CHAPTER-12
CIRCULATION

Q1. Give the division of blood circulatory system of man.

Ans: The internal transport or blood circulatory system of man is divided into:

(i) Cardiovascular system

(ii) Lymphatic system.

Q2. Give the division of cardiovascular system of man.

Ans: The cardiovascular system consists of:

(i) Heart (a strong muscular organ)

(ii) Blood vessels (arteries, capillaries, veins)

(iii) Blood.

Q3. What is heart? Describe the origin of its name.

Ans: The heart functions as a pump and is responsible for the circulation of the blood through the blood vessels. The human heart is a hollow, fibromuscular organ. The Greek name for the heart is *cardia* from which we have the adjective **cardiac.** The Latin name for the heart is *cor* from which we have adjective **coronary.** The adult heart has the shape of a cone. The blunt, rounded point of the cone is the apex and the larger flat part at the opposite end of the cone is the base.

Q4. Describe coronary circulation.

Ans: The wall of the heart has its own supply of blood vessels to meet its vital needs. The myocardium is supplied with blood by the **right** and **left coronary arteries.** From the capillaries in the myocardium, the blood enters the **cardiac veins.** The course of these vessels parallels that of the coronary arteries. These cardiac veins converge to form the **coronary** sinus **channel** on the posterior surface of the heart. The coronary venous blood then enters the heart through an opening into the right atrium.

Q5. Explain the function of valves in veins and there location in veins.

Ans: Veins having diameters greater than 2mm contain valves that allow blood flow toward the heart but not in the opposite direction. Valves are present only in the lower part of the body especially in the abdomen and hind limbs. In the upper region above the heart there is no valve. As the blood pressure in the veins is comparatively low, so the flow of blood in the veins is helped by gravity, semilunar valve and muscular contraction.

Q6. What is cardiac output?

Ans: Blood flow means simply the quantity of blood that passes through a given point in the circulation in a given period. The overall blood flow in the circulation of an adult at rest is about 5000 ml/min. This is called **cardiac output.** It is the amount of blood pumped by the heart in a unit period.

Q7. Write a note on congenital heart problems.

Ans: Congenital heart problems:

Heart diseases can be classified as congenital or acquired. Congenital heart problems result from abnormalities in the embryonic development and may be attributed to heredity, nutritional problems (poor diet) of the pregnant mother, or viral infection.

(a) Patent ductus arteriosus:

(i) Before birth, the two major arteries—the aorta and the pulmonary artery—are connected by a blood vessel called the **ductus arteriosus**. This vessel is an essential part of foetal blood circulation.

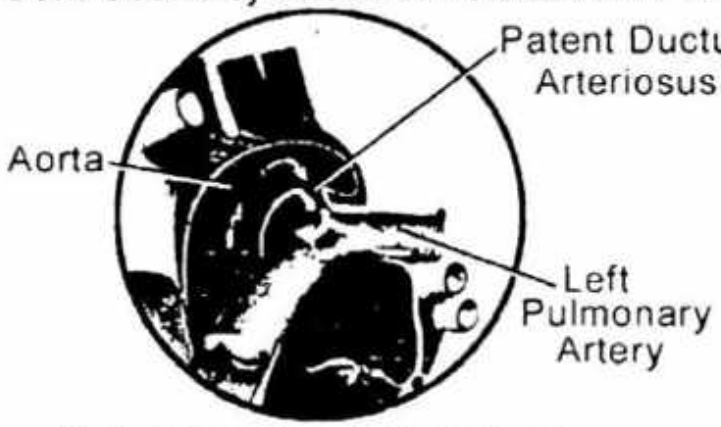
(ii) Before a baby is born, the foetus's blood does not need to go to the lungs to get oxygenated. The ductus arteriosus is a hole that allows the **blood to skip the circulation to the lungs**.

(iii) However, when the baby is born, the blood must receive oxygen in the lungs. Within minutes or up to a few days after birth, the vessel is supposed to close as part of the **normal changes occurring** in the baby's circulation.

(iv) If the ductus arteriosus is still open (or patent) the blood may skip this necessary step of circulation. The open hole is called the **patent ductus arteriosus**.

(v) **Patent ductus arteriosus** allows oxygen-rich blood from the aorta to mix with oxygen-poor blood from the pulmonary artery. This can put strain on the heart and increase blood pressure in the lung arteries.

(vi) **Treatment** options for a patent ductus arteriosus include monitoring, medications and closure by cardiac catheterization or surgery.



Patent Ductus Arteriousus

(b) Blue- baby syndrome:

(i) **Blue- baby syndrome** or **blue baby** is usually caused by a heart defect which laymen often call "a hole in the heart"

(ii) Normally, oxygenated blood from the lungs is separated from deoxygenated blood from other tissues.

(iii) A defect in the heart **ventricle walls** can allow deoxygenated blood to **mix** with the blood from the lungs.

(iv) The resulting blood going through the aorta has less oxygen than usual, and the baby looks blue.

(v) An operation is usually done to fix this.

Science Titbits

When a stethoscope is used to listen to the heart sounds, distinct sounds normally are heard. The **first heart sound** is a low-pitched sound, often described as a **"lub"** sound. It is caused by vibration of the atrioventricular valves which close near the beginning of ventricular systole. The **second** heart **sound** is a higher pitched sound often described as a **"dub"** sound. It results from closure of the aortic and pulmonary semilunar valves, near the end of systole. 'lub' is also written as 'lubb' and 'dub' as 'dupp'.

Science, Technology and Society Connections

- **Rationalize the use of artificial pacemaker in patients of cardiac arrhythmias.**

A **cardiac arrythmia** is a disturbance in electrical rhythm of heart. It may be **bradycardia** (heart beat less than 40 beats per minute) or **tachycardia** (heart beat more than 100 beats per minute). Pacemaker supplies electrical initiation to myocardial contraction. The pacemaker is put surgically under the skin where it may be programmed. It generates electrical rhythm at a set rate, so in this way arrythmia are controlled.

Skills: Analyzing and Interpreting

- **Justify how Vasodilation and Vasoconstriction is Reflective of Emotions?**

During emotional rage such as apprehension and rage vasodilation occurs due to secretion of **epinephrine.** It is a hormone that is responsible for fear, flight and fright conditions. The sympathetic vasodilator fibres are part of a regulatory system that originates in cerebral cortex and ends at postganglionic neurons in blood vessels on skeletal muscles, activate them to release acetylcholine, and vasodilation occurs. Blood discharge through thoroughfare channels rather than capillaries so heat loss occurs and the skin becomes hot and red. While in vasoconstriction blood supply becomes less to skin, so heat is preserved and the skin becomes cold. Situations such as shock, hypotension and tachycardia occur by stimulation of arterial stretch receptors and production of hypertension and bradycardia (slowness of the heart) occur by increased intracranial pressure.

Teacher's Point

Teacher would guide the students to hypothesize the role and effects of diuretic drugs in regulating blood pressure

Did You Know?

Atrial septal defect is a congenital heart defect. If the interatrial septum is defective then oxygen-rich blood can flow directly from the left side of the heart to mix with the oxygen-poor blood in the right side of the heart, or vice versa. It results in cyanosis (blueness of the skin).During development of the foetus, the interatrial septum develops to separate the left and right atria. However, a hole in the septum called the foramen ovale, allows blood from the right atrium to enter the left atrium during foetal development. This opening allows blood to bypass the nonfunctional foetal lungs while the foetus obtains its oxygen from the placenta. After birth, the pressure in the right side of the heart drops as the lungs open and begin working, causing the foramen ovale to close entirely

Teacher's Point

Teacher would guide the students to list major hospitals of cardiology working in your province.

Did You Know?

A new study suggests that one may have what doctors call "masked" hypertension, blood pressure that tends to be higher outside of the medical clinic environment. Masked hypertension was typically more common among males than females. Having diabetes raised the odds for the condition, and so did advancing age, the research showed. The findings were published Jan. 18, 2017 in the *American Journal of Epidemiology*.

Did You Know?

Platelets are bits of cytoplasm pinched off from large cells in the bone marrow. The structure of red blood cells or **erythrocytes** suits its main function, which is to carry oxygen. Human erythrocytes are biconcave disk, thinner in the centre than at the sides. A biconcave disk has more surface area for gas exchange than a flat disk or a sphere has. Their smaller size also gives the erythrocytes greater total surface area for gas exchange. Erythrocytes are formed in bone marrow.

There are four kinds of white blood cells or leukocytes. Leukocytes fight infection by releasing chemicals e.g., histamine. Neutrophils and monocytes are phagocytes, eating bacteria and foreign proteins. Eosinophils are phagocytic. Lymphocytes are the key in immunity. Some lymphocytes produce antibodies.

Teacher's Point

Teacher would guide the students to trace the path of lymph from lymph capillary until it is returned to the blood

Skills: Initiating and Planning

- **Justify in what ways blood circulatory system is dependent on the lymphatic system.**

The lymphatic system represents an accessory route by which fluid can flow from the interstitial spaces into the blood. And, the most important, the lymphatic system can carry proteins and large particulate matter away from the tissue spaces, neither of which can be removed by absorption directly into the blood capillary. This removal of proteins from the interstitial spaces is an essential function, without which we would die within 24 hours. Thus blood circulatory system is dependent on lymphatic system.

- **Interpret why the swelling of the lymph nodes is a cause of concern.**

Lymphatic flow is determined by the interstitial fluid pressure and activity of lymphatic pump. Lymph node swelling is a cause of concern because lymph node swells in different diseases, e.g., in pyrexia (fever) of unknown origin enlarged lymph nodes appear. Enlargement of anterior and tonsillar nodes is usually associated with tonsillitis or pharyngitis, posterior lymphoadenopathy may suggest a glandular fever syndrome or HIV infection. The causes of lymphoadenopathy (swelling of lymph node) are bacterial (streptococcal, tuberculosis), viral, protozoan, fungal (histoplasmosis), leukeemias, lymphomas etc.

Activity

1. Correlating the *lub-dub* sounds of the closing of heart valves with the monitoring of the heartbeat
2. Identification of the phases of heartbeat on a printed ECG and comparison of the ECG of a cardiac patient with that of a healthy man
3. Dissection of the heart of sheep and describing its internal structure
4. Differentiation of an artery and a vein by observing prepared slides
5. Measuring blood pressure by using sphygmomanometer

EXERCISE

MCQs

1. Select the correct answer.

(i) The rhythmic beating of cardiac muscle in the mammalian heart is initiated by the.

(A) atrio-ventricular node
(B) parasympathetic nervous system
(C) Purkinje tissue
(D) sino-atrial node

(ii) A red blood cell, entering the right side of the heart, passes by or through the following structures:

1. atrioventricular valve **2. semilunar valve**
3. right atrium **4. right ventricle**
5. sinoatrial node

In which order will the red blood cell passes the structures?

(A) 2 → 3 → 1 → 4 → 5
(B) 3 → 1 → 5 → 2 → 4
(C) 3 → 5 → 1 → 2 → 4
(D) 5 → 3 → 1 → 4 → 2

(iii) What effect would be caused by cutting the sympathetic nerve fibres to the heart?

(A) a decrease in the heartbeat rate
(B) a decrease in the length of the diastole phase
(C) a decrease in the length of the systole phase
(D) a decrease in the stroke volume

(iv) What produces systolic blood pressure?

(A) contraction of the right atrium
(B) contraction of the right ventricle
(C) contraction of the left atrium
(D) contraction of the left ventricle

(v) Human heart is

(A) myogenic (B) neurogenic
(C) cardiogenic (D) digenic

(vi) Typical lub-dub sounds heard in heart in heartbeat are due to

(A) closing of bicuspid and tricuspid valves.
(B) closing of semilunar valves
(C) blood under pressure through aorta.
(D) closure of bicuspid -tricuspid valves followed by semilunar valves

(vii) Bicuspid valve connects

(A) left atrium and left ventricle
(B) left atrium and right ventricle
(C) right atrium and left ventricle
(D) right atrium and right ventricle

(viii) Pacemaker is situated in heart

(A) in the wall of right atrium
(B) on interauricular septum
(C) on interventricular septum
(D) in the wall of left atrium

(ix) During ventricular systole in a mammalian heart the

(A) ventricular pressure increases
(B) atrioventricular valves open
(C) semilunar valves close
(D) aortic pressure decreases

(x) Lymph returns----------to blood

(A) oxygen
(B) carbon dioxide
(C) interstitial fluid
(D) white blood cells

(xi) Lymph most closely resembles which of the following?

(A) blood
(B) urine
(C) water
(D) interstitial fluid

(xii) Which of these factors has little effect on blood flow in arteries?

(A) total cross sectional area of vessels
(B) blood pressure
(C) skeletal muscle contraction
(D) heartbeat

(xiii) The Sino Atrial node (SA node)

(A) regulates the rhythm of contraction
(B) is also called AV node
(C) regulates the rate of contraction
(D) is also called bundle of His

Answers

(i) D	**(ii) D**	**(iii) A**	**(iv) D**	**(v) A**
(vi) D	**(vii) A**	**(viii) A**	**(ix) A**	**(x) C**
(xi) D	**(xii) C**	**(xiii) A**		

SHORT QUESTIONS

2. Why do we have a circulatory system?

Ans: Carbon dioxide and waste chemicals have to be removed from the lungs and kidneys respectively. Our bodies are too large for materials to simple diffuse in and out. So we have a system of internal transport - a **circulatory system** that transports oxygen and carbon dioxide, distributes nutrients to the body cells and conveys the waste products of metabolism to specific site for disposal

(vii) Bicuspid valve connects

(A) left atrium and left ventricle
(B) left atrium and right ventricle
(C) right atrium and left ventricle
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3. Which side of the human heart contains oxygenated blood?

Ans: The left side of heart carries oxygenated blood. Four **pulmonary veins,** carrying oxygenated blood from the lungs, enter the left atrium. The **left atrium** sends blood through the **bicuspid valve** to the **left ventricle.** The left ventricle sends blood through the **aortic semilunar valve** into the **aorta** to the body proper.

4. What are the contraction and relaxation of human heart called?

Ans: In a continuous, rhythmic cycle heart is passively filled with blood from the large veins and then the heart actively contracts, propelling the blood throughout the body. Its alternating relaxations and contractions make up the **cardiac cycle.** The cardiac cycle is a sequence of one heartbeat.

5. Name two circulatory systems in the body of man.

Ans: Following are the two circulatory systems in the body of man.

(i) Cardiovascular system **(ii)** Lymphatic system

6. Where is SA node, AV node, Purkinje fibre, Bundle of His located?

Ans: Sinoatrial node:

Sinoatrial node in short is called **SA node.** It consists of specialized plexus of cardiac muscles embedded in the upper wall of the right atrium. It is close to where vena cavae enter the atrium. The SA node has been developed from the sinus venosus and has become a part of the atrium, so it is called **sinoatrial node.**

Atrioventricular node:

Another specialized group of cardiac muscle fibres called **atrioventricular node.** In short it is called **AV node.** It is present near the junction of right atrium and right ventricle.

Bundle of His:

AV node is connected to a strand of specialized muscles (in the ventricular septum) known as **atrioventricular bundle** or **bundle of** His (pronounced as "hiss"). This bundle passes through a small opening in the fibrous skeleton to reach the interventricular septum, where it divides to form right and left bundle branches, which extend beneath the endocardium on either side of the interventricular septum to the apices of the right and left ventricles respectively.

Purkinje fibres:

The inferior, terminal branches of the bundle of His are called **Purkinje fibres,** which are large-diameter cardiac muscle fibres.

7. Why action potentials travel along the Purkinje fibres more rapidly than through other muscle fibres?

Ans: The inferior, terminal branches of the bundle of His are called **Purkinje fibres,** which are large-diameter cardiac muscle fibres. They have fewer myofibrils than most cardiac muscle cells and do not contract forcefully. **Intercalated disks** are well developed between the Purkinje fibres and **contain numerous gap junctions.** As a result of these structural modifications, action potentials travel along the Purkinje fibres much more rapidly than through other cardiac muscle tissue.

8. Name the artery supplying blood to the heart.

Ans: The wall of the heart has its own supply of blood vessels to meet its vital needs. The myocardium is supplied with blood by the **right** and **left coronary arteries.**

9. What is blood pressure?

Ans: Blood pressure is the **force exerted by the blood against any unit area** on the inner walls of the blood vessel. The standard reference for the blood pressure is the mercury (Hg) manometer, which measures pressure in millimetres of mercury (mm Hg).

10. Name the instrument used in measuring blood pressure.

Ans: Sphagmonometer is used in measuring blood pressure.

11. Why SA node is called pacemaker of the heart?

Ans: Cardiac muscle cells have the capacity to generate spontaneous action potentials, but cells of the SA node do so at a greater frequency. As a result, the SA node is called the **pacemaker** of the heart.

12. What is a cardiac cycle?

Ans: In a continuous, rhythmic cycle heart is passively filled with blood from the large veins and then the heart actively contracts, propelling the blood throughout the body. Its alternating relaxations and contractions make up the **cardiac cycle**. The cardiac cycle is a sequence of one heartbeat.

13. What is an arterial pulse? What is the normal human pulse rate?

Ans: Arterial pulse indicates the rate at which left ventricles contracts and pushes blood into Aorta. A normal resting heart rate for adults ranges from 60 to 100 beats a minute.

14. Why is AV node essential for the conduction of cardiac impulse?

Ans: When impulse from SA node reaches AV node they become weak to cause ventricular contraction so they are renewed at AV node that is why they are essential for the conduction of cardiac impulse. Impulse takes 0.11 sec to get renewed within AV node.

15. What are the risks associated with atherosclerosis?

Ans: Risks associated with atherosclerosis:

(i) Atherosclerosis is characterized by formation of yellow fatty streaks containing high proportion of cholesterol in the intima of large and medium sized arteries resulting in the **narrowing of the vascular lumen**.

(ii) Later, fibres are deposited in the cholesterol and these often start to calcify and become hard, a process known as **arteriosclerosis.** The deposits are called **athromatous plaques.**

(iii) **As a plaque** increases in size it protrudes into the lumen of the artery and begins to block it. The plaque first forms thrombus and may form embolus.

16. Why can you feel your pulse in arteries but not in veins? If there is no pulse in your veins what pushes the blood in veins back to the heart?

Ans: We feel pulse in arteries but not in veins because the blood pressure in arteries are much higher than in the veins, plus the arteries walls are muscular to keep them wide open, and make them uncompressible thus, we can feel the pulse without blocking the blood flow.

On the other hand, the veins walls are not muscular which make it very easier to block by some pressure. So if we press it hard we won't feel the pulse.

OR

We feel pulse in arteries but not in veins because veins return low pressure blood to the heart. They have thinner walls than arteries. The pulse is the spurt of high pressure blood that passes along the arteries, when left ventricle contract it can be felt where arteries pass close to the body surface.

17. List the risk factors in your family history and life style for cardiovascular disease. Which factors can be changed? Which cannot? What can you do to lower your risk of heart disease?

Ans: Prevention of Cardio Vascular Disease:

We can take steps to prevent the occurrence of CVD.

(i) When a person **smokes,** the drug nicotine causes arterioles to constrict and blood pressure to rise.

(ii) **Stimulants** such as cocaine and amphetamines can cause an irregular heart attack and stroke.

(iii) Drinking alcohol and lack of exercise are also the factors that cause CVD

Factors that can be avoided by change in life style:

Some of the factors can obviously be avoided by changes in life style.

(i) One should try to maintain normal body weight.

(ii) It is recommended that one should take diet having low cholesterol, low saturated fats and low salt.

(iii) For calcium, magnesium and potassium one should take grains, fruits, green vegetables and vitamin D.

18. Define the term thrombus and differentiate between thrombus and embolus.

Ans: The clotted mass of blood within a vessel or the heart during life is called **thrombus.**

The occlusion (a closing of an opening) of some part of the cardiovascular system by any mass transported to the site through the blood stream is called **embolism.**

Embolus is a detached intravascular solid, liquid or gaseous mass that is carried to a site distant from its point of origin. About 99% emboli arise from dislodgement of thrombi and are therefore called **thromboemboli.** Thrombus and embolus cause death.

19. Identify the factors causing atherosclerosis and arteriosclerosis.

Ans: Major factors that cause atherosclerosis:

The major factors that cause atherosclerosis and arteriosclerosis are:

Hypercholesterolemia, (hyperlipidemia), Hypertension, Cigarette smoking, Diabetes mellitus,

Minor risk factors: The minor risk factors are:

(a) Increasing age. **(b)** Lack of exercise.

(c) Stressful competitive life. **(d)** Obesity.

20. State the congenital heart problem related to malfunctioning of cardiac valves.

Ans: Congenital heart problem:

It is related to the malfunctioning of cardiac valves. **Valvular stenosis** results from scaring of the valve leaflets, may cause reduction in diameter of the valve orifice. Severe destruction of valve apparatus may cause valve ring dilation.

with thickening and shortening of chordae tendinae resulting in **regurgitation** of blood through the valve when it is closed, i.e., valve closure is incomplete.

21. List the advantages and disadvantages of coronary bypass.

Ans: Following are the advantages and disadvantages of coronary bypass.

Advantages:

(i) Procedure is safe.

(ii) Angina is abolished or greatly reduced in almost 90% of the patients.

(iii) It is used in the patients with: **(a)** 2 to 3 vessel diseases **(b)** disease of left main coronary artery **(c)** impaired left ventricular function **(d)** diabetic patients **(e)** lesion not suitable for angioplasty.

Disadvantages:

(i) Defused left ventricular damage

(ii) Per operative (during operation), myocardial infarction.

(iii) Infection

(iv) Wound pain

(v) Longer hospital stay

22. List the changes in the life styles that can protect man from hypertension and cardiac problems.

Ans: We can take steps to prevent the occurrence of CVD.

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23. What is the major feature of human lymphatic system?

Ans: The lymphatic system includes lymph, lymphocytes, lymphatic vessels, lymph nodes, tonsils, spleen and thymus gland. About one sixth of the body consists of spaces between the cells, which collectively are called the **interstitium.** The fluid in these spaces is the **interstitial fluid** or **intercellular fluid.**

24. Justify why blood circulatory system is dependent on the lymphatic system.

Ans: The lymphatic system represents an accessory route by which fluid can flow from the interstitial spaces into the blood. And, the most important, the lymphatic system can carry proteins and large particulate matter away from the tissue spaces, neither of which can be removed by absorption directly into the blood capillary. This removal of proteins from the interstitial spaces is an essential function, without which we would die within 24 hours. **Thus blood circulatory system is dependent on lymphatic system.**

25. Interpret why the swelling of the lymph node is cause of conern.

Ans: Lymphatic flow is determined by the interstitial fluid pressure and activity of lymphatic pump. Lymph node swelling is a cause of concern because lymph node swells in different diseases, e.g., in pyrexia (fever) of unknown origin enlarged lymph nodes appear. Enlargement of anterior and tonsillar nodes is usually associated with tonsillitis or pharyngitis, posterior lymphoadenopathy may suggest a glandular fever syndrome or HIV infection. The causes of lymphoadenopathy (swelling of lymph node) are bacterial (streptococcal, tuberculosis), viral, protozoan, fungal (histoplasmosis), leukeemias, lymphomas etc.

26. Define/Describe/Explain briefly:
circulatory system, angiology, pericardium, chordae tendineae, pacemaker, myogenic, ECG, capillaries, pulmonary circulation, cardiac input, brarorefiex, baroreceptors, volume receptors, thrombosis, embolism, angina pectoris, congenital heart problem, myocardial infarction, angioplasty, stent, hypertension, hypotension, posturnal hypotensuion, interstitial fluid, lymph, vasomotion, embolism, spleen.

Ans: Circulatory system:

All the cells of our body need food from small intestine and oxygen from the lungs. Carbon dioxide and waste chemicals have to be removed from the lungs and kidneys respectively.

Our bodies are too large for materials to simple diffuse in and out. So we have a system of internal transport - a **circulatory system** that transports oxygen and carbon dioxide, distributes nutrients to the body cells and conveys the waste products of metabolism to specific site for disposal.

Angiology:

The study of the diseases of cardiovascular system is called **angiology.**

Pericardium:

The pericardium is a closed sac that surrounds heart. It consists of inelastic white fibrous tissues.

Chordae tendineae:

They are strong connective tissue strings which attach **papillary muscles to the** cusps of the atrioventricular valves.

OR

Each ventricle contains cone-shaped muscular pillars called **papillary** (meaning, pimple-shaped) **muscles. These** muscles are attached by thin, strong connective tissue strings called **chordae tendineae** (meaning, heart strings) to the cusps of the atrioventricular valves.

Pacemaker:

A pacemaker is a small device that helps your heart beat more regularly. It does this with a small electric stimulation that helps control your heartbeat. Your doctor puts the pacemaker under the skin on your chest, just under your collarbone. It's hooked up to your heart with tiny wires.

OR

Cardiac muscle cells have the capacity to generate spontaneous action potentials, but cells of the SA node do so at a greater frequency. As a result, the SA

node is called the **pacemaker** of the heart it set the pace of heart which helps your heart beat more regularly

Myogenic:

Myogenic is the term used for muscles or tissues that can contract on their own, without any external electrical stimulus, from the brain or spinal cord.

Example: An example of this phenomena is actually present in our kidneys to regulate the flow of blood in vessels. Another example is the human heart.

ECG:

A recording of the electrical activity of the heart is called electrocardiogram (ECG) An ECG is a simple, noninvasive procedure Electrodes are placed on the skin of the chest and connected in a specific order to a machine that, when turned on measures electrical activity all over the heart. Output usually appears on a long scroll of paper that displays a printed graph of activity on a computer screen.

Capillaries:

Capillaries are the smallest of blood vessels. They serve to distribute oxygenated blood from arteries to the tissues of the body and to feed deoxygenated blood from the tissues back into the veins. The capillaries are thus a central component in the circulatory system.

Pulmonary circulation:

Pulmonary circulation transports oxygen-poor blood from the right ventricle to the lungs, where blood picks up a new blood supply. Then it returns the oxygen-rich blood to the left atrium.

OR

Pulmonary circulation is the system of blood vessels and associated tissues forming the part of the cardiovascular system that carries oxygen-poor ("deoxygenated") blood away from the heart, to the lungs, and returns oxygen-rich ("oxygenated") blood from the lungs back to the heart.

Cardiac input:

Cardiac input describes the volume of blood being taken by the heart, in particular by the left or right atrium, per unit time.

Braroreflex:

The baroreflex or baroreceptor reflex is one of the body's homeostatic mechanisms that help to maintain blood pressure at nearly constant levels.

Baroreceptors:

Baroreceptors (or archaically, pressoreceptors) are sensors, located in the blood vessels of all vertebrate animals.

They play an important role in:

(i) Increase in the pressure of blood.

(ii) Triggers increased action potential generation rates.

(iii) Peripheral resistance.

(iv) Baroreflex

Volume receptors:

Volume receptors are low pressure baroreceptors that are found in the atria of the heart and carotid arteries.

When these receptors detect a blood volume decrease in the atria, a signal is transmitted from the receptors to the hypothalamus in the brain.They are actually are sensors

Thrombosis:

The clotted mass of blood within a vessel or the heart during life is called **thrombus**

Embolism:

The occlusion (a closing of an opening) of some part of the cardiovascular system by any mass transported to the site through the blood stream is called **embolism**

Angina pectoris:

Due to atherosclerosis a person may feel occasional chest pain, a condition known as **angina pectoris** (Latin *angere* to choke and *pecto* breast). **Angina** is most likely to occur when the heart is labouring hard because of physical or emotional stress.

Congenital heart problem:

It is related to the malfunctioning of cardiac valves. **Valvular stenosis** results from scaring of the valve leaflets, may cause reduction in diameter of the valve orifice. Severe destruction of valve apparatus may cause valve ring dilation, with thickening and shortening of chordae tendinae resulting in **regurgitation** of blood through the valve when it is closed, i.e., valve closure is incomplete.

Myocardial infarction:

Myocardial infarction (MI), commonly known as a heart attack occurs when blood flow decreases or stops to a part of the heart, causing damage to the heart muscle.

Angioplasty:

In angioplasty a cardiologist threads a plastic tube into an artery of an arm or a leg and guides it through a major blood vessel toward the heart. When the tube reaches the region of plaque in a coronary artery a balloon is attached to the end of the tube is inflated forcing the vessel open. However, the artery may not remain open, so slotted tubes called **stents** are expanded inside the artery to keep the artery open. Stents are coated with heparin to prevent blood clotting and chemicals to prevent arterial closing.

Stent:

In medicine, a stent is a metal or plastic tube inserted into the lumen of an anatomic vessel or duct to keep the passageway open, and stenting is the placement of a stent.

OR

A stent is a tiny tube that your doctor can insert into a blocked passageway to keep it open. The stent restores the flow of blood or other fluids, depending on where it's placed.

Hypertension:

Any blood pressure that is above the normal expected pressure for an individual in a given environment is called hypertension. Hypertension is defined as blood pressure higher than 140/90 mmHg (millimeters of mercury).

Hypotension:

Any blood pressure that is below the normal expected pressure for an individual in a given environment is called hypotension. Hypotension is defined as blood pressure lower than 90/60 mmHg (millimeters of mercury)

Postural hypotension:

Postural hypotension is a form of low blood pressure that happens when you stand up from sitting or lying down. Postural hypotension can make you feel dizzy or lightheaded, and maybe even faint.

Postural hypotension may be mild and last for less than a few minutes.

Interstitial fluid:

Interstitial fluid (ISF) is a solution that bathes and surrounds the tissue cells of multicellular animals. It is found in the spaces between body tissues.

Lymph:

Lymph is a clear fluid that travels through your body's arteries, circulates through your tissues to cleanse them and keep them firm, and then drains away through the lymphatic system

OR

Lymph is the fluid that circulates throughout the lymphatic system. Lymph means clear water and it is derived from the fluid and protein that has been squeezed out of the blood (i.e. blood plasma)

Vasomotion:

The precapillary sphincters and metarterioles often open and close cyclically several times per minute, with the duration of the open phases being about proportional to the metabolic needs of the tissue. The cyclic opening and closing is called vasomotion

Embolism:

The occlusion (a closing of an opening) of some part of the cardiovascular system by any mass transported to the site through the blood stream is called **embolism**

Spleen:

The spleen is an organ in the upper far left part of the abdomen, to the left of the stomach

The spleen plays multiple supporting roles in the body

(i) It acts as a filter for blood as part of the immune system.

(ii) Old red blood cells are recycled in the spleen, and platelets and white blood cells are stored there.

(iii) The spleen also helps fight certain kinds of bacteria that cause pneumonia and meningitis

27. **Writ the differences between:**

(a). **cardia and coronary**

(b) **pericardium and endocardium**

(c) **bicuspid valve and tricuspid valve**

(d) **systole and diastole**

(e) **SA node and AV node**

(f) **P-wave and T-wave of ECG**

(g) **arteries and veins**

(h) blood capillaries and lymph capillaries
(i) vasodilatation and vasoconstriction
(j) interlobar arteries and interlobular arteries
(k) baroreceptor and volume receptor
(l) thrombus and embolus
(m) hypertension and hypotension
(n) interstitial fluid and lymph

Ans: (a) cardia and coronary:

Cardia	Coronary
Cardia is the Greek name for heart.	Latin name for the heart is cor.
Cardia is the origin of the adjective cardiac.	Cor is the origin of the adjective **coronary**.

(b) pericardium and endocardium:

Pericardium	Endocardium
The pericardium is a closed sac that surrounds heart.	The smooth inner surface of the heart chambers is the **endocardium**.
Consists of inelastic white fibrous tissues.	Consists of simple squamous epithelium over a layer of connective tissue.
Its function is to reduce the friction between the heart wall and surrounding tissues when the heart is beating. The inelastic nature of the pericardium as whole prevents the heart from being overstretched or overfilled with blood.	Its function is to provide protection and support to the valves and heart chambers

(c) bicuspid valve and tricuspid valve:

Tricuspid valve	Bicuspid valve
The tricuspid valve is present between the right atrium and the right ventricle.	The bicuspid valve is present between the left atrium, and the left ventricle.
This valve opens to allow blood to be pumped from the right atrium into the right ventricle. Once the blood has passed through the valve closes so the blood can not pass back.	It also allows the flow of blood in one direction. After the oxygenated blood flows from the atrium to the ventricle the valve closes to prevent the blood from flowing back
It has three flaps.	It has only 2 flaps.

(d) systole and diastole:

	Diastolic	Systolic
Definition	It is the pressure that is exerted on the walls of the various arteries around the body in between heart beats when the heart is relaxed.	It measures the amount of pressure that blood exerts on arteries and vessels while the heart is beating

Normal range	60 – 80 mmHg (adults), 65 mmHg (infants), 65 mmHg (6 to 9 years)	90 – 120 mmHg (adults), 95 mmHg (infants), 100 mmHg (6 to 9 years)
Importance with age	Diastolic readings are particularly important in monitoring blood pressure in younger individuals.	As a person's age increases, so does the importance of their systolic blood pressure measurement.
Blood Pressure	Diastolic represents the minimum pressure in the arteries.	Systolic represents the maximum pressure exerted on the arteries.
Ventricles of the heart	Fill with blood	Left ventricles contract
Blood Vessels	Relaxed	Contracted
Blood Pressure reading	The lower number is diastolic pressure.	The higher number is systolic pressure.

(e) SA node and AV node:

	SA Node	**AV Node**
Abbreviation	SA node stands for sinoatrial node.	AV node stands for the atrioventricular node.
Also Known As	SA node is known as the pacemaker of the heart.	AV node is also known as pace setter of the heart.
Conducting System of Heart	SA node is the first component of conducting a system of the heart.	AV node is the second component of conducting a system of the heart.
Influenced By	It is influenced by autonomic nervous system	It is influenced by the impulses from SA node.
Location	SA node is located in the superior lateral wall of the opening of superior vena cava (SVC).	AV node is located in the posterior septal wall of right atrium just near to opening of the coronary sinus.
Beats per Minute	SA node has the rate of impulse discharge of almost 90-100 beats per minute.	AV node normal firing rate is 40-50 times per minute.
Length	It is longer	It is shorter

(f) P-wave and T-wave of ECG:

P-wave	**T-wave**
P-wave is characterized by the depolarization of the atrial fibres of the SA node.	T-wave is characterized by the ventricular repolarization.

The P wave represents excitation and occurs just prior to contraction of the atria.	T-wave occurs just before the ventricles relax
It is of atrial origin.	It is of ventricular origin
During this phase, the impulse of contraction is generated by the SA node, causing atrial depolarisation.	During this phase, the ventricles relax and return to their normal state

(g) arteries and veins:

	Arteries	Veins
Overview	Arteries are red blood vessels that carry blood away from the heart	Veins are blue blood vessels that carry blood towards the heart
Oxygen Concentration	Arteries carry oxygenated blood	Veins carry deoxygenated blood
Direction of Blood Flow	From the heart to various parts of the body.	From various parts of the body to the heart
Anatomy	Thick, elastic muscle layer that can handle high pressure of the blood flowing through the arteries	Thin, elastic muscle layer with semilunar valves that prevent the blood from flowing in the opposite direction
Location	Deeper in the body	Closer to the skin
Walls	Arterial walls are more rigid	Veins have collapsible walls
Valves	Aren't present (except for semi-lunar valves)	Are present, especially in limbs.
Thickest layer	Tunica media	Tunica adventitia
Types	Pulmonary and systemic arteries	Superficial veins, deep veins, pulmonary veins and systemic veins
Disease	artherogenesis-myocardial ischemia	deep vein thrombosis

(h) blood capillaries and lymph capillaries:

Blood capillaries	Lymph capillaries
They are reddish, easy to observe.	They are Colorless difficult to observe
They are joined to arterioles at one end and to venules at another end.	They have closed ends
Narrower than lymph capillaries.	Wider than blood capillaries
Wall consists of normal endothelium and well developed basement membrane	Wall consists of thin endothelium and poorly developed basement membrane
Contain red blood.	Contain colorless lymph.
Have relatively high pressure	Have relatively low pressure

(i) vasodilatation and vasoconstriction:

Vasodilatation	Vasoconstriction
Vasodilatation is the dilation of blood vessels	Vasoconstriction is the constriction of blood vessels.
Increase lumen size	Decrease lumen size
It causes increased blood flow per unit time	It causes decreased blood flow per unit time
During Vasodilatation smooth muscles relax.	During Vasoconstriction smooth muscles contract.
Kinins are powerful Vasodilatator	Norepinephrine is a powerful Vasoconstricter.

(j) interlobar arteries and interlobular arteries:

Interlobar arteries	Interlobular arteries
Interlobar arteries are the division of renal artery	Interlobular arteries radiate from the arcuate arteries.
They pass between the renal pyramids through renal column	They project into the renal cortex.
They give rise to arcuate arteries	They give rise to microscopic afferent glomerular arterioles.

(k) baroreceptor and volume receptor:

Baroreceptor	Volume receptor
Baroreceptors (or archaically, pressoreceptors) are sensors	Atrial volume receptors (also known as Veno-atrial stretch receptors) are low pressure baroreceptors.
Located in the blood vessels of all vertebrate animals	They are found in the atria of the heart
They play an important role in: **(i)** Increase in the pressure of blood. **(ii)** Triggers increased action potential generation rates. **(iii)** Peripheral resistance **(iv)** Baroreflex.	They play an important role in: **(i)** Renal vasodilation. **(ii)** Control of water concentration in the glomerular filtrate. **(iii)** Production of vasopressin. **(iv)** Water retention in urine.

(l) thrombus and embolus:

Thrombus	Embolus
The clotted mass of blood within a vessel or the heart during life is called **thrombus.**	**Embolus** is a detached intravascular solid, liquid or gaseous mass that is carried to a site distant from its point of origin
Thrombosis is caused due to disturbed flow of blood, hypercoagulability, and injury to endothelial lining of the blood vessel	About 99% emboli arise from dislodgement of thrombi and are therefore called **thromboemboli.**
Example: Deep venous **thrombus**	**Example:** pulmonary embolus

(m) hypertension and hypotension:

Hypertension	Hypotension
Any blood pressure that is above the normal expected for an individual in a given environment.	Any blood pressure that is below the normal expected for an individual in a given environment.
Hypertension is defined as blood pressure higher than 140/90 mmHg (millimeters of mercury)	Hypotension is defined as blood pressure lower than 90/60 mmHg (millimeters of mercury)
Reasons that can cause hypertension Physical inactivity Salt-rich diets with processed and fatty foods, alcohol and tobacco use	Reasons that can cause hypotension include Heart problems, Endocrine problems, Dehydration, Blood loss, lack of nutrients in your diet.

(n) interstitial fluid and lymph:

Interstitial fluid	Lymph
Interstitial fluid (ISF) is a solution that bathes and surrounds the tissue cells of multicellular animals	Lymph means clear water and it is derived from the fluid and protein that has been squeezed out of the blood (i.e. blood plasma).
Found in the spaces between body tissues	Found in the lymphatic system

EXTENSIVE QUESTIONS

28. Draw label and describe the external structure of human heart.

Ans: Structure of Human Heart:

Location:

The heart is located in the thoracic cavity between the lungs. The heart lies deep, obliquely and slightly to the left of the sternum. The base of heart extends to the second intercostals space and the apex of the heart is in the fifth intercostals space, approximately 9 cm to the left of the midline.

Pericardium:

The pericardium is a closed sac that surrounds heart. It consists of two parts:

(i) Outer part **(ii) Inner part**

(i) Outer part:

The outer part consists of inelastic white fibrous tissue.

(ii) Inner part

The inner part is made up of two membranes. The inner membrane is attached to the heart and the outer one is attached to the fibrous tissue.

Pericardial fluid is secreted between them and reduces the friction between the heart wall and surrounding tissues when the heart is beating. The inelastic nature of the pericardium as whole prevents the heart from being **overstretched or overfilled with blood.**

(m) hypertension and hypotension:

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Any blood pressure that is above the normal expected for an individual in a given environment.	Any blood pressure that is below the normal expected for an individual in a given environment.
Hypertension is defined as blood pressure higher than 140/90 mmHg (millimeters of mercury)	Hypotension is defined as blood pressure lower than 90/60 mmHg (millimeters of mercury)
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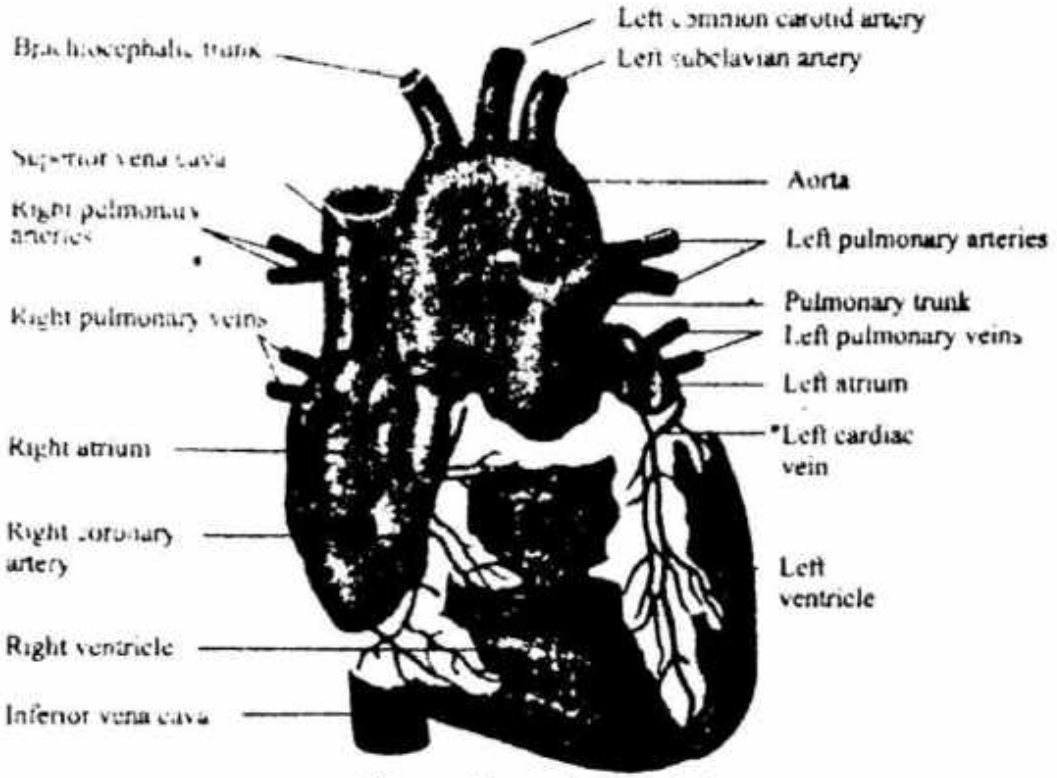
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Pericardial fluid is secreted between them and reduces the friction between the heart wall and surrounding tissues when the heart is beating. The inelastic nature of the pericardium as whole prevents the heart from being **overstretched or overfilled with blood.**



Human Heart, External view

Chambers of heart: The heart consists of four chambers:

(i) Two atria **(ii) Two ventricles**

Atria: Atria (meaning, entrance chamber). The atria lie above the ventricles. The atria are separated from each other by an **interatrial groove.**

Ventricles: **Ventricles** (meaning, belly). The ventricles are separated from each other by an **interventricular groove.** In normal intact heart the **sulci** (singular, *sulcus*) are covered by fat and only after this fat is removed the actual sulci can be seen.

Note: On the surface of the heart **Atria and Ventricles** are separated from each other by an **atrioventricular groove** or **sulcus** (meaning ditch).

29. Draw label and describe the internal structure of human heart.

Ans: The heart wall is composed of the three layers of tissue.

(i) Epicardium **(ii)** Myocardium **(iii)** Endocardium

(i) Epicardium:

The **epicardium** is a thin **serous membrane** comprising of the smooth outer surface of the heart.

(ii) Myocardium:

The thick middle layer of the heart, the **myocardium,** is composed of cardiac muscle cells

(iii) Endocardium:

The smooth inner surface of the heart chambers is the **endocardium,** which consists of simple squamous epithelium over a layer of connective tissue.

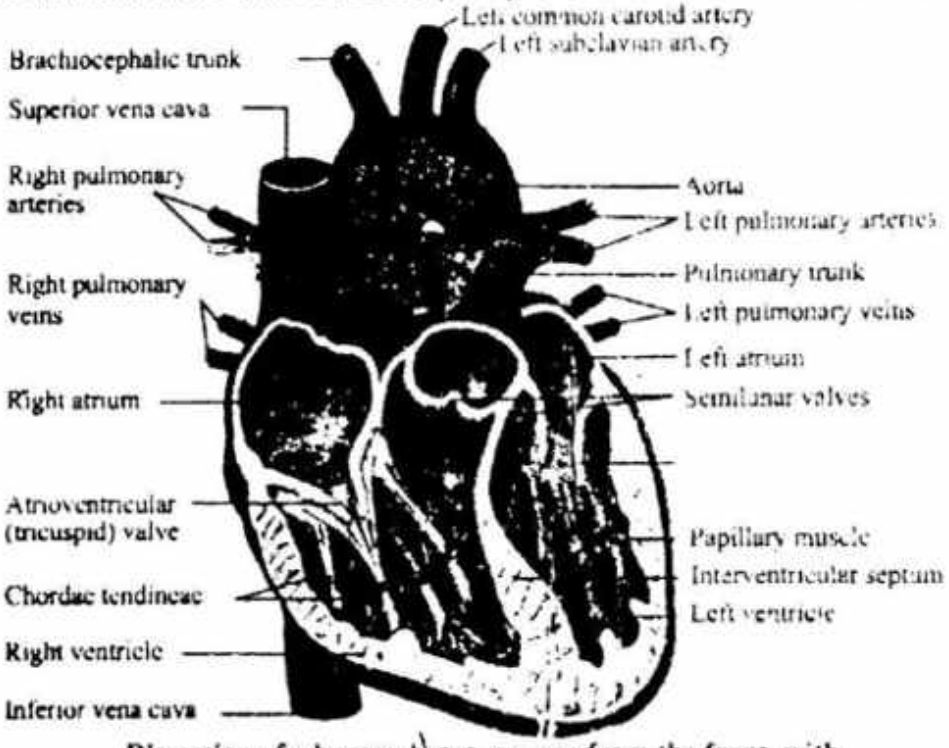
Valves of heart:

The **heart valves** are formed by a fold of the endocardium, making a double layer of endocardium with connective tissue in between.

Comparison of heart valves:

The thickness of the walls of each chamber is different. The right ventricle has thinner walls than the left ventricle in a ratio of 1:3, it pumps blood to the lungs, which are at a short distance from the heart.

The atria have comparatively thin walls as they only have to force blood into the ventricles and this does not require much power. On the other hand, the ventricles have to force blood out of the heart hence they have relatively thick walls, especially the left ventricle which has to pump blood around the whole body.



Dissection of a human heart, as seen from the front, with the ventral part of both atria and both ventricles removed

The **right atrium** receives the superior vena cava, the inferior vena cava, and the coronary sinus (the coronary sinus is an additional opening into the right atrium that receives venous blood from the myocardium of the heart itself). The **left atrium** receives the four pulmonary veins. The two atria are separated from each other by the **interatrial septum.** The atria open into the ventricles through **atrioventricular canals.** The **right ventricle** opens into the pulmonary trunk, and the **left ventricle** opens into the aorta. The two ventricles are separated from each other by the **interventricular septum.**

An atrioventricular valve is on each atrioventricular canal and is composed of **cusps,** or flaps. The atrioventricular valve between the right atrium and the right ventricle has three cusps and is called the **tricuspid valve.** The atrioventricular valve between the left atrium and left ventricle has two cusps and is therefore called the **bicuspid** or **mitral** (meaning, resembling a bishop's miter, a two-pointed hat), **valve.** Each ventricle contains cone-shaped muscular pillars called **papillary** (meaning, pimple-shaped) **muscles.** These muscles are attached by thin, strong connective tissue strings called **chordae tendineae** (meaning, heart strings) to the cusps of the atrioventricular valves. The papillary muscles contract when the ventricles contract and prevent the valves from opening into the atria by pulling on the chordae tendineae attached to the valve cusps. Blood flowing from the atrium into the ventricle pushes the valve open into the ventricle, but, when the ventricle

contract, blood pushes the valve back towards the atrium. The atrioventricular canal is closed as the valve cusps meet. The aorta and pulmonary trunk possess **aortic** and **pulmonary semilunar** (meaning halfmoon shaped) **valves.** Each valve consists of three pockets like semilunar cusps, the free inner borders of which meet in the centre of the artery to block blood flow.

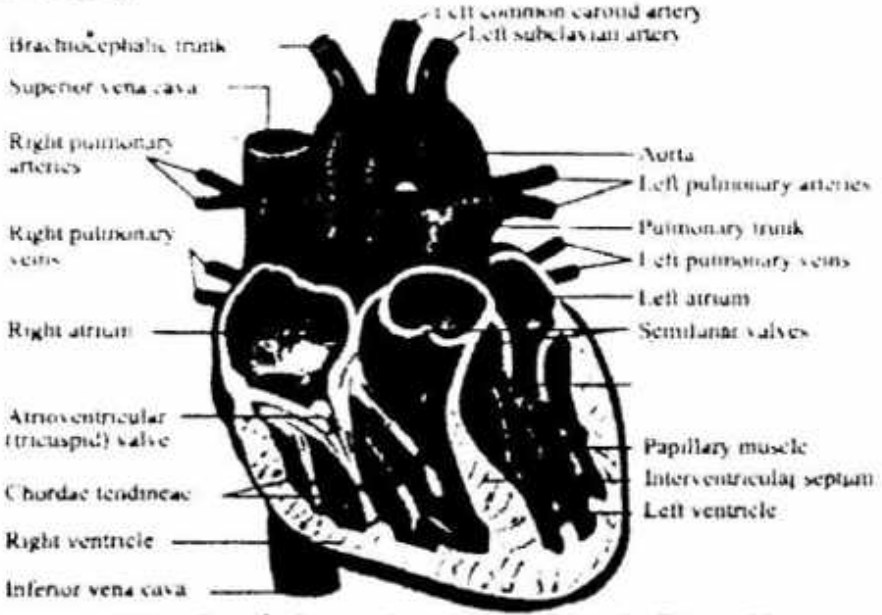
30. Describe the structure of the walls of the human heart and rationalize the thickness of the walls of each chamber.

Ans: Valves of heart:

The **heart valves** are formed by a fold of the endocardium, making a double layer of endocardium with connective tissue in between.

Comparison of heart valves:

The thickness of the walls of each chamber is different. The right ventricle has thinner walls than the left ventricle in a ratio of 1:3. it pumps blood to the lungs, which are at a short distance from the heart. The atria have comparatively thin walls as they only have to force blood into the ventricles and this does not require much power. On the other hand, the ventricles have to force blood out of the heart hence they have relatively thick walls, especially the left ventricle which has to pump blood around the whole body.



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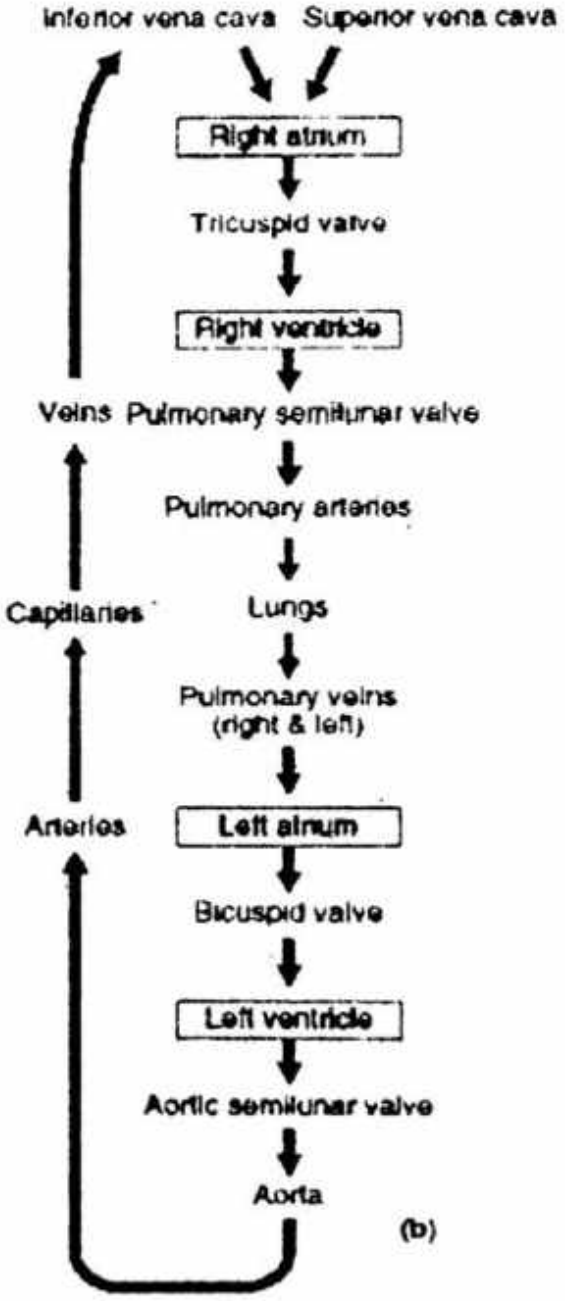
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valve. Each ventricle contains cone-shaped muscular pillars called **papillary** (meaning, pimple-shaped) **muscles.** These muscles are attached by thin, strong connective tissue strings called **chordae tendineae** (meaning, heart strings) to the cusps of the atrioventricular valves. The papillary muscles contract when the ventricles contract and prevent the valves from opening into the atria by pulling on the chordae tendineae attached to the valve cusps. Blood flowing from the atrium into the ventricle pushes the valve open into the ventricle, but, when the ventricle contract, blood pushes the valve back towards the atrium. The atrioventricular canal is closed as the valve cusps meet. The aorta and pulmonary trunk possess **aortic** and **pulmonary semilunar** (meaning halfmoon shaped) **valves.** Each valve consists of three pockets like semilunar cusps, the free inner borders of which meet in the centre of the artery to block blood flow.

31. Describe the flow of blood through human heart as regulated by the valves.

Ans: Passage of Blood through Heart:

The superior vena cava and the **inferior vena cava,** both carrying deoxygenated blood, enter the right atrium. **The right atrium** sends blood through the tricuspid valve to the right ventricle. The right ventricle sends blood through the **pulmonary semilunar valve** into the **pulmonary trunk** and the two **pulmonary arteries** to the lungs. Four **pulmonary veins,** carrying oxygenated blood from the lungs, enter the left atrium. The **left atrium** sends blood through the **bicuspid valve** to the **left ventricle.** The left ventricle sends blood through the **aortic semilunar valve** into the **aorta** to the body proper. The heart is a **double pump** because the right ventricle of the heart sends blood to the lungs, and the left ventricle sends blood throughout the body.



Passage of blood through heart

32. State the phases of heartbeat in man.

Ans: Phases of heartbeat:

Atrial systole:

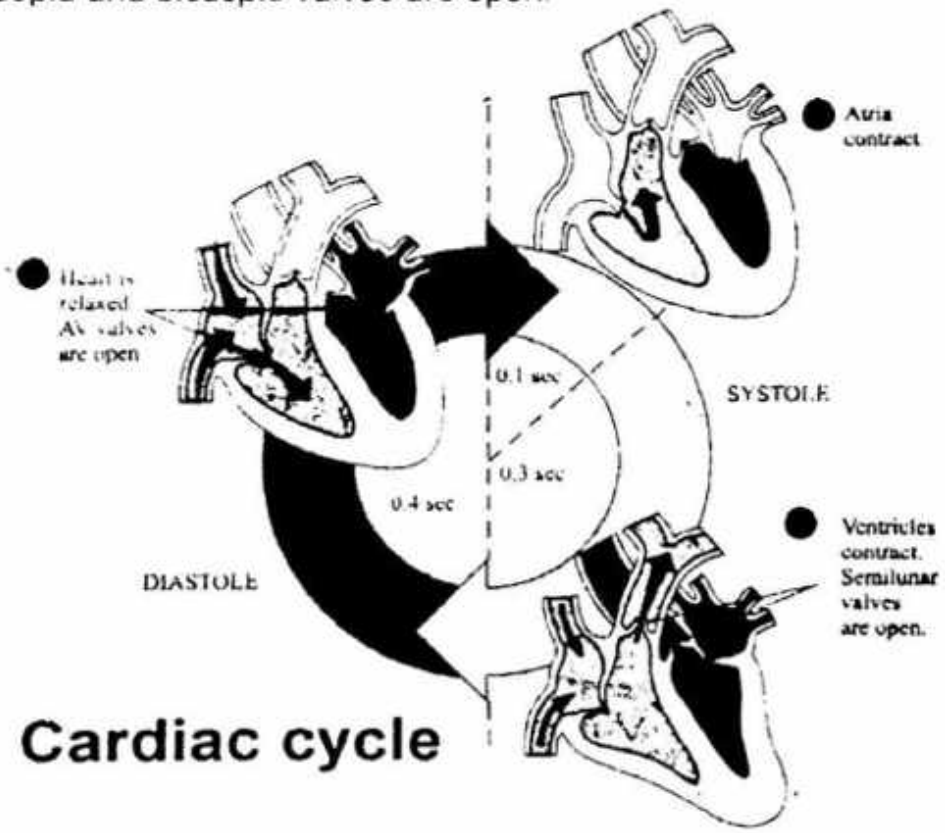
The term systole means to contract and diastole means to dilate. **Atrial systole** is contraction of the atrial myocardium. In **atrial systole** the two atria contract simultaneously and blood is pushed through the atrio-ventricular valve into the still relaxed ventricles. At this phase semilunar valve is closed, tricuspid and bicuspid valves are open.

Atrial diastole:

Atrial diastole is relaxation of the atrial myocardium. In **atrial diastole** blood enters the right atrium from the body through the vena cavae. At first the bicuspid and tricuspid valves are closed, but as the atria fill with blood, pressure in them rises. Eventually it becomes greater than that in the relaxed ventricles and the valves are pushed opens

Ventricular systole

Ventricular systole is contraction of the ventricular myocardium.In **atrial systole** the two atria contract simultaneously and blood is pushed through the atrio-ventricular valve into the still relaxed ventricles. At this phase semilunar valve is closed. tricuspid and bicuspid valves are open.



Cardiac cycle

Ventricular diastole:

Ventricular diastole is the relaxation of the ventricular myocardium. When the word "systole" and "diastole" are used without reference to specific chambers, they mean ventricular systole or diastole.In **ventricular diastole** the high pressure developed in the aorta and pulmonary artery tends to force some blood back towards the **ventricles** and close the **semilunar valves** of the aorta and pulmonary artery

Hence back flow in the heart is prevented. In this phase **bicuspid valve** and **tricuspid valve** are open, **aortic semilunar valve,** and **pulmonary semilunar valve** are closed. The normal cardiac cycle is of 0.7 to 0.8 second depending on the capability of cardiac muscle to contract. The heart muscle rests 0.1 to 0.3 second between the beats.

33. Describe the conducting system of human heart.

Ans: Conducting system of the heart:

The heart will go on beating after it has been cut right out of the body. Cardiac muscles are **myogenic** *(myo:* muscle, *genie,* giving rise to), i.e., its rhythmic contraction arise from within the muscle itself.

Cardiac muscle has an **intrinsic rhythmicity** that allows the heartbeat to originate in and be conducted through the heart without extrinsic stimulation. Specialized strands of interconnecting cardiac muscle tissue that coordinate cardiac contraction constitute the **conduction system.** The conduction system constitutes the cardiac cycle. The components of the conduction system are:

(a) Sinoatrial node. **(b)** Atrioventricular node.
(c) Atrioventricular bundle **(d)** Conducting myofibrils.

Sinoatrial node:

Sinoatrial node in short is called **SA node.** It consists of specialized plexus of cardiac muscles embedded in the upper wall of the right atrium. It is close to where vena cavae enter the atrium. The SA node has been developed from the sinus venosus and has become a part of the atrium, so it is called sinoatrial node.

Atrioventricular node:

There is another specialized group of cardiac muscle fibres called **atrioventricular node.** In short it is called **AV node.** It is present near the junction of right atrium and right ventricle.

Atrioventricular bundle:

AV node is connected to a strand of specialized muscles (in the ventricular septum) known as **atrioventricular bundle** or **bundle of** His (pronounced as "hiss").

Events of Conducting system:

(i) **Bundle of** His passes through a small opening in the fibrous skeleton to reach the **interventricular septum**, where it divides to form right and left bundle branches, which extend beneath the **endocardium** on either side of the interventricular septum to the apices of the **right and left ventricles** respectively.

(ii) The inferior, terminal branches of the bundle branches are called **Purkinje fibres,** which are large-diameter cardiac muscle fibres. They have fewer myofibrils than most cardiac muscle cells and **do not contract forcefully**

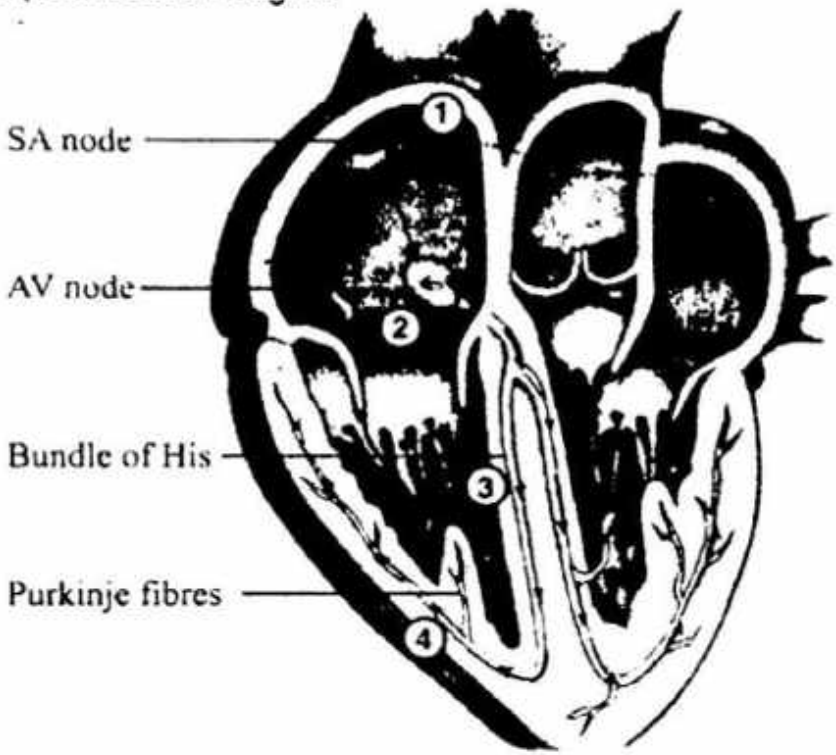
(iii) **Intercalated disks** are well developed between the Purkinje fibres and contain numerous gap junctions.

(iv) As a result of these structural modifications, **action potentials** travel along the **Purkinje fibres** much more rapidly than through other cardiac muscle tissue. Cardiac muscle cells have the capacity to generate spontaneous action potentials, but cells of the SA node do so at a **greater frequency**

(v) As a result, the SA node is called the **pacemaker** of the heart. When the heart beats under resting conditions, approximately **0.04 second** is required

for action potentials to travel **from the SA node to the AV node**. Within the AV node action potentials are propagated slowly compared with the remainder of the conducting system

(vi) As a consequence, there is a delay of **0.11 second** from the time action potentials reach the AV node until they pass to the AV bundle. The total delay of **0.15 second allows** completion of the atrial contraction before ventricular contraction begins.



Conducting System of the Heart

1. Action potentials originate in the sinoatrial (SA) node and travel across the wall of the atrium (arrows) from the SA node to the atrioventricular (AV) node

2. Action potentials pass through the AV node and along the atrioventricular (AV) bundle, which extends from the AV node, through the fibrous skeleton, into the interventricular septum.

3. The AV bundle divides into right and left bundle branches, and action potentials descend to the apex of each ventricle along the bundle branches.

4. Action potentials are carried by the Purkinje fibres from the bundle branches to the ventricular walls.

34. Explain the role of SA node, AV node and Purkinji fibres in controlling heartbeat.

Ans: Role of SA node, AV node and Purkinji fibres in controlling heartbeat:

The conduction system constitutes the cardiac cycle. The components of the conduction system are the:

(a) Sinoatrial node. **(b)** Atrioventricular node

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Sinoatrial node:

Sinoatrial node in short is called **SA node.** It consists of specialized plexus of cardiac muscles embedded in the upper wall of the right atrium. It is close to

where vena cavae enter the atrium. The SA node has been developed from the sinus venosus and has become a part of the atrium, so it is called sinoatrial node

Atrioventricular node:

There is another specialized group of cardiac muscle fibres called **atrioventricular node.** In short it is called **AV node.** It is present near the junction of right atrium and right ventricle

Atrioventricular bundle:

AV node is connected to a strand of specialized muscles (in the ventricular septum) known as **atrioventricular bundle** or **bundle of** His (pronounced as "hiss")

Events of conducting system:

(i) **Bundle of** His passes through a small opening in the fibrous skeleton to reach the **interventricular septum**, where it divides to form right and left bundle branches, which extend beneath the **endocardium** on either side of the interventricular septum to the apices of the **right and left ventricles** respectively.

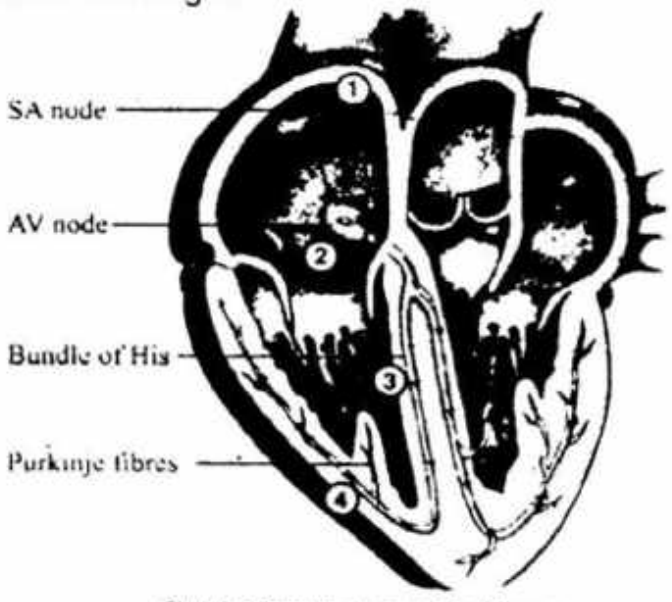
(ii) The inferior, terminal branches of the bundle branches are called **Purkinje fibres,** which are large-diameter cardiac muscle fibres. They have fewer myofibrils than most cardiac muscle cells and **do not contract forcefully**

(iii) **Intercalated disks** are well developed between the Purkinje fibres and contain numerous gap junctions

(iv) As a result of these structural modifications, **action potentials** travel along the **Purkinje fibres** much more rapidly than through other cardiac muscle tissue. Cardiac muscle cells have the capacity to generate spontaneous action potentials, but cells of the SA node do so at a **greater frequency**

(v) As a result, the SA node is called the **pacemaker** of the heart. When the heart beats under resting conditions, approximately **0.04 second** is required for action potentials to travel **from the SA node to the AV node**. Within the AV node action potentials are propagated slowly compared with the remainder of the conducting system.

(vi) As a consequence, there is a delay of **0.11 second** from the time action potentials reach the AV node until they pass to the AV bundle. The total delay of **0.15 second allows** completion of the atrial contraction before ventricular contraction begins.



Conducting System of the Heart

1. Action potentials originate in the sinoatrial (SA) node and travel across the wall of the atrium (arrows) from the SA node to the atrioventricular (AV) node
2. Action potentials pass through the AV node and along the atrioventricular (AV) bundle, which extends from the AV node, through the fibrous skeleton, into the interventricular septum.
3. The AV bundle divides into right and left bundle branches, and action potentials descend to the apex of each ventricle along the bundle branches.
4. Action potentials are carried by the Purkinje fibres from the bundle branches to the ventricular walls.

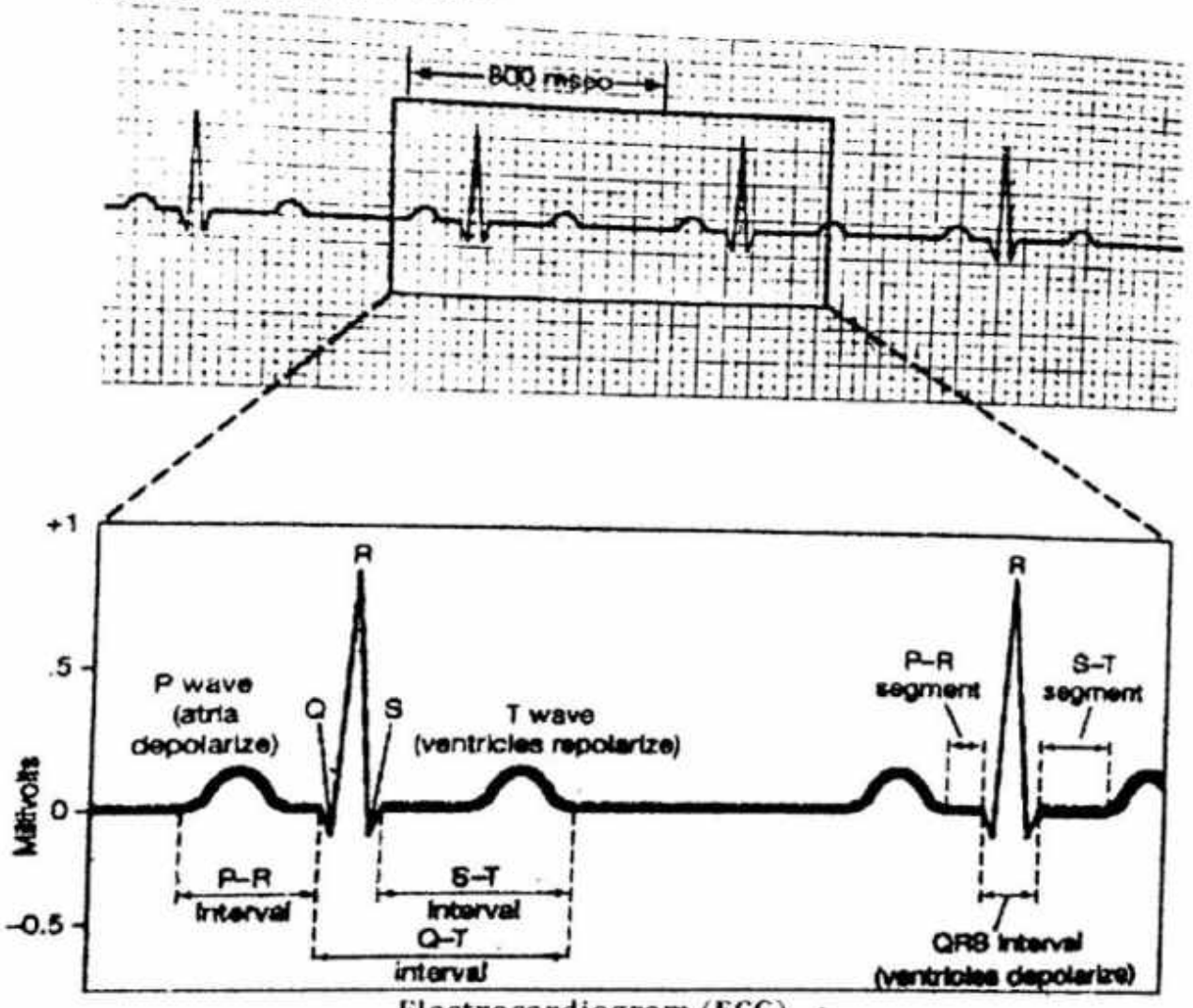
35. Explain electrocardiogram with the help of diagram.

Ans: Electrocardiogram:

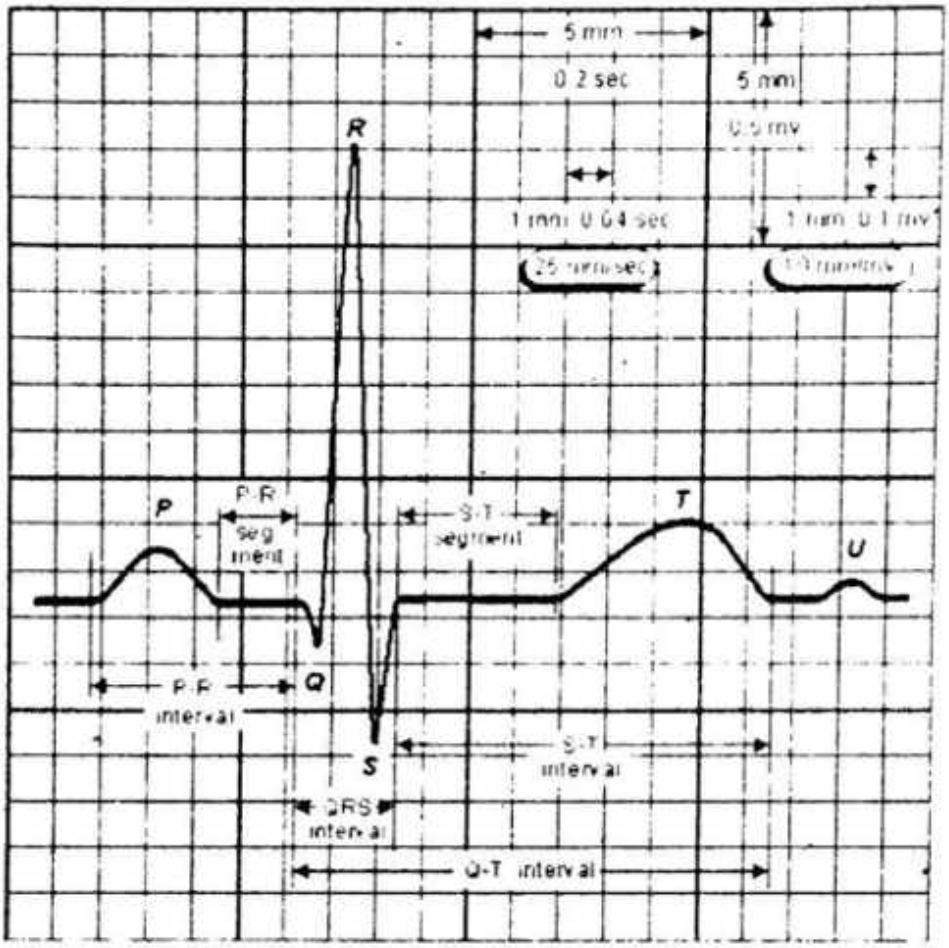
(i) The electrical impulses that pass through the conduction system of the heart during the cardiac cycle can be recorded as an electrocardiogram (ECG).

(ii) The electrical changes result from depolarization and repolarization of cardiac muscle fibres and can be detected on the surface of the skin using an instrument called the **electrocardiograph.**

(iii) The wave deflections, designated P, QRS, and T, are produced as specific events of the cardiac cycle occur. Depolarization of the atrial fibres of the SA node produces the **P wave.**



Electrocardiogram (ECG)



(iv) The ventricles of the heart are in diastole during the expression of the P wave. On the ECG recording, the P-R **interval** is the period of time from the start of the P wave to the beginning of the QRS complex.

(v) This interval indicates the amount of time required for the SA depolarization to reach the ventricles.

(vi) The **QRS complex** begins as a short downward deflection (Q), continues as a sharp upward spike (R), and ends as a downward deflection (S).

(vii) The **QRS** complex indicates the depolarization of the ventricles. During this interval, the ventricles are in systole and blood is being ejected from the heart.

(viii) The time duration known as the S-T **segment** represents the period between the completion of ventricular depolarization and initiation of repolarization. The **T wave** is produced by ventricular repolarization.

Uses of electrocardiogram:

(i) ECG is used to detect **cardiac arrhythmias** (irregular heartbeat) and conduction defects. It is used to diagnose and localize myocardial hypertrophy (increase in size of heart), **ischemia** (a deficiency of blood in a body part) or **infarction** (decrease in oxygen content). It may also give information about electrolyte imbalance and **toxicity of certain drugs**.

(ii) A normal ECG indicates that the **heart is functioning properly**. The P wave represents excitation and occurs just prior, to contraction of the atria. The second wave, or the **QRS complex**, occurs just prior to **ventricular contraction**. The third, or **T, wave** occurs just before the **ventricles relax**.

36. Describe the structure of blood vessels in man.

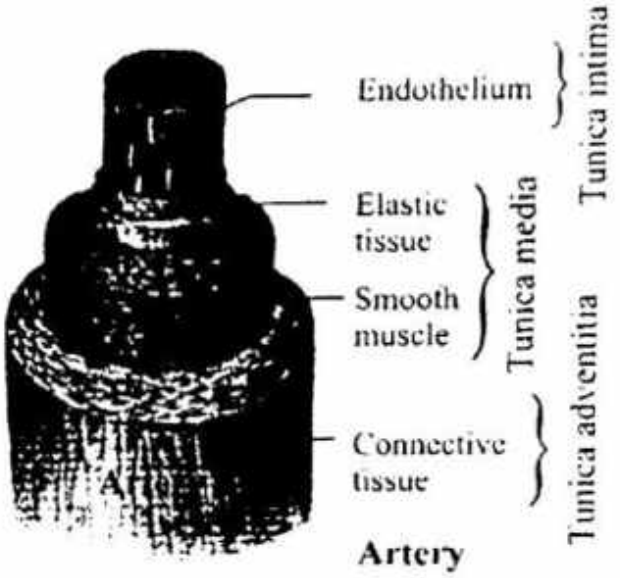
Ans: Blood Vessels:

There are three types of blood vessels, the **arteries** (and arterioles), which carry blood away from the heart, the veins, which return blood to the heart, and **capillaries**, which permit exchange of materials with the tissues.

Arteries:

Arteries carry blood away from the heart. Arteries are pink in colour and are situated within the muscles. Arteries vary in size.

Arteries branch into **arterioles** and **capillaries**. The lumens of arteries have no valves. The wall of an artery consists of three coats or tunics: tunica adventitia, tunica media and tunica intima.

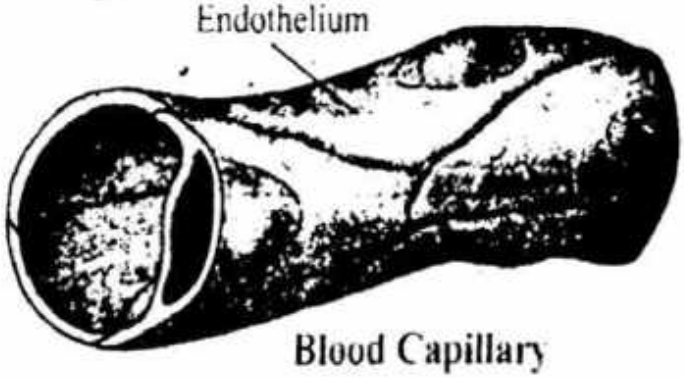


Artery

The outermost layer is called **tunica** adventitia. It is composed of white fibrous connective tissue. The middle layer is called **tunica media**, and has variable amount of elastic fibres. It is many layered in thickness. It consists of one or two layers of circular smooth muscle cells. The innermost layer of the artery is called **tunica intima**. It is composed of simple squamous epithelium and elastic fibres composed of elastin. Arterioles transport blood from small arteries to capillaries. Aorta is approximately 23 mm and arterioles are about 0.2 mm in diameter.

Capillaries:

The capillary wall consists primarily of endothelial cells. Most capillaries range from 7 to 9 urn in diameter, and thus branch without a change in their diameter. Capillaries are approximately 1 mm long. Red blood cells flow through most of capillaries in a single file.

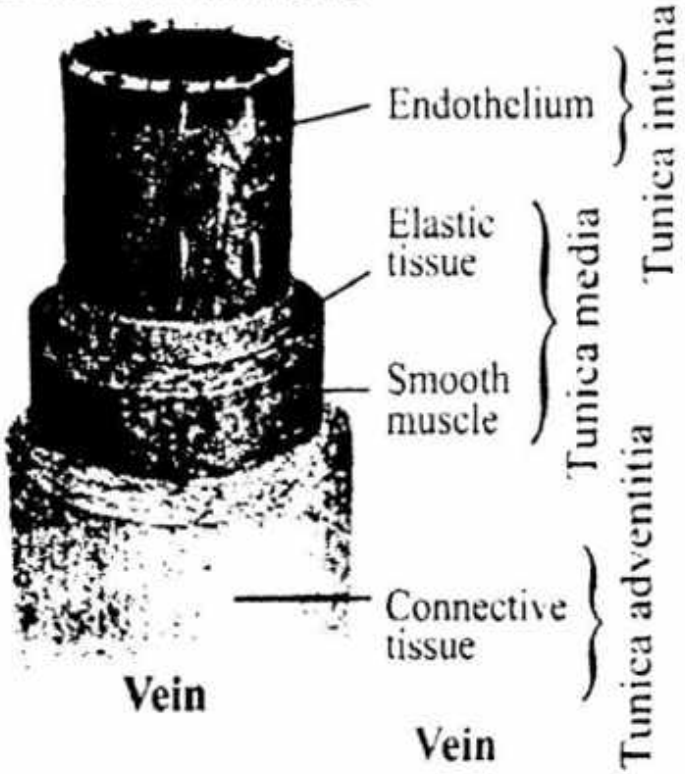


Blood Capillary

Veins:

The blood vessels that bring blood back to the heart are called veins. Veins are relatively not deep in the muscles. Veins can be seen as blue vessels under the skin. A vein also consists of tunica adventitia, tunica media and tunica intima. **Tunica adventia** is composed of collagenous connective tissue. **Tunica media** is composed of a thin layer of circularly arranged smooth muscle cells, collagen fibres and a few sparsely distributed elastic fibres. **Tunica** intima is a smooth muscle and

consists of endothelial cells, thin layer of elastic fibres. **Venules** with a diameter of 40 to 50 pm are tubes composed of endothelium. The venules collect blood from the capillaries and transport it to the small veins.



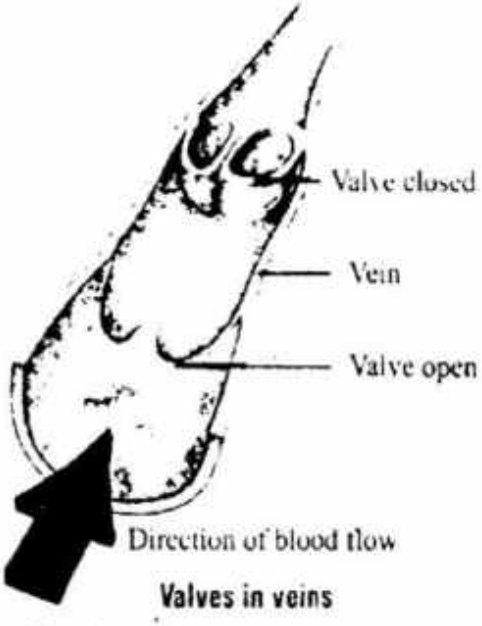
37. What is the role of arterioles in vasodilatation and vasoconstriction?

Ans: Role of arterioles in vasodilatation and vasoconstriction:

The amount of blood flowing through a blood vessel can be regulated by contraction or relaxation of smooth muscle in the tunica media.

Vasoconstriction:

A decrease in blood flow results from vasoconstriction, a decrease in blood vessels diameter caused by smooth muscle contraction. Blood circulation is also controlled by hormones (vasoconstriction agents) acting on arterioles. Norepinephrine is an especially powerful vasoconstriction hormone, and epinephrine is less.



Valves in veins

Vasodilation:

An increase in blood flow is produced by vasodilation (vasodilatation) an increase in blood vessel diameter because of smooth muscle relaxation.

Several substance called **kinins** (vasodilator agents) can cause powerful vasodilation are formed in the blood and tissue fluids of some organs, e.g., histamine. Most of the prostaglandins are vasodilator agents

Note: Though some of the prostaglandins are vasoconstrictor.

38. What is the role of precapillary sphincter?

Ans: Precapillary sphincter:

Blood Flow in the capillaries is regulated by smooth muscle cells called **precapillary sphincter**, which are located at the origin of the branches

Arterioles:

Arterioles supply blood to each capillary network, blood then flows through the capillary network and into the venules.

Metarterioles:

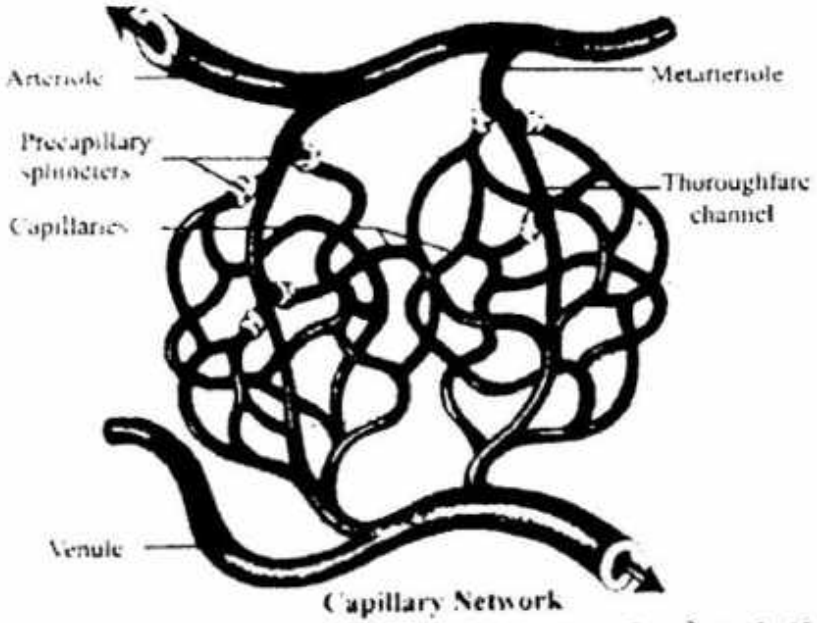
The branch that originates from arterioles is called **metarterioles** which open into **thoroughfare channel**. Blood flows from arterioles through metarterioles.

Thoroughfare channel:

From a metarteriole blood flows into a **thoroughfare channel.** Several capillaries branch from the thoroughfare channels. **Precapillary sphincter** can open and close the entrance to the capillary.

Role of precapillary sphincter:

Precapillary sphincters are normally either completely open or completely closed, and the degree of constriction of the metarteriole also varies. The precapillary sphincters and metarterioles often open and close cyclically several times per minute with the duration of the open phases being about proportional to the metabolic needs of the tissue. The cyclic opening and closing is called vasomotion



Capillary Network

39. Describe pulmonary circulation and systemic circulation.

Ans: Vascular Pathway:

Cardiovascular system includes two circuits, the **pulmonary circuit** which circulates blood through lungs and **systemic circuit** which circulates blood to all other parts of the body.

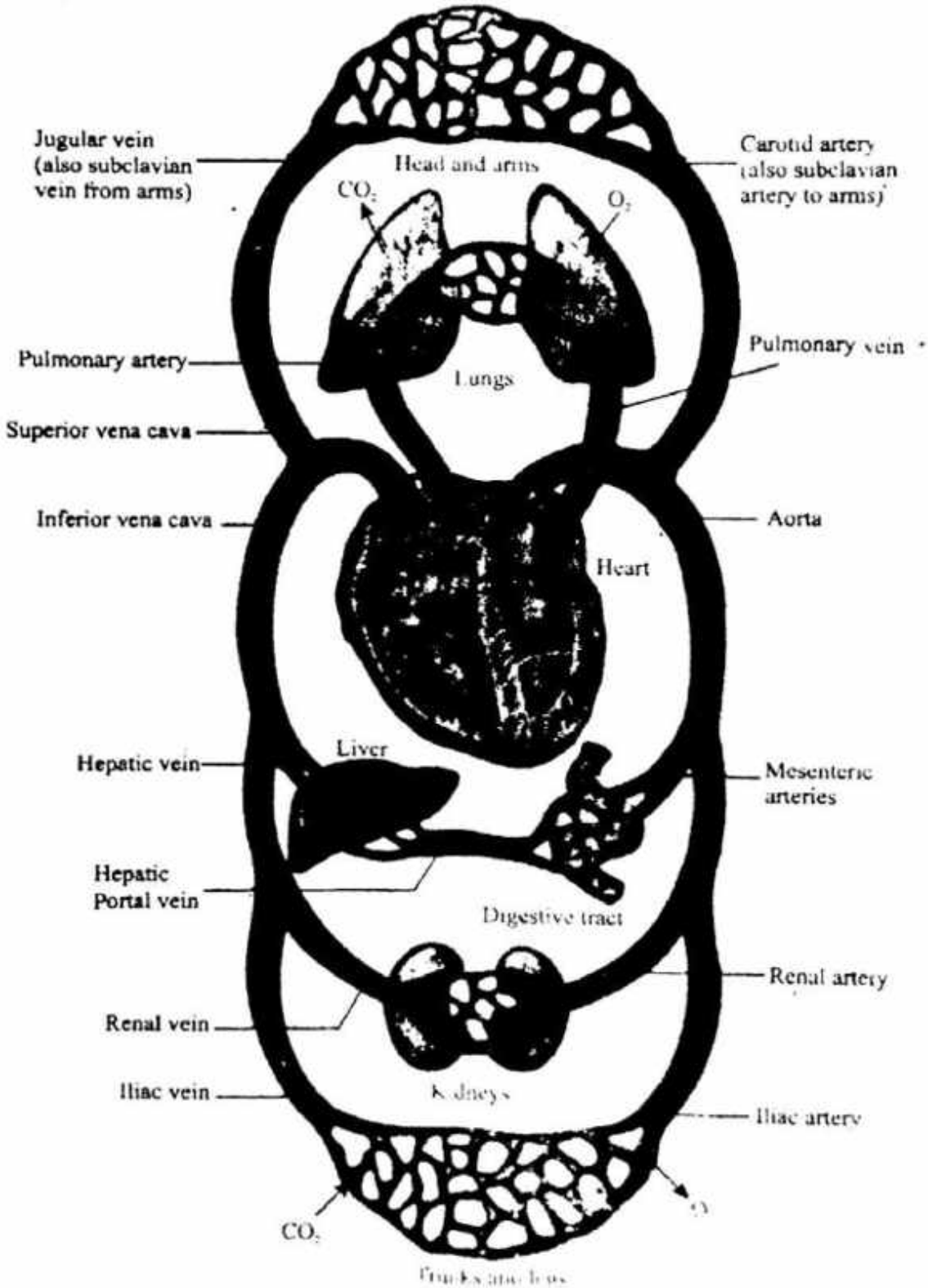
Pulmonary circulation:

The left atrium receives oxygenated blood from the lungs through a pair of **pulmonary veins**, which open by common aperture into it. From left atrium the blood flows into the left ventricle. The superior and inferior vena cavae bring deoxygenated blood and open into the right atrium. From right atrium blood flows

into the lungs for oxygenation by a **pulmonary arch** or **trunk** which divides into two **pulmonary arteries,** each going to the lung of its own side. This part of circulation is called **pulmonary circulation** or **circuit**. The pulmonary arteries carry deoxygenated blood and pulmonary veins carry oxygenated blood.

Systemic circulation:

The systemic circuit includes all the **arteries** and **veins** other than involved in pulmonary circuit.



Cardiovascular System

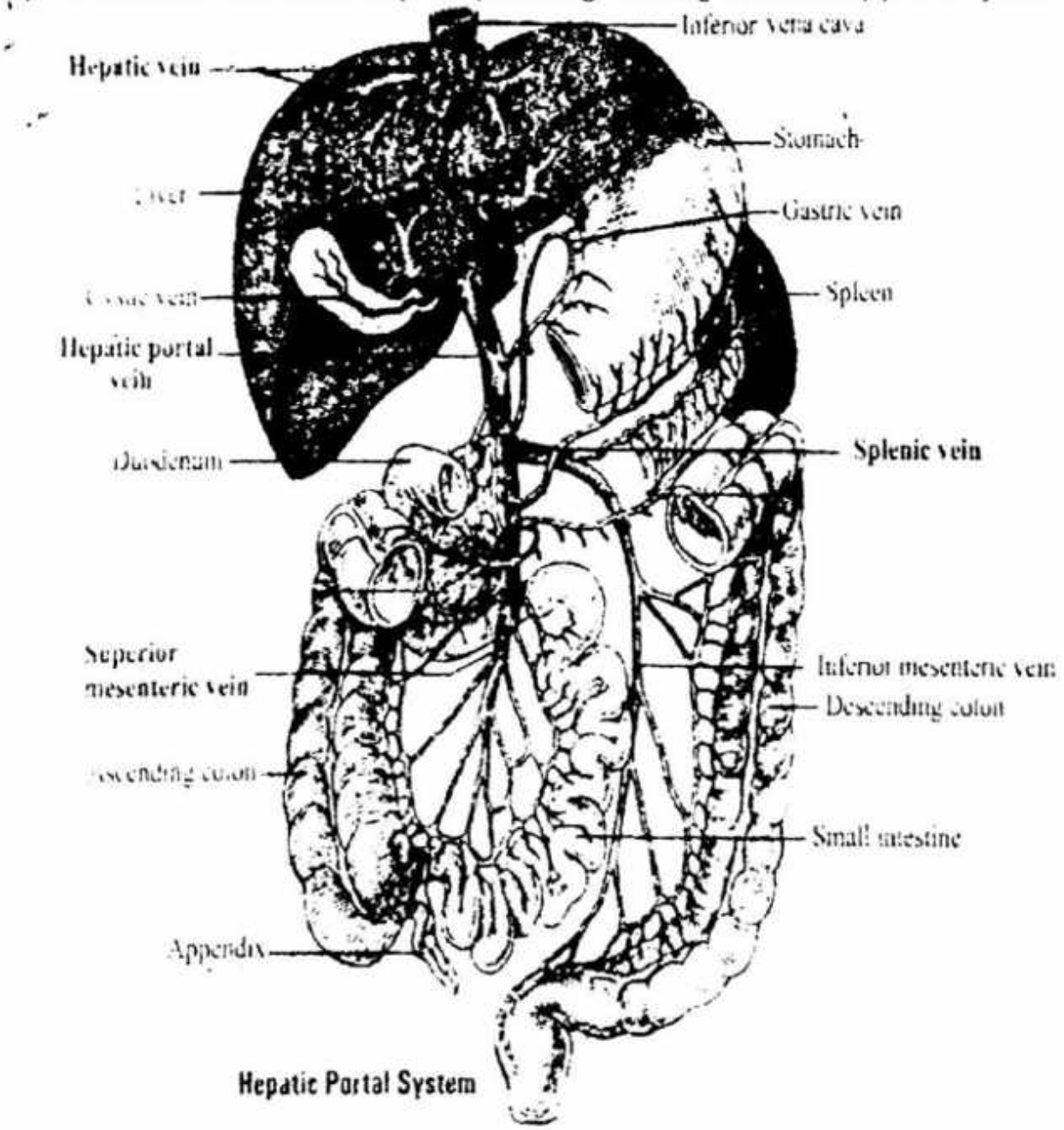
The largest artery in the systemic circuit is the **aorta**. The largest veins are the **superior** and **inferior venae cavae**. The path of systemic blood to any organ in the body begins in the **left ventricle** which pumps blood in the aorta. Branches from **aorta** go to the organs and major body regions. The **superior vena cava** collects blood from the head, the chest and the arms.

The **inferior vena cava** collects blood from the lower body regions. Both enter the right atrium. The aorta and the venae cavae are the major pathways in the systemic circuit. In most instances the artery and the vein that serve the same organ are given the same name.

40. Describe hepatic portal system.

Ans: Hepatic portal system:

A portal (meaning door) system is vascular system that begins and ends with capillary beds and has no pumping mechanism such as the heart. The **portal system** that begins with capillaries in the viscera and ends with the sinusoidal capillaries in the liver is the hepatic (meaning, relating to the liver) portal system.



Hepatic Portal System

Hepatic portal vein:

(i) The **hepatic portal vein**, the largest vein of the system, is formed by the union of the **superior mesenteric vein**, which drains the small intestine and the **splenic vein**, which drains the spleen.

(ii) The splenic vein receives the **inferior mesenteric** and **pancreatic veins**, which drain the large intestine and pancreas respectively.

(iii) The hepatic portal vein also receives **gastric veins** before entering the liver. Within the liver the blood flows through a series of dilated capillaries called sinusoids.

(iv) Blood from the liver sinusoids is collected into **central veins**, which empty into **hepatic veins.**

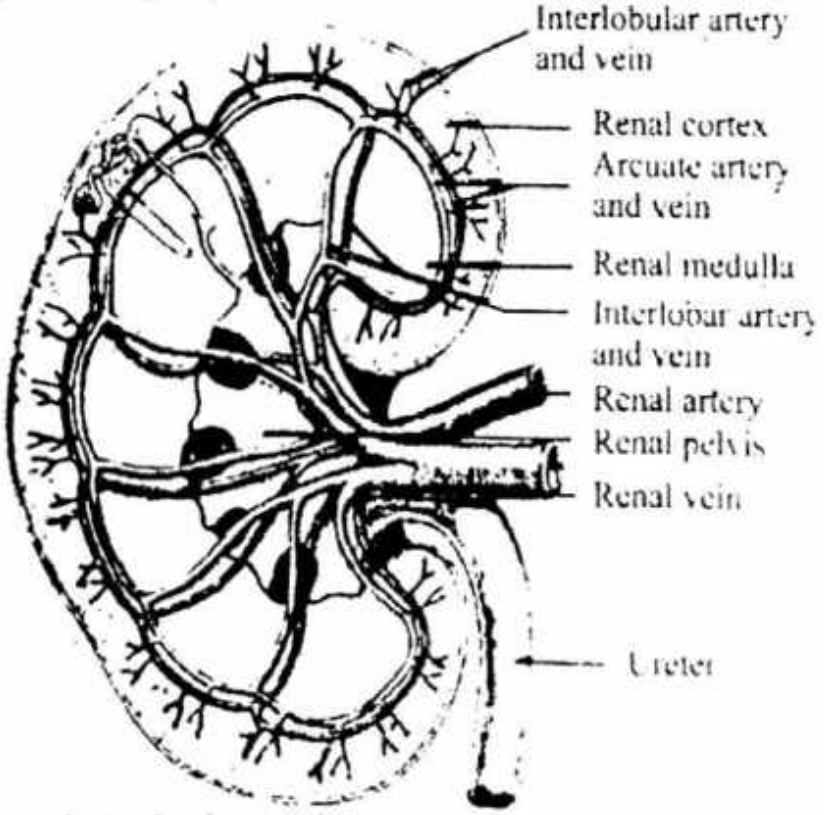
(v) Blood from the gallbladder is collected by the **cystic veins** also enters the hepatic veins.

(vi) The hepatic veins join the inferior vena cava.

41. Describe renal circulation.

Ans: Renal circulation:

Arterial blood enters the kidney at the hilum through **renal artery**, which divides into **interlobar arteries** that pass between the renal pyramids through renal column. **Arcuate arteries** branch from the interlobar arteries at the boundary of renal cortex and renal medulla. Small **interlobular arteries** radiate from the arcuate arteries and project into the renal cortex. Microscopic **afferent glomerular arterioles** arise from the branches of the interlobular arteries. From here blood enters either the **peritubular capillaries** or **vasa recta**. From these capillary networks the blood is drained into interlobular veins, arcuate veins and interlobar vein. The interlobar veins descend between the renal pyramids, converge, and leave the kidney as a single renal vein that empties into the inferior vena cava.



Principal Arteries and Veins of Kidney.

42. Give an account of blood pressure in man.

Ans: Blood Pressure:

Blood pressure is the force exerted by the blood against any unit area on the inner walls of the blood vessel.

Standard refeţence:

The standard reference for the blood pressure is the mercury (Hg) manometer, which measures pressure in millimetres of mercury (mm Hg). If the blood pressure is **100 mm Hg** the pressure is great enough to lift a column of mercury 100 mm

Systolic pressure and Diastolic pressure:

When the ventricles of the heart contract the arterial blood pressure is the highest. It is called **systolic pressure.** When the ventricles of the heart relax, the arterial blood pressure is the lowest. It is **called diastolic pressure.**

Baroreceptors:

Baroreceptors can be divided into two categories based on the type of blood vessel in which they are located: high-pressure arterial baroreceptors and low-pressure baroreceptors or volume receptors.

High-pressure arterial baroreceptors:

These are mechanoreceptors located in the walls of the aorta and carotid sinus in the carotid arteries. They sense the blood pressure and relay the information to the brain, so that a proper blood pressure can be maintained.

(i) Vasodilatation:

Stimulation of parasympathetic nerves in these areas caused cardiac output, produces vasodilatation throughout the body and consequent reduction in blood pressure as well as a slowing the heart rate.

(ii) Vasoconstriction:

The opposite occurs when blood pressure is low. In this case, a fall in blood pressure increases nerve impulse transmission along **sympathetic nerves**. This causes body-wide vasoconstriction and a rise in blood pressure. Baroreceptors act immediately as part of a negative feedback system called the **baroreflex.**

Volume receptors:

Low-pressure baroreceptors or volume receptors are found in the atria of the heart and carotid arteries. When these receptors detect a blood volume decrease in the atria, a signal is transmitted from the receptors to the hypothalamus in the brain.

The hypothalamus, in turn, increases the production of vasopressin. These receptors also produce renal vasodilations, resulting in increase of the water amount in the glomerular filtrate which, combined with the increased production of vasopressin by the hypothalamus, will cause water retention in urine. This increases the blood volume, resulting in the increase of blood pressure.

Comparison of the rate of blood flow through arteries, arterioles, capillaries, venules and veins:

(i) Blood travels over a thousand times faster in the aorta, i.e., about 30cm/sec on average than in capillaries i.e., about **0.26 cm/sec**.

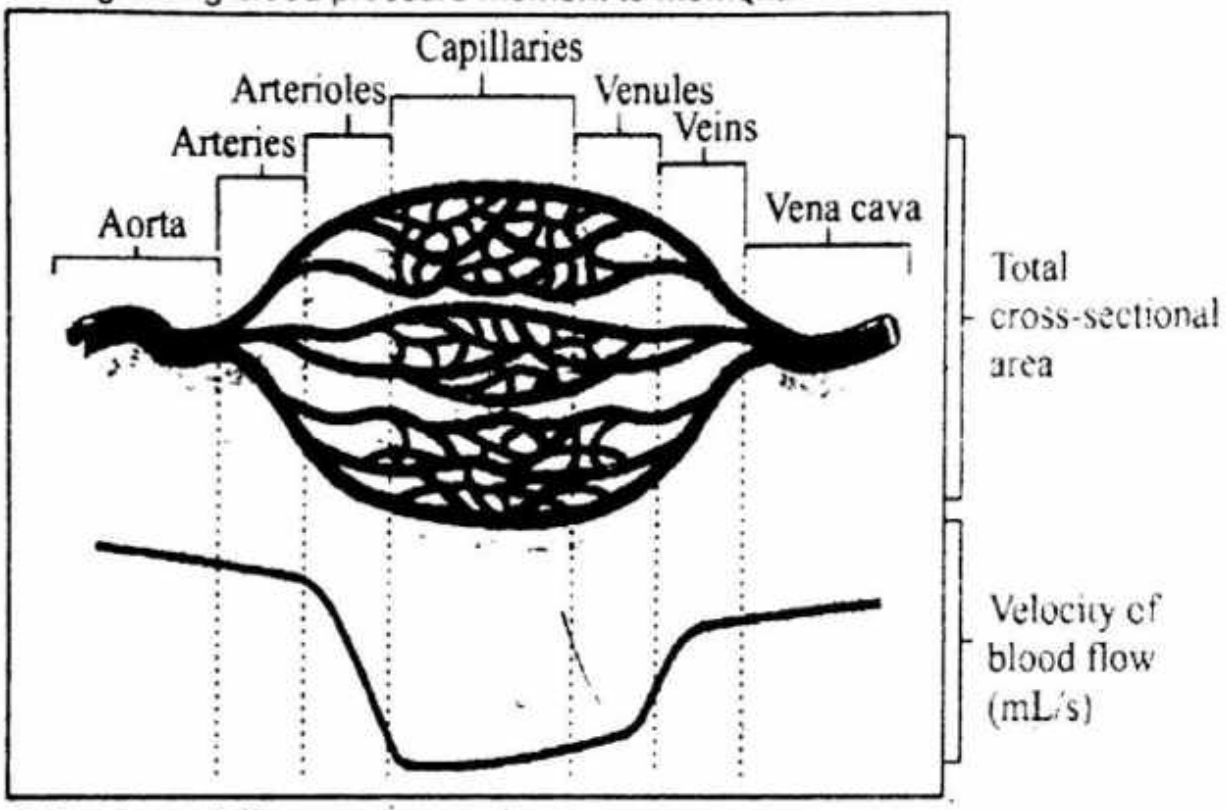
(ii) It is the total cross-sectional area of capillaries that determines flow rate.

(iii) Each artery conveys blood to such an enormous number of capillaries that the total cross-sectional area is much greater in capillary beds than in any other part of the circulatory system. For this reason the blood slows

substantially as it enters the arterioles from arteries and slows further still in the capillary beds.

(iv) As blood leaves the capillaries and enters the venules and veins it speeds up again as a result of the reduction in total cross-sectional area.

(v) The carotid sinus and aortic arch baroreceptor reflexes are important in regulating blood pressure moment to moment.



Explaination of diagram:

Blood vessel types and velocity of blood flow: Total cross-sectional area for each of the major blood vessel types is the space through which blood flows, measured in square centimeters. The cross-sectional area of the aorta is about 2.5 crri2. The crosssectional area of each capillary is much smaller, but there are so many that the total cross-sectional area is more than that of the aorta. The line at the bottom of the graph shows that blood velocity drops dramatically in arterioles, capillaries, and venules. As the total cross-sectional area increases the velocity of blood flow decreases

43. Compare the rate of blood flow through arteries, arterioles, capillaries, venules and veins.

Ans: Comparison of the rate of blood flow through arteries, arterioles, capillaries, venules and veins:

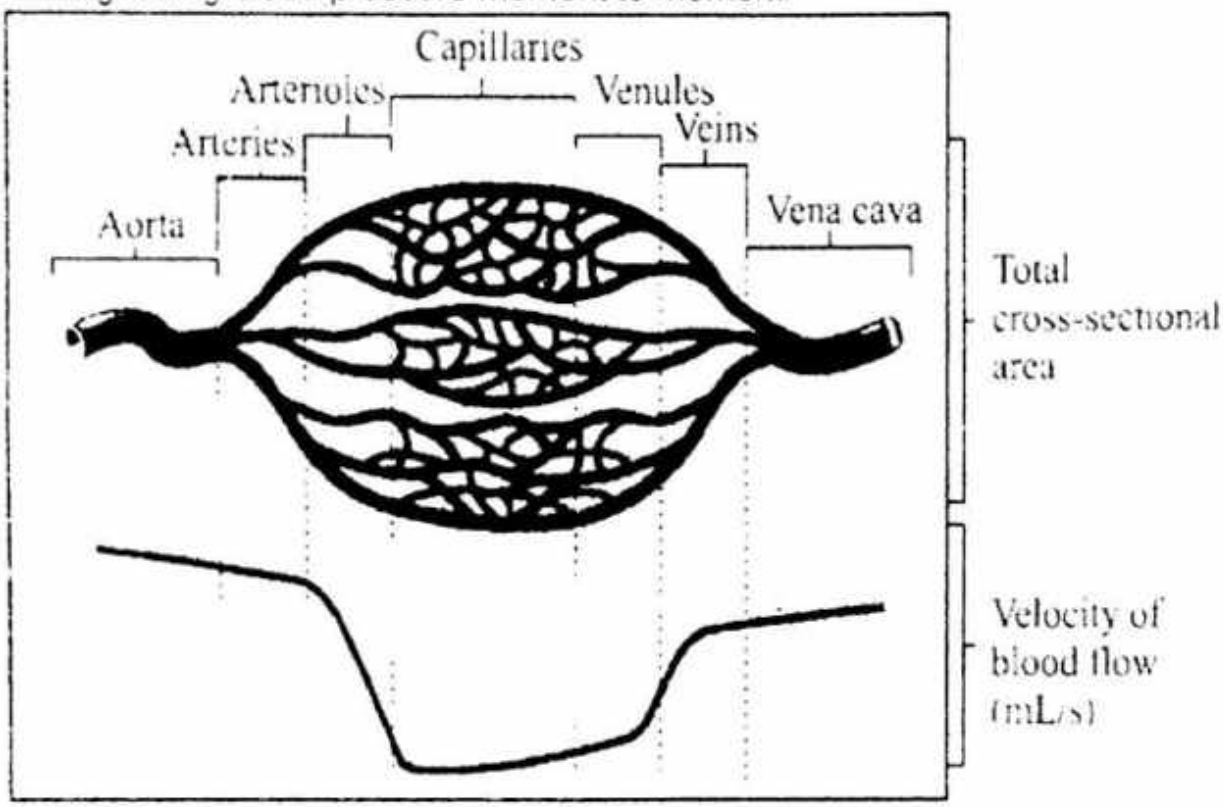
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44. Describe the following:

(a) Thrombosis **(b) Atherosclerosis**
(c) Angina pectoris **(d) Heat attack**
(e) Heat failure

Ans: (a) Thrombosis:

The formation of a clotted mass of blood within a vessel or the heart during life in called **thrombosis**. The clotted mass of blood within a vessel or the heart during life is called **thrombus**. The occlusion (a closing of an opening) of some part of the cardiovascular system by any mass transported to the site through the blood stream is called **embolism**.

Embolus is a detached intravascular solid, liquid or gaseous mass that is carried to a site distant from its point of origin. About 99% emboli arise from dislodgement of thrombi and are therefore called **thromboemboli**. Thrombus and embolus cause death

(b) Atherosclerosis:

Atherosclerosis is characterized by formation of yellow fatty streaks containing high proportion of cholesterol in the intima of large and medium sized arteries resulting in the narrowing of the vascular lumen. Later, fibres are deposited in the cholesterol and these often start to calcify and become hard a process known as **arteriosclerosis.** The deposits are called **athromatous plaques.**

As a plaque increases in size it protrudes into the lumen of the artery and begins to block it. The plaque first forms thrombus and may form embolus.

Major factors that cause atherosclerosis:

The major factors that cause atherosclerosis and arteriosclerosis are.

(i) Hypercholesterolemia (hyperlipidemia).
(ii) Hypertension.
(iii) Cigarette smoking.
(iv) Diabetes mellitus.

Minor factors that cause atherosclerosis:

Minor risk factors are:

(i) Increasing age.
(ii) Lack of exercise.
(iii) Stressful competitive life.
(iv) Obesity.

(c) Angina pectoris:

Due to atherosclerosis a person may feel occasional chest pain, a condition known as **angina pectoris** (Latin *angere* to choke and *pecto* breast).

Angina is most likely to occur when the heart is labouring hard because of physical or emotional stress. Angina is a signal that part of the heart is not receiving a sufficient supply of oxygen and that part of the heart attack could occur in future.

(d) Heat attack:

Many heart attacks occur without warning. A blood clot may completely block a coronary artery, or atherosclerosis may reach a critical level causing massive damage to the heart muscle.

Symptoms:

All of a sudden, the person feels a heavy squeezing ache or discomfort in the centre of the chest.

The pain may radiate to shoulder, arm neck or jaw. Other symptoms may include sweating, nausea, shortness of breath and dizziness or fainting. The whole process is called **myocardial** (heart muscle) **infarction** (death due to lack of oxygen).

After effects:

When heart muscles die, they are not replaced because cardiac muscles do not divide. When a person survives a heart attack scar tissue (a type of connective tissue) grows into the areas where the heart muscles have died. The scar tissue cannot contract as cardiac muscle. As a result the damaged heart is permanently weakened.

(e) Heat failure:

Congestive heart failure is a clinical syndrome resulting from deficient cardiac stroke volume, relative to body need, with inability of the cardiac output to

keep pace with the venous return i e heart is unable to pump all the blood coming to it.

Congenital heart problem:

(i) It is related to the malfunctioning of cardiac valves.

(ii) **Valvular stenosis** results from scaring of the valve leaflets, may cause reduction in diameter of the valve orifice.

(iii) Severe destruction of valve apparatus may cause valve ring dilation, with thickening and shortening of chordae tendinae resulting in **regurgitation** of blood through the valve when it is closed, i.e., valve closure is incomplete.

45. Explain the following:

(a) Principle of angiography **(b) Coronary bypass**

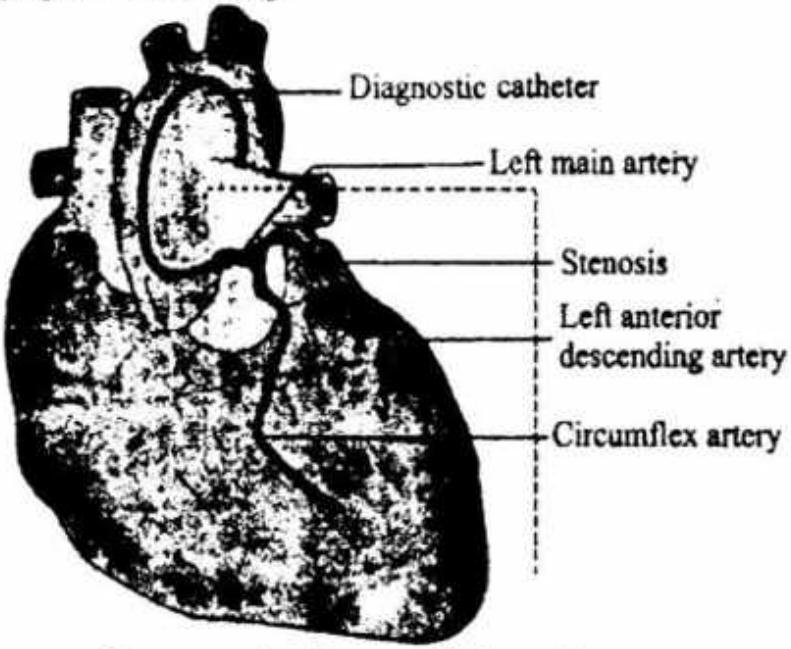
(c) Angioplasty **(d) Open heart surgery**

Ans: (a) Principle of angiography:

(i) Cardiac catheterization is a technique in which specially designed catheter is inserted into a vein or artery and advanced into the heart under **radiographic fluoroscopic guidance.**

(ii) This allows the operator to obtain **angiograms** by injecting contrast media into an area of interest. It is used to **evaluate disease** of the mitral valve, **aortic valve and aorta**, to determine the size and function of the left ventricle.

(iii) Coronary angiography is used to **detect stenosis** (constriction, narrowing of a tube or passage) and guide **revascularisation** procedures such as balloon **angiography and stenting**.



Coronary Angiogram-Schematic of the Vessels and Branches

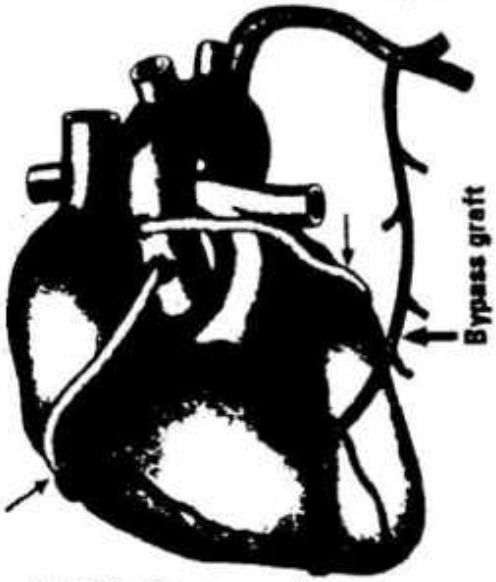
(b) Coronary bypass:

(i) A coronary bypass is a surgical procedure that relieves the effects of obstruction in the **coronary arteries**

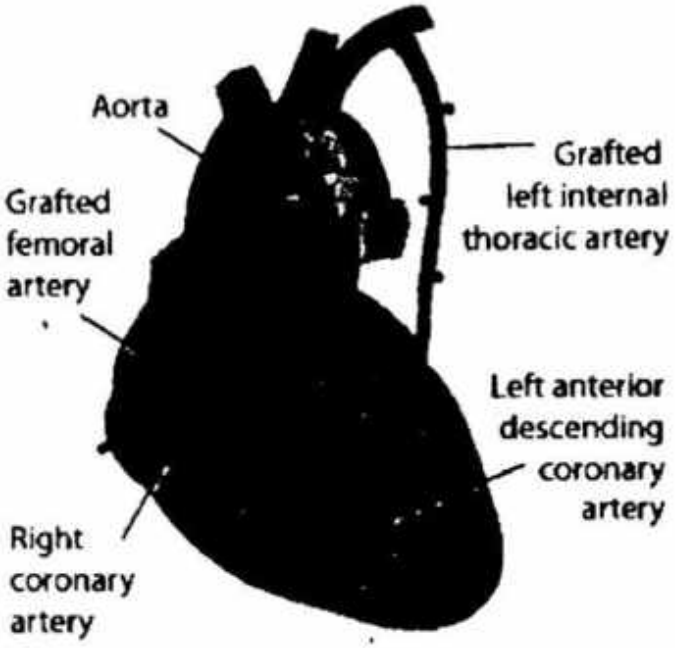
(ii) The technique involves taking healthy segments of blood vessel from other parts of the patient's body usually a vein from the leg called **great**

saphenous vein and an artery of thorax called **internal thoracic artery** and using them to bypass obstructions in the **coronary arteries**.

(iii) The technique is common for those who suffer from severe occlusion of parts of the **coronary arteries**.



A triple Coronary Artery Bypass Graft Operation (shown by arrows)



(c) Angioplasty:

Working:

In angioplasty a cardiologist threads a plastic tube into an artery of an arm or a leg and guides it through a major blood vessel toward the heart.

When the tube reaches the region of plaque in a coronary artery a balloon is attached to the end of the tube is **inflated forcing the vessel open**.

Stents:

The artery may not remain open, so slotted tubes called **stents** are expanded inside the artery to keep the artery open. Stents are coated with **heparin** to prevent blood clotting and chemicals to prevent arterial closing.

(d) Open heart surgery:

Introduction:

This is a surgery in which the patient's chest is opened. The surgery is performed on the heart. The term **"open"** refers to the chest, not to the heart itself. The heart may or may not be opened depending on the particular type of surgery. Heart surgery is used to correct heart problems in children and adults.

Working:

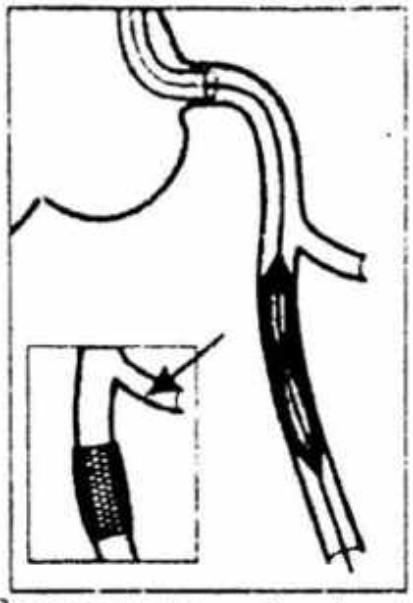
(i) An incision is made through the breastbone (sternum) while the patient is under general anesthesia. Tubes are used to re-route the blood through a special pump called a **heart-lung bypass machine**.

(ii) This machine adds **oxygen to the blood** and keeps the blood warm and moving through the rest of the body while the surgeon is repairing the heart.

(iii) Using the machine allows the **heart to be stopped**. Stopping the heart makes it possible to repair the heart muscle itself, the **heart valves**, or the blood vessels outside the heart.

(iv) After the repair is done, the heart is started again and the machine is removed.

(v) The **breastbone and the skin incision** are then closed



Coronary Angioplasty and Stenting

46. Explain hypertension and hypotension. What are the factors that regulate blood pressure?

Ans: Hypertension:

Introduction:

"Hypertension is defined as blood pressure higher than 140/90 mmHg (millimeters of mercury)".

Blood pressure is the force of blood against your blood vessels as it circulates. This force is necessary to make the blood flow, delivering nutrients and oxygen throughout your body. High blood pressure also called **"hypertension,"** is a serious medical condition

Reason:

It happens when the force of the blood pumping through your arteries is too strong When our heart beats, it pushes blood through our arteries to the rest of our body When the blood pushes harder against the walls of our arteries, our blood pressure goes up

Fluctuations in the Blood Pressure:

Our blood pressure may be different at different times of the day It is usually higher when we first wake up, after we exercise, or when we are under stress A diagnosis of hypertension may be made when one or both readings are high **120/80** mmHg is normal blood pressure. Modem lifestyle factors are responsible for a growing burden of hypertension: physical inactivity, stress, salt-rich diets with processed and fatty foods, alcohol and tobacco use. Hypertension can strain the heart damage blood vessels, and increase the risk of heart attack stroke kidney problems and death

Factors regulating blood pressure:

Factors that regulate blood pressure are heart rate stroke volume, resistance to blood flow by the blood vessels, strength of the heartbeat, and

vasomotor centre in the medulla. The factors that can lead to hypertension include intake of alcohol, lack of exercise, age and history of high blood pressure in the family

Postural hypotension:

Hypotension is defined as blood pressure lower than 90/60 mmHg (millimeters of mercury).

Causes and symptoms:

In some individuals, sudden standing or after eating causes a fall in blood pressure, dizziness, dimness of vision, and even fainting. Hypotension occurs primarily in adults older than 65

Factors:

Factors include high blood pressure, medications like alpha blockers, some heart conditions, heat exposure can cause sweating, bed rest and pregnancy as woman's circulatory system expands rapidly during pregnancy

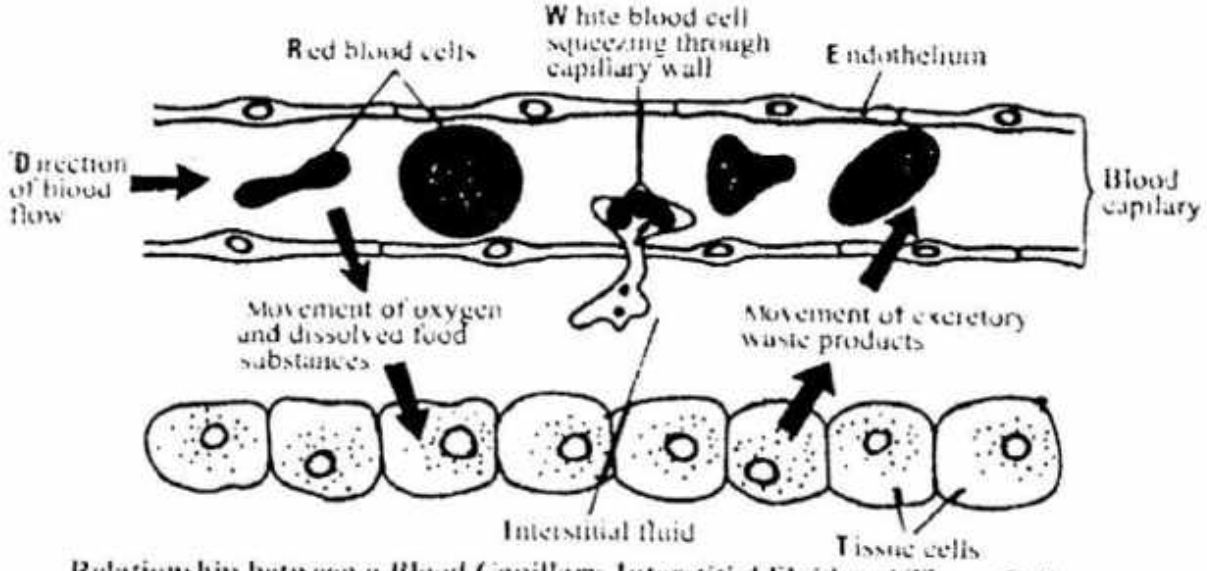
It also occurs in diseases such as diabetes, syphilis, and Parkinson's disease.

47. Describe the formation, composition and function of intercellular fluid.

Ans: The lymphatic system includes lymph, lymphocytes, lymphatic vessels, lymph nodes, tonsils, spleen and thymus gland. About one sixth of the body consists of spaces between the cells which collectively are called the **interstitium**. The fluid in these spaces is the **interstitial fluid** or **intercellular fluid.**

Formation:

The fluid in the interstitium is derived by filtration and diffusion from the capillaries



Relationship between a Blood Capillary, Interstitial Fluid and Tissue Cells

Composition:

Interstitial fluid contains almost the same constituents as plasma except for much lower concentrations of proteins because proteins do not pass outward through the walls of the capillaries with ease. This fluid is mainly entrapped in the minute space among the proteoglycan filaments. This combination of proteoglycan filaments and the fluid entrapped within them has the characteristics of gel and therefore is called **tissue gel.**

Function:

Instead of flowing, interstitial fluid mainly **diffuses** through the gel. This diffusion allows rapid transport of the interstitium of water molecules electrolytes, nutrients, cellular excreta, oxygen, carbon dioxide etc., through the interstitium. Materials are exchanged between the blood and interstitial fluid and between the interstitial fluid and the body cells. In other words, to get from the blood to body cells or vice versa, materials must pass through the interstitial fluid.

48. Describe the lymphatic system of man.

Ans: Lymphatic system of man:

The lymphatic system includes lymph, lymphocytes, lymphatic vessels, lymph nodes, tonsils, spleen and thymus gland. About one sixth of the body consists of spaces between the cells, which collectively are called the **interstitium.** The fluid in these spaces is the **interstitial fluid** or **intercellular fluid.**

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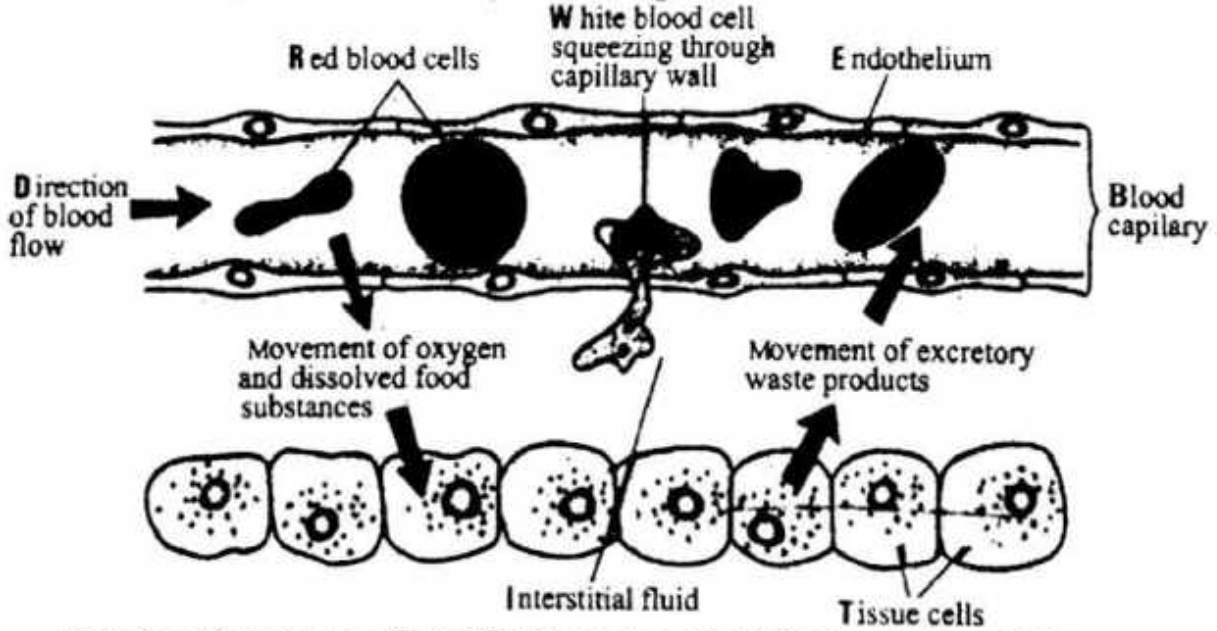
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Relationship between a Blood Capillary, Interstitial Fluid and Tissue Cells

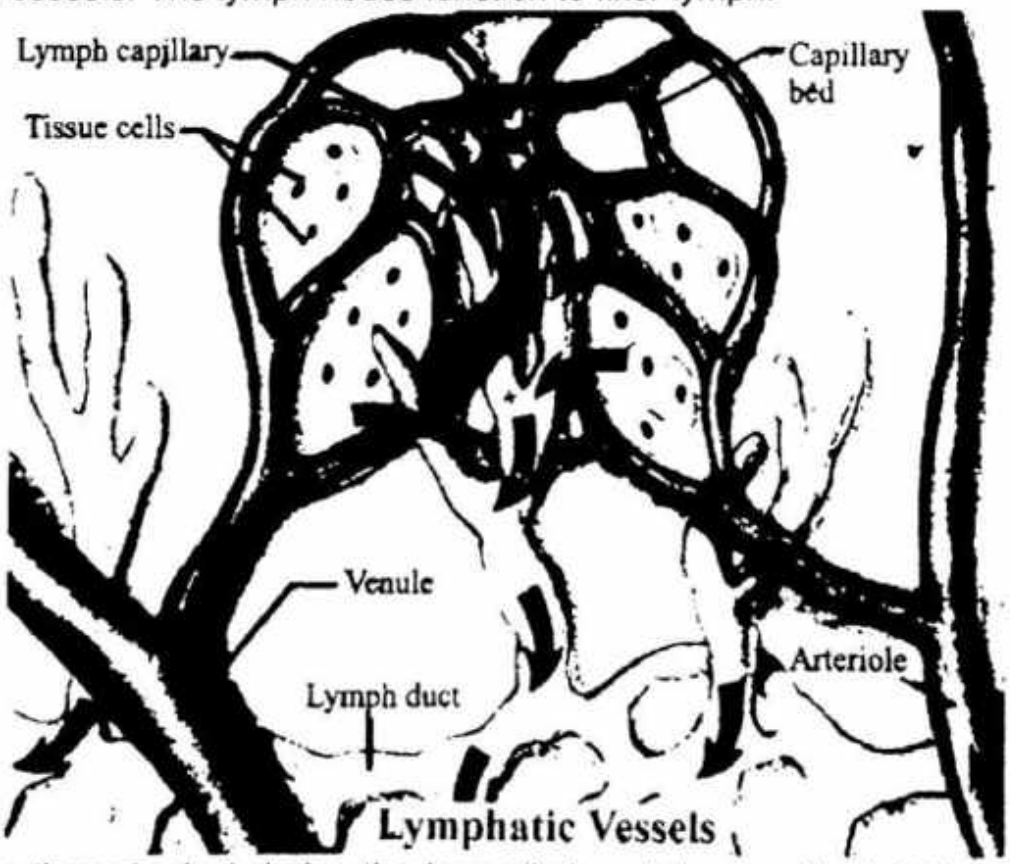
Comparison of the composition of interstitial fluid and lymph:

Approximately 30 litres of fluid pass from the blood capillaries into the interstitial space each day, whereas only 27 litres pass from the interstitial space back into blood capillaries. The remaining 3 litres of fluid enters the lymphatic capillaries, where the fluid is called **lymph** (meaning clear spring water) and passes through the lymphatic vessels back to the blood. In addition to water lymph contains solutes such as ions, nutrients, gases and some proteins, hormones, enzymes and waste products.

Lymphatic vessels:

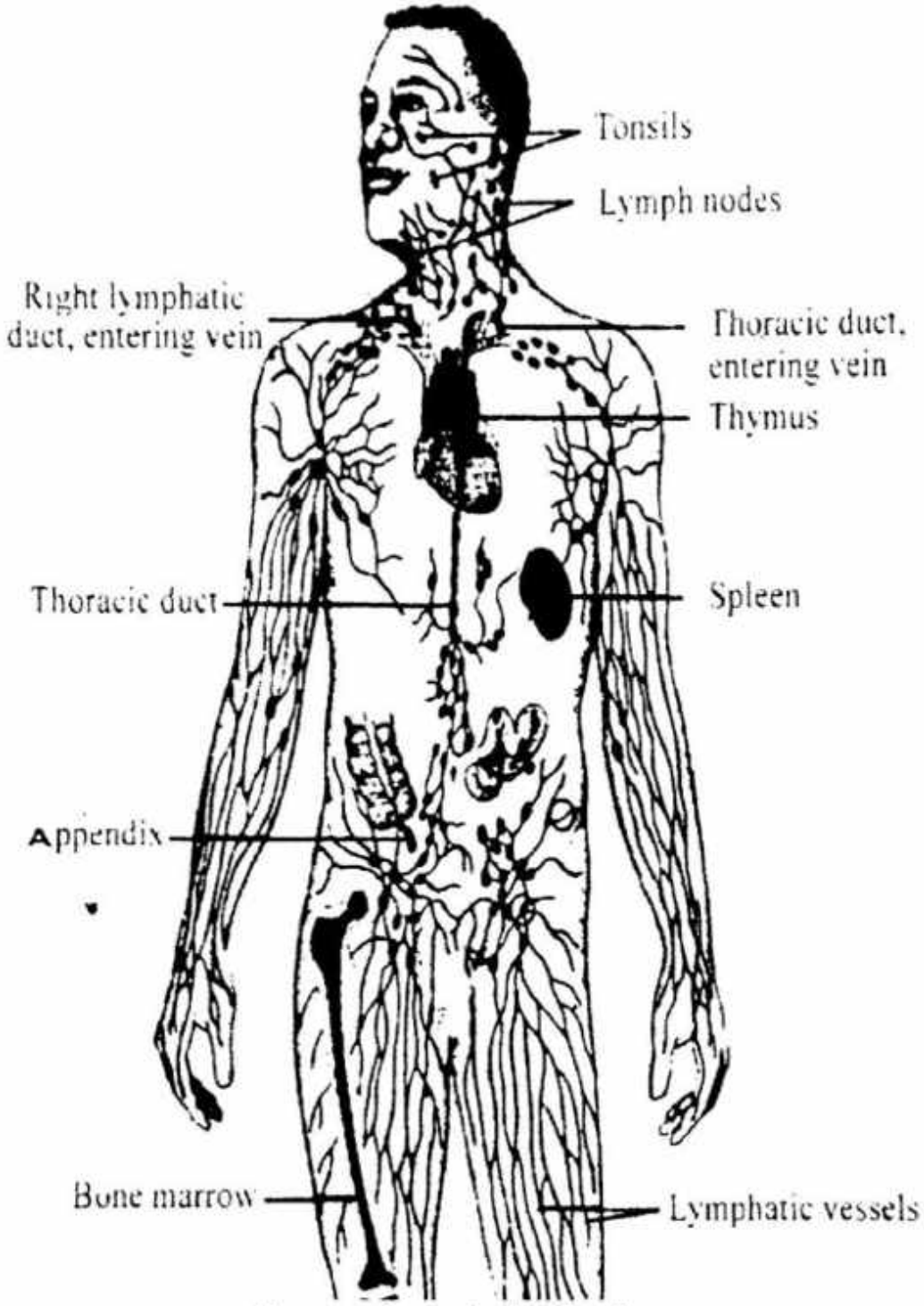
The lymphatic system unlike the circulatory system only carries fluid away from tissue. The lymphatic system begins in the tissues as **lymph capillaries,** which differ from blood capillaries as they lack a basement membrane. The lymph capillaries are far more permeable than blood capillaries and nothing in the interstitial fluid is excluded from the lymph capillaries. The lymph capillary epithelium functions as a series of one-way valve that allows fluid to enter the capillary but prevent it from passing back into the interstitial spaces.

The lymph capillaries join to form larger lymph vessels that resemble small veins. Small lymphatic vessels have a beaded appearance because of the presence of one-way valves along their lengths that are similar to the valves of veins. Lymph nodes are round, oval, or bean-shaped bodies distributed along the various lymphatic vessels. The lymph nodes function to filter lymph.



Lymphatic Vessels

The thoracic duct drains the lower limbs, abdomen, the left thorax, the left upper extremity, and the left side of the head and neck. The duct ends by entering the left subclavian vein. The right lymphatic duct is much short and smaller in diameter than the thoracic duct. It drains the right thorax, right upper limb, and right side of the head and neck and opens into the right subclavian vein.



Human Lymphatic System

Role of lacteal present in the villi:

Each villus contains a **lymph capillary** called **lacteal**. The lymphatic system absorbs fats and other substances from the digestive tract. Fat enters the lacteals and pass through these lymphatic vessels to venous circulation. The lymph passing through these lacteals has a milky appearance because of its fat contents. **Chylomicrons** (these are proteins, triglycerol 90% phospholipids 4% and cholesterol 5%) enter the lacteal. Chylomicrons enter the lymph capillaries because lymph capillaries lack basement membrane and are more permeable to large particles

Lymph nodes are small, round or bran-shaped structures, ranging in size from 1 to 25 mm long, and are distributed along the course of the lymphatic vessels. They filter the lymph, remove bacteria and other materials. In addition, lymphocytes congregate (assemble), function and proliferate within lymph nodes.

Spleen:

The spleen is located in the upper left abdominal cavity just beneath the diaphragm. It is a lymphoid organ. The spleen detects and responds to foreign substances in the blood, destroys worn-out erythrocytes, and acts as a blood reservoir, and to make blood available in times of low blood pressure or when the body needs extra oxygen-carrying capacity

49. Describe the role of lymph vessels (lacteals) present in villi.

Ans: Role of lacteal present in the villi:

Each villus contains a **lymph capillary** called **lacteal.** The lymphatic system absorbs fats and other substances from the digestive tract. Fat enters the lacteals and pass through these lymphatic vessels to venous circulation.

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50. Describe the function of lymph nodes and state the role of spleen as containing lymphoid tissue..

Ans: **Lymph nodes** are small, round or bran-shaped structures, ranging in size from 1 to 25 mm long, and are distributed along the course of the lymphatic vessels. They filter the lymph, remove bacteria and other materials. In addition, lymphocytes congregate (assemble), function and proliferate within lymph nodes.

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