Body fluids and circulation

NOTES

For NEET and AIIMS

Examinations

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1.0 Circulatory system

- It is the movement of body fluids inside the body of animals so as to transport materials from the region of the formation to the region of utilization or disposal. A circulatory system is a complex of structures involved in the flow of body fluids of an organism so as to accomplish transport of materials
- Circulation of body fluids can be of the following types

1. Intracellular circulation

   It occurs inside the individual cells through Cyclosis or cytoplasmic streaming. Examples: Paramecium, Amoeba.

2. Extracellular circulation

   In multi-cellular animals, the living cells are bathed in an intercellular or extracellular fluid which circulates in the body for transport of materials

   extracellular circulation can be

   a) Extra-organismic circulation: Outside water circulates in the body of an organism

   b) Intra-organismic circulation: It involves circulation of body fluid

i) Parenchymal circulation

   In flatworms, fluid-filled spaces present in parenchyma tissue between the body wall and internal organs are used in the distribution of substances.

ii) Coelomic Circulation

   Coelomic fluid is employed in the transport of substances,Pseudocelom is used for this purpose in roundworms. Hemocoel does so in arthropods

iii) Blood vascular system

It contains blood and a pumping structure (heart) for circulation of materials inside the body. Lymphatic system accompanies blood vascular system.

1.01 Functions of circulatory system

1) Transport of nutrients
2) Transport of waste products.
3) Transport of respiratory gases
4) Transport of metabolic intermediates like lactic acid from muscles to liver
5) Transport of hormones.
6) Regulation of pH by means of a buffer.
7) Regulation of temperature.
8) Distribution of water.
9) Support or turgidity of certain organs like penis and nipples
10) Prevention of diseases by means of antibodies and antitoxin present in it
11) Disposal of cell wreckage.
12) Homeostatis or providing a stable internal environment for cells
13) Determination of pigmentation in the case of blood vascular system.
14) Plugging the area of injury.
15) As connective tissue

2.0 Open circulatory system

- Open circulation occurs in arthropods and mollusks.
- 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 lacrimal 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 systembecause, with some of the blood pooled in sinuses, the heart cannot build up enough pressure to make blood flow rapidly.
- An open system cannot achieve the high rates of oxygen transport that active animals require.
- Animals with open systems are either small and sluggish or use the open system only for the transport of food and wastes and use a different system for the transport of gases.
- Respiratory pigment, if present, is dissolved in the plasma, no red corpuscles are present.

3.0 Closed circulatory system

- The closed circulatory system is a type of blood vascular system in which blood remains confined and flows inside blood vessels only, never coming in direct contact with body cells. It occurs in most annelids, cephalopod, and vertebrates. Annelids are the simplest animals to have closed circulatory system.
- Flow of blood is

Heart → artery → arteriole → capillary →venule→ vein → heart

- Circulatory system as discovered by William Harvey (1628), blood capillaries by Malpighi (1661) blood pressure by Halls (1732) and sphygmomanometer by Riva-Rocci(1896)

3.01 Heart

- In prawn, the heart is arterial as it pumps only oxygenated blood. Vertebrate heart shows evolutionary development.
- Sinus venosus is a distinct sac which is specialized to receive venous blood. It opens into auricle.
- Conus/ truncusarteriosus is another similar sac into which ventricle opens for distribution of arteries
- In fishes, the heart is two-chambered with an auricle/atrium and a ventricle. Both sinus venous and conusarteriosus are present. There are a single circulation and heart pumps only venous (deoxygenated) blood to gillfrom where it passes to different body parts. Heart of fishes is therefore venous or branchialArteriovenous heart occurs in lungs fishes amphibians, reptiles, birds, and mammals because it receives both venous (deoxygenated and arterial (oxygenated) blood. there is double circulation, pulmonary (to and fro lungs) and systematic (to and fro other body parts)
- In amphibians, there are two auricles/ atria.
- In amphibians, there are two auricles/ atria, one ventricle, a sinus venosus and cons/ truncusarteriosus. Mixing of oxygenated and deoxygenated blood occur in the ventricle.

- In reptiles, the heart has two atria and an incompletely divided ventricle. Sinus venous is present but conusarteriosus has merged with ventricle and aorta.
- In crocodiles, the ventricle is almost completely divided through mixing of blood does occur
- The heart is completely four-chambered in mammals and birds with neither sinus venous nor conusarteriosus. There are two atria and two ventricles. There are two atria and two ventricles. The left part of the heart is connected with oxygenated blood (scarlet red) and right part with deoxygenated blood (purple red)

3.02 Artery

It is a blood vessel that carries blood away from the heart towards an organ. Artery generally contains oxygenated blood (deoxygenated in the pulmonary artery). The blood flows in an artery under alternate increased pressure and with jerks. Arteries are deep-seated with thick elastic wall and comparatively, narrows lumen. They become empty after death. Valves are absent. The wall is made up of three regions tunica external, tunica media or tunica adventitia is an outer coat made of loose connective tissue with abundant white (collagen) and fewer yellow (elastin) fibers as well as longitudinal smooth or unstriped muscle fibers. There is a well-developed external elastic lamina on the inner side. The middle coat or tunica media is thick having unstriped circular muscles and elastic connective tissue. The inner coat, tunica interna or tunica intima is also made of connective tissue. It has a number of folds. The lumen is lined by an endothelium of elongated flat thin

squamous tissue. There is an elastic membrane of yellow fibers called internal elastic membrane or lamina.

3.03 Veins

It is a blood vessel that carries blood from an organ towards the heart. Vein generally contains deoxygenated blood (oxygenated in pulmonary veins). The flow of blood is smooth, without jerks and under little pressure intervals, a vein contains semilunar valves to maintain blood flow in one direction. Each semilunar valve has two cusps, rarely three or one venous flow of blood is maintained by milking action of surrounding muscles, contraction of the diaphragm and other body movements. Veins are mostly superficial with thin wall and wide lumen. After death a vein retains blood. Structurally, the wall of the vein has the same three parts as in an artery, tunica external, tunica media and tunica interna. Tunica Externa is the outer coat with loose connective tissue, abundant white, and fewer yellow fibers. It is well developed but external elastic lamina is not much differentiated. Tunica media is comparatively thinner in vein with a few smooth circular muscles. Tunica interna is similar to the artery but with fewer folds, less developed internal elastic membrane and less elongated endothelial tissues. Semilunar valves are made of folds of endothelium with some enclosed connective tissue.

3.04 Capillary

It is a very fine blood vessel where the wall is made of a single layer of the endothelium of tessellated cells. A fine intercellular cleft occurs between the adjacent endothelial cells. Basement membrane lies on the outside. Blood capillaries are formed by arterioles. They join to produce venule. The lumen of blood capillary is so fine that

red blood corpuscles can pass through it in a single file. The WBC can come out of them through the process of diapedesis. Because of their extremely thin walls, blood capillaries take part in the exchange of materials between blood and tissue fluid. In lungs, they pick up oxygen and give out CO_2 through diffusion. All the blood capillaries are not functional all the time. Some of them work only at the time of intense activity. Their working is controlled by precapillary sphincters present in the area of their origin.

3.05 Arteriovenous anastomosis

It is a direct vascular connection between an arteriole and venule bypassing capillary supply. The connection occurs in certain exposed parts like fingertips, nose, pinnae, eyelids, lips, tongue etc. It is meant for controlling blood supply and temperature of the exposed parts.

3.06 Vascular plexus

Anastomosis of blood vessels is like arteries in certain regions to provide extra blood e.g. cutaneous plexus, papillary plexus, and nasal plexus.

5.0 Blood

It is complex mobile fluid connective tissue of reddish colour in which the fluid matrix is not synthesized by the contained cells. An adult human has 5-5.5 liters of blood. pH is 7.4. Blood consists of two parts, plasma and blood corpuscles (formed elements)

5.01 Plasma

- It is a slightly alkaline non-living intercellular substance which constitutes about 60% part of the blood. It is a pale yellow but transparent and clear fluid.

- It is composed of 91-92% of water, 7% proteins, 0.9% inorganic substances, 0.1% glucose and traces of other constituents (amino acids, fatty acid, fat drops, cholesterol, anticoagulants, hormones, excretory products, vitamins etc.)
- The main categories of protein are albumins, globulins, and fibrinogen. Albumins produce colloidal osmotic pressure. It also carriesCa and some fatty acid α-globulin, β-globulin carry fat soluble vitamins, cholesterol, and ions other globulins are prothrombins, thromboplastin, and anti-hemophiliac factors. Fibrinogen takes part in blood coagulation by forming fibrin
- Mineral salts like chlorides, bicarbonates, sulfates and phosphate of sodium, potassium calcium, iron and magnesium constitute about 0.9% of plasma. Buffer of the blood is sodium bicarbonates

5.01.01 Function of blood plasma

i) Transport

ii) Retention of fluid in the blood.

iii) Maintenance of blood pH

iv) Body immunity

v) Prevention of blood loss

vi) Conducting heat to skin for dissipation

vii) Uniform distribution of heat all over body

5.01.02 Blood glucose

- Usually blood glucose level is about 80-100 mg per 100 ml of blood 12 hours after a normal meal
- It blood glucose level exceeds 180 mg per 100 ml, it starts appearing in the urine. This condition is called glycosuria. If it

is less it causes hypoglycemia and if it is higher it causes hyperglycemia.

5.01.03 Blood cholesterol

It normal amount is 80-180 mg in 100 ml of blood plasma. Increased blood cholesterol may lead to its deposition in the internal wall of the blood vessels like arteries and veins which cause high blood pressure and heart problem

5.02.00 Formed elements

5.02.01 Erythrocytes (red blood corpuscles or RBCs)

- A normal adult man and woman have 5 to 4.5 million RBCs per cubic millimeter of blood respectively.
- Less amount of hemoglobin leads to anemia which may be caused by loss of blood or destruction of RBCs.
- An abnormal rise in RBC count is called polycythemia. Decrease in the number of RBC count is called erythrocytopenia which cause shortage in the blood and tissues
- They are biconcave, disc-shaped enucleate reddish coloured cells of 7-8μm in diameter and 1-2μm thick. Red colour is due to the presence of hemoglobin
- Hemoglobin is a conjugate protein which is made up of a protein called globin and a non-protein group heme (=haeme) hence the hemoglobin.
- Hemoglobin is oxygen-carrying pigment. 100ml of blood of a normal man contains 15g of hemoglobin and of normal woman an average of 13g of hemoglobin
- Erythropoiesis is the process by which red blood cells are produced. In human adults, this usually occurs within the bone marrow.

- The life of an RBC is about 120 days. The worn out RBCs are destroyed in the spleen and liver
- Their iron is returned to the red bone marrow for reuse in the synthesis of fresh hemoglobin
- Their pigment is degraded to yellowish pigment bilirubin which is excreted in bile.

5.02.02 Erythrocyte sedimentation rate (ESR)

If blood containing an anticoagulant (oxalate) is allowed to stand in a narrow vertical tube the erythrocyte settle to the bottom half of the tube. The rate at which this occurs is called the erythrocyte sedimentation rate. ESR is very useful in diagnosing various diseases including tuberculosis. ESR in men is 0-5 mm/hr. and in women, it is 0-7mm/ hour.

5.02.03 Leucocytes(white bold corpuscles or WBCs)

→They are colourless, active and mobile nucleated blood corpuscles with a number 7000±3500 /mm^3. Leucocytes are of two types granulocytes (with granules and polymorphic nucleus) and agranulocyte(without granules and monomorphic nucleus).

→ The life of granulocyte is normally 40 to 8 hours circulating in the blood and another 4-5 days in the tissue

→Monocytes have a short lifespan of 10-20 hours. The lymphocytes have life span of few days or months or years

→Granulocytes are of three types (neutrophils, basophils, eosinophils) while agranulocyte are of two types (Monocytes and lymphocytes)

- Neutrophils

They have granules that stain with neutral dyes nucleus 2-7 lobed, nearly circular, 62% of all leucocytes, phagocytic.

- Eosinophils

  Coarse granules that get stained with acidic dyes (bright red with cosine), nucleus bilobed, size 10-14μm, 2-3% of total leucocytes, number increases in asthma.

- Basinophile

  Fewer coarsegranules stained with a basic dye (methylene blue), nucleus S-shaped and 3 lobed, 0.5% - 1%, allergic reactions by releasing histamine, also heparin and serotonin.

- Lymphocytes:

  Large nucleus with granule-free pale blue cytoplasm, 30% of total leucocytes, manufactures globins some of which function as antibodies in immunological reactions. Lymphocytes have a size of 7-10μm, nucleus stains more deeply with basic dyes than surrounding cytoplasm. Large lymphocytes have 10-14μm, nucleus stains more deeply with basic dyes than surrounding cytoplasm. Large lymphocytes have 10-14 μm and more cytoplasm. On basis of site of maturation, two kinds -:β-lymphocytes, and T-lymphocytes

- Monocytes

  Largest leucocytes, 10-18 μmkidney-shaped nucleus, 5-6% of total leucocytes motile, Phagocytic, scavengers, production of interleukin and pyrogen.

  5.02.04 Thrombocytes(blood platelets)

  → There are about 250,000 platelets in cubic millimeters of blood. Increase and decrease in the number of platelets is known as thrombocytosis and thrombocytopenia respectively.

- → They are rounded or oval disc-like bodies platelets are 2-3 µm in diameter. They are colourless
- → Platelets are formed from the megakaryocytes (very large cells of the bone marrow). Formation of thrombocytes is called thrombopoiesis.
- → Normal life span of blood platelets is about a week
- → When an injury is caused, the blood platelets release certain chemicals which are called the platelet factors (thromboplastin). The platelet factors help in the clotting of blood

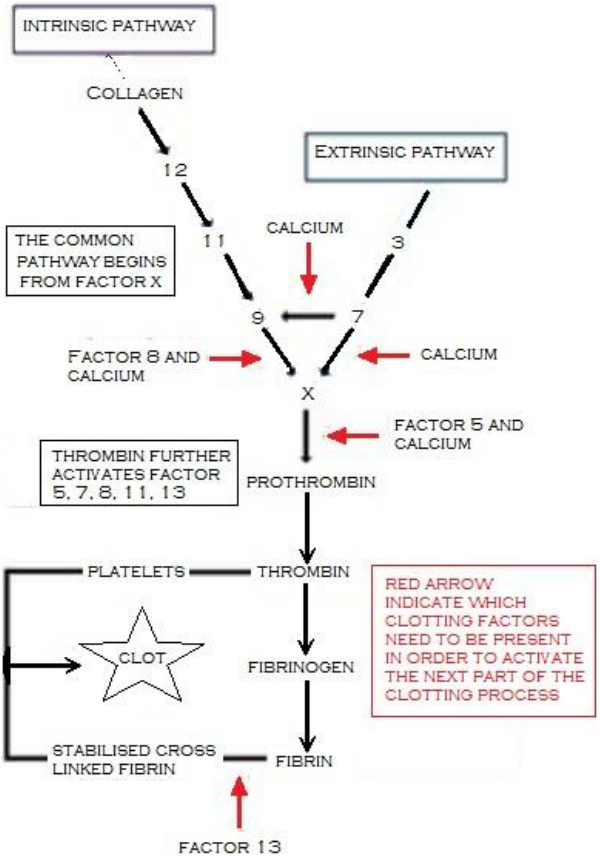
6.0 Blood coagulation (blood clotting)

When an injury is caused to a blood vessel, bleeding starts which are topped by a process called blood clotting or blood coagulation

- → First step: At the site of an injury, the blood platelets disintegrate and release a phospholipid called platelet factor-3 (Thromboplastin). Injured tissues also release a lipoprotein factor called thromboplastin. These two factors combine with calcium ions Ca^{+2} and certain protein of the blood to form an enzyme called prothrombinase.
- → Second step: The prothrombinase inactivates heparin in the presence of calcium. Prothrombinase catalyzes the breakdown of Prothrombin into an active protein called thrombin and some small, peptide fragments.
- → Third step: Thrombin acts as an enzyme and first brings about depolymerization of these monomers. Later thrombin stimulates polymerization of these monomers into long insoluble fibers – like polymers called fibrin. The thin, long and solid fibers of fibrin from a dense network

upon the wound and trap blood corpuscles to form a clot. The clot seals the wound and stops bleeding. Soon after the clot seals the wound and stops bleeding. Soon after the clot starts contracting and a pale yellow fluid, the serum, starts oozing out. This serum is blood plasma minus fibrinogen and blood corpuscles.

Vitamin K is essential for blood clotting as it is necessary for the synthesis of Prothrombin in the liver



6.0.01 List of clotting factors

Factor I

Name :Fibrinogen

Source: Liver

Pathway : Both extrinsic and intrinsic

Activator :Thrombin

Actions: When fibrinogen is converted into fibrin by thrombin, it forms long strands that compose the mesh network for clot formation.

FactorII

Name :Prothrombin

Source: Liver

Pathway : Both extrinsic and intrinsic

Activator : Prothrombin activator

Actions: Prothrombin is converted into thrombin which then activated fibrinogen into fibrin.

Factor III

Name :Thromboplastin / Tissue Factor

Source: Platelets (intrinsic) and damaged endothelium (cells) lining the blood vessel (extrinsic).

Pathway: Both extrinsic and intrinsic

Activator: Injury to blood vessel

Action: Activates factor VII (VIIa).

Factor IV

Name: Calcium

Source: Bone and absorption from food in gastrointestinal tract

Pathway: Both extrinsic and intrinsic

Action: Works with many clotting factors for activation of the other clotting factors. These are called calcium-dependent steps.

Factor V

Name :Proaccerin / Labile factor / Ac-globulin (Ac-G)

Source: Liver and platelets

Pathway: Both extrinsic and intrinsic

Activator: Thrombin

Action: Works with Factor X to activate prothrombin (prothrombin activator).

Factor VII

Name :Proconvertin / Serum prothrombin conversion accelerator (SPCA) / stable factor

Source: Liver

Pathway: Extrinsic

Activator: Factor III (tissue factor)

Actions: Activates Factor X which works with other factors to convert prothrombin into thrombin.

Factor VIII

Name : Anti-hemolytic factor / antihemophilic factor (AHF) or globulin (AHG) / antihemophilic factor A

Source: Endothelium lining blood vessel and platelets (plug)

Pathway: Intrinsic

Activator: Thrombin

Actions: Works with Factor IX and calcium to activate Factor X.

Deficiency: Hemophilia A

Factor IX

Name : Christmas factor / Plasma thromboplastin component (PTC) / Antihemophilic factor B

Source: Liver

Pathway: Intrinsic

Activator: Factor XI and calcium

Actions: Works with Factor VIII and calcium to activate Factor X.

Deficiency: Hemophilia B

Factor X

Name:Stuart Prower factor / Stuart factor

Source: Liver

Pathway: Extrinsic and intrinsic

Activator : Factor VII (extrinsic) / Factor IX + Factor VIII + calcium (intrinsic)

Actions: Works with platelet phospholipids to convert prothrombin into thrombin. This reaction is made faster by activated Factor V.

Factor XI

Name : Plasma thromboplastin antecedent (PTA) / antihemophilic factor C

Source: Liver

Pathway: Intrinsic

Activator: Factor XII + prekallikrein and kininogen

Actions: Works with calcium to activate Factor IX.

Deficiency: Hemophilia C

Factor XII

Name: Hageman factor

Source: Liver

Pathway: Intrinsic

Activator: Contact with collagen in the torn wall of blood vessels

Actions: Works with prekallikrein and kininogen to activate Factor XI. Also, activates plasmin which degrades clots.

Factor XIII

Name:Fibrin-stabilizing factor

Source: Liver

Activator: Thrombin and calcium

Actions: Stabilizes the fibrin mesh network of a blood clot by helping fibrin strands to link to each other. Therefore it also helps to prevent fibrin breakdown (fibrinolysis).

Prekallikrein

Source: Liver

Pathway: Intrinsic

Actions: Works with kininogen and Factor XII to activate Factor XI.

Kininogen

Source: Liver

Pathway: Intrinsic

Actions: Works with prekallikrein and Factor XII to activate Factor XI.

7.0 Functions of blood

i) Transport of food materials: Blood transports the digested food from the alimentary canal to the different body cells

ii) Transport of respiratory gases: Oxygen is carried from the respiratory organs to the tissues and carbon dioxide from the tissue to the respiratory organ by blood.

iii) Transport of hormones: Hormones are carried by blood from the endocrine glands to the places of use

iv) Transport of excretory matter: Blood transport the excretory matter to the kidney or other excretory organs.

v) Transport of heat: Blood allows the transfer of heat from the deeper tissue to the surface of the body where it can be lost.

vi) Defense against infection: Some white blood corpuscles are Phagocytic in action, however, certain blood corpuscles produce antitoxins to neutralize the toxins released by the foreign germs.

vii) Temperature regulation: Blood maintains the body temperature to a constant level after distributing heat within the body.

viii) Water balance: Blood maintains water to a constant level by bringing about constant exchange of water between circulating blood and the tissue fluid

ix) Maintenance of pH: Blood helps to regulate the pH of the body.

x) Prevention of excessive loss of blood: When any part of the body is injured, loss of blood is prevented by the formation of a clot.

xi) Helps in healing: Blood maintains necessary supplies for the repair of damaged tissue. Eosinophils and basophiles help in the healing of the wound.

xii) Maintenance of physiological co-operation: Blood maintains a physiological co-operation between parts of the body by circulating from one to other parts.

8.0 Blood group

- Karl Landsteiner reported first time ABO blood groups in a human being (1900). AB blood group was found out by de Castellan and Steini (1902)
- If a blood transfusion is made between an incompatible donor and recipient, the reaction of antigen on the cells and antibodies in the plasma produce clots that clog capillaries.

Blood Group	Genotype	Antigens In RBC	Antibodies in blood plasma	Receive blood	Donate blood	Percentage Humans
A	I^AI^A or I^AI^O	A	B	A, O	A, AB	41%
B	I^BI^B or I^BI^O	B	A	B, O	B, AB	10%
AB	I^AI^B	AB	None	O, A, B, AB (Universal Recipient)	AB	4%
O	I^OI^O	None	a, b	O	O, A, B, AB (Universal Donor)	45%

8.01 Rh (rhesus) blood group

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

- 85% of humans (93% Indians) have blood protein called Rh factor (Rh^+). Other without the factor are called Rh^-
- Rh is tested with the help of Rh antiserum or plasma containing Rh antibodies. Agglutination occurs in Rh^+ cases while non-agglutination shows Rh^- nature. Rh^+ is dominant over Rh^-. The antigen formation is determined by a dominant allele R. It gives rise to the Rh^+ condition. Presence of double recessive, rr, does not form antigen so that the individual is Rh^-
- Rh^+ blood given to Rh^- person produces an anti –Rh factor 'a'. the first baby is safe due to late development of anti-Rh factor 'a'.
- However, the second Rh^+ baby will either die in foetus stage or born anemic with several abnormalities due to the disintegration of red bloodcells (erythroblastosisfoetalis) by anti-Rh factor 'a' (anti –Rh globulin is available to overcome the defect) and consequent production of excess bilirubin. The latter can damage the brain of the infant. However, can damage the brain of the infant. However, the reverse does not have the effect.

Oswal Hope Robertson is the creator of the first blood bank.

8.02 Importance of blood groups

i) Knowledge of blood group is essential for blood transfusion

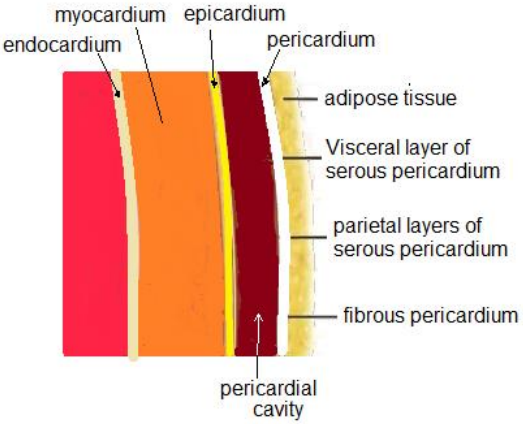
ii) Rh compatibility is required for both marriage and transfusion in order to prevent erythroblastosis

iii) Preliminary information about disputed parentage and progeny is provided by blood grouping.

iv) Blood grouping is used in the forensic identification of blood stains.

9.0 Human Heart

- It is a reddish conical muscular mesodermal hollow organ of an about 12cm length 9 cm breadth, weighs about 300gm and lies behind the sternum in the mediastinum space of holder cavity in between the two lungs. Broader base is upwards.
- The mammalian heart comprises of four complete chambers two ventricles and two auricles (atria)
- Heart wall consists of connective tissue, blood vessels, and cardiac muscle fibers. The latter form a cross – connected network for smooth passage of constriction wave. The cardiac muscle or myocardium does not tire due to
  a) Alternate rest and activity
  b) Non- formation of lactic acid
- The heart is covered by a double fibrinogenous sac or pericardium. It has two components outer non-distensible tough fibrous pericardium (prevents excessive expansion of heart) and inner thin serous pericardium.
- Serous pericardium has two thin secretory membranes,
  (i) outer parietal have two sub layers
  a) Outer: Fibrous connective tissue
  b) Inner : Simple squamous epithelium
  (ii) and inner visceral or epicardium made up of simple squamous epithelium



It encloses a narrow pericardial cavity having pericardial fluid (serous fluid) for frictionless movement, protection from shock and mechanical injury

Functions of pericardial fluid

(i) It prevents the heart from external jerks

(ii) It provides moisture to heart

(iii) Keeps the heart contained within the chest cavity

(iv) Prevents the heart from over-expanding when blood volume increases

(v) Limits heart motion

(vi)Reduces friction between the heart and surrounding tissues

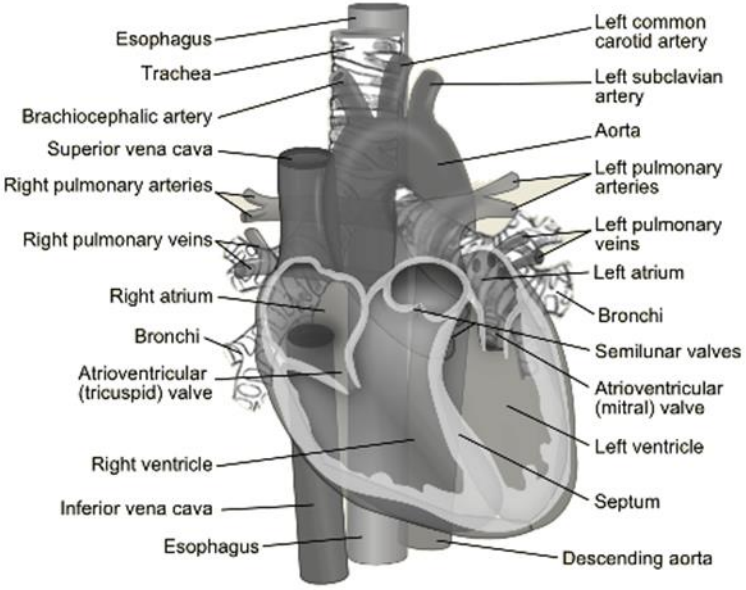
(vii) Protects the heart against infection

- There is a depression or coronary sulcus between atria and ventricles, interatrial sulcus (two parts, anterior and posterior) between two ventricles. Coronary arteries are housed in these sulci. They supply blood to walls of the heart.
- Atrial appendages are protruded part of atria which overhangs the ventricles. Low ridges occur internally in the region of the

atrial appendage. They are called musculipectinati. Blood vessels connected to heart are known as great blood vessels

- Deoxygenated blood flows through the right half of heart and oxygenated blood flows through the left half of heart. The right and left atria are separated by an interatrial septum. It bears a depression called fossa ovalis (in the area of foetal opening called foramen ovale). Right atrium/auricle receives deoxygenated blood from superior vena cava (upper part of the body), inferior vena cava (middle and lower part of the body) and coronary sinus (heart walls). The basis valve occurs at the opening of coronary sinus and Eustachian valve at the opening of inferior vena cava
- Backflow in superior vena cava is prevented by the obliquity of opening. The left atrium/auricle receives oxygenated blood from two lungs through four pulmonary veins. Right and left ventricles are separated by an interventricular septum
- The left ventricle is larger, includes the apex part and has an extra thick wall as compared to right ventricle due to its mechanical requirement of pumping oxygenated blood to all parts of the body, walls of ventricle possess a network of low ridges or columnae carnea and a few large muscular projection or papillary muscles/ musculuspapillaris).
- Right ventricle contains a moderator band that extends between upper papillary muscle and inter-ventricular septum. Atria opens into ventricles through atrioventricular apertures is guarded by valves. Right atrial- ventricular aperture is guarded by tricuspid valve possessing three flaps and left atrioventricular aperture is guarded by bicuspid and mitral valve possessing two flaps.

- The flaps of the valves are held in their position by fine inelastic cords or chordaetendineae connected to papillary muscles. Left ventricle opens into the aorta. The opening is guarded by an aortic semilunar valve between two.

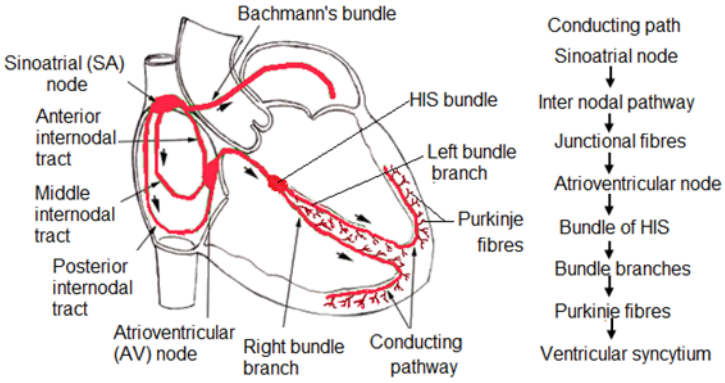


10.0 Conduction of heart beat

- The automatic rhythmicity of the heart is its ability to contract spontaneously at a regular rate
- In practice, this represents apex or ventricular beat with an advantage of 72/minutes in an adult human. It is high in infants and low in aged persons. Similar heart beat is fast in small animals (200/min in Rabbit and 500/min in Sparrow) and low in large animals (25 /min in elephant) as well as cold-blooded animals (64/min in frog).

- The heartbeat is of two types: Neurogenic and myogenic. The neurogenic heart beat is initiated by a nerve impulse coming from a nerve 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 path of modified heart muscle itself. It is found in hearts of mollusks and vertebrates.
- In the myogenic heartbeat, contraction is initiated by a specialized path of modified heart muscles, the sino-atrial node (SA node) which is situated in the wall of the right auricle near the opening of superior vena cava.
- 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 sino-atrial node spreads as a wave of contraction over the right and left atrial wall pushing the blood through the strio ventricular valves into the ventricles.
- This wave of contraction next reaches the atrioventricular (AV – node) or pacesetter is stimulated to emit an impulse of contraction spreading to the ventricular muscle in the atrioventricular bundle and the Purkinje fibers.
- The atrial muscle fibers are separated from those of the ventricles by a fibrous tissue ring. These are no functional continuity between the atria and ventricles. They only conducting tissue between the atria and the ventricles is the atrioventricular bundle or the Bundle of His).

- The atrioventricular bundle (Bundle of His) was discovered by His (1983) and consists of a set of specialized muscle strands originating from AV node and pass downwards into the inter-ventricular septum. This bundle then divided into the left and right bundle branches, one going to each ventricle.
- Within the myocardium of the ventricles, the branches break up into a network of fine branching, anastomosing filaments of fibers known as Purkinje fibers.
- The bundle of His and the Purkinje fibers convey the impulse of contraction from the AV node to the myocardium of Ventricles.



10.01 Pace-maker

- SA node is called natural pacemaker of heart as impulse generated by it spreads to booth atria and through AV node to ventricles for their rhythmic contraction.
- Disruption or insufficiency of any component of this impulse conducting system results in slowing down or irregularity of heart rhythm or independent contraction of atria and ventricles. Failure of the atrial impulse to pass into ventricles for a few seconds to few hours is called ventricular escape or

Stokes- Adam syndrome. In all such cases, an artificial pace – maker is implanted.

- It is an electric device first developed by Greatbatch and Chardack(1960) which is connected to heart for covering up any deficiency of myogenic functioning so as to make it beat normally (72-80/ min) A pacemaker has a pulse generator having long lasting lithium halide cells (with over 10 years of life) and a biocompatible plastic covered fine metallic string for functioning as muscles stimulating electrode. There are various types of the pacemaker.
    i) External pacemaker
    ii) Epicardial pacemaker
    iii) Endocardium pacemaker
    iv) Demand pacemaker
    v) Atrial synchronized
    vi) Temporary pacemaker
    vii) Permanent pacemaker
- In common type, the pulse generator is placed below skin under right clavicle while the string/cable is passed via superior vena cava-right atrium and allowed to rest against the tip of the right ventricle.
- A pacemakeris liable to be influenced by microwave ovens, metal detectors, electric shaver's cell phone etc.

10.02 Cardiac cycle

- The cardiac cycle consists of one heart or one cycle of contraction and relaxation of the cardiac muscle. The contraction phase is called the systole while the relaxation phase is called diastole.

- When both the atria and ventricles are in diastolic and relaxed phase, this is referred to as a joint diastole. During this phase, the blood flows from the superior vena cava and inferior vena cava into the atria and from material to the respective ventricles through auriculo-ventricular valves. But there is no flow of blood from ventricles to the aorta and pulmonary trunk as the semilunar valves remain closed
- The successive stages of the cardiac cycle are briefly described below

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

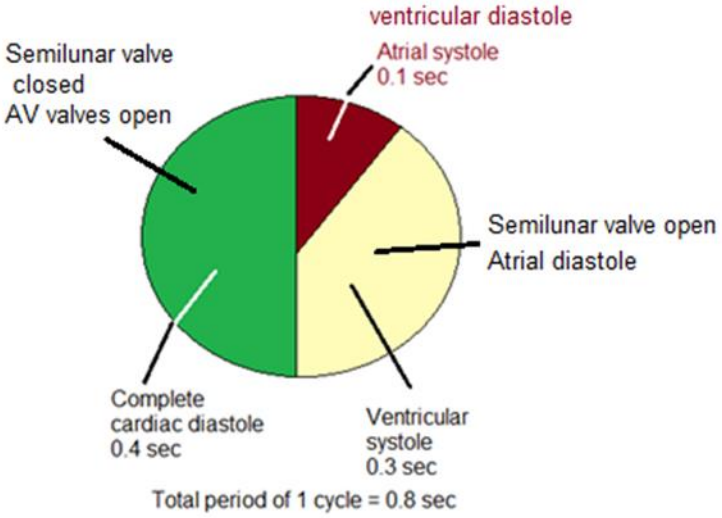
  Beginning of ventricular systole: The ventricles begin to contraction, stimulated by the AV node. The bicuspid and tricuspid valve close immediately producing part of the first heart sound.

  Complete ventricular systole: When the ventricles complete their contraction, the blood flows into the pulmonary trunk and aorta as the semilunar valves open.

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

  Complete ventricular diastole: The tricuspid and bicuspid valves are 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 flow. It is due to the fact that this blood flows. It is

due to the fact that the pressure within the relaxed ventricles is less than that in atria and veins



In single cardiac cycle of human

(1) Atrial systole = 0.1 sec

(2) Atrial diastole = 0.7 sec total 0.8 sec

(3)Ventricular systole = 0.3 sec

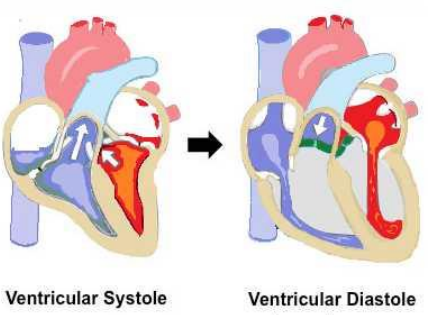
(4) Ventricular diastole = 0.5 sec total 0.8 sec

Joint diastole 0.8-0.4 = 0.4sec is a period during which entire heart is in diastole

11.0 Heart sounds

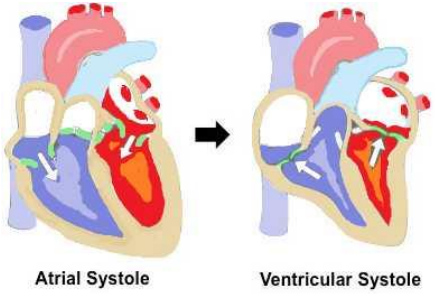
- There are sounds produced during heart beat due to closure of valves
- Lubb (S_1) first sound, systolic sound) is the first heart sound which is dull, loud or low pitched, of long duration (0.16 and

0.19 seconds) and is produced due to closure of atrioventricular valves (tricuspid and bicuspid valves)



SECOND HEART SOUND ('DUPP')
CLOSURE OF THE *Semilunar valves*

- Dup (S_2, second sound, diastolic sound) is the second heart sound which is sharp high pitched, of shorter duration (0.1 sec) and is produced due to the closer of semilunar valves at the base of great arteries. A pause or gap occurs between the second sound and the first sound of next cycle. It coincides with ventricular diastole.
- Incomplete closure of valves due to disease or other defect produces abnormal heart sound called murmur. Heat sounds are listened by means of an instrument called stethoscope.



FIRST HEART SOUND ('LUBB')
CLOSURE OF THE *Atrioventricular valves*

12.0 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 by the volume of blood ejected by each ventricle during each beat, which is called the 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 litre/min/sq.m

13.0 Regulation of heart beat

13.01 Neural regulation

The cardiac center lies in the medulla oblongata of the brain. The cardiac center is formed of cardio-inhibitor and cardio-accelerated parts. The former decreases the rate of heart beat and the latter accelerates it. The cardio-inhibitor is connected with the heart through vagus nerve (it carries – parasympathetic nerve fibers) and cardio accelerator through sympathetic nerve fibers. Sensory fibersextended from the receptors present in the superior vena cava aorta and carotid sinuses to the cardiovascular center in the medulla oblongata. The impulses received from the aorta and carotid sinuses decrease the heart rate, whereas the impulses from Vena Cava increase the heart rate.

13.02 Hormonal regulation

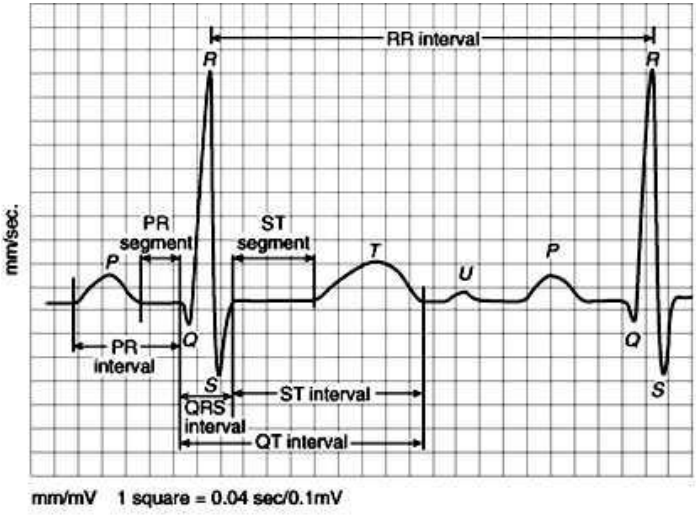
Adrenaline and noradrenaline hormones are secreted by the medulla of the adrenal glands. Noradrenaline accelerates the heart

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 glands increases oxidative metabolism of the body cells. This requires more oxygen and thus indirectly increases heartbeat.

Body temperature also affects the pacemaker. Just $1^{O}C$ rise in temperature increases with exercise to provide additional oxygen and food to muscles.

14.0 Electrocardiogram (ECG)

- ECG is graph record of the elastic current produced by the excitation of the cardiac muscles. The instrument used to record the changes in an electrocardiograph. Waller (1887) first recorded the electrocardiogram but Einthoven (1906) studied ECG in detail and got Nobel Prize. He is also considered "father of the electrocardiography



- A normal ECG is composed of P waves, a QRS wave (complex) and a T wave. The letters are arbitrarily selected and do not stand for any particular words
- The P wave is a small upward wave that indicates the depolarization of the 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 seconds. The normal P-R interval is 0.12 to 0.2 second. Normal QRS complex duration is 0.12 second. The normal Q-T interval is 0.4 second.
- Enlargement of the P wave indicates enlargement of atria. During atherosclerotic heart diseases and rheumatic fever, the P-R interval is lengthened. 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 infection and depressed when the heart muscle receives insufficient oxygen.
- T wave is flat when the heart muscles receive insufficient oxygen as in atherosclerotic heart disease. It may be elevated when the body's potassium level is increased.
- When ECG of person to be recorded, four leads (metal electrodes) are attached to the arms and legs. It is done after

lining and putting special jelly, which improves electrical conduction. With the help of 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 deflection wave.

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

15.0 Blood pressure

- It is the pressure exerted by the flow of blood on the walls of arteries and measured as millimeters of mercury by the instrument is called sphygmomanometer(Riva-Rocci). It has a high systolic value (normal 120 mmHg) and low diastolic value (normal 80 mmHg). The difference between two is called pulse pressure.

15.01 Hypertension (hyperpiesis)

- It is sustained the rise in arterial blood pressure or high blood pressure with systolic more than 140 mmHg and diastolic more than 90mmHg. The reason is stiffening of arterial walls due to cholesterol walls, varicose veins, obesity, toxins, hormones, defective kidney etc. Other forms of hypertension are known as primary hypertension. It accounts for 90% of the cases.
- High blood pressure harms three vital organs-heart, brain and kidney. It makes the heart to overwork due to which congestive heart disease develops quite early. A blood pressure of 220/120 mmHg may cause internal hemorrhage due to rupturing of some blood vessel. Cerebral hemorrhage causes

stroke or CVA. Damage to optic arteries leads to blindness while a similar damage to renal vessels causes nephritis. It leads to renal failure.

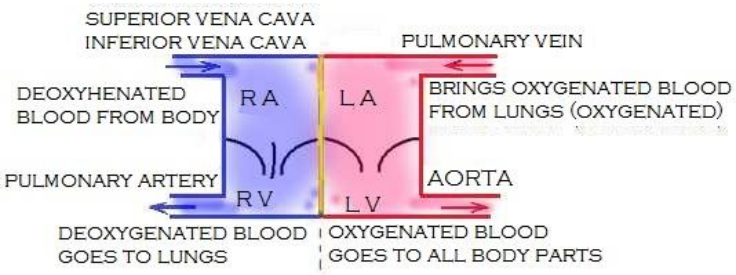
15.02 Hypotension (hypopiesis)

It is low blood pressure with systolic below 110 mmHg and diastolic below 70 mmHg

Hypertension is caused by low metabolic rate, starvation, anemia, chronic vasodilation of arterioles, lower pumping activity, valvular defects, nervous disorders, Addison's disease.

There is an increasing relationship between the rate of heart beat and blood pressure. The phenomenon is called Marley's law of heart

16.0 Double circulation



Double circulation is the passage of same blood twice in the heart through separate pathways for completing one cycle. It causes only 25% of the blood being oxygenated at one time.

Double circulation consists of two parts, pulmonary circulation, and systematic circulation.

1) Pulmonary circulation: The movement of blood between heart and lung is called pulmonary circulation.

Deoxygenated blood from the body enters right atrium. It is passed to the rightventricle and then into a pulmonaryarch sending to lungs for oxygenation. From lungs, the oxygenated blood is brought into left atrium

2) Systematic circulation: This is a movement of blood between the heart and different parts of the bodyexcept for lungs. Oxygenated blood is received by left atrium. It is passed to left ventricle which pumps it into the aorta for supply to body parts including walls of the heart. On deoxygenation, the blood passes back into the right atrium of the heart through the coronary sinus, inferior vena cava, and superior vena cava. The purpose of systematic circulation is to transport O_2 and nutrients to tissue and remove CO_2 and nitrogenous waste from them.

17.0 Arterial system

- It comprises all the arteries coming out of the heart and supplying blood to different parts of the body. The heart gives out two main arterial vessels, pulmonary arch (from right ventricle) and aorta.
- Pulmonary arch carries deoxygenated blood. It divides into two pulmonary arteries one for each lung. Aorta carries oxygenated blood. It is swollen into the aortic oxygenated blood. It is swollen into aortic sinus at its origin. Aortic sinus gives out right and left coronary arteries to the heart. Aorta then produces a short and wide innominate on right side, a left common carotid and a left subclavian before bending down as the dorsalaorta. Innominate or brachiocephalic forms a right common carotid and a right subclavian. Subclavianprovides

oxygenated blood to forelimbs, chest and spinal cord. Carotids supply oxygenated blood to neck, face, mouth, eyes, scalp, and brain

- Dorsal aorta has two parts, thoracic and abdominal. Thoracic aorta gives out esophageal (to the esophagus), phrenic (to the diaphragm), branches to back and intercostals (to intercostal muscles) in the thoracic cavity. Abdominal aorta supplies blood to visceral organs and lower extremities. It first gives out thick celiac artery with branches like hepatic (liver), gastric (stomach), splenic (spleen), duodenal (duodenum) and pancreatic (pancreas). Below celiac, abdominal aorta gives out a superior mesenteric artery (small intestine), two super renal (adrenal or suprarenal glands), two renal (kidneys), two genitals and inferior (posterior) mesenteric artery (large intestine) and then divides into two iliac (pelvic region and lower limbs)
- 4% of arterial blood passes into the heart, 10% to the liver, 8% to the brain, 15% of thedigestive tract and the remaining for rest of the body.

18.0 Venous system

- It comprises all the veins that bring blood to the heart. The venous system consists of pulmonary veins, coronary sinus, portal system and venae cavae. Pulmonary veins are four in number, two from each lung. They bring oxygenated blood to the left atrium. Coronary sinus collects deoxygenated blood from all the walls of the heart. It opens into the right atrium. Superior vena cava is formed by two brachiocephalic veins each of which receives deoxygenated blood from a jugular vein

(from head and neck), subclavian vein (upper limb) and internal thoracic vein (part of the chest). Before opening into the right atrium, superior vena cava receives a small azygos vein from the esophagus and intercostal area.

- Inferior vena cava is formed by the union of two common iliac veins (pelvis and lower limbs). While on its way to the heart, it receives genital veins (gonads), lumbar veins (muscles of the back), renal (liver) and phrenic veins (diaphragm). It then opens into the right atrium.

19.0 Portal system

- It is a system made of a portal vein and the capillary complex formed by it in an organ than one of its origins. A portal vein is a vein which collects blood from one organ by a set of capillaries and distributes that blood into a second organ through another set of capillaries instead of sending blood into the heart. There are three types of portal systems – hepatic, hypophysial and renal.

19.01 Hepatic portal system

- It occurs in all vertebrates and is meant for taking blood from digestive tract, pancreas, and spleen into the liver. The system has a large hepatic portal vein that is formed by four veins- splenic (spleen), inferior mesenteric (rectum and the distal part of the colon), superior mesenteric (small intestine, caecum and proximal part of the colon) and gastroepiploic(from stomach and pancreas). Hepatic portal vein enters liver and breaks into capillaries. The system function as a short circuit for

  (i) Removal of glucose, amino acids, and other nutrients.

(ii) Deamination of extra amino acids and conversion of harmful ammonia into urea

(iii) Separation of toxic chemicals and their detoxification

(iv) Direct pouring of liver products into venous blood

19.02 Hypophyseal portal system

It is a minor portal system that occurs in higher vertebrates. The system consists of a single hypophysial portal vein. The portal vein is formed by capillaries in the hypothalamus. It passes into the anterior lobe of pituitary glands and breaks up into capillaries there. The hypophyseal portal system is meant for pouring hormones secreted by hypothalamus directly into the anterior part of the pituitary.

19.03 Renal portal system

It occurs in lower vertebrates (fish and amphibians), reduced in reptiles and aves and is absent in mammals. It consists of renal portal veins that bring blood from a posterior part of the body directly into kidneys for removal of waste products.

20.0 Lymphatic system

It comprises lymph, lymphatic capillaries, lymphatic vessels, lymphatic nodes and lymphatic ducts.

20.01 Lymph

Lymph, a colourless fluid is a part of tissue fluid, which in turn, is a part of blood plasma. So the composition of tissue fluid and lymph is 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 oxygen but contains abundant

carbon dioxide and other metabolic wastes. Amoeboid shaped white blood corpuscles may be present in the lymph.

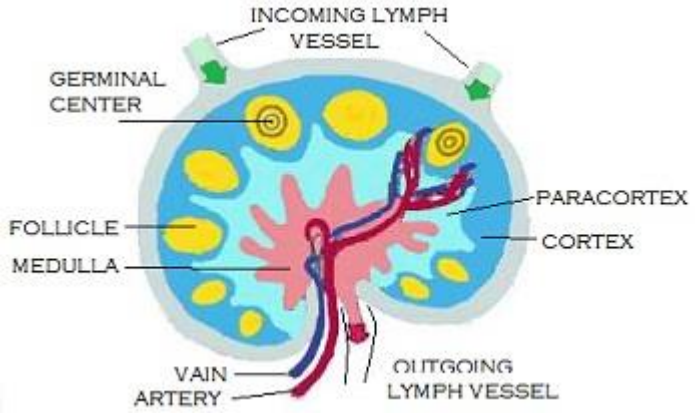
20.02 Lymphatic capillaries

Lymphatic capillaries lie close to the blood capillaries but differ from them to 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.

20.03 Lymphatic vessel

The lymphatic capillaries unite 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.

20.04 Lymph node



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

20.05 Thoracic duct

The lymphatic vessels of left side unite to form a thoracic duct. This duct begins at the cisterna chyli, which is a sac-dilation situated in the front of the first and second number vertebrate. The thoracic duct contains several valves. It discharges its lymph into the left subclavian vein.

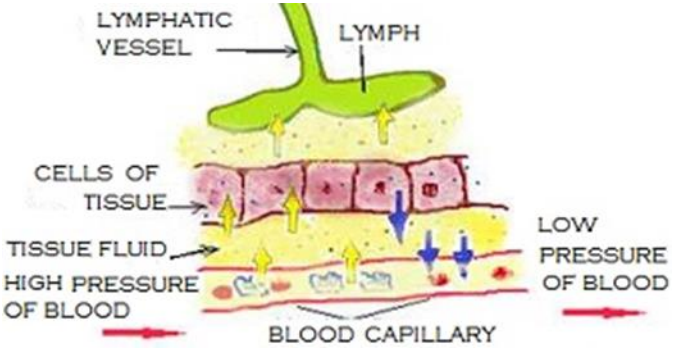
20.06 Right lymphatic duct

The lymphatic vessel of the right side of the thorax, head, and neck unite to form the right lymphatic duct. It is about 1 cm in length. It discharges its lymph into the right subclavian vein.

20.07 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 lymphatic, causing the 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 prevent its

backflow. Movement of villi assists flow of lymph in the lacteals. Gravity helps in moving the lymph down the lymphatic vessels of head and neck.



20.08 Functions of lymph

The lymph or lymphatic system serves functions as:

- It drains excess tissue fluid from the extracellular spaces bin to the fluid.
- 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 kidney does not face a sudden pressure of urine execration.
- It carries carbon dioxide and nitrogenous waste materials that diffuse into the tissue fluid to the blood.
- It takes lymphocytes and antibodies from lymphatic nodes to the blood.
- It transported fat that is digested and absorbed in the intestine to the blood in the form of chylomicron droplets.
- It destroys the invading microorganisms and foreign particles in the lymphatic nodes.

- It maintains quality and quantity of the blood by restoring the fluid and solute that leaves it.
- It brings plasma protein macromolecules synthesized in the liver cells and hormones produced in the endocrine glands to the blood.

20.09 Spleen

The spleen is the largest component of the lymphatic system. It is large (7-10 cm 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 nodes) 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.

20.09.01 Functions

i) Destruction of worn-out red corpuscles
ii) Reservoir of red corpuscles
iii) Formation of agranulocyte
iv) Production of antibodies
v) Storage of iron
vi) Erythropoiesis
vii) Disposal of foreign elements

20.10 Thymus

The thymus is also a lymphatic organ. It lies in the upper chest near the neck. It is prominent in children but begins to degenerate in early childhood. It educates the lymphocytes in the foetus to distinguish cells from foreign cells.

20.11 Tonsils

Tonsils too are lymphatic tissues. They are located in the throat. They do not filter lymph. They are thought to protect against infection.

21.0 Some common cardiovascular defects

1. Arteriosclerosis:

   Sclerosis and hardening of walls of generally smaller arteries and arterioles are called arteriosclerosis. The common cause is deposition of calcium in tunica media cholesterol may get calcified. The walls of arteries become stiff and rigid. There is a loss of elasticity. The phenomenon is called hardening of arteries. Limb arteries are usually the first to undergo arteriosclerosis. Lesions develop at branch points. It ultimately leads to distal obstruction causing pain, numbness of extremities, Peripheral edema, cyanosis etc. rupturing of some vessels also occur. It forms a blood clot and blocks the flow of blood.

2. Atherosclerosis:

   It is wall thickening and narrowing of the lumen of medium and large arteries. In atherosclerosis, yellowish plaques (atheromas) of cholesterol and other lipids are deposited within tunica intima and inner part of tunica media were smooth muscles abound. They are mostly caused by low-densitylipoproteins or LDL which can pass through the endothelium. Plaques grow. The smooth muscles also proliferate probably caused by the release of platelet-derived growth factor (PDGF). This occurs due to the

roughness of inner arterial lining. Thickening of arterial wall reduces the lumen size. In extreme cases, thegrowth of plaques may completely block an artery. Atherosclerosis leads to hypertension, reduced blood supply to limbs and other organs resulting in their dysfunctioning.

Atherosclerosis in coronary arteries results in reduced O_2 supply to heart walls causing angina, myocardial infection or heart attack or stroke.

3. Coronary artery disease (CAD)

   Coronary arteries undergo atherosclerosis. There is deposition of calcium, fat and fibrous tissue which results in narrowing of the arterial lumen. The flow of blood in the affected arteries is reduced. The cardiac muscles supplied by the affected arteries will begin to deteriorate. There are a thoracic pain, nausea, perspiration and E.C. G changes. The defect can be treated through angioplasty (breaking of arterial blockage by balloon catheter) and bypass surgery.

4. Angina or Angina pectoris

   It is recurrent, spasmodic suffocating thoracic (or heart) pain which often radiates to the left arm. Angina is generally caused by the deficient blood supply to heart muscles. It is precipitated by excitement or strenuous physical activity. Angina pectoris can occur in all types of individuals, Both men and women of any age. However, it is more common in middle-aged and elderly persons. Reduced blood supply to myocardial muscles occurs either due to constriction or obstruction of blood vessels.

5. Heart Failure

It is the inability of the heart to supply blood in adequate quantities to all parts of the body. Heart failure is a syndrome of ventricular dysfunction. The person suffering from heart failure has reduced exercise capacity. The health of different muscles of the body would also be affected. Heart failure should not be confused with a heart attack (heart muscle damaged due to inadequate blood supply) or cardiac arrest in which case there is a stoppage of the heartbeat.

6. Cardiomegaly: hypertrophy of the heart. Inflammation of heart is carditis.
7. Cardiomyopathy: aNoninflammatory disease of heart muscle.
8. Ischaemic heart: Heart with degenerate or defective components due to rheumatic disorder or fever in childhood.
9. Rheumatic heart: Heart with degenerate or defective components due to the rheumatic disorder of fever in childhood.
10. Embolus: Mass of clotted blood, other formed elements, fragments, air, calcium etc. coming from a larger blood vessel is forced into a smaller or narrow blood vessel resulting in its blockage and hence obstruction of blood circulation.
11. Myocardial Infarction: Complication due to reduced blood supply to heart wall-pain, pallor, perspiration, nausea, ECG changes.
12. Heart Burn (Pyrosis). The sensation of burning occurring in waves in esophagus tending to rise upward towards neck

often with reflux into the mouth. It has nothing to do with the heart.

13. Varicose Veins: Unnatural permanently distended veins.
14. Hematoma: Localized collection of usually clotted blood in a tissue or organ due to injury and rupturing of the blood vessel.

22.0 Distinguish

22.0.01 Blood and Lymph

	Blood	Lymph
1	Blood is pumped throughout the body by the heart	lymph is moved along through the normal function of the body.
2	Blood transports oxygen throughout the body	Lymph removes waste from the system.
3	Blood flows through the body in a circular motion	The movement of lymph is in a single direction.
4	Blood contains red blood cells, white blood cells and platelets	Lymph is a whitish and clear liquid
5	You can see blood if there is damage to the vessels	Lymph cannot be seen with the naked eyes.
6	The kidneys purify the blood	lymph is purified in the nodes itself.

22.0.01 Open and closed circulatory System

	Open Circulatory System	Closed Circulatory System
1	Blood isn't restricted to blood vessels. Blood is in	Blood is always restricted in blood vessels i.e. arteries,

	direct contact with body tissues.	capillaries and veins.
2	There are no characteristic blood vessels. Haemolymph flows in sinuses of hoemocoel	There is a sophisticated and unified system of arteries, capillaries and veins.
3	When blood is in direct contact with tissues, only then exchange of materials takes place.	Through capillaries, nutrients and waste materials are exchanged between tissues and blood by means of tissue fluid.
4	System doesn't support transport of gases.	Not only nutrients are transported, gases are also transported.
5	This system can't maintain blood pressure. There is no respiratory pigment dissolved in blood. It is white.	This system can maintain Blood Pressure. Haemoglobin, a respiratory pigment is present in blood.

22.0.03 Mitral Valve and Aortic Valve

	Mitral Valve	Aortic Valve
1	mitral valve is located between the left atrium and the left ventricle	the aortic valve is located between the left aorta and the left ventricle.
2	the mitral valve has only two.	The aortic valve has three flaps, like the other valves
3	The mitral closes when the aortic valve opens and vice	The aortic valve closes when the mitral valve opens and

	versa	vice versa
4	The mitral valve may fall prey to a mitral valve prolapse, which refers to a loosening of the muscles	aortic valve is more susceptible to a narrowing and causes lesser flow to the next chamber. This is called an aortic valve disease.

22.0.04 SA node Vs AV node

	SA node	AV node
1	SA node stands for sinoatrial node.	AV node stands for the atrioventricular node.
2	SA node is known as the pacemaker of the heart.	AV node is also known as pace setter of the heart.
3	SA node is the first component of conducting a system of the heart.	AV node is the second component of conducting a system of the heart.
4	SA node is controlled by the autonomic nervous system (ANS). It is innervated by the parasympathetic nervous system by the Vagus nerve.	AV node is controlled or influenced by the impulses from SA node.
5	SA node is located in the superior lateral wall of the opening of superior vena cava (SVC).	AV node is located in the posterior septal wall of right atrium just near to opening of the coronary sinus.
6	SA node has the rate of impulse discharge of almost 90-100 beats per minute.	AV node normal firing rate is 40-50 times per minute.

22.0.05 Systole Vs Diastole

	Systole	Diastole
1	Systole is the contraction phase of the cardiac cycle of the heart.	Diastole is the relaxation phase of the cardiac cycle of the heart.
2	In systole stage, when the heart contracts, it pumps blood from the heart Chambers into the aorta and a pulmonary artery.	In Diastole stage, when the heart relaxes, it allows the heart chambers to be filled with blood from venacava and pulmonary veins.
3.	The blood pressure of the systole stage is high in arteries	The blood pressure of the diastolic stage is low in arteries
4	The systolic pressure for a normal person is 90-120mmHg (adult), 95mmHg(infant)	The diastolic pressure for a normal person is 60-80mmHg (adult), 65mmHg(infant)
5	The systolic pressure undergoes considerable fluctuations at different conditions like the extent of work done by heart,	The diastolic pressure undergoes much less fluctuation in health and remains within a limited range. The increase in diastolic pressure indicates that the heart is approaching towards failure.

22.0.06 Neurogenic heart Vs Myogenic heart

	Neurogenic heart	Myogenic heart
1	Neurogenic hearts ,the beating rhythm is set through nerve impulsesout side the heart	Myogenic heartrhythm is set byspecialised muscle in heart and specialized conducting muscle for spreading
2	Anthropods and annelids.	In some invertebrates and all vertebrates
3	Heart removed from bodyStops beating.	Heart removed from body Continues to beat for some time.

22.0.07 Heart sound LUBB Vs DUP

	I Heart sound S_1	II Heart Sound S_2
1	LUBB	DUP
2	Atrioventricular valve closed	Semilunar valve closed
3	Dull: Prolonged (0.15 sec	Sharp : Short times, high pitch (0.1s)
4	Point of maximum intensity Apex Beat/Mitral area	Point of maximum intensity Base of heart

22.0.08 Atherosclerosis Vs Arteriosclerosis

	Atherosclerosis	Arteriosclerosis
1	gradual increase in the deposition of plaque (consists of cholesterol, lipids, calcium, white blood cells and clumps of	hardening of the normally flexible walls due to loss of elasticity of the arterial musculature.

	platelets)	
2	narrowing passageway causes the blood pressure to rise and may lead to a heart attack or stroke.	buildup of blood as it tries to flow through the arteries, leading to high blood pressure.
3	Plaques are formed due to proliferation of smooth muscles of the inner wall of arteries	No plaque formation, but arteries are stiff and rigid due to calcification
4	Takes place in Lumen of large and medium size arteries of body	Can take place in medium to small arteries of limbs
5	blood pressure to rise and may lead to a heart attack or stroke.	high blood pressure causes a breakdown of the arteries in the body and may cause the heart to become overworked

22.0.09 Artery and Vein

	Artery	Vein
1	Arteries carry oxygenated blood, away from the heart except pulmonary artery	Veins carry deoxygenated blood, towards the heart except pulmonary veins
2	These are mostly deeply situated in the body	These are superficial and deep in location
3	These are thick-walled, highly muscular except arteries of	These are thin-walled

	cranium and vertebral column	
4	These posses narrow lumen, constricted	These posses wide lumen
5	Valves are absent	Valves are present which provide unidirectional flow of blood
6	These are reddish in color	These are bluish in color
7	These show spurty movement of blood giving pulse	These show sluggish movement of blood
8	Blood in arteries moves with pressure	Blood in arteries moves with pressure
9	Arteries empty up at the time of death, but don not collapse due to thick walls	Veins get filled up at time of death, if emptied they collapse
10	If arterial wall is injured, the blood comes out like a 'fountain' in a large area all around the artery	If venous wall is injured, blood comes out, collects in a pool in a small area around vein

20.0.10 P-wave and T wave

	P-wave	T-wave
1	In ECG P wave indicates the activation of the SA nodes	In ECG the T-wave represents ventricular relaxation
2	During this phase, the impulse of contraction is generated by the SA node, causing atrial depolarization	During this pahse,the ventricles relaxed and return to their normal state

3	It is atrial origin	It is ventricular origin
4	It last for 1sec	It lasts for 5 sec

20.0.11 Lymphocytes and Leukocytes

	Lymphocytes	Leukocytes
1	lymphocyte is a type of leukocyte	Leukocyte is a white blood cell
2	Lymphocytes cells are produced from lymphoid progenitor cells, which is another stem cell line.	All leukocyte cells except lymphocytes are produced from myeloid stem cell which is a stem cell line.
3	The major function of lymphocytes is to take care of adaptive immunity	all other leukocytes take care of innate immune system in the human bodies.
4	lymphocytes may be further categorized into B cells and T cells, which are responsible for cell-mediated and humoral immune response.	leukocytes are: neutrophils (40% - 75%) eosinophils (1% - 6%) basophils (less than 1%) monocytes (2%-10%) lymphocytes (20%-45%)

THAT'S ALL FOLKS!

सर्वे भवन्तु सुखिनः सर्वे सन्तु निरामयाः। सर्वे भद्राणि पश्यन्तु मा कश्चिद्दुःखभाग्भवेत्॥

All should/must be happy, be healthy, see good; may no one have a share in sorrow.