut across, they retain their tubular form.	9> when they are empty or cut across they collapse.
10> In tunica interna, elastic membrane is thick and endothelial cells are more elongated.	10> In tunica interna, elastic membrane is thin and endothelial cells are less elongated.
11> Tunica media is thick, having more muscle fibres and elastic fibres.	11> Tunica media is thin, having fewer muscle fibres and elastic fibres.

Regulation of blood flow :- There is a triple mechanism to regulate the flow of blood to the organs in a closed circulatory system :-

1> **Arterial musculature :-** The small arteries and specially the arterioles have well-developed muscular walls. They expand and carry more blood if the organ becomes more active and contract and send less blood if the organ become less active.

2> **Precapillary sphincters :-** The capillary network of each organ has a few "thorough-fare" channels through which blood flows all the time. other capillaries recieve blood only at the time of intense activity of their organ. These capillaries have precapillary sphincters at their origin. The sphincters open / close to → meet the varying metabolic needs of the organ.

3> **Arteriovenous anastomoses :-** In certain regions of the body occur direct arteriovenous connections which act as short circuit routes between arterioles and venules.
⇒ These circuits serve to regulate the quantity of blood which flows through the capillary bed according to the needs of the region.

Vertebrate Heart

:→ Vertebrates have a single heart. It is a hollow muscular organ composed of cardiac muscle fibres. It acts as a pumping organ of the blood vascular system.

⇒ The heart is divided internally into intercommunicating chambers, the number of which varies in different vertebrate groups.

⇒ The study of heart is called cardiology.

⇒ Fish handle only deoxygenated blood. Thus heart is often called as a venous heart. It is 2-chambered (a auricle and a ventricle). Both the accessory chambers, Sinus venosus and Conus arteriosus are present. Lung fish (**Protopterus**) has a 3-chambered heart, the auricle being divided by almost a complete septum.

⇒ Amphibian heart receives both deoxygenated and oxygenated blood and is often called arteriovenous heart. It is 3-chambered (two auricles and ventricles). Two accessory chambers :- Sinus venosus and truncus arteriosus are also present. The heart supplies mixed blood to the body parts.

⇒ In Reptiles the heart also receives both deoxygenated and oxygenated blood and is thus arteriovenous heart. It is incompletely **four chambered** having 2 auricles and partly divided ventricle. Only one accessory chamber, namely Sinus venosus is present.

⇒ Avian and mammalian heart is 4-chambered having right and left auricles and right and left ventricles. The right auricle receives the deoxygenated blood from the body and sends it into the right ventricle that pumps it to the lungs via a pulmonary arch for oxygenation.

⇒ The left auricle receives oxygenated blood from the lungs and sends it into the left ventricle, which pumps it to the body through a single aortic arch. Thus the deoxygenated and oxygenated blood remain fully separate, and there is a complete double circulation. There are no accessory chambers.

Human Heart

:→ The mammalian heart comprises of 4 complete chambers :- 2 ventricles and 2 auricles (atria).

⇒ The wall of the heart comprises of 3 layers :- the outer or external covering layer epicardium, intermediate cardiac muscular tissue myocardium and internal layer endocardium that is in contact with blood.

⇒ Epicardium (visceral pericardium) is a serous membrane covered on its free surface with a layer of mesothelial cells that secretes a serous fluid into the space between the visceral and parietal pericardium. This pericardial fluid allows smooth movement when the heart beats. The inelastic nature of pericardium prevents the heart from being overstretched or overfilled with blood.

⇒ The Myocardium is composed of specialized muscle tissue known as cardiac muscular tissue. The nuclei in the fibres are less numerous and are centrally placed. The muscle fibres branch and anastomose and also show transverse markings, the intercalated discs, at the boundaries between contiguous cells.

⇒ The myocardium is thin in the auricles than the ventricles as the ventricles need to pump or empty blood into the vessels. Hence they need stronger and thicker walls.

⇒ The wall of the left ventricle is the thickest as it has to pump blood to all parts of the body at a much greater pressure.

⇒ The endocardium is a thin membrane lined with a flattened endothelium continuous with that of the intima of the blood vessels. **The endocardium is thicker in the atria than in the ventricles.**

⇒ The two atria are separated by a thin interatrial septum that has an oval thin area called fossa ovalis that marks the position of an opening, foramen ovale between two auricles in the foetus.

⇒ The inner surface of the auricles is smooth but for a network of low ridges the musculi pectinati in the region of the auricular appendages.

⇒ The right auricle receives two large veins:- superior vena cava and inferior vena cava.

⇒ The SVC brings deoxygenated blood from the head and upper region of the body. The IVC returns the deoxygenated blood from the lower region of the body.

⇒ The opening of the IVC is bordered by a membranous, falciform fold, which is a remnant of the fetal valve of Eustachian.

⇒ The right auricle also receives a small coronary sinus. It returns deoxygenated blood from the heart wall. Its opening is guarded by a small fold the valve of Thebasian.

⇒ A patch of modified heart muscle the sinoatrial node (SA node) is present in the wall of right atrium close to the point of entry of the vena cava.

⇒ Another aggregate of modified heart muscle tissue called the atrio ventricular (AV) node is present at the lower right end of the interatrial septum. The left atrium receives oxygenated blood via pulmonary veins (= four in man).

⇒ The two atria are separated from the ventricles by membranous valves. The valve separating the right auricle from the right ventricle is known as the right atrio ventricular valve or tricuspid valve (as it is made of three flaps or cusps). The valve separating the left atrium and the left ventricle is called left atrioventricular valve or bicuspid valve or the mitral valve (since it is made of two flaps).

⇒ Fine tendinous cords called chordae tendinae are attached to the ventricular surface of the valves. On the other end, the chordae tendinae are attached to cone-shaped projections of the ventricular wall k/as papillary muscles.

⇒ During aterial systole (contraction) the blood flows from the atria to the ventricles. When the ventricles contract the valves close and the chordae tendinae support the valves preventing reflux of blood into the atria.

⇒ The two ventricles are separated from each other by a thick inter ventricular septum, the inner surface of the ventricles is raised into a network of low, muscular ridges called the columnae carnae / trabeculae carnae.

⇒ At its upper right angle, the left ventricles gives off a large blood vessels called the systemic aorta.

⇒ Aorta has 3 regions:- ascending aorta, arch of aorta and descending aorta.

⇒ At the base of the ascending aorta there are three membranous, pocket-shaped semilunar valves with their cavities directed away from the ventricles.

⇒ These valves check the return of the blood to the ventricle.

⇒ Just beyond the semilunar valves, the ascending aorta gives off right and left coronary arteries that supply blood to the heart wall.

⇒ The arch of aorta gives of 3 large arteries:- brachio cephalic, left common carotid, and left subclavian arteries.

⇒ The descending arch extends through the trunk and supplies oxygenated blood to the various parts except the lungs.

Heart Beat :- The rhythmic contraction (= systole) and relaxation (= diastole) of the cardiac muscles is known as heart beat.

⇒ Each heart beats includes one systole (contraction phase) and one diastole (relaxation phase) of the heart to distribute and recieve blood to and from the body. The heart of a healthy person beats 72 times per minute.

⇒ Beating is an inherent capacity of the heart. The heart of resting human being pumps about 5 Ltr. of blood/minute. This means that a quantity of blood equal to the total amount contained in the body passes through the heart each minute.

Conduction of Heart Beat :- The automatic rhythmicity of the heart is its ability to contract spontaneously at a regular rate. Heart beat results from a wave of electric potential called cardiac impulse, spreading over cardiac chambers.

⇒ The heart beat is of two types:- neurogenic and myogenic, the neurogenic heart beat is initiated by a nerve impulse coming from a nerve ganglion (mass of nerve cells) situated near the heart. It is present in the heart of some annelids and most arthropods. The Myogenic heart beat is initiated by a patch of modified heart muscle itself. It is found in hearts of molluscs and vetebrates.

⇒ In the myogenic heart beat, contraction is initiated by a specialized patch of modified heart muscles the Sinoatrial node (SA Node) which is situated in the wall of the right auricle near the opening of the superior vena cava (SVC).

⇒ The SA node acts as the "pacemaker" of the heart because it is capable of initiating impulses which then can stimulate the heart muscles to contract. It thus establishes the basic rhythm at which the heart beats.

⇒ The impulse of contraction emitted by the sinoatrial node spreads as a wave of contraction over the right and left atrial wall pushing the blood through the atrio ventricular valves into the ventricles (atrial systole — 0.1 sec).

⇒ This wave of contraction next reaches the atrio-ventricular node (AV node - pacesetter) which is stimulated to emit an impulse of contraction spreading to the ventricular muscle via the atrio ventricular bundle and the Purkinjae fibres.

⇒ The atrial muscles fibres are separated from those of the ventricles by a fibrous tissue ring.

⇒ There is no functional continuity between the atria and the ventricles. the only conducting tissue between the atria and the ventricles. is the atrio ventricular bundle or the Bundle of His.

⇒ The atrio ventricular bundle (Bundle of His) was discovered by His (1893) and consists of a set of specialized muscle strands originating from the AV node and pass downwards into the inter ventricular septum. This bundle than divides into the left and the right bundle branches, one going to each ventricles.

⇒ Within the myocardium of the ventricles the branches break up into a network of fine branching anastomking filaments or fibres known as Purkinje fibres.

⇒ The Bundle of His and the Purkinje fibres convey the impulse of contraction from the AV node to the myocardium of ventricles.

Artificial Pacemaker: → SA node may become defective. It then fails to generate cardiac impulse at the normal rate. The heart beat becomes slow and irregular. Tissues receive less blood. This disorder may be corrected by implanting an artificial pacemaker in the patient's chest. This instrument stimulate the heart electrically at regular intervals to beat at normal rate. (Page 5)

Regulation of heart Beat: → The rate of heart beat is regulated by two mechanism:—

(A) Neural Regulation: → The cardiac centre lies in the medulla oblongata of the brain. The cardiac centre is formed of cardio-inhibitor and cardio-accelerator parts.

⇒ The cardio-inhibitor decreases the rate of the heart beat whereas cardio-accelerator increases the same.

⇒ The cardio-inhibitor is connected with the heart through vagus nerve (it carries parasympathetic nerve fibres) Cardio-accelerator through sympathetic nerve fibres.

⇒ Sensory fibres extend from the receptors present in the superior vena cava, aorta and carotid sinuses to the cardiovascular centre in the medulla oblongata.

⇒ The impulses received from the aorta and carotid sinuses ↓↓ decreases the heart rate, whereas the impulses from the vena cava increases ↑↑ the heart rate.

(B) Hormonal Regulation: → Adrenaline (epinephrine) and noradrenaline (norepinephrine) hormones are secreted by the medulla of the adrenal glands.

⇒ Noradrenaline accelerates ↑↑ the heart beat under normal conditions while adrenaline does this function at the time of emergency.

⇒ These hormones directly influence the SA Node.

⇒ Thyroxine hormone secreted by thyroid gland increases oxidative metabolism of the body cells this requires more O_2 and thus indirectly ↑↑ heart beat.

⇒ Body temperature also affects the pacemaker. Just 1°C rise in temp. increases ↑↑ the heart rate about 10 beats/minute. This is why our pulse rate is much higher in fever. The heart rate also ↑↑ with excercise to provide additional O_2 and food to muscles.

Pulse: → is the alternate expansion and elastic recoil of an artery with each systole. Pulse is strongest in the arteries closet to heart. Pulse can be detected in superficial artery like radial artery of wrist and temporal artery. Normal pulse rate ranges 70-90/minute. The pulse rate is the same as the heart rate. The factors which affect the pulse rate are as follows:—

(1) The pulse rate in childern is more rapid than in adults.

(2) The pulse rate is more rapid in the female than in the male.

(3) When the person is standing up the pulse rate is more rapid than when he/she is lying down.

(4) When any strong emotion is experienced the pulse rate is increased, for example anger, excitement, fear etc.

(5) Any excercise increases ↑↑ the rate of the pulse.

⇒ Tachycardia is the term applied to a rapid heart/pulse rate (over 100/minute).

⇒ Bradycardia is the term indicating a slow heart/pulse rate (under 50/minute).

Differences between heart beat and Pulse :-

Heart Beat	Pulse
1) It is the rhythmic contraction and relaxation of heart.	It is the rhythmic contraction and relaxation in aorta and its main arteries.
2) It is regulated by the nervous and endocrine system.	It is due to the flow of blood from the heart and is dependent on the rate of heart beat.
3) One complete heart beat consists of one systole and one diastole and lasts for about 0.8 seconds.	Pulse is a regular jerk of an artery, It depends on the rate of heart beat.

Cardiac Output :→ The volume of blood pumped by each ventricle per minute is called the cardiac output. It is determined by multiplying the heart rate with the volume of blood ejected by each ventricle during each beat which is called stroke volume.

⇒ Cardiac output = Heart Rate × Stroke volume ⇒ 72 beats/min × 0.08 litre/beat = 5.5 litres/min.

⇒ Cardiac index is the minute volume per sq. m. of body surface area. Its normal value is 3.3/min/sq.m.

Cardiac Cycle :→ The cardiac cycle consists of one heart beat or one cycle of contraction and relaxation of the cardiac muscle. The contraction phase is called the systole while the relaxation phase is called the diastole.

⇒ When both the atria and ventricles are in diastolic or relaxed phase, this is referred to as a **Joint diastole**. during this phase the blood flows from the superior and inferior venae cavae into the atria and from the atria to the respective ventricles through auriculo ventricular valves. But there is no flow of blood from the ventricles to the aorta and pulmonary trunk as semilunar valves remain closed.

⇒ The successive stages of the cardiac cycle are briefly described below:-

1) **Atrial systole**:- The atria contract due to wave of contraction, stimulated by the SA node. The blood is forced into the ventricles as the bicuspid and tricuspid valves are open.

2) **Beginning of ventricular systole** :→ The ventricles begin to contract due to a wave of contraction, stimulated by the AV Node. The bicuspid and tricuspid valves close immediately producing part of the first heart sound.

3) **Complete Ventricular Systole** :→ when the ventricles complete their contraction, the blood flows into the pulmonary trunk and aorta as the semilunar valves open.

4) **Beginning of ventricular diastole** :→ The ventricles relax and the semilunar valves are closed. This causes the **second heart sound**.

5) **Complete ventricular diastole** :→ The tricuspid and bicuspid valves open when the pressure in the ventricles falls and blood flows from the atria into the ventricles.

⇒ Contraction of the heart does not cause this blood flows, it is due to the fact that the pressure within the relaxed ventricles is less than that in the atria and veins.

Heart Sounds :→ two sounds are heared normally through a stethoscope during each cardiac cycle. The first is a low, slightly prolonged "lubb" (first sound) caused by sudden closure of the mitral and the tricuspid valve at the start of ventricular systole. (Page 6)

⇒ The second is a shorter, high pitched "dup" (second sound) caused by vibrations associated with closure of the aortic and pulmonary valves just after the end of the ventricular systole. The first sound has a duration of 0.15 second and a frequency of 25-45 Hz. The second sound lasts about 0.12 seconds with a frequency of 50 Hz.

⇒ Murmurs are abnormal sounds heard in various parts of the vascular system. The major cause of cardiac murmur is a disease of the heart valves. It may arise due to improper closing of any heart valve or in patients with inter-ventricular septal defect.

⇒ Heart sounds gives valuable information about working of valves. There is a gap/pause between the second sound and the next cardiac cycle. Each cardiac cycle takes 0.8 seconds to occur.

Electrocardiogram (ECG) :→ ECG is graphic record of the electric current produced by the excitation of the cardiac muscles. The instrument used to record the changes is an electro cardiograph. Waller (1887) first recorded the electro cardiogram but Einthoven (1903) studied ECG in details, therefore he got Nobel prize in 1924 for the discovery of ECG. He is also considered "Father of the electro cardiography".

⇒ A normal ECG is composed of P wave, a QRS wave (complex) and a T wave. The letters are arbitrarily selected and do not stands for any particular words.

⇒ The P wave is a small upward wave that indicates depolarization of atria (atrial contraction). It is caused by the activation of SA Node.

⇒ The QRS wave (complex) begins after a fraction of second of the P wave. It begins as a small downward deflection (Q) and continues as large upright (R) and triangular wave, ending as downward wave (S) at its base. It represents ventricular depolarization (ventricular contraction).

⇒ The T-wave is a dome-shaped which indicates ventricular repolarization (ventricular relaxation).

⇒ Each large square represents 0.2 second. Normal P-R interval is 0.12 to 0.2 second. Normal QRS complex duration is 0.12 second. Normal Q-T interval is 0.4 second.

⇒ Enlargement of P wave indicates enlargement of Atria. during atherosclerotic heart disease and rheumatic fever the ~~Q~~ P-R ~~interval~~ interval is registered. This is due to the inflammation of atria and AV node.

⇒ The enlarged Q and R waves indicate a myocardial infarction (heart attack). The S-T segment is elevated in acute myocardial infarction and depressed when the heart muscle receives insufficient oxygen.

⇒ T wave is flat when the heart muscles receive insufficient O_2 as in **atherosclerotic heart disease**. It may be elevated when the body's potassium level is increased.

⇒ The importance of ECG is that it gives accurate information about the heart. Therefore, ECG is of great diagnostic value in cardiac diseases.

⇒ When ECG of a person is to be recorded, four leads (metal electrodes) are attached in the arms and legs. It is done after cleaning and putting a special jelly, which improves electrical conduction.

⇒ With the help of a rubber suction cup, an additional electrode is placed on the chest. Now the electrocardiograph is switched on which detects and amplifies the electrical current of the heart and transmits to the recording pen. The latter draws a wavy line that is called the deflection waves. (electrocardiogram).

Blood Pressure :-

Blood pressure is defined as the force or pressure which the blood exerts on the walls of the artery in which it is contained. The arterial blood pressure is the result of the discharge of the blood from the left ventricle into the already full aorta.

⇒ The blood pressure is measured from brachial artery by an instrument called sphygmomanometer in terms of height in millimeters of a column of mercury.

⇒ When the left ventricle contracts pushing the blood into the aorta, the pressure produced is known as systolic blood pressure (120 mmHg).

⇒ Pulse pressure is lower in case of kids.

⇒ When the complete diastole occurs and the heart is resting, the pressure within the blood vessels is called as the (diastolic blood pressure 80 mmHg)

⇒ The blood pressure is expressed as BP = 120/80 mmHg. The difference b/w the systolic and diastolic pressure is called pulse pressure. The average of blood pressure level is called mean blood pressure. Its normal value is 40 mmHg but becomes more in case of Hypertension.

(A) Systolic or maximum pressure :- It is pressure developed in arteries of the body during contraction of left ventricle which forcefully pours blood into aorta. The pressure has been named systolic after the contraction or systole of ventricle.

⇒ Its value is maximum near the end of ventricular contraction when most of the ventricular blood has been pushed into arteries.

⇒ Forceful passage of blood into arteries causes their elastic walls to expand.

⇒ The value of systolic pressure depends upon age. Its normal value for adults is 120 mmHg. The normal pressure increases to 135-140 mm Hg with age. The value is lower 70-90 mmHg in younger individuals.

(B) Diastolic or minimum pressure :- Diastolic pressure is the pressure found in the arteries of the body, when the left ventricle is in the state of getting filled (diastole) and is not pouring blood into arterial system.

⇒ The pressure is present in the arteries due to elastic recoil or contraction of arterial walls. It helps in maintaining flow of blood. The normal value of diastolic pressure for adults is 80 mmHg.

⇒ It is lower in children and adolescents (upto 60 mmHg).

⇒ The normal value is higher in older persons (95-100 mm Hg).

⇒ Baroreceptors or pressureceptors are nerve endings that lie in the walls of the arteries. They are stimulated when stretched.

⇒ The signals are transmitted from each carotid sinus through very small Hering's nerve to the glossopharyngeal nerve and then to the vagus nerves to the same area of the medulla oblongata.

⇒ The baroreceptors respond rapidly to changes in arterial pressure. A rise in arterial pressure stretches the baroreceptors and causes them to transmit signals into the CNS.

⇒ "Feed back" signals are then sent back through the ANS to the circulation to reduce arterial pressure downward towards the normal level.

Aberration in blood pressure

A> **High blood pressure** :→ The maintenance of a normal systolic blood pressure is important for health. Any value above 150 mmHg in an otherwise healthy adult means high blood pressure or hypertension. There are 2 main causes of high blood pressure :- 1> Thickening or hardening of the arteries due to deposition of cholesterol (arterio sclerosis)

2> Kidney disease (nephritis)

⇒ Also overeating with resultant obeity, stress - physical, social etc :- Smoking and heredity can also lead to high blood pressure.

⇒ The Symptoms of hypertension include :- headache, throbbing of the head, tiredness, fatigue, palpitation of the heart.

⇒ Treatment comprises of a well balanced programme of mild excercise followed by rest. Beverages containing caffeine and excessive salt need to be avoided. Somking must be stopped because tobacco constricts the smaller vessels raising blood pressure.

⇒ A substance reserpine obtained from the roots of a herb called Rauwolfia produces a long ~~ab~~ continued reduction in blood pressure.

(B) **Low blood pressure** :→ A fall in systolic blood pressure below the normal range in an adult is called low blood pressure / hypotension. A reading below 100 mm is an indication of weak circulation

⇒ Hypotension occurs in case of shock and severe haemorrhage, resulting from extensive tissue injury.

⇒ It also occurs in some cases of heart failure and in certain endocrine disturbances like hypothyroidism and Addison disease of the adrenal gland.

⇒ Tired and worn out attitude is the main symptom of a low blood pressure.

⇒ It can be controlled by sufficient rest, mild excercise, and stimulants like tea, coffee etc :-

Factors affecting blood pressure :→

1> **Total blood volume** :→ A sufficient amount of blood must circulate in the blood vessels to maintain the normal blood pressure.

⇒ If the blood volume is increased, the vessels will be over stretched and the pressure will rise.

⇒ If there is a decrease in volume (e.g. as in haemorrhage) the blood vessels will partly collapse and will not be able to press strongly against the blood within them. Hence pressure will fall.

(2) **Vasomotion** (Nervous control of the blood vessels) :→

⇒ In closed circulation, blood pressure is determined by the force of the heart and total volume of blood and also by nervous regulation of the amount of space suitable within the blood vessels.

⇒ The medulla oblongata of the brain has a

(P.T.O)

Vasomotor Centre located near the heart rate centre. Motor nerves from the vaso motor centre carry impulses to the smooth muscles in the walls of the arteries.

⇒ There are two types of such motor nerves:– the Vasoconstrictors (produce constriction or narrowing of vessels) and the Vasodilators (cause widening of vessels).

⇒ Vaso constriction occurs when a blood vessel receives many constriction impulses from the vasomotor centre. Vaso dilation takes place when dilator impulses are more.

⇒ Vaso constriction raises the blood pressure while vasodilation lowers it.

(3) The elasticity of arterial wall:→

⇒ Arterial walls have a considerable amount of elastic tissue. As the left ventricle empties blood into the aorta, it distends and then retreats pushing the blood onwards. This sort of distension occurs all through the arterial system.

⇒ During cardiac diastole the vessels recoil and press upon the blood pushing it onwards through the arterioles thus maintaining the diastolic pressure.

(4) Peripheral Resistance (PR):→ Blood pressure is directly proportional to PR.

⇒ It means resistance against which the heart pumps.

⇒ Increase in PR raises both the systolic and diastolic pressure.

⇒ PR is dependent on the internal diameter and distensibility or elasticity of blood vessels and viscocity of the blood.

⇒ Narrowing of the vascular lumen, stiffening of the vascular wall and increase in blood viscocity raises the PR and thereby the blood pressure.

Blood Groups:→

Karl Landsteiner reported first time ABO blood groups in human beings. A, B, and O blood groups were discovered by Landsteiner (1900) while AB blood group was found out by de Castello and Steini (1902)

⇒ ABO blood groups are determined by the gene I (isoagglutinin). There are 3 alleles I^A, I^B and I^O of this gene. Proteins produced by the I^A and I^B alleles are called A antigen and B antigen respectively.

⇒ People with blood group A have the A antigen on the surface of their RBCs, and antibodies to antigen B in their plasma.

⇒ Person with blood group B have B antigen on their RBCs and antibodies against A antigen in their plasma.

⇒ Individuals with AB blood group have both antigen A and B on their RBCs and no antibodies for either of the antigen in their plasma.

⇒ Type O individuals are without A and B antigens on their RBCs, but have antibodies for both these antigens in their plasma.

⇒ Individuals with blood group AB can recieve blood of A, B or O group, while those with blood group O can donate blood to anyone. This is the most important blood group for transfusion.

⇒ If a blood transfusion is made between an incompatible donor and recipient, reaction of antigens on the cells and antibodies in the plasma produces clots that clog capillaries.

Rh (Rhesus) factor / Rh blood Group:→

A protein named rhesus antigen is present on the surface of red blood corpuscles in many person. It was discovered in 1940 by Landsteiner and Wiener in the blood of Rhesus monkey, hence its name.

⇒ Depending on the race, 85 to 99% of the white population have this rhesus antigen (also called Rh factor) and are called Rh positive (Rh^+) others who do not have this factor are known as Rh-negative (Rh^-). Rh^+ is dominant to Rh^-.

⇒ Formation of Rh protein is controlled by a dominant gene which may be called as R. Thus RR (homozygous) and Rr (hetero-zygous) persons are dominant and are Rh(+), and rr (homo-zygous) are recessive and are (Rh^-) negative.

⇒ Both Rh^+ and Rh^- individuals are phenotypically normal. The problem arises during blood transfusion and pregnancy.

(A) Incompatibility during blood transfusion :→ The first blood transfusion of (Rh^+) blood to the person with (Rh −) blood causes no harm, because the (Rh(−)) person develops anti Rh factors or antibodies in his/her blood.

⇒ In second blood transfusion of Rh^+ blood to the Rh − person, the latter's anti Rh factors attack and destroy the red blood corpuscles of the donor.

Blood transfusion :→ is the process of transferring blood or blood-based products from one person into the circulatory system of another.

⇒ Blood transfusion may treat medical conditions such as massive blood loss due to trauma, surgery, shock and where the red cell producing mechanisms (or some other normal and essential component) fails.

(B) Incompatibility during pregnancy (Page 8)

⇒ If father's blood is Rh(+) and mother's blood is Rh −, and the foetus blood is Rh(+). This is a serious problem.

⇒ If the (Rh −) blood of mother has not earlier come in contact with (Rh+) blood through transfusion, her first child does not suffer (although the Rh^+ blood of the foetus stimulates the formation of anti Rh factors or antibodies in the mother's blood yet enough anti Rh factors are not produced in the mother's blood to harm the foetus).

⇒ But in the subsequent Rh + foetuses the anti Rh factors (antibodies) of the mother's blood destroy the foetal red blood corpuscles. This results in haemolytic disease of the new born (HDN). It is called erythroblastosis foetalis (destruction of the erythrocyte of foetus). New born may survive but it is often anaemic.

⇒ In order to prevent HDN, Rh − mothers are injected with a defective anti Rh − antibody during all pregnancies carrying Rh + foetus.

⇒ Blood preservation :→ is the process by which blood or its components are kept viable outside of the organism from which they are derived.

⇒ Blood substitute is that substance that mimic the function of blood.

Human ABO Blood Groups and their Compatibility

Blood Group	Genotype	Antigen in red blood corpuscles	Antibody in blood plasma	Can give blood to	Can get blood from
A	I^AI^A or I^AI^O	A	b.	A, AB	A, O.
B.	I^BI^B or I^BI^O	B	a	B, AB.	B, O.
AB	I^AI^B.	AB.	None	AB.	all.
O	I^OI^O	None	a, b.	All	O.

Lymphatic System :→ It comprises lymph, lymphatic capillaries, lymphatic vessels, lymphatic nodes and lymphatic ducts.

1) **Lymph** :→ lymph, a colourless fluid is a part of the tissue fluid, which in turn, is a part of blood plasma.

⇒ So the composition of tissue fluid and lymph is the same as that of blood plasma but it lacks RBCs and large plasma proteins.

⇒ As compared to the tissue fluid, the lymph contains very small amount of nutrients and O_2, but contains abundant CO_2 and other metabolic wastes.

⇒ Amoeboid shaped white blood corpuscles may be present in the lymph.

2) **Lymphatic Capillaries** :→ they lie close to the blood capillaries but differ from them to the extent that they end blindly.

⇒ Moreover, they have extremely thin walls. They are composed of a single layer of endothelial cells.

⇒ The lymphatic capillaries of intestine absorb the digested fats. They are milky in appearance and are therefore called the lacteals.

3) **Lymphatic Vessels** :→ The lymphatic capillaries unit to form large lymphatic vessels. They are composed of an outer coat of fibrous tissue, middle coat of muscular tissue and an inner lining of endothelial cells.

⇒ The lymphatic vessels have numerous valves.

4) **Lymph nodes** :→ These are small oval or bean shaped structures located along the length of lymphatic vessels.

⇒ Lymph nodes are most numerous in the thoracic mediastinum, on the posterior abdominal wall in the abdominal mesenteries and in the pelvis, neck and proximal ends of the limbs.

⇒ lymphatic nodes perform the following main functions :-

1) Both B-lymphocytes and T-lymphocytes are produced here.
2) Macrophages of lymph nodes remove bacteria, foreign materials and cell debries from the lymph.
3) B. lymphocytes change to plasma cells that produce antibodies against invading antigens, while T- lymphocytes attack cells --- that are 'foreign' to the host body.

5) **Thoracic duct** :→ The lymphatic vessels of left side unite to form a thoracic duct.

⇒ This duct begins at the cisterna chyli which is a sacdilation situated in front of the I and II number vertebrae.

⇒ The thoracic duct contains several valves. It discharges its lymph into the left subclavian vein.

6) **Right lymphatic duct** :→ The lymphatic vessels of the right side of the thorax, head and neck unite to form the right lymphatic duct. It is about 1cm in length.

⇒ It discharges its lymph into the right subclavian vein.

Lymph movement :→ The lymph flows in lymphatic vessels very slowly. Forcing out of fluid from the blood capillaries sets up some pressure in the tissue fluid.

⇒ This establishes a pressure gradient in the lymphatics, causing flow of lymph in the latter.

⇒ Movements of viscera and contractions of the body muscles help considerably in squeezing the lymph along.

⇒ The valves present in lymphatic vessels prevents its back flow. Movement of villi assists flow of lymph in the lacteals.

⇒ Gravity helps in moving the lymph down the lymphatic vessels of head and neck.

Functions of Lymph or lymphatic System :- The lymph or lymphatic system serves many functions (Page 9)

⇒ It drains excess tissue fluid from the extra cellular spaces back into the blood.

⇒ Some of the fluid from the digestive tract is absorbed into the lymph. The lymphatic vessels store this fluid temporarily, and release it gradually so that the kidneys do not face a sudden pressure of urine excretion.

⇒ It carries CO_2 and nitrogenous waste materials that diffuse into the tissue fluid to the blood.

⇒ It takes lymphocytes and antibodies from the lymphatic nodes of the blood.

⇒ It transports fats digested and absorbed in the intestine to the blood in the form of chylomicrons droplets.

⇒ It destroys the invading microorganisms and foreign particles in the lymphatic nodes.

⇒ It maintain the quality and quantity of the blood by restoring the fluids and solutes that leave it.

⇒ It brings plasma protein macromolecules synthesized in the liver cells and hormone produced in the endo-crine glands to the blood.

Spleen :-

→ Spleen is the largest component of the lymphatic system. It is a large (7-10cm in diameter) bean-shaped vascular, dark red organ located in the abdomen, just below the diaphragm at the tail of the pancreas behind the stomach.

⇒ The spleen is composed of red pulp (reticular tissue rich in RBCs, having small patches of white pulp (lymphatic nodules) scattered in it.

⇒ The red pulp is enclosed by a capsule of white fibrous tissue. the capsule sends trabeculae into the pulp, and is surrounded by visceral peritoneum.

⇒ Spleen serves many functions :-

1> Destruction of worn-out red corpuscles.
2> Reservoir for red corpuscles.
3> Formation of agranulocytes.
4> Production of antibodies.
5> Storage of Iron.
6> Erythropoiesis
7> Disposal of foreign elements.

Thymus :-

→ Thymus is also a lymphatic organ. It lies in the upper chest near the neck. It is prominent in childern but begins to degenerate in early child hood.

⇒ It "educates" the lymphocytes in the foetus to distinguish body cells (self) from foreign cells (non-self).

Tonsils :-

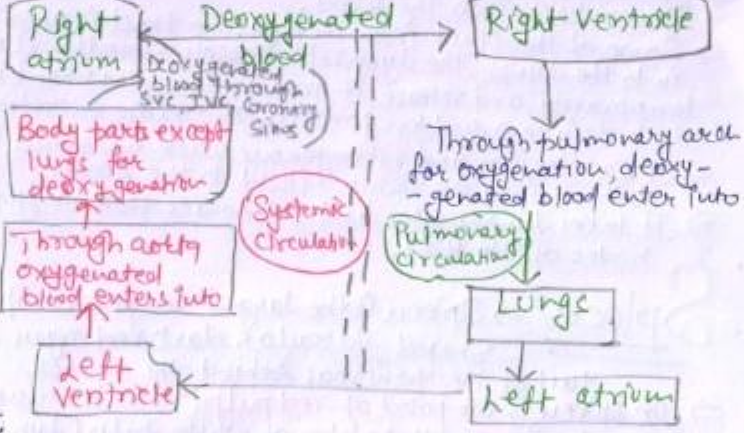
→ they too are lymphatic tissues. They are located in the throat.

⇒ They do not filter lymph. They are thought to protect against infection.

⇒ Lymphoid tissue is also found in Peyer's patches and vermiform appendix.

Blood	Lymph
1> It consists of plasma, RBC, WBC and platelets.	1> It consists of plasma and WBC (lymphocytes most abundant)
2> It is red in colour due to presence of haemoglobin in RBC.	2> It is colourless as haemoglobin is absent.
3> It's plasma more proteins, Ca^{2+} and phosphorus.	3> Its plasma has fewer proteins, less Ca^{2+} and phosphorus.
4> Glucose concentration is less in blood.	4> Glucose concentration is higher in lymph.
5> Amount of CO_2 and other metabolic wastes is normal.	5> Amount of CO_2 and other metabolic wastes is much more.
6> It carries material towards and away from the tissue, therefore it act as a vehicle	6> It transfer materials from the blood to the body cells, and vice-versa therefore it acts as "middle man".

Blood Circulation :- In humans there are two circuits of blood circulation for greater efficiency and to completely prevent the mixing of oxygenated and deoxygenated blood. Usually it is called double circulation.



⇒ Double circulation is the passage of same blood twice in the heart through separate pathways for completing one cycle.

⇒ Double circulation consists of pulmonary circulation and systemic circulation.

⇒ Pulmonary Circulation is the movement of blood from the heart ~~through separate pathways~~ to the lungs, and back to the heart again. Deoxygenated blood is pumped out of the right ventricle of the heart into the pulmonary trunk, then to the pulmonary arteries and into the lungs via pulmonary veins, oxygenated blood is then drained into the left atrium. Blood is then circulated in the systemic circulation.

⇒ Systemic Circulation occurs when the left ventricle contract, as the ventricles fill up and contracts, blood is forced through the aortic valve into the aorta which circulates blood throughout the body. At the capillaries exchange occurs and deoxygenated blood is returned to the right atrium by way of the IVC and SVC. The systemic circulation has arterial and venous system.

1) Arterial System comprises all arteries coming out from the heart and supplying blood to different parts of the body.

2) Venous System comprises all the veins that bring blood to heart.

Two main arterial vessels are pulmonary arch and aorta.

Two main veins are two pre cavals and one post cavals.

⇒ The advantage of double circulation is that the blood can be sent to the lungs to pick up O_2 and then returned to the heart to be pumped again before travelling around the body.

⇒ The blood therefore is pumped through the capillary bed (which slow it down and reduces its pressure) then receives another pump before it enters another capillary bed.

⇒ Double circulatory systems are therefore high pressure system. In this there is no mixing of the O_2 rich blood and O_2 poor blood in the heart.

Venous Return

⇒ The amount of blood returned to the heart through the vena cava plays an important role in cardiac output.

⇒ The force of contraction of the left ventricle pushing blood into aorta and its branches upto capillaries is not sufficient enough to return the blood through the veins back to the heart.

⇒ Several factors involved in assisting the venous return to the heart are :-

(A) Position of body :- When a person is standing or sitting gravity assists the venous return from head and neck.

(B) Muscular contraction :- Contraction of skeletal muscle puts a squeezing pressure on the veins pushing the blood towards the heart.

(C) Respiratory movement :- An enlargement of thoracic cavity during inspiration creates a -ve pressure within the thoracic cavity which assists the flow of blood towards the heart.

Circulation (oxygenated) through Special Regions :-

1) **Coronary Circulation** :- The flow of O_2 blood from the ascending aorta to the heart muscle and the return of deoxygenated blood from the heart muscle to the right atrium is called Coronary (cardiac) circulation.

⇒ The right and left coronary arteries arise from the ascending aorta which supply oxygenated blood to the heart muscle (myo-cardium).

⇒ The Coronary veins brings deoxygenated blood to the Coronary Sinus, the latter carries deoxygenated blood to the right atrium.

2) **Portal Circulation** :- A vein which collects blood from one organ by one set of capillaries and distributes blood to some other organ by another set of capillaries instead of sending it to the heart is called a portal vein.

⇒ Portal vein together with the small veins by which it receives blood and the capillaries by which it supplies blood to a specific organ forms a portal system.

⇒ A portal system is named after the organ to which it carries blood. The vertebrates have 2/3 portal systems :- hepatic, renal, and hypophysial.

(A) **Hepatic Portal System** is present in all vertebrates including man. It carries the venous blood from the alimentary canal, pancreas and spleen to the liver hence its name.

⇒ The hepatic portal system includes a single large vein, the hepatic portal vein. This vein recieves a number of small veins from the different regions of the digestive tract and its associated structures. At its other end it bifurcates into right and left branches, which enter the corresponding liver lobes and break up into capillaries to supply the blood. Blood from the liver is carried by a pair of hepatic veins to the inferior vena cava.

⇒ The hepatic portal system has a great significance :-

It brings the digestive products, such as glucose, and amino acids, from the alimentary canal to the liver.

The liver retains the excess sugar and converts it into --- glycogen, which is stored for future use. The process is called glycogenesis.

If the sugar level of the blood falls, glycogen is changed back to glucose glycogenolysis, which is carried to the blood stream by hepatic veins.

The liver also deaminates the unwanted amino acids, relasing only those that are necessary for the body.

The liver converts the harmful ammonia resulting from deamination, into urea for removal by the kidneys.

Liver synthesises certain useful substances and release them into the blood for use in the body tissues. These include heparin, fibrinogen, prothrombin and Vitamin A.

(B) **Renal Portal System** is present in fishes and amphibians is reduced in reptiles & birds, and is absent in mammals.

⇒ It supplies the blood from the posterior region of the body to the kidneys by way of renal portal veins, hence it name. It enables the kidneys to remove waste products from the blood before sending it to the heart via renal veins and post caval.

(C) **Hypophysial portal System** is a minor portal system in the pituitary body.

⇒ A hypophysial portal vein collects blood from the hypothalamus of the brain and distributes it to the anterior lobe of the pituitary body.

⇒ This portal system enables the hormones from the hypothalamus to reach the anterior pituitary lobe.

3> Cerebral Circulation :-> the main arterial inflow to the brain in humans is via 4 arteries:- 2 internal carotids and two vertebrals.

=> The vertebral arteries unite to form the basilar artery. The basilar artery and the carotids form the Circle of willis below the hypothalamus.

=> The venous drainage from the brain is by sinuses which open into internal jugular veins in humans.

=> Brain receives 750 to 900 ml of blood / minute. It is about 15 to 16% of total cardiac output.

=> Since ~~blood~~ venous blood pressure is zero in brain, the most important factor regulating cerebral blood flow is the arterial blood pressure.

4> Capillary Circulation :-> After entering an organ, each artery divides to form arterioles which generally have lesser diameter than that of artery.

=> Arterioles give rise to metarterioles (meta = beyond) which are called by some physiologist terminal arterioles.

=> Metarterioles have a structure midway between that of arterioles and capillaries. From metarterioles two types of capillaries arise, some of which have same diameter as that of metarterioles and are called preferential channels, where as others have less diameter than that of metarterioles and are called true capillaries.

=> At the beginning of true capillaries, there is a ring of smooth muscle fibres called a pre-capillary sphincter.

=> This sphincter controls the flow of blood into a true capillary.

=> when the pre-capillary sphincter are relaxed (open) blood flows into the capillary bed, when pre-capillary sphincter contract (close or partially close) blood flow through the capillary bed ceases or decreases.

<6> Fetal Circulation :- Blood passes from the foetus to the placenta via two umbilical arteries.

=> At the placenta foetal blood picks up O_2 and nutrients and eliminates CO_2 and wastes.

=> The oxygenated blood returns from the placenta via a single umbilical vein. A large quantity of blood is passed from umbilical vein into the inferior vena cava through ductus venosus.

=> The oxygenated blood from the ductus venosus mixes with deoxygenated blood returning from lower body parts of the foetus in the inferior vena cava. The mixed blood enters the right atrium.

=> Deoxygenated blood from upper body parts of the foetus enters the right atrium through SVC.

=> Major portion of blood is diverted into left atrium via foramen ovale which is an opening in the septum between right and left atria. From left atrium blood passes to left ventricles which sends blood to the aorta.

=> ~~foramen ovale~~ From right atrium, blood enters right ventricle. Blood from right ventricle, is pumped into pulmonary artery. From pulmonary artery blood enters the aorta through ductus arteriosus but little amount of this blood reaches the nonfunctioning foetal lungs.

=> The blood in the aorta is carried to all foetal tissues through systemic circulation. Thus the blood flows into the umbilical arteries and back to the placenta for another exchange of materials.

(7) Cutaneous circulation :→ serves two functions namely :-
(i) the supply of nutrition to the skin and
(ii) the loss of heat from the body and regulation of body temperature.
⇒ Under normal conditions, the blood flow to skin is about 250 ml / sq. metre / minute.
⇒ During increased body temperature, when there is cutaneous vasodilation the blood flow increases upto 2800 ml / sq metre / minute.

⇒ The cutaneous blood flow is mainly regulated by body temperature and the hypothalamus of the brain which plays an important role in this.
⇒ When body temp^n is ↑↑, the hypothalamus is activated ↑ this cause cutaneous vasodilation, this ↑↑ causes the loss of heat from the body through sweat.
⇒ When body temp is ↓↓, there is vasoconstriction in the skin. Thus the blood flow to skin is reduced and heat loss is prevented.

Disorders of Circulatory System :→

1> **Atherosclerosis** :→ It is the deposition of lipids (cholesterol) on the wall lining of arteries called atheromatous or atherosclerotic plaque. These plaques may completely block the artery. Such plaques is formed in the coronary artery, reduce the blood supply to the heart and may result in heart attack or stroke.

2> **Arteriosclerosis** :→ It is the hardening of the arteries due to deposition and thickening due to precipitation of Ca^{2+} salts with the cholesterol.
⇒ Such artery loses the property of distension and its wall may rupture, resulting in the formation of clot / thrombosis in the coronary artery leading to heart attack and even death.

3> **Heart block** :→ It is a condition in which the sinus node is normal but the impulses are interrupted at any point along the conducting system of the heart.
⇒ Thus impulses do not follow the normal conduction pathway.
Two common types of heart block are found :-
A) **AV Block** :→ It occurs at the atrioventricular node. The impulses from the SA Node do not reach the AV Node.
B) **Bundle branch block** :→ It involves one of the branches of the bundle of His.

<4> **Angina pectoris** :→ Sclerosis of the coronary arteries can cause pain usually starts in the centre of the chest and spreads down the left arm.
⇒ The chest pain may be associated with restlessness, fear or anxiety, a pale skin, profuse sweating, and vomiting (all because of adrenergic discharge), the pain last for only a few moments.

5> **Coronary thrombosis** :→ A clot may form in the lumen of a coronary artery it is called coronary thrombosis.
⇒ Therefore, a large portion of the heart muscle is deprived of blood and the patient develops a 'heart attack'.
⇒ Anticoagulant durgs like TPA (tissue plasminogen factor) and streptokinase helps to prevent the formation and extension of blood clots if given within 4 hours of attack.

6> **Heart attack** :→ Heart attack also called myocardial infarction (MI) refers to a sudden event in which a portion of the heart muscle stops working because it no longer receives blood, usually due to a blockage in the coronary artery.
Generally a heart attack occurs when

plaque (fat, cholesterol, and calcium) builds up and then ruptures in the coronary artery, creating a place where a blood clot can form. (thrombus)

Sign of heart attack :- Chest pain, pain or discomfort in the upper body (arms, back, neck, jaws or stomach), shortness of breath (usually occurs at the same time as chest pain), cold sweat, nausea or vomiting and light headedness.

Controllable risk factors :- High cholesterol, cigarette smoking, excess weight, sedentary lifestyle, stress, high B.P., diabetes and certain drugs, such as oral contraceptives for women who smoke.

7) Rheumatic heart disease (RHD) :- The patient may have an acute rheumatic fever, joints pains and infection of throat.
⇒ Rheumatic fever may cause permanent damage of one or more valves (mitral or aortic semilunar valves) pericarditis and myocarditis.

8) Congenital heart diseases :- Defects or diseases of the heart from the birth are k/as congenital heart diseases and are due to some error in the development of the heart.
⇒ It is possible that some of these defects may be due to an infectious disease like rubella (German measles) in the mother or administration of some harmful drugs during first 3 months of pregnancy.
⇒ A small number of cases of congenital heart diseases are associated with chromosomal abnormalities.

9) Oedema (Puffiness) :- If the lymph capillaries fail to return lymph to the blood, fluid accumulates in the tissues resulting in a local swelling called Oedema. It may be caused by obstruction in the lymphatic system, ---- excessive capillary pressure, too little protein in the blood or injuries that causes fluids to accumulate in the tissues.

10) Ebstein disease :- It is a congenital downward displacement of the tricuspid valve into the right ventricle.

11) Fibrillation :- It is a condition in which the heart muscle is contracting very rapidly but in an uncoordinated fashion.
⇒ There are atrial and ventricular fibrillation, ventricular fibrillation is immediately life threatening unless it can be stopped by defibrillation, a machine called a defibrillator is used to do this.

12) Cardiac arrest :- Complete stoppage of the heart beat (sudden and complete loss of cardiac function)

13) Heart failure :- It is the state of heart when it does not pump blood effectively enough to meet the need of the body.

14) Ischaemia :- Inadequate flow of blood to a part of the heart caused by obstruction to its blood supply.