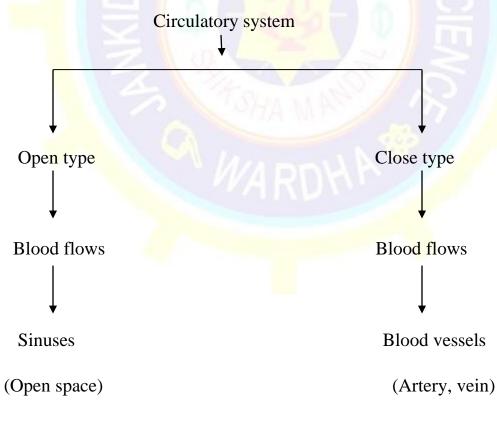
CIRCULATION

> Introduction:-

Living organism need a constant supply of oxygen and nutrients for various metabolic activities and continuous removal of unwanted by-products is necessary from the body. It is made possible only by the presence of circulatory system. But the system needs some circulating fluid to carry out metabolites. Circulating media are of different kinds such as hydrolymph, haemolymph, lymph and blood. In all vertebrates lymph and blood acts as circulating fluid. Blood is the major circulating fluid in human body.

• Definition:

The system in which blood is circulated throughout the body is called circulatory system.



➢ Blood:-

Origin – mesodermal

PH - 7.4

Taste - salty

Colour – 1) Oxygenated blood- bright red

2) Deoxygenated blood- dark red

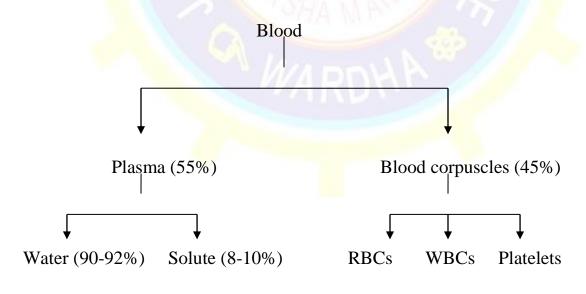
It is a viscous, alkaline (slightly) fluid connective tissue. The average sized adult has about 8% of the total body weight.

> Haematology:-

(Haeme – blood, logus- study)The study of blood is called <u>Haematology</u>.

Composition of blood:-

It is composed of two main components. A liquid part called plasma and Blood corpuscles.



4 Plasma: It is straw coloured, slightly alkaline, viscous fluid.

• Constituent of plasma:-

1) Plasma protein - 7% of the total solute.

i) Serum albumin (4%) - to maintain viscosity of blood.

ii) S.globulin (2.5%) – to provide immunity against antigens.

iii) Fibrinogen (0.3%) – necessary for clotting process.

iv) Heparin - as anticoagulant.

v) Prothrombin – as coagulating factor.

2) Inorganic substances – Ca, Na, K, Mg, Cl, PO₄, SO₄.

3) Nutrients – amino acids, glucose, fats, phospholipids.

4) Nitrogenous waste – urea, uric acid, ammonia, creatinine.

5) Respiratory gases $-O_2$, CO_2 , N.

6) Regulatory substances – enzymes and hormones.

> Function of plasma:-

i) It helps in the transport of components of nutrition, excretion, respiration and homeostasis.

ii) It helps to keep constant pH of blood.

iii) It keeps normal osmotic pressure of blood.

iv) It forms the tissue fluid which keeps the tissue moist and helps in exchange of materials between the blood and body cells.

Blood Corpuscles:-

A **blood cell** also called a **hematopoietic cell,hemocyte** or **hematocyte** is a cell produced through hematopoiesis and found mainly in the blood.

<u>Red blood cells</u> – Erythrocytes <u>White blood cells</u> – Leucocytes <u>Platelets</u> – Thrombocytes

Types of blood cells :

Types of blood cells :

Fythrocytes

Fythrocytes

Nonocyte

Platelets

Platelets

Fythrocytes

Nonocyte

Platelets

Platelets

Neutrophil

Basophil

1) **RBCs:-**

- Origin 1) foetus liver, spleen
 - 2) Adult red bone marrow

Size - 7μ m in diameter, 2.5 μ m in thickness.

Life span -120 days

Adult male - 5.1- 5.8 million/cu.mm of blood.

Adult female – 4.3- 5.2 million/cu.mm of blood.

RBCs are circular, biconcave, non-nucleated cells but in embryonic condition nucleus is present. The cytoplasm of RBCs contains respiratory pigment called Haemoglobin. Every second, 2-3 million RBCs are produced in the bone marrow and released into the circulation.

Haemoglobin: - In embryonic condition, RBCs are nucleated while mature human RBCs are anucleated. At the centre of RBCs, sponge mass is present called stroma which contain respiratory pigment called haemoglobin. It is a conjugated protein contain iron part called Haeme and protein part called globin. On an average, in a healthy male it should be between 14-16 gm % and in a female it should be about 12-14 gm %

2) WBCs:-

Origin - Bone marrow, spleen, lymph nodes, tonsils, payers patches.

Size - 8-15µm in diameter.

Life span - 3-4 days

Number of cells: - 5000-9000/cu.mm of blood

The process of formation of WBCs is called Leucopoiesis. Leukocytes are cells of the immune system involved in defending the body against both infectious disease and foreign materials.

THE WHITE BLOOD CELLS THAT PROTECT 100 TRILLION CELLS

| Blood cell type | Lifespan in blood | Function |
|-----------------|------------------------------------|---------------------------|
| Neutrophil | 7 hours | immune defenses |
| Eosinophil | 8 to 12 days | defense against parasites |
| Basophil | a few hours to a few days | inflammatory response |
| Monocyte | 3 days | immune surveillance |
| B-lymphocyte | memory cells may live for years | antibody production |
| T-lymphocyte | memory cells may live for years | cellular immune response |

Granulocytes: - It show granular cytoplasm and lobed nucleus.

1) Neutrophils :-

They are also known as polymorphonuclear cells because they contain a nucleus is irregular and contains 3-5 lobes. Their cytoplasm is dotted with granules that contain enzymes that help them digest pathogens. They constitute about 70% of total WBCs.

• **Function** - They are phagocytic cells and engulf micro-organism.

2) Eosinophils :-

Their nucleus is bi-lobed. The cytoplasmic granules are stained with acidic dyes such as eosin. Eosinophils compose about 2- 4% of the WBC total. They primarily deal with parasitic infections.

• **Function** - Eosinophils are inflammatory cells in allergic reaction. They secrete chemicals that destroy these large parasites.

3) Basophills :-

The nucleus is twisted. The cytoplasmic granules are stained with basic dyes such as methylene blue. Because they are the rarest of the white blood cells (less than 0.5% of the total count)

• Function - Basophils are chiefly responsible for allergic and antigen response by releasing the chemical histamine causing the dilation of blood vessels and heparin as anticoagulant.

Agranulocytes:-It show absence of granules in cytoplasm and nucleus is not lobed

1) Lymphocyte:-

Lymphocytes are much more common in the lymphatic system than in blood. The cytoplasm is without granule and having large round nucleus. They constitute 30% of total WBCs. Lymphocytes are round cells that contain a single, large round nucleus. There are two main classes of cells, the B cells that mature in the bone marrow, and the T cells that mature in the thymus.

• Function :- They produce antibodies. They are responsible for immune response of the body.

2) Monocyte:-

The cytoplasm is clear with a kidney shaped nucleus. They constitute about 5% of total WBCs. Monocytes are the largest type of WBCs.

• Function - Once monocytes move from the bloodstream out into the body tissues, they differentiated into macrophages allowing phagocytosis and are then known as scavengers. They remove dead cell debris as well as attack microorganisms.

4) Thrombocytes / Platelets :-

Origin - megakaryocytes of the bone marrow

Size $-2.5-5\mu m$ in diameter

Life span - 5-10 days

Number of cells: - 2.5 lakh/cu.mm of blood

Platelets have no cell nucleus. They are fragments of cytoplasm that are derived from the megakaryocytes of the bone marrow, and then enter the circulation. Platelets are irregularly shaped fragments of cells that circulate in the blood until they are either activated to form a blood clot or are removed by the spleen. Platelets are found only in mammals. The platelets are the lightest and the smallest components of blood.

• **Function**:-The main function of platelets is to contribute to homeostasis. The process of stopping bleeding at the site of interrupted endothelium.

Function of blood:-

- It transport respiratory gases like CO₂ and O₂.
- It transports the digestive food from the alimentary canal to the tissue.
- It helps in thermoregulation.
- It carries hormones from the endocrine glands.
- It helps in maintenance of ionic balance.

- It protects the body by the phagocytic action.
- Blood Co-agulation:- Blood does not clot inside the blood vessel due to presence of active anti-coagulants like heparin and antithrombin.
- **Definition**: Blood Co-agulation is a process of conversion of liquid blood into semisolid jelly.
- **4** Process:-
 - 1) Platelets and injured tissue release thromboplastin which initiates formation of enzyme prothrombinase in blood.
 - 2) Prothrombinase in presence of Ca^{2+} ions convert inactive protein prothrombin into thrombin.
 - 3) Thrombin converts soluble fibrinogen into insoluble fibrin.
 - 4) Fibrin threads along with dead RBCs and plasma form a clot.

The normal clotting time is 2-8 minutes.

Platelets + injured tissue ______ prothrombinase Prothrombin ______ Thrombin ______ fibrinogen (soluble)______ fibrin (insoluble) + dead RBCs ______ Clot.

Definition:-

- *Heart beat*: The rhythmic contraction and relaxation of heart is called heart beat.
- *Heart rate*: The heart of healthy person beats 72/min.This is called Heart rate.
- *Stroke volume*:- Volume of blood pumped by ventricles per heart beat.It is about 70ml of blood /heart beat.

- *Cardiac output*:- Volume of blood pumped by ventricles in each minute.It is about 5 lit/min (70x72/min)= 5040 ml.
- *Tachycardia:* Increased heart rate over 100 beats per minute.
- Bradycardia: Decreased heart beat below 60 beats per minute.

Pulse :-

It is a pressure wave that travels through the arteries after each ventricular systole. Pulse rate is same as that of heart rate 72/minute. Study of the pulse is known as sphygmology. Pulse rate is higher in children's, females and standing position. It increases during exercise and emotional state (anger, fear, excitement). It is lower in adult males and lying position.

≻ Heart :-

Origin – mesodermal.

Size – length -12cm, Breadth - 9cm

Weight -250-300 gms.

Colour – Dark reddish.

The heart is a muscular conical organ in humans about the size of one fist with broad base and narrow apex tilted towards left. The heart is located in the middle compartment of the mediastinum in the chest. The back surface of the heart lies near the vertebral column, and the front surface sits behind to the sternum and rib cartilages.

• Pericardium:-

The heart is enclosed in a protective double layered peritoneum called pericardium, which contains a small amount of fluid. It consists of two layers.

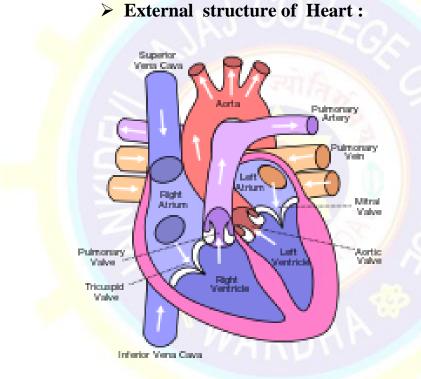
1) Fibrous pericardium:- it is outer layer, made up of tough inelastic fibrous connective tissue.

2) Serous pericardium:- it is inner layer, made up of outer parietal layer and inner visceral layer.

> Heart wall:-

The wall of the heart is made up of three layers:

- 1) Epicardium:- outer, single layer of flat epithelial cell.
- 2) Myocardium:- middle, composed of cardiac muscles fiber responsible for systole and diastole.
- 3) Endocardium:- inner, single layer of flat epithelial cell.



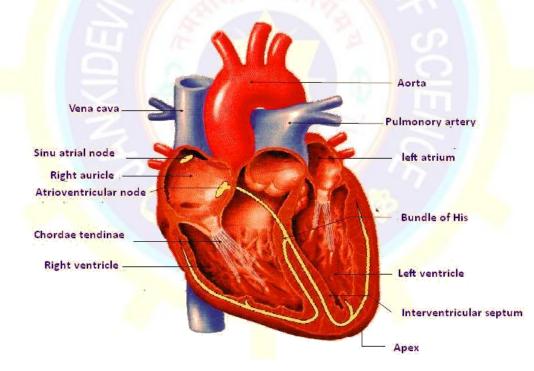
Human heart consists of four chambers two atria and two ventricles.

<u>Atria</u> :- Superior, small, thin walled receiving chambers.

Ventricles:- Inferior, large thick walled distributing chambers.

A transverse groove is present between atria and ventricles called atriaventricular groove or coronary sulcus. The interventricular sulcus is present between right and left ventricles. In these sulci, there are situated coronary arteries and coronary veins. The coronary vein join to form coronary sinus which opens into the right atrium.

Right atrium is larger in size than the left atrium. From the right ventricle, arises pulmonary trunk, while from left ventricle arises systemic aorta. The pulmonary trunk and systematic aorta are connected by ligamentum arteriosum that represents remanant of ductus arteriosus of foetus.



Internal structure of Human Heart :

Structure of human heart

Internally heart is four chambered with two atria and two ventricles.

Atria: These are two, thin walled receiving separated from each other by inter-atrial septum.

1) Right atrium :-

It receives deoxygenated blood through superior, inferior vena cava and coronary sinus. The opening of inferior vena cava is guarded by thebesian valve.

An oval depression, the fossa ovalis is present on the right side of interatrial septum which represents the remnant of foramen ovale of the foetus.

2) Left Atrium :-

It receives oxygenated blood from lungs through two pairs of openings of pulmonary veins. Each atrium opens into ventricles of its side through atrioventricular aperture guarded by valves. The right atrioventricular valve has three flaps hence called tricuspid valve and left atrioventricular valve has two flaps called bicuspid valve or mitral valve. These valves are attached to papillary muscles of ventricles by chordate tendinae which prevents the valve from turning back into the atria during the contraction of ventricles.

Ventricles: These are two, thick walled distributing chambers separated from each other by interventricular septum.

1) Left ventricle:- It has thickest wall because it has to pump blood to all parts of the body. Inner surface of the ventricle is thrown into a series of irregular muscular ridges called trabeculae cornea.

2) Right ventricles:- From R.V arises a pulmonary trunk carrying deoxygenated blood to lungs for oxygenation. From L.V arises a

systematic aorta carrying oxygenated blood to all parts of the body. Pulmonary trunk and systematic aorta has three semilunar valves at the base which prevents the backward flow of blood during ventricular diastole.

> The Heart Valves :

Four valves regulate blood flow through your heart:

- The tricuspid valve regulates blood flow between the right atrium and right ventricle.
- The pulmonary valve controls blood flow from the right ventricle into the pulmonary arteries which carry blood to your lungs to pick up oxygen.
- The mitral valve lets oxygen-rich blood from your lungs pass from the left atrium into the left ventricle.
- The aortic valve opens the way for oxygen-rich blood to pass from the left ventricle into the aorta your body's largest artery.

(a) SA node Bachmann's bundle Internodal fiber AV node Bundle of His Bundle branches

Conduction System of the Heart

The heart is able to both set its own rhythm and to conduct the signals necessary to maintain and coordinate this rhythm throughout its structures. About 1% of the cardiac muscle cells in the heart are responsible for forming the conduction system that sets the pace for the rest of the cardiac muscle cells.

The conduction system starts with the pacemaker of the heart—a small bundle of cells known as the sinoatrial (SA) node. The SA node is located in the wall of the right atrium inferior to the superior vena cava. The SA node is responsible for setting the pace of the heart as a whole and directly signals the atria to contract. The signal from the SA node is picked up by another mass of conductive tissue known as the atrioventricular (AV) node.

The AV node is located in the right atrium in the inferior portion of the interatrial septum. The AV node picks up the signal sent by the SA node and transmits it through the atrioventricular (AV) bundle. The AV bundle is a strand of conductive tissue that runs through the interatrial septum and into the interventricular septum. The AV bundle splits into left and right branches in the interventricular septum and continues running through the septum until they reach the apex of the heart. Branching off from the left and right bundle branches are many Purkinje fibers that carry the signal to the walls of the ventricles, stimulating the cardiac muscle cells to contract in a coordinated manner to efficiently pump blood out of the heart.

> Cardiac cycle

The cardiac cycle includes all of the events that take place during one heart beat. There are 3 phases to the cardiac cycle: atrial systole, ventricular systole, and joint diastole. It last for 0.8 sec.

- *Atrial systole*: During the atrial systole phase of the cardiac cycle, the atria contract and push blood into the ventricles. To facilitate this filling the AV valves stay open and the semilunar valves stay closed to keep arterial blood from re-entering the heart. The atria are much smaller than the ventricles so they only fill about 25% of the ventricles during this phase. The ventricles remain in diastole during this phase.
- *Ventricular systole*: During ventricular systole, the ventricles contract to push blood into the aorta and pulmonary trunk. The pressure of the ventricles forces the semilunar valves to open and the AV valves to close. This arrangement of valves allows for blood flow from the ventricles into the arteries. The cardiac muscles of the atria repolarize and enter the state of diastole during this phase.
- Joint diastole: During the relaxation phase, all 4 chambers of the heart are in diastole as blood pours into the heart from the veins. The ventricles fill to about 75% capacity during this phase and will be completely filled only after the atria enter systole. The cardiac muscle cells of the ventricles repolarize during this phase to prepare for the next round of depolarization and contraction. During this phase, the AV valves open to allow blood to flow freely into the ventricles while the semilunar valves close to prevent the regurgitation of blood from the great arteries into the ventricles.
 - Regulation of Cardiac activity :-

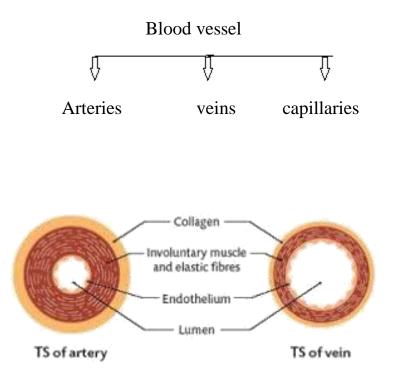
The normal activities of the heart are regulated by specialized muscles (autoregulated), hence the heart is called myogenic. The cardiovascular centre lies in the medulla oblongata of the brain. S.A node receives sympathetic and para sympathetic nerves which secretes adrenaline and acetylcholine.

Adrenaline – to stimulate and increases heart beat.

Acetylcholine – to decrease the heart rate.

During inspiration the heart rate increases and during expiration the heart rate falls. This phenomenon is known as <u>Sinus arrhythmias</u>.

Blood vessels: - The study of blood vessels is called angiology.



1) Arteries :-

These are the blood vessels that carry the blood from heart to various parts of the body. They are thick walled, muscular, elastic and without valves. The artery starts as a large vessel and ends into fine capillaries. They are deeply situated in the body. They carry oxygenated blood except pulmonary arteries which carries deoxygenated blood. Arteries divide and redivide to form arterioles. Arterioles divide and redivide to form capillaries.

<u>Histology</u>: The wall of artery is made up of three layers.

a) Tuica externa : It is the outermost coat formed by fibrous conn. tissue.

b)<u>Tunica media</u> : It is middle coat formed by smooth muscle fibres and an elastic tissue. It is having high B.P during ventricular contraction.

c) <u>Tunica interna</u> : It is innermost coat formed by a single layered flat endothelial cells. It is internally covered by a sheath of elastic tissue.

2) Veins :

Veins are blood vessels that carry blood toward the heart.Most veins carry deoxygenated blood from the tissues back to the heart exceptions are the pulmonary and umbilical veins, both of which carry oxygenated blood to the heart. In contrast to veins, arteries carry blood away from the heart.

Veins are less muscular than arteries and are often closer to the skin. There are valves in most veins to prevent backflow.

3) Capillaries:-

The capillaries are the smallest of the blood vessels and are part of the microcirculation. The capillaries have a width of a single cell in diameter to aid in the fast and easy diffusion of gases, sugars and nutrients to surrounding tissues. Capillaries have no smooth muscle surrounding them and have a diameter less than that of red blood cells; a red blood cell is typically 7 micrometers outside diameter, capillaries typically 5 micrometers inside diameter.

These small diameters of the capillaries provide a relatively large surface area for the exchange of gases and nutrients.

Double circulation :-

Human heart is four chambered and shows double circulation as blood passes twice through the heart .The blood follows two routes i.e pulmonary and systematic.

1) Pulmonary Circulation:

The circulation between heart and lungs is called pulmonary circulation. The course of blood from right ventricle to the left ventricle of heart through lungs is called pulmonary circulation. The right ventricle pumps deoxygenated blood into the pulmonary trunk which carries it to lungs for oxygenation. The oxygenated blood from the lungs is brought to left atrium by two pairs of pulmonary artery.

2) Systemic circulation:

The systemic circulation is the circulation between heart and body parts except the lungs. In systemic circulation, oxygenated blood away from the heart through the aorta from the left ventricle.

3) Coronary Circulation :

The cardiac muscles of heart receive oxygenated blood through coronary arteries. The deoxygenated blood is collected by coronary veins join to from coronary sinus which opens into right atrium.

Blood Pressure :-

The lateral pressure or force exerted by blood on the wall of arteries is called atrial blood pressure.

- 1) <u>Systolic B.P</u>: It is the pressure of blood during ventricular systole. It is maximum .Normal sys.B.P is 120 mm Hg.
- 2) <u>Diastolic B</u>.P : It is the pressure of blood during ventricular diastole .It is minimum. Normal diastole B.P is 80mm Hg.

Normal B.P= <u>Systolic B.P</u> =<u>120</u> mmHg

Diastolic B.P 80

Blood related Disorders :

1)Hypertension : Occurrence of persistent high B.P is called hypertension.

Such person has systolic B.P more than 140mmHg and diastole B.P more than 90 mm Hg.

<u>Causes</u> : Smoking ,alcohol, fat rich diet,obesity,emotional stress, excess secretion of epinephrine, aldosterone,atheriosclerosis etc.

<u>Symptoms</u> : It is commonly called silent killer because it may present for years with no significant symptoms.Breathlessness,giddiness,bursting blood vessels of vital organs like eye (blindness) ,kidney (nephritis) ,brain (stroke or paralysis) etc.

Coronary artery Disease (CAD) :

A condition in which the flow of blood to the heart is reduced due to blockage in coronary arteries called CAD. <u>Causes</u>: Atherosclerosis i.e deposition of fatty substance in the lining of arteries and results in the form of plague that decreases the diameter of artery. As a result heart muscles get inadequate amount of blood.

<u>Symptoms</u>:mild chest pain called angina pectoris or heart attack called myocardial infarction which may cause death.

> Angina pectoris :

A condition of chest pain due to inadequate supply of oxygen to the cardiac muscles of heart is called angina pectoris.

<u>Causes</u>: Narrowing and hardening of coronary artery due to atherio or arteriosclerosis, wrong life style, excess exertion and stress.

<u>Symptom</u> : Severe pain in chest ,compression of chest pain spread into the neck , lower jaw, left arm and shoulder.

Heart Failure: It is the result of progressive weakening of heart muscle and the failure of the heart to pump blood effectively.

<u>Causes</u>: Hypertension, congestion of lungs etc, advanced age, malnutrition, chronic infection, toxins, severe anaemia, hyperthyroidism.

ECG:

The electrocardiogram is a non-invasive device that measures and monitors the electrical activity of the heart through the skin. The ECG produces a distinctive waveform in response to the electrical changes taking place within the heart.

The first part of the wave called the P wave is a small increase in voltage of about 0.1 mV that corresponds to the depolarization of the atria during atrial systole. The next part of the ECG wave is the QRS complex which features a small drop in voltage (Q) a large voltage peak (R) and another small drop in voltage (S). The QRS complex corresponds to the depolarization of the ventricles during ventricular systole. The atria also repolarize during the QRS complex but have almost no effect on the ECG because they are so much smaller than the ventricles.

The final part of the ECG wave is the T wave, a small peak that follows the QRS complex. The T wave represents the ventricular repolarization during the relaxation phase of the cardiac cycle.

Uses : It is useful to detect the abnormal functioning of the heart like hypertension, rheumatic heart , cardiac arrest, CAD ,heart block, ECG can be used clinically to diagnose the effects of heart attacks, congenital heart problems and electrolyte imbalances.

4 Pacemaker:

- 1) The SA node in the heart is the natural pacemaker.
- 2) It is autorhythmic and able to generate the impulse of contraction rhythmically.
- 3) Sometimes SA node may become defective; it then fails to generate cardiac impulse at the normal rate.
- 4) Such disorder may be corrected by implanting an artificial pacemaker in the patient's chest.
- 5) The artificial pacemaker is an electronic device.
- 6) The device is connected to SA node by wires in case of arrhythmic impulse.
- 7) The device is preprogrammed to give rhythmic impulses.
- 8) It is powered by Ni-Cd battery.
- 9) The device has a life of few years (3-7 yrs).

Lymphatic System :-

In addition to the blood vascular system, all vertebrates possess lymphatic system. It consists of following parts;

1) Lymph:

The lymphatic system is part of the circulatory system and a vital part of the immune system comprising a network of lymphatic vessels that carry a clear fluid called lymph. It contains lymphocytes and other white blood cells. It also contains waste products and cellular debris together with bacteria and proteins.

2) Lymphatic capillaries:

These are thin walled vessels present in all tissue spaces. They are interwoven with the blood capillaries but are not connected with them. They are blind at one end and are wider than blood capillaries. Each is lined by endothelium of thin and flat cells.

3)Lymphatic Vessels :

Lymphatic capillaries unite to form larger tubes called lymphatic vessels. These have thinner walls and numerous valves to prevent backflow. The two main lymphatic vessels are thoracic or left lymph duct and right lymph duct. **Thoracic duct**: It is the main collecting duct of lymphatic system. It receives lymph from left side of head, neck, chest, left upper extremity and entire body below the ribs. The lymphatic vessel coming from intestine contains milky in appearance and called lacteals. (L.lactis – milk) The right lymphatic duct drains lymph from the upper side of the body.

4) Lymph nodes:

A lymph node is an organized collection of lymphoid tissue, through which the lymph passes on its way back to the blood. Lymph nodes are located at intervals along the lymphatic system. Several afferent lymph vessels bring in lymph, which percolates through the substance of the lymph node and then drained out by an efferent lymph vessel. There are between five and six hundred lymph nodes in the human body, many of which are grouped in clusters in different regions as in the underarm and abdominal areas. Lymph node clusters are commonly found at the base of limbs (groin, armpits) and in the neck. Lymph nodes are particularly numerous in the mediastinum in the chest, neck, pelvis, axilla, inguinal region, and in association with the blood vessels of the intestines. They act a filter as macrophages of lymph nodes remove bacteria, foreign material and cell debris. They produce lymphocytes and antibodies. Lymphocytes are concentrated in the lymph nodes.

• Function:

i) It is responsible for the removal of interstitial fluid from tissues.

ii) It absorbs and transports fatty acids and fats as chyle from the digestive system.

iii) It transports white blood cells to and from the lymph nodes into the bones.

iv)The lymph transports antigen-presenting cells such as dendritic cells to the lymph nodes where an immune response is stimulated.

