BODY FLUIDS AND CIRCULATION

FUNCTION OF BLOOD PLASMA

i) Transport
ii) Retention of fluid in 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

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 urine. This condition is called glucosuria. If it is less it causes hypoglycemia and if it is higher it causes hyperglycemia.

BLOOD CHOLESTEROL

Its 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 causes high blood pressure and heart problem

FORMED ELEMENTS

Erythrocytes (Rd blood corpuscles or RBCs)

- A normal adult man and woman havae 5 to 4.5 million RBCs per cubic millimeter of blood respectively.
- Less amount of haemo globin 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 causes 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 haemoglobin
- Haemoglobin is a conjugate protein which is made up of a protein called globin and a non protein group heme (=haeme) hence the haemoglobin.

- Haemoglobin is oxygen carrying pigment. 100ml of blood of a normal man contains 15g of haemoglobin and of normal woman an average of 13g of haemoglobin
- 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 haemoglobin
- Their pigment is degraded to yellowish pigment bilirubin which is excreted in bile.

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.

- Leucocytes (White bold corpuscles or WBCs)
  → They are colourless, active and mobile nucleated blood corpuscles with a number 7000 ± 3500 /mm^3. Leucytes are of two types granulocytes (with granules and polymorphic nucleus) and agranulocytes (without granules and monomorphic nucleus).
  → The life of granuloctes is normally 40 to 8 hours circulating in the blood and another 4-5 days in the tissue
  → Monoctes have a short life span of 10-20 hours. The lymphocytes have life span of few days or months or years
  → Granulocytes are of three types (neutrophiles, basophiles, losinophiles) while agranulocytes are of two types (monocytes and lymphocytes)
- Neutrophile
  They have granules that stain with neutral dyes nucleus 2-7 lobed, nearly circular, 62% of all leucoctes, phagocytic.
- Esoinophile
  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 asthama.
- Basinophile

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

- Lymohocytes: Large nucleus with granule free pale blue cytoplasm, 30% of total leucocytes, manufacture globins some of which function as antibodies in immunological reactions. Lymphocytes have 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 μm kidney shaped nucleus, 5-6% of total leucocytes motile, phagocytic, scavengers, production of interleukin and pyrogen.

THROMBOCYTES (BLOOD PLATELETS)

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

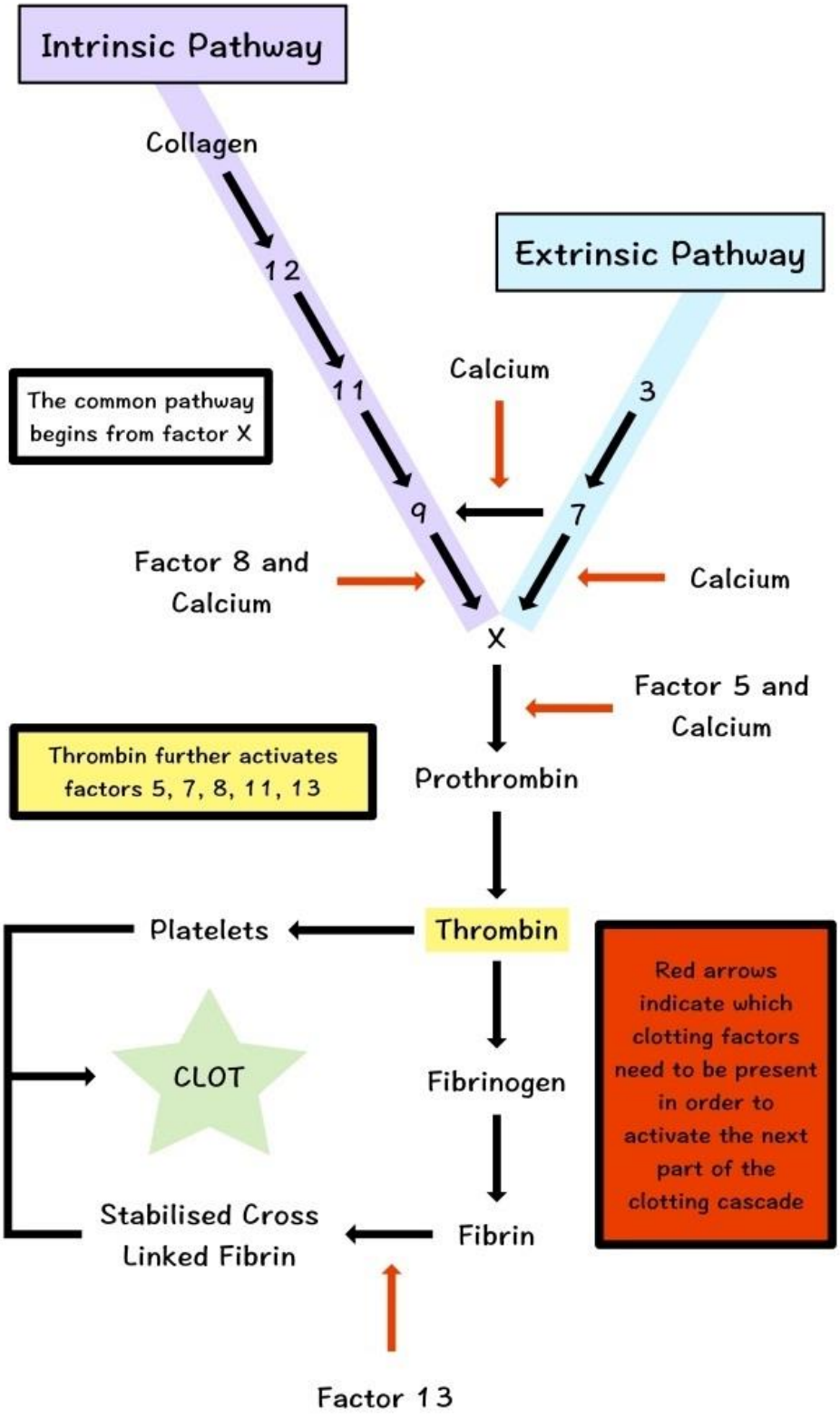
→ When an injury is caused, the blood platelets release certain chemicals which are called the platelet factors (thrombo plastin). The platelet factors help in the clotting of blood

BLOOD COAGULATION (BLOOD CLOTTING)

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

→ First step: At the site of an injury, the blood patelets disintegrate and release a phospholipid called platelet factor-3 (Thromboplastin). Injured tissues also release a lipoprotein factor called hromoplastin. These two factors combine with calcium ions Ca^{+2} and certain protein of the blood to form an enzyme called pro-thrombinase.

→ Second step: The prothrombinase inactivates heparin in the presence of calcium. Prothrombinase catalyzes breakdown of prothrombin into an active protein called thrombin and some small, peptide fragments.



→ Third step: Thrombin acts as enzyme and first brings about depolymerization of these monomers. Later thrombin stimulates repolymerization of these monomers into long insoluble fibres – like polymers called fibrin. The thin, long and solid fibres 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

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-hemoplytic 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.

FUNCTIONS OF BLOOD

i) Transport o f 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 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 eccessive 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 basophils help in the healing of wound.
xii) Maintenance of physiological co-operation: Blood maintains a physiological co-oeration between parts of the body by circulating from one to other parts.

BLOOD GROUP

- Karl Landsteiner reported first time ABO blood groups in 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, 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%

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 nonagglutination shows Rh^- nature. Rh^+ is dominant over Rh^-. The antigen formation is determined by a dominant allele R. It gives rise to 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 anaemic with several abnormalities due to disintegration of red blood cells (erythroblastosis foetalis) by anti-Rh factor ‘a’ (anti –Rh globulin is available to overcomthe 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.

IMPORTANCE OF BLOOD GROUPS

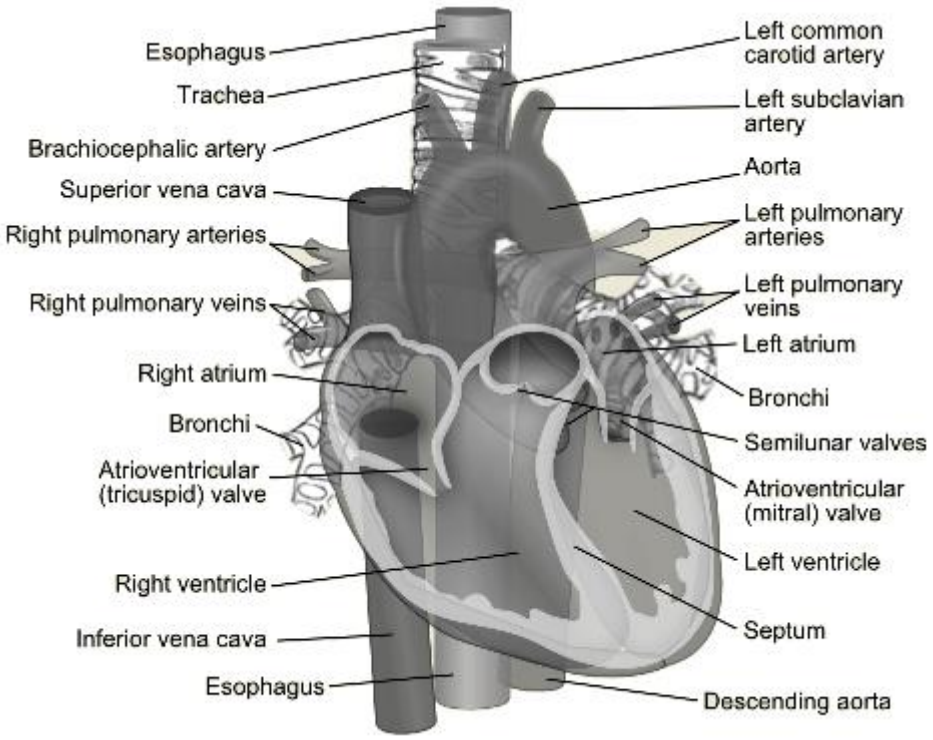
i) Knowledge of blood group is essential for blood transfusion
ii) Rh compatibility is required for both marriage and transfusion in order to prevent erythroblastosis
iii) Preliminary information about disputed parentage and progeny is provided by blood grouping.
iv) Blood grouping is used in forensic identification of blood stains.

Human Heart

- It is a reddish conical muscular mesodermal hollow organ of a about 12cm length 9 cm breadth, weighs about 300gm and lies behind the sternum in the mediastinum space of thoader 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 fibres. 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
- Heart is covered by a double fibrosenous 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, outer parietal and inner visceral. It encloses a narrow pericardial cavity having pericardial fluid for frictionless movement, protection from shock and mechanical injury
- There is a depression or coronary sulcus between atria and ventricles, inter-atrial sulcus (two parts, anterior and posterior) between two ventricles. Coronary arteries are housed in these sulci. They supply blood to walls of heart.
- Atrial appendages is protruded part of atria which overhangs the ventricles. Low ridges occur internally in the region of atrial appendage. They are called musculi pectinati. Blood vessels connected to heart are known as great blood vessels
- Deoxygenated blood flows through right half of heart and oxygenated blood flows through left half of heart. The right and left atria are separated by inter atrial 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 body), inferior vena cava (middle and lower part of body) and coronary sinus (heart walls). The basius valve occurs at the opening of cornonary sinus and Eustachian valve at the opening of inferior vena cava

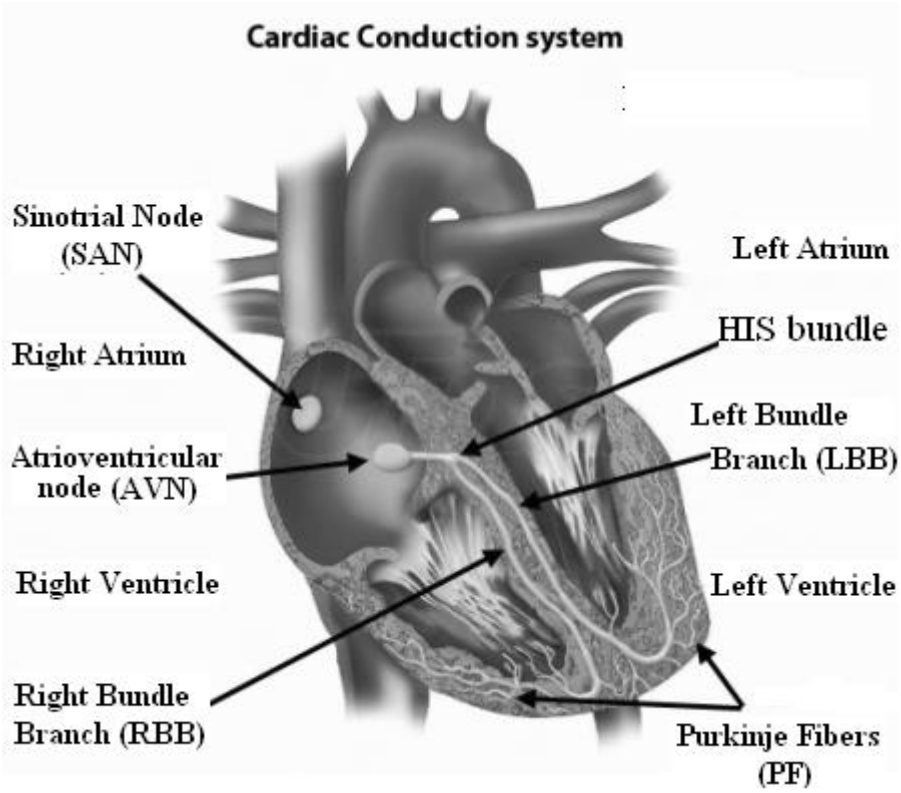
- Back flow in superior vena cava is prevented by obliquity of opening. The left atrium / auricle receives oxygenataed blood from two lungs through four pulmonary veins. Right and left ventricles are separated by an interventricular septum
- Left ventricle is larger, includes the apex part and has extra thick wall as compared to right ventricle due to its mechanical requirement of pumping oxygenated blood to all parts of body, walls of ventricle posses a network of low ridges or columnal carnea and a few large muscular projection or papillary muscles/musculi papillares.
- Right ventricle contains a moderator band that extends between upper papillary muscle and inter-ventricular septum. Atria opens into ventricles through atrio-ventricular apertures is guarded by valves. Right atrio-ventricular aperture is guarded by tricuspid valve possessing three flaps and left atrio-ventricular 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 chordae tendineae connected to papillary muscles. Left ventricle opens into aorta. The opening is guarded by an aortic semilunar valve between two.



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 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 sprrow) and low in large animals (25 /min in elephant) as well as cold blooded animals (64/min in frog).
- The heart beat 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 heart beat, contraction is initiated by a specialized path of modified heart muscles, the sinoatrial 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 sinoatrial 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 atrio-ventricular (AV – node) or pacesetler. Which is stinulated to emit an impulse of contraction spreading to the ventricular muscle in the atrioventricular bundle and the purkinje fibres.
- The atrial muscle fibres are separated from those of the ventricles by a fibrous tissue ring. These is no functional continuity between the atria and ventricles. They only conducting tissue between the atria and the ventricles is the atrio ventricular 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, anastomising filaments of 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.



PACE-MAKER

- SA node is called natural pace maker 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 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 pacemaker.
  i) External pacemaker
  ii) Epicardial pacemaker
  iii) Endocardial 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 right ventricle.
- Pacemaker are liable to be influenced by microwave ovens, metal detectors, electric shavers cellphone etc.

CARDIAC CYCLE

- The cardiac cycle consists of one heart or one cycle of contraction and relaxation of the carbiac muscle. The contraction phase is called the systole while the relaxation phase is called 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 vena cava and inferior vena cava into the atria and from ateria 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

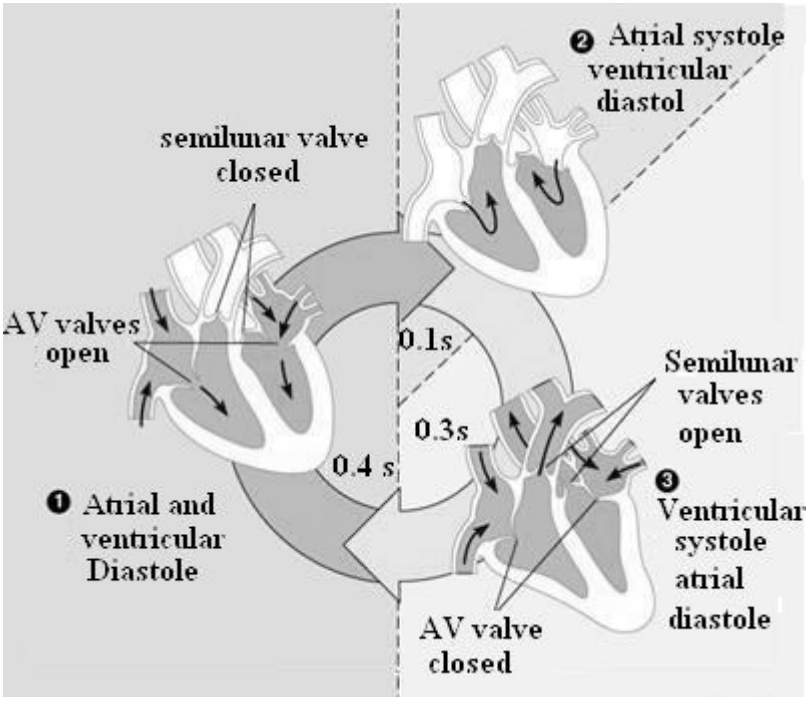
  Atrial systole: The atria contract due to wave of contraction, stimulated by SA node. The blood is forced into the ventricles as the bicuspid and tricuspid valves are open.

  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 semidunar 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.



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 atrio ventricular valves (tricuspid and bicuspid valves)
- Dup (S_2, second sound, diastolic sound) is the second heart sound which is sharp high pitched, of shorted duration (0.1 sec) and is produced due to 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 instrument called stethoscope.

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 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

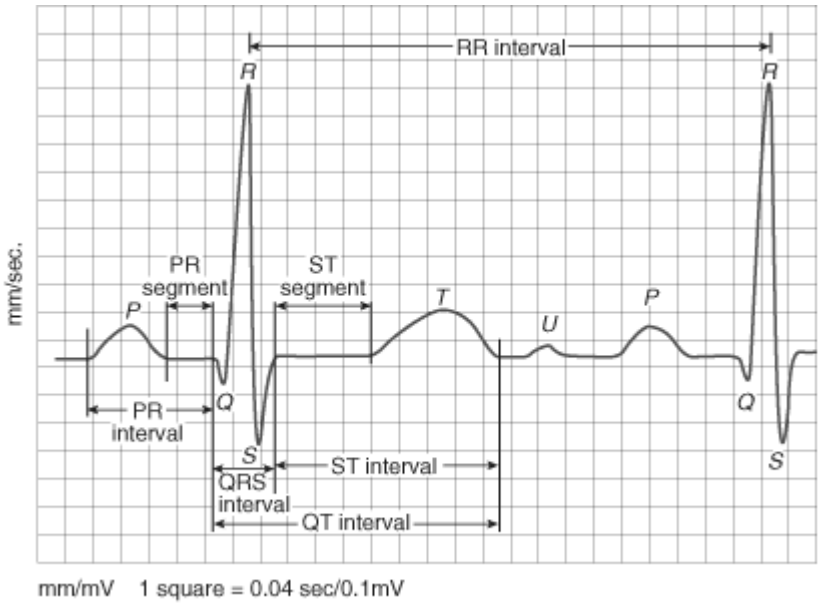
REGULATION OF HEART BEAT.

- Neural Regulation:
  The cardiac centre lies in the medulla oblongata of the brain. The cardiac centre 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 fibres) and cardio accelerator through sympathetic nerve fibres. Sensory fibres extended from the receptors present in the superior vena cava aorta and carotid sinuses to the cardiovascular centre in medulla oblongata. The impulses received from the aorta and carotid sinuses decreases the heart rate, whereas the impulses from Vena cava increases the heart rate.
- 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 heart beat.
Body temperature also affect the pacemaker. Just $1^{O}C$ rise in temperature increases with exercise to provide additional oxygen and food to muscles.

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 ® 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 repolarisation (ventricular relaxation)

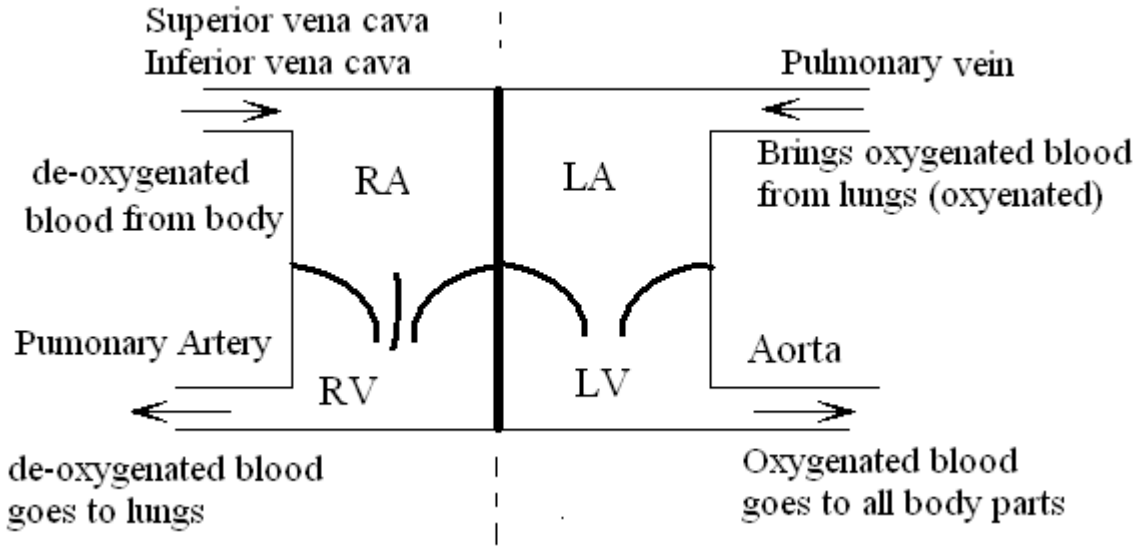
- Each large square represents 0.2 second. Normal P-R interval is 0.12 to 0.2 second. Normal QRS complex duration is 0.12 second. Normal Q-T interval is 0.4 second.
- Enlargement of the P wave indicates enlargement of atria. During atherosclerotic heart diseases and rheumatic fever, the P-R interval is lengthened. This is due to the inflammation of atria and AV nose
- The enlarged Q and R waves indicate a mycocardial infection (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 receives 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 in the arms and legs. It is done after leaning 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.

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 sphygmanometer (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.
- Hypertension (hyperpiesis)
  It is sustained 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.
  Hypertension caused by hormones is called hypertension. Other forms of hypertension are known as primary hypertension. It accounts to 90% of the cases.

- High blood pressure harms three vital organs-heart, brian and kidney. It makes heart to overwork due to which congestive heart disease develops quite early. A blood pressure of 220/120 mmHg may cause internal haemorrhage due to rupturing of some blood vessel. Cerebral haemorrhage 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.
- Hypotension (Hypopiesis)
  It is low blood pressure with systolic below 110 mmHg and diastolic below 70 mmHg
  Hyptension is caused by low metabolic rate, starvation, anaemia, chronic vasodilation of arterioles, lower pumping activity, valvular defects, nervous disorders, Addison's disease.
  There is an increase relationship between rate of heart beat and blood pressure. The phenomenon is called marey's law of heart

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 body enters right atrium. It is passed to right ventricale and then into pulmonary arch for sending to lungs for oxygenation. From lungs the oxygenated blood is brought into left atrium

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

ARTERIAL SYSTEM

- It comprises all the arteries coming out of heart and supplying blood to different parts of 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 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 subclaxian before bending down as dorsal aorata. Innominate or branchiocephalic forms a right common carotid and a right subclavian. Subclavin provide oxygenated blood to fore limbs, 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 oesophageal (to oesohagus), phrenic (to diaphragm), branches to back and intercoastals (to intercoastal muscles) in 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 coelic, abdominal aorta gives out a superior mesenteric artery (small intestine), two super renal (adrenal or supra-renal glands), two renals (kidneys), two genitalis and inferior (posterior) mesenteric artery (large intestine) and then divides into two iliacs (pelvic region and lower limbs)
- 4% of arterial blood passes into heart, 10% to liver, 8% to brain, 15% to digestive tract and the remaining to rest of the body.

VENOUS SYSTEM

- It comprises all the veins that bring blood to the heart. 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 left atrium. Coronary sinus collects deoxygenated blood from all the walls of heart. It opens into right atrium. Superior vena cava is formed by two branchiocephalic 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 chest). Before opening into right atrium,

superior vena cava receives a small ozygos vein from oesophagus and intercoastal area.

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

PORTAL SYSTEM

- It is a system made of a portal vein and the capillary complex formed by it in an organ than the one of its origin. A portal vein is the 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 heart. There are three types of portal systems – hepatic, hypophysial and renal.
- Hepatic portal system : It occurs in all vertebrates and is meant for taking blood from digestive tract, pancreas and spleen into liver. The system has a large heapatic portal vein that is formed by four veins-splenic (spleen), inferior mesenteric (rectum and distial part of colon), superior mesenteric (small intestine, calcum and proximal part of 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

- Hypophysical 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 anterior lobe of pituitary glands and breaks up into capillaries there. Hypophyseal portal sytam is meant for pouring hormones secreated by hypothalamus directly into anterior part of pituitary.
- 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 posterior part of the body directly into kidneys for removal of waste products.

LYMPHATIC SYSTEM

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

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.

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.

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.

LYMPH NODER

- 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.

THORACIC DUCT

The lymphatic vessels of left side unite to form a thoracic duct. This duct begins at the cisternal chili, 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.

RIGHT LYMPHATIC DUCT

The lymphatic vessel of the right side of the thorax, head and neck unite to form right lymphatic duct. It is about 1 cm 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 prevent its back flow. Movement of villi assist flow of lymph in the lacteals. Gravity helps in moving the lymph down the lymphatic vessels of head and neck.

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 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 do 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.

SPLEEN

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 viscernal peritoneum.

FUNCTIONS

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

THYMUS

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.

TONSILS

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

SOME COMMON CARDIOVASCULAR DEFFECTS

1. Arteriousclerosis:
   Sclerosis and hardening of walls of generally smaller arteries and arterioles is 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 extrimities, peripheral oedema, cyanosis etc. rupturing of some vessels also occur. It forms blood clot and blocks the flow of blood.

2. Atherosclerosis:
   It is wall thicknening and narrowing of 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 where smooth muscles abound. They are mostly caused by low density lipoprotenins or LDL which can pass through endothelium. Plaques grow. The smooth muscles also proliferate probably caused by release of platelet derived growth factor (PDGF). This occurs due to roughness of inner arterial lining. Thickneining of arterial wall reduces the lumen size. In extreme cases growth 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 infaction 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. Flow of blood in the affected arteries is reduced. The cardiac muscles supplied by the affected arteries will begin to deteriorate. There is 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 left arm. Angina is generally caused by 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 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. Health of different muscles of the body would also be affected. Heart failure should not be

confused with heart attack (heart muscle damaged due to inadequate blood supply) or cardiac arrest in which case there is stoppage of heart beat.

6. Caardiomegaly : hypertrophy of heart. Inflammation of heart is carditis.
7. Cardiomyopathy : Noninflammatory 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 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 bllod circulation.
11. Myocardial Infarction: Complication due to reduced blood supply to heart wall-pain, pallor, perspiration, nausea, ECG changes.
12. Heart Burn (Pyrosis). Sensation of burning occurring in waves in oesophagus tending to rise upward towards neck often with reflex into mouth. It has nothing to do with heart.
13. Varicose Veins: Unnatural permanently distended veins.
14. Haematoma: Localised collection of usually clotted blood in a tissue or organ due to injury and rupturing of blood vessel.