BODY FLUIDS AND CIRCULATION

- Body fluids, found within animals, include blood, lymph, tissue fluid, urine, bile, sweat and synovial fluids. Body fluids are generally involved with the processes of transport, excretion or lubrication. Body fluids allow the distribution of oxygen and nutrients to the tissues and organs and the transport of waste products from the tissues, enabling their elimination from the body.

BLOOD VASCULAR SYSTEM

- It is a circulatory system containing a special body fluid (or blood) and a pumping organ (or heart) for moving it.
- Blood vascular system is of two types : open circulatory system and closed circulatory system.

Open circulatory system

- Open circulatory system occurs in arthropods and molluscs. The blood is not completely enclosed within vessels.
- Respiratory pigment, if present, is dissolved in the plasma, no red corpuscles are present.

Closed circulatory system

- Closed circulatory system was discovered by **William Harvey (1628).** He is regarded as the **father of modern physiology.** It occurs in **annelids (earthworms), some molluscs and all vertebrates.** In closed circulatory system, materials move between the blood and interstitial fluid through thin walls of capillaries.

  The closed circulatory system has a double advantage over the open circulatory system. The closed circulatory system generates sufficient blood pressure to maintain far more rapid flow of blood than the open circulatory system. Secondly, arterial musculature and capillary sphincters in the closed circulatory system regulate the flow of blood.

- Blood vascular system consists of blood vessels, blood and heart.

BLOOD VESSELS

- Blood vessels are intricate network of hollow tubes that transport blood throughout the entire body.
- Blood vessels (except capillaries) are made up of three layers:
  - **Tunica externa (tunica adventitia) :** It is composed of connective tissue as well as collagen and elastic fibres which allow the arteries and veins to stretch and prevent overexpansion due to the pressure.
  - **Tunica media :** It is composed of smooth muscle and elastic fibres. This layer is thicker in arteries than in veins.
  - **Tunica interna (tunica intima) :** It is composed of an elastic membrane lining and smooth **endothelium** which is covered by elastic tissues.
- There are three types of blood vessels : arteries, veins and capillaries.
- **Arteries** are elastic vessels that transport blood away from the heart.
- **Veins** are elastic vessels that transport blood to the heart. In some veins the tunica interna layer also contains valves.
- **Capillaries** are extremely small vessels located within the tissues of the body that transport blood from the arteries to the veins. Oxygen, carbon dioxide, nutrients and wastes are exchanged through thin walls of the capillaries.
- The **largest artery** of the body is **aorta,** which originates from the heart and branches out into smaller arteries.
- The only vein that does not have valves is **vena cava.**

Table : Differences between arteries and veins

Arteries	Veins
Arteries carry blood away from the heart for distribution to the body.	Veins bring blood from the body back to the heart.
They contain oxygenated blood, except the pulmonary arteries.	They contain deoxygenated blood, except the pulmonary veins.
The flow of the blood is intermittent and fast.	The flow of the blood is slow and steady.
Their blood has considerable pressure.	Their blood has low pressure.
They have thick, elastic walls and narrow lumen.	They have thinner, scarcely elastic walls and wide lumen.
They have no valves in them.	They have valves to prevent back flow of blood and to counteract gravity.
In tunica interna, elastic membrane is thick and endothelial cells are more elongated.	In tunica interna, elastic membrane is thin and endothelial cells are less elongated.
Tunica media is thick, having more muscle fibres and elastic fibres.	Tunica media is thin, having fewer muscle fibres and elastic fibres.

BLOOD

- Blood is a mobile connective tissue composed of fluid, plasma and formed elements.
- The volume of blood in an adult person of 70 kg weight is about **5.5 litres.** It is a slightly alkaline fluid having pH 7.4. pH of blood in arteries is more than that in veins.

Plasma

- Plasma is 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 **water and mineral salts.** Buffer of the blood is **sodium bicarbonate.** Nutrients include glucose, fatty acids, phospholipids, cholesterol, fats, amino acids, nucleosides, etc. **Plasma proteins** are mainly albumin,

globulin, immunoglobulin, prothrombin and fibrinogen. Excretory substances include ammonia, urea, uric acid. Other substances present are **anticoagulant, hormones, vitamins and enzymes.**

Formed elements

- **Formed elements** or blood corpuscles are of three types: **erythrocytes, leucocytes** and **thrombocytes.**

Erythrocytes

- Erythrocytes or **red blood corpuscles (RBCs)** are the most abundant cells in the human body. The total number of RBCs per microlitre of blood is termed as the **total count of RBCs.**
- An abnormal rise in RBC count is called **polycythemia.** Decrease in the number of RBCs is called **erythrocytopenia** which causes oxygen shortage in the blood and tissues.
- The shape of RBCs vary in different classes of vertebrates. Red blood corpuscles of all adult mammals are enucleated (non-nucleated). They are mostly biconcave and circular, however in camel and Llama RBCs are oval.
- The RBCs impart red colour to the blood. Red colour is due to the presence of **haemoglobin.** Matured mammalian RBCs do not have cell organelles including nucleus, mitochondria, ribosomes, centrioles and endoplasmic reticulum. Thus, almost entire cytoplasm is filled with haemoglobin.
- Haemoglobin is a **conjugate protein** which is made up of a protein part called **globin** and a non protein group **heme,** hence the name haemoglobin. Heme is an iron (Fe^{++}) – porphyrin complex. A mammalian haemoglobin molecule is a complex of **4 heme molecules joined with 4 globin molecules.**
- 100 ml of blood of a normal man contains 15g of haemoglobin and of normal woman an average of 13 g of haemoglobin. Less amount of haemoglobin leads to **anaemia.**
- The life of an RBC is about **120 days.** The worn out RBCs are **destroyed in the spleen and liver.** Their pigment is degraded to yellowish pigment **bilirubin** which is excreted in bile.

- Concave surface of mammalian RBCs helps in increasing the surface area.
- The adult haemoglobin molecule is made of 2 **alpha chains** with 141 amino acids each and 2 **beta chains** with 146 amino acids each.
- People living in hills have more RBCs.

Leucocytes

- The number of leucocytes or white blood cells (WBCs) per microlitre of blood is called the **total leucocyte count** (TLC). This varies from **5,000 to 10,000 per cubic millimetre of blood** in humans.
- Rise in WBC count is termed **leucocytosis.** Abnormal increase of WBCs is in malignancies like **leukemia** (blood cancer). Fall in WBC count is called **leukopenia.**
- They can change their shape like *Amoeba* and are thus, capable of amoeboid movement. This enables them to squeeze out of blood capillaries into the tissues. This process is called **diapedesis.**

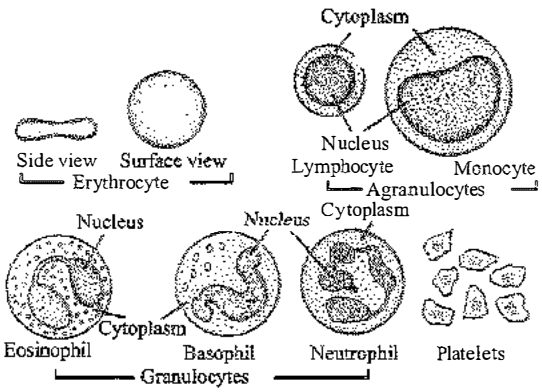


Fig.: Human blood corpuscles

- Leucocytes are colourless and are of two main types : **agranulocytes** and **granulocytes.**
- In **agranulocytes,** granules are not found in the cytoplasm. It is of two types, **lymphocytes** and **monocytes.** Lymphocytes produce antibodies to destroy microbes. Monocytes are the largest of all types of leucocytes. They are motile and phagocytic in nature. They engulf bacteria and cellular debris.
- **Granulocytes contain granules** in their cytoplasm. According to their staining property, the granulocytes are of three types, eosinophils, basophils and neutrophils.
  - **Eosinophils (1 – 6%)** have **bilobed nucleus** and coarse granules that **take acidic stains.** They play a role in the immune system. The coarse granules contain hydrolytic enzymes and peroxidase
  - **Basophils (0 – 1%)** have **nucleus which is three lobed** and have less number of coarse granules. Their granules **take basic stain** and release **heparin, histamine** and **serotonin.**
  - **Neutrophils (40 – 75%)** stain equally well with both **basic and acidic dyes.** They are quite large and have **many lobed nucleus** and abundant granules. Neutrophils are **phagocytic** in nature and are the **most numerous** of all leucocytes.

Thrombocytes (blood platelets)

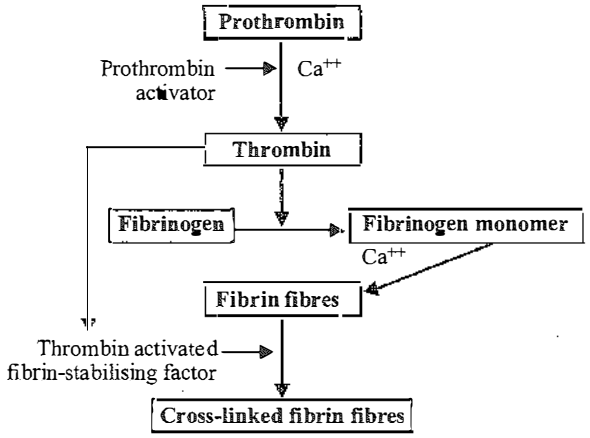
- There are about **2,50,000** platelets in a cubic millimeter of blood. Increase and decrease in the number of platelets is known as **thrombocytosis** and **thrombocytopenia** respectively.
- When an injury is caused, the blood platelets release certain chemicals which are called the **platelet factors** (*e.g.*, **throm-boplastin**). The platelet factors help in the clotting of blood.

BLOOD COAGULATION

- When an injury is caused to a blood vessel, bleeding starts which is stopped by a process called **blood clotting** or **blood coagulation.**
- At the site of an injury, the blood platelets disintegrate and release a phospholipid, **thromboplastin.** Injured tissues also release thromboplastin.
- In response to rupture of the vessel or damage to the blood, an intricate cascade of chemical reactions occurs. The net result is formation of a complex of activated substances

called **prothrombin activator.** The prothrombin activator catalyzes conversion of **prothrombin** into **thrombin.**

- The thrombin acts as an enzyme to convert **fibrinogen** into **fibrin** fibres that enmesh platelets, blood cells, and plasma to form the clot.



Flow chart: Scheme for conversion of prothrombin to thrombin

- **The rate-limiting factor in causing blood coagulation is the formation of prothrombin activator,** as the terminal steps normally occur rapidly to form the clot itself. The normal clotting time is about 2 to 8 minutes.
- Prothrombin is a plasma protein, an alpha 2-globulin, having a molecular weight of **68,700.**
- It is present in normal plasma in a concentration of about 15 mg/dl.
- It is an unstable protein that can split easily into smaller compounds, one of which is thrombin, which has a molecular weight of **33,700.**
- Prothrombin is formed by the liver.
- Vitamin K is required by the liver for normal formation of prothrombin as well as for formation of a few other clotting factors (fibrinogen).
- In the early stages of polymerisation, the fibrin monomer molecules are held together by weak non-covalent hydrogen bonding, and the newly forming fibres are not cross-linked with one another, therefore, the resultant clot is weak and can be broken apart with ease.
- But in few minutes, process strengthens the fibrin reticulum, which involves a substance called **fibrin-stabilising factor** present in normal plasma globulins.
- Thrombin activates the fibrin-stabilising factor.
- Then this activated substance operates as an enzyme to cause covalent bonds between more and more of the fibrin monomer molecules, as well as multiple cross-linkages between adjacent fibrin fibres thus adding strength to the fibrin meshwork.
- The pale yellow fluid formed after blood coagulation is called **serum.** It lacks all fibrinogen and most of the other clotting factors.

BLOOD GROUPS

- Blood of human being is grouped into two groups – ABO and Rh groups.

ABO blood group

- **Karl Landsteiner** reported **ABO blood groups** in human beings for first time. A, B and O blood groups were discovered by **Landsteiner** (1900) while AB blood group was found out by **de Castello and Steini** (1902).
- ABO grouping is based on the presence or absence of two surface antigens on the RBCs namely A and B. The plasma contains two natural antibodies.

Table : Human ABO blood groups and their compatibility

Blood group	Antigens in red blood corpuscles	Antibodies in blood plasma	Can give blood to	Can get blood from
A	A	b	A, AB	A, O
B	B	a	B, AB	B, O
AB	AB	None	AB	All
O	None	a, b	All	O

- A person with blood group O **(universal donor)** can donate the blood to all the blood groups but can receive blood only from his/her own group.
- A person with blood group AB **(universal recepient)** can receive the blood from any blood group, but can donate blood only to his/her own blood group.

Rh blood group

- Another antigen, the Rh antigen (Rhesus antigen) is also observed on the surface of RBCs of majority of humans. Such individuals are called **Rh positive** (Rh+ve) and those in whom this antigen is absent are called **Rh negative** (Rh-ve). Rh-ve person if exposed to Rh+ve blood, will form specific antibodies against the Rh antigens.
- A special case of **Rh incompatibility** (mismatching) has been observed between the Rh-ve blood of a pregnant mother with Rh+ve blood of the foetus. Rh antigens of the foetus do not get exposed to the Rh-ve bloods of the mother in the first pregnancy as the two blood are well separated by the placenta. However, during the delivery of the first child, there is a possibility of exposure of the maternal blood to small amounts of the Rh+ve blood from the foetus. In such cases, the mother starts preparing antibodies against Rh antigen in her blood. In case of subsequent pregnancies, the Rh antibodies from the mother (Rh-ve) can leak into the blood of the foetus (Rh+ve) and destroy the foetal RBCs. This could be fatal to the foetus or could cause severe anaemia and jaundice to the baby. This condition is called **erythroblastosis foetalis.**

HEART

- **Human heart,** a mesodermally derived organ, is situated in the thorax between the lungs with its apex resting on the diaphragm. The heart measures **12 cm in length** and **9 cm in breadth.**
- The wall of the heart consists of three layers: the external covering layer, or **epicardium** (serous inelastic membrane), the intermediate cardiac muscular tissue or **myocardium** (cardiac muscular tissue) and the internal layer or **endocardium** which is in contact with the blood.
- Heart is enclosed in a double fibro-serous sac called **pericardium** which consists of outer **parietal pericardium** and inner **visceral pericardium.** In between the two layers, a **pericardial cavity** is present filled with **pericardial fluid.**
- The mammalian heart comprises of four complete chambers—two **ventricles** and two **auricles** (atria).
- The myocardium is thin in auricles than the ventricles as ventricles need to pump or empty the blood into vessels. The endocardium is thicker in atria than in the ventricles.
- Auricle is divided by an **interatrial** or **interauricular septum.** On this septum, a depression, called **fossa ovalis** is present which is the remnant of embryonic **foramen ovale** (through which both the auricles communicate with each other).
- The **right atrium receives deoxygenated blood** from superior vena cava, inferior vena cava and coronary sinus. The **left atrium receives oxygenated blood** from two lungs through four pulmonary veins.
- Right and left ventricles are separated by an **interventricular septum. Left ventricle is thicker than the right ventricle** because it has to push blood to all the body parts at much greater pressure.
- A patch of modified heart muscle, the **sinoatrial node** (SA node) is present in the wall of right atrium close to the point of entry of the vena cava.
- Another aggregate of modified heart muscle tissue called the **atrio-ventricular (AV) node** is present at the lower right end of the interatrial septum.
- The atrium and the ventricle of the same side are also separated by a thick fibrous tissue called the **atrio-ventricular septum.** However, each of these septa are provided with an opening through which the two chambers of the same side are connected.
- **Bicuspid** valve or **mitral** valve is present in between the left atrium and left ventricle. **Tricuspid valve** (consist of three flaps) is present between the **right atrium** and **right ventricle.**
- **Chordae tendineae** are the special fibrous cords attached to the flaps of biscuspid and tricuspid valves and are joined to the other ends with the **papillary muscles. Semilunar** valves (pulmonary valve and aortic valve) are present where artery leaves the heart. The valves of the heart maintain **unidirectional flow** of blood and prevent its regurgitation in the opposite direction.

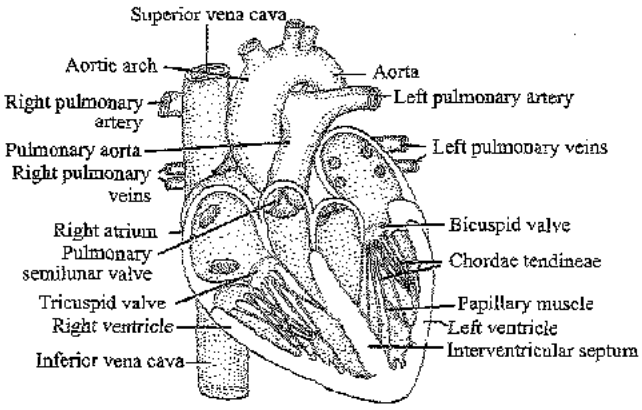


Fig.: Internal structure of human heart.

Heart beat

- The rhythmic contraction (= systole) and relaxation (= diastole) of cardiac muscles is known as **heart beat.** The heart of a healthy person beats 72 times per minute. The heart of resting human being pumps about 5 litres of blood per minute.
- The automatic rhythmicity of the heart is its ability to contract spontaneously at a regular rate.
- 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.
- The impulse of contraction emitted by the sinoatrial node spreads as a wave of contraction over the right and left atrial wall.
- This wave of contraction next reaches the **atrio-ventricular node** (AV node) which is stimulated to emit an impulse of contraction spreading to the ventricular muscle *via* the **atrio-ventricular bundle (Bundle of His)** and the **Purkinje fibres.**

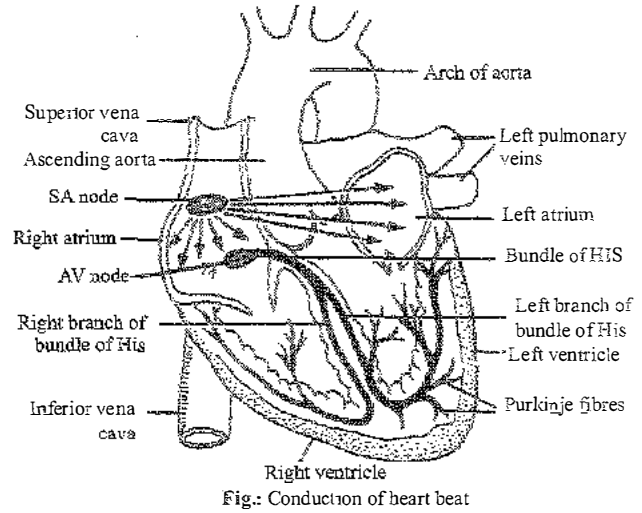


Fig.: Conduction of heart beat

Cardiac cycle

- Each cycle is initiated by spontaneous generation of an action potential in the **sinus node.** The action potential travels from here rapidly through both atria and then through the AV bundle into the ventricles.

- Because of this special arrangement of the conducting system from atria into ventricles, there is a delay of more than **0.1 second** during the passage of cardiac impulse from atria into ventricles. This allows atria to contract ahead of ventricular contractions,thereby pumping the blood into ventricles before the strong ventricular contraction begins.
- Thus, the atria act as primer pumps for the ventricles. The ventricles provide power for moving blood through the body's vascular system.
- Immediately after ventricular contraction begins, the ventricular pressure rises abruptly, causing the AV valves to close. An additional 0.02 to 0.03 second is required for the ventricle to build up sufficient pressure to push the semilunar valves open against the pressures in the aorta and pulmonary artery.
- During ventricular contraction, contraction does occur in the ventricles, but there is no emptying. This is called the period of **isometric contraction**, *i.e.*, tension is increasing in the muscle but little or no shortening of the muscle fibers is occurring.
- When the left ventricular pressure rises slightly above 80 mm Hg, it pushes the semilunar valves open. Blood begins to pour out of the ventricles, with about 70 per cent of the blood emptying occurring during the first third of the period of ejection and the remaining 30 per cent emptying during the next two thirds.
- At the end of systole, ventricular relaxation begins suddenly, allowing both the right and left intraventricular pressures to decrease rapidly.
- The elevated pressures in the distended large arteries push blood back toward the ventricles which snaps the aortic and pulmonary valves closed.
- For another **0.03 to 0.06 second,** the ventricular muscle continues to relax, even though the ventricular volume does not change, giving rise to the period of **isovolumic relaxation.** During this period, the intraventricular pressures decrease rapidly back to their low diastolic levels.
- The AV valves open to begin a new cycle of ventricular pumping.

Pulse

- A pulse is a series of waves of dilation that pass along the arteries, caused by pressure of blood pumped from the heart through contractions of the left ventricle. In humans it can be felt easily where arteries pass close to the skin surface, *e.g.*, at the wrist.
- **Tachycardia** is the term applied to a rapid heart or pulse rate (over 100/minute). **Bradycardia** is the term indicating a slow heart or pulse rate (under 50/minute).

Cardiac output

- The amount of blood pumped by heart per minute is called **cardiac output** or **heart output.** Heart of a normal person beats 72 times per minute and pumps out about 70 ml of blood per beat. Thus the cardiac output is 72 × 70 or 5040 ml per minute *i e.*, about 5 litres per minute which is equivalent to the total body blood volume.

Blood pressure

- **Blood pressure** is the pressure against the walls of the blood vessels produced by the blood by contraction of the left ventricle. The blood pressure is **high in the arteries,** gradually drops in the arterioles and capillaries, and becomes **very low in the veins.** The average blood pressure is expressed as **120/80** mm **Hg.** Blood pressure is measured by **sphygmomanometer** in the brachial artery.
- When the left ventricle contracts pushing the blood into the aorta, the pressure produced is known as **systolic blood pressure (120** mm **Hg).** When the complete diastole occurs and the heart is resting the pressure within the vessels is called as **diastolic blood pressure (80** mm **Hg).**

Heart sound

- Heart sounds may be heard by **stethoscope.** Phonocardiogram is an instrument for amplifying and recording of heart sounds. **First heart sound – lubb** is created by the closure of atrio-ventricular valves at the beginning of ventricular systole and opening of semilunar valves. **Second heart sound – dup** is created at the end of ventricular systole when the semilunar valve closes and the AV valves open.

ELECTROCARDIOGRAM

- ECG is a graphic record of the electric current produced by the excitation of the cardiac muscles. The instrument used to record the changes is an **electrocardiograph.**
- A normal electrocardiogram (ECG) is composed of a **P wave,** 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 **depolarisation of the atria** (atrial contraction). 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 depolarisation** (ventricular contraction). The T wave is a dome-shaped which indicates **ventricular repolarization** (ventricular relaxation).

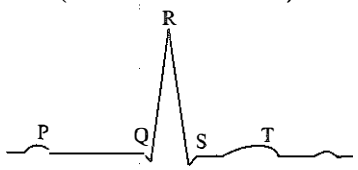


Fig.: Diagrammatic representation of a standard ECG

DOUBLE CIRCULATION

- **Double circulation** is the passage of blood twice in the heart through separate pathways for completing one cycle. Double circulation consists of **pulmonary** and **systemic circulation.**
- The flow of deoxygenated blood from the right ventricle to the lungs and the return of oxygenated blood from the lungs to the left atrium is called the **pulmonary circulation.**

- The flow of oxygenated blood from the left ventricle to all parts of the body and deoxygenated blood from various body parts to the right atrium is called **systemic circulation.** There is, therefore, no mixing of the oxygen rich blood and oxygen deficient blood in the heart.
- The **advantage of double circulation** is that the blood can be sent to the lungs to pick up oxygen and then be returned to the heart to be pumped again before travelling around the body.
- Double circulation is present in lung fishes, amphibians, birds, reptiles and man where arteriovenous heart (means when it receives both venous or deoxygenated and arterial or oxygenated blood) is present.
- In fish, **single circulation** is present where blood from the heart first goes to the gills to collect oxygen, but continues round the whole body before returning into heart. The heart of fish is called **venous heart** as it receives deoxygenated blood.

REGULATION OF CIRCULATION

- A special neural centre in the medulla oblongata can moderate the cardiac function through autonomic nervous system (ANS). **Sympathetic nervous system accelerates the heart beat. Parasympathetic nervous system slows the heart beat.**
- The substance secreted at the end of the vasoconstrictor nerves is called **norepinephrine (noradrenaline).** It **regulates the blood pressure under normal conditions.** Another hormone called **epinephrine (adrenaline)** is also secreted by the medulla of the adrenal endocrine gland. It also acts directly on the blood vessels; usually to cause **vasoconstriction.**

DISORDERS

- **Angina pectoris** is a sudden recurring thoracic pain radiating to arms, especially left arm when the demand for blood by the heart exceeds the supply of the coronary arteries. It can occur by excessive exercise.
- **Myocardial infarction** is a complication due to reduced blood supply to heart wall. It results in pain, perspiration, nausea and the ECG changes.
- **Rheumatic heart** is the heart with insufficient blood supply to its muscles due to rheumatic disorder or fever in childhood.
- **Atherosclerosis** is wall thickening and narrowing of lumen of medium and large arteries. In atherosclerosis, yellowish plaques (atheromas) of cholesterol and other lipids are deposited within the interna and inner media of arteries.
- **Arteriosclerosis** is sclerosis and thickening of walls of smaller arteries and arterioles. Arteriosclerosis proper is common in elderly persons.

LYMPHATIC SYSTEM

- It comprises of the following parts:
  - **Lymph,** a colourless fluid, is a part of the tissue fluid, which in turn, is a part of blood plasma. Lymph contains very small amount of nutrients and oxygen but contains abundant carbon dioxide and other metabolic wastes. Amoeboid shaped white blood corpuscles are also present.
  - **Lymphatic capillaries** lie close to the blood capillaries but differ from them to the extent that they end blindly. The lymphatic capillaries unite to form large **lymphatic vessels.** The lymphatic vessels have numerous **valves.** The lymphatic vessels of left side unite to form a **thoracic duct.** The thoracic duct contains several valves. It discharges its lymph into the **left subclavian vein.** The lymphatic vessels of the right side of the thorax, head and neck unite to form the **right lymphatic duct** which discharges its lymph into the **right subclavian vein.**
  - **Lymph nodes** are small oval or bean shaped structures located along the length of lymphatic vessels. Both **B-lymphocytes** and **T-lymphocytes** are produced in lymph nodes.

Lymph movement

- The lymph flows in lymphatic vessels very slowly. Movements of viscera and contractions of the body muscles help considerably in squeezing the lymph along the lymphatic vessels.

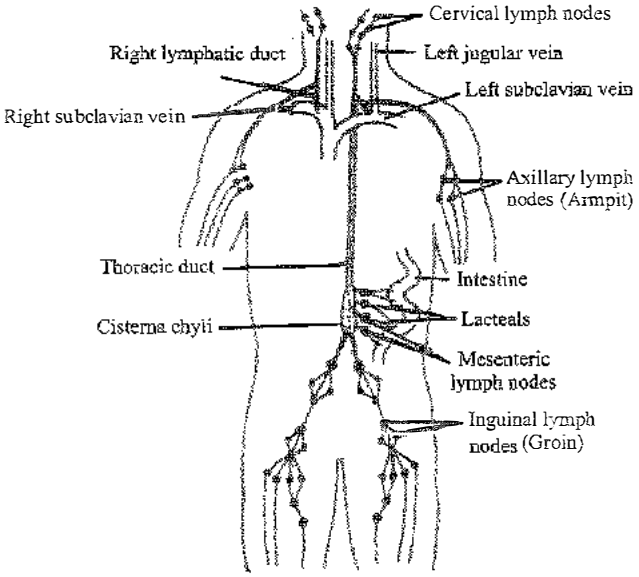


Fig.: Human lymphatic system

Functions of lymphatic system

- It transfers materials from the blood to the body cells and *vice versa*, therefore, it acts as "middle man".
  - It drains excess tissue fluid from the extracellular spaces back into the blood.
  - It takes lymphocytes and antibodies from the lymphatic nodes to the blood.
  - It transports fats 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 the quality and quantity of the blood by restoring the fluid and solutes that leave it.

CONCEPT MAP

Blood Vascular System

- It is a circulatory system containing body fluid and a pumping organ.

Blood vessels

- They are intricate network of hollow tubes that transport blood throughout the body.

Arteries

- They are elastic vessels that transport blood away from the heart.

Veins

- They are elastic vessels that transport blood to the heart.

Capillaries

- They are extremely small vessels that transport blood from the arteries to the veins. Respiratory gases, nutrients and wastes are exchanged through the capillaries within the tissues.

Blood

- Blood is a mobile fluid connective tissue.

Plasma

- It is slightly alkaline, non-cellular and pale yellow fluid that constitutes about 60% of the blood.

Formed elements

Erythrocytes

- They are most abundant cells in the human body which are filled with haemoglobin.

Leucocytes

- They are the colourless cells that show amoeboid movement.

Agranulocytes

- Granules are not found in cytoplasm and are of two types, lymphocytes and monocytes.
- They are motile and phagocytic in nature.

Granulocytes

- Granules are present in their cytoplasm.
- They are of three types eosinophils (take acidic stain), basophils (take basic stain) and neutrophils (take basic and acidic stains).

Platelets

- They release platelet factors that help in the clotting of blood (or thromboplastin) on injury.

Blood coagulation

- In response to rupture of the vessel or damage to the blood, a complex cascade of chemical reactions occur which results in the formation of the blood clot.

Heart

- It is a mesodermally derived organ that comprises four complete chambers (two ventricles and two auricles).
- Right auricle receives deoxygenated blood from the body and left auricle receives oxygenated blood from lungs.

Heartbeat

- The rhythmic contraction and relaxation of the cardiac muscles is known as heart beat.
- The heart undergoes automatic rhythmicity initiated from SA node that spreads as a wave of contraction over the right and left atrial wall.

Cardiac cycle

- It is the sequence of events that occurs in the heart during one full heart beat.
- These events comprise contraction and relaxation of the chambers of the heart, associated with opening and closing of heart valves.