

Unit 11: Human Circulatory System

Long Questions

DESCRIPTIVE QUESTIONS

STRUCTURE AND FUNCTIONING OF HEART

Q1. Describe the structure of walls of heart and rationalize the thickness of the walls of each chamber.

Ans. Location: It is situated in the middle of chest cavity (between the lungs). Its back surface is near **vertebral column** while its front surface is **behind sternum** and rib cartilages. Human heart is a hard-working pump that moves blood through body.

Pericardium

Heart is enclosed in a sac called **pericardium**. Pericardium separates heart from surrounding organs. It is composed of the following two layers;

1. **Fibrous pericardium:** Outer layer of pericardium is called fibrous pericardium. It is made of **strong connective tissue**. It protects heart against **external pressure** and **shocks**. It also prevents excessive dilation of heart.
2. **Serous pericardium:** Inner layer of pericardium is called serous pericardium. It is a sac, made of two layer i.e.,
 - a) **Parietal pericardium:** Outer parietal pericardium – present beneath fibrous pericardium.
 - b) **Visceral pericardium:** Inner visceral pericardium (**also called epicardium**) – closely attached to the underlying heart.

Pericardial cavity: The space between parietal and visceral pericardium is called pericardial cavity. It contains up to **50 ml pericardial fluid**. It lubricates heart and protects it from infections.

Wall of the Heart

The wall of heart is composed of **three layers**.

- **Epicardium:** The inner layer of pericardium i.e., epicardium makes the outer lining of heart wall.
- **Myocardium:** Beneath epicardium, there is the **thickest layer of heart wall** i.e., myocardium. Myocardium is made of **cardiac muscles** (Cardiomyocytes).
- **Endocardium:** Endocardium is present beneath myocardium. It is a single layer of **epithelial cells** and make the **inner linings** of heart chambers.

★ **Note:** All questions and paragraphs marked with a star ★ are explanations of the Box Information provided in the textbook.

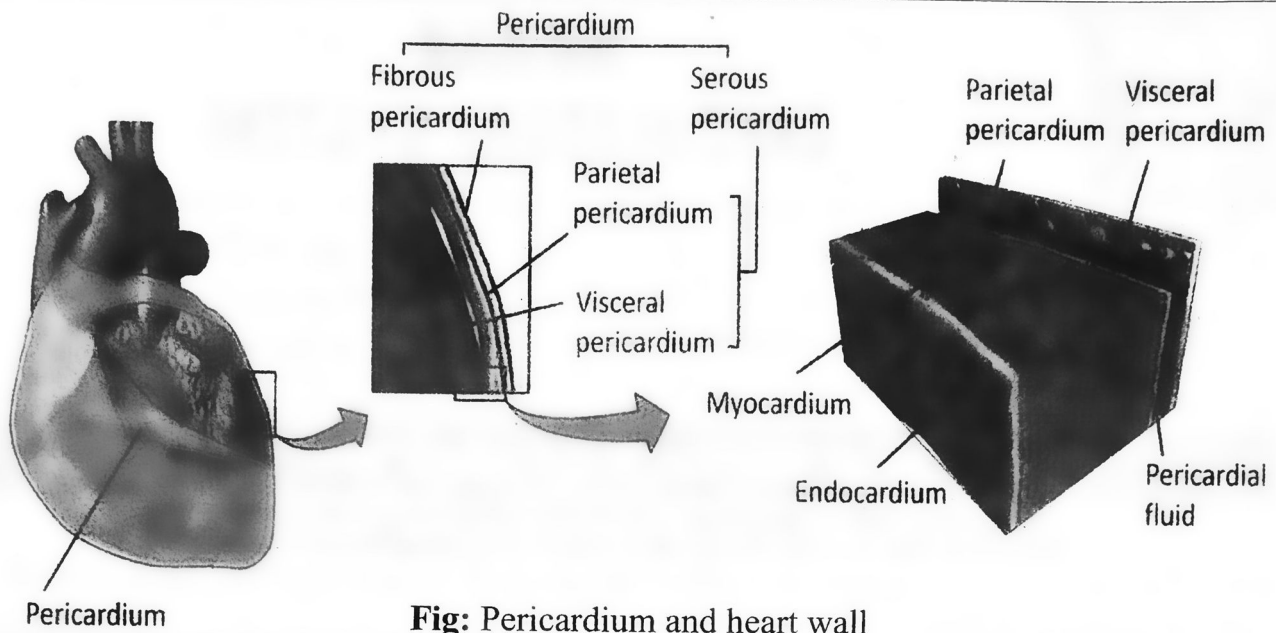


Fig: Pericardium and heart wall

Chambers and Valves of Heart

There are four chambers of heart i.e., two upper thin walled and comparatively smaller than ventricles are called **atria** and two lower thick-walled and comparatively larger than atria are called **ventricles**.

Atria receive blood from body and pass it to ventricles which distribute blood to body.

Septa of Heart

The chambers of human heart are completely separated by septa which are of three types.

- Atria and ventricles are separated by **atrioventricular septum**.
- The left and right atria are separated from each other by an **interatrial septum**.
- The left and right ventricles are separated from each other by an **interventricular septum**. It is much thicker than the interatrial septum.

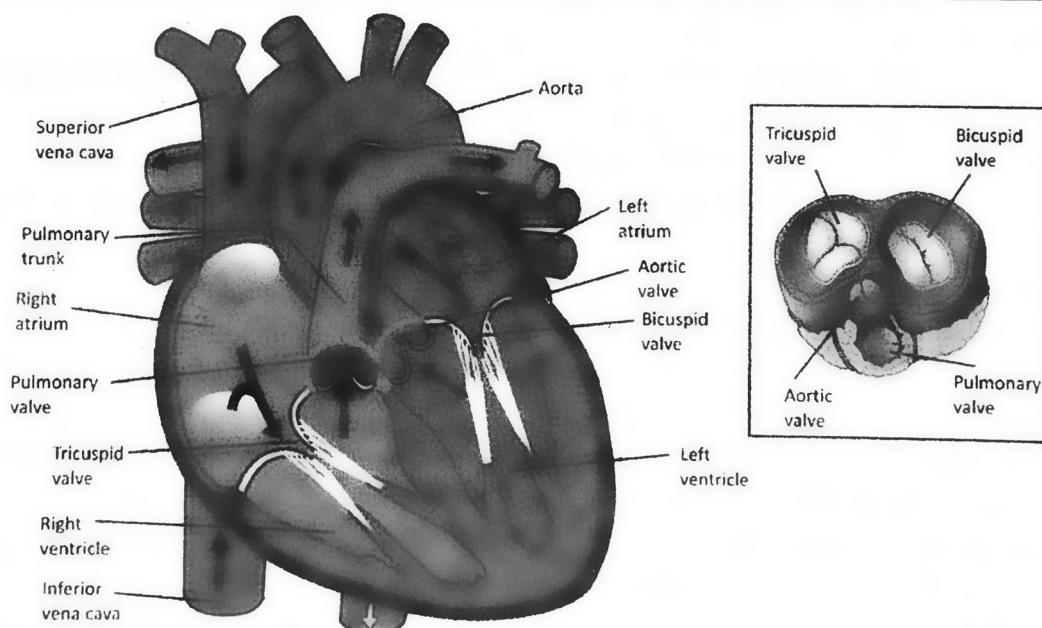


Fig: Human heart and valves

Atrioventricular valves: At the entrance points of ventricles (in atrioventricular septum), there are two atrioventricular valves i.e., a tricuspid valve and a bicuspid valve.

- **Tricuspid valve** is made of three cusps and is present between right atrium and right ventricle.
- **Bicuspid (mitral) valve** is made of two cusps and is present between left atrium and left ventricle.
- When ventricles contract, tricuspid and bicuspid valves close and prevent the back of flow of blood into atria.

Semilunar valves: At the **exit points of ventricles**, there are two semilunar valves (with shapes like half-moon). These are called pulmonary valve and aortic valve.

- **Pulmonary valve** is located at the base of pulmonary artery between right ventricle and pulmonary trunk.
- **Aortic valve** is present at the base of aorta between left ventricle and aorta.
- When **ventricles relax**, pulmonary and aortic valves close to prevent back flow of blood from pulmonary artery and aorta into ventricles.

Q2. Describe the flow of blood through heart as regulated by valves.

Ans. Circulation of Blood through Heart

- Human heart functions as a **double pump**. It carries out pulmonary circulation (supply of blood to lungs) and systemic circulation (supply of blood to all organs of body – except lungs).
- Complete separation of deoxygenated (right side) and oxygenated (left side) blood is maintained in heart.

Route of deoxygenated blood: The **right atrium receives deoxygenated** blood from body via two veins i.e., superior vena cava and inferior vena cava. Right atrium passes this blood to right ventricle via tricuspid valve. When right ventricle contracts, deoxygenated blood is passed to pulmonary trunk via semilunar pulmonary valve. The **pulmonary trunk divides** into left and right pulmonary arteries which carry deoxygenated blood to **lungs** for oxygenation.

Route of oxygenated blood: The oxygenated blood **from lungs** is brought to left atrium by four pulmonary veins. Left atrium passes this blood to left ventricle via bicuspid (or mitral) valve. When left ventricle contracts, oxygenated blood is passed to aorta via semilunar aortic valve. Aorta carries this blood to all parts of body (except lungs).

★ The wall of left ventricle is **thicker** (about 3 times) than that of the right ventricle because it has to **push** the blood to all over body.

Q3. What is heart beat? Describe the stages of cardiac cycle. How abnormal & normal heart sounds are produced in heart?

Ans. Cardiac Cycle Heartbeat

Definition: The sequence of events that occur during one complete heart beat are called **cardiac cycle**.

Heart works in continuous cycles. Its chambers relax and are passively filled with blood from large veins. Then, its chambers contract and propel the blood throughout body. Its alternating relaxations and contractions are collectively called a cardiac cycle or one **heartbeat**.

Stages of cardiac cycle

Cardiac cycle is completed in three distinct stages.

- (i) **Cardiac diastole / diastole:** In this phase atria are relaxed and being filled with blood, the ventricles are also relaxed. This relaxed period of heart chambers is called diastole.
- (ii) **Atrial systole:** As blood accumulates in atria, their blood pressure rises, due to which both of them contract. This is called atrial systole. It passes the blood through tricuspid and bicuspid valves into the two relaxed ventricles.
- (iii) **Ventricular systole:** When ventricles are filled with blood, both of them contract. This is called ventricular systole and it pumps the blood to pulmonary and aortic valves open.

Duration of one cardiac cycle:

The total duration of one complete heart beat or cardiac cycle is 0.8sec, in which **diastole** lasts about **0.4 sec**, **atrial systole** takes about **0.1 sec**, and the **ventricular systole** lasts about **0.3 sec**. In one's life, heart beats about **2.5 billion** times, without stopping.

Sounds of Heartbeat

There are two heartbeat sounds produced during heartbeat i.e. **lubb** and **dubb** which can be heard by using stethoscope.

1. **Lubb sound:** When both ventricles contract simultaneously to pump the blood to pulmonary arteries and aorta, the tricuspid and bicuspid valves close and "lubb", sound is produced.
2. **Dubb sound:** When ventricular systole ends and both ventricles relax simultaneously, the pulmonary and aortic semilunar valves close and "dubb" sound is produced.
3. **Murmurs:** If the valves are not closing fully, or if they open narrowly, turbulence is created within the heart. This **turbulence** can be heard as a heart murmur. A murmur sounds like a **hiss** (hissing or whooshing sound).

★ Most cases of heart murmurs are not serious, and those that prove serious can be corrected by replacing the damaged valves with artificial ones or with valves taken from an organ donor.

Q4. Describe the initiation and control of heartbeat. Also describe the components of electrical conduction system of heart.

Ans. Control of Heartbeat (Heart Excitation and Contraction)

The control system of heart is composed of following structures:

- (i) SA – node
- (ii) AV – node
- (iii) Bundle of His
- (iv) Purkinje fibres (AV-bundle)

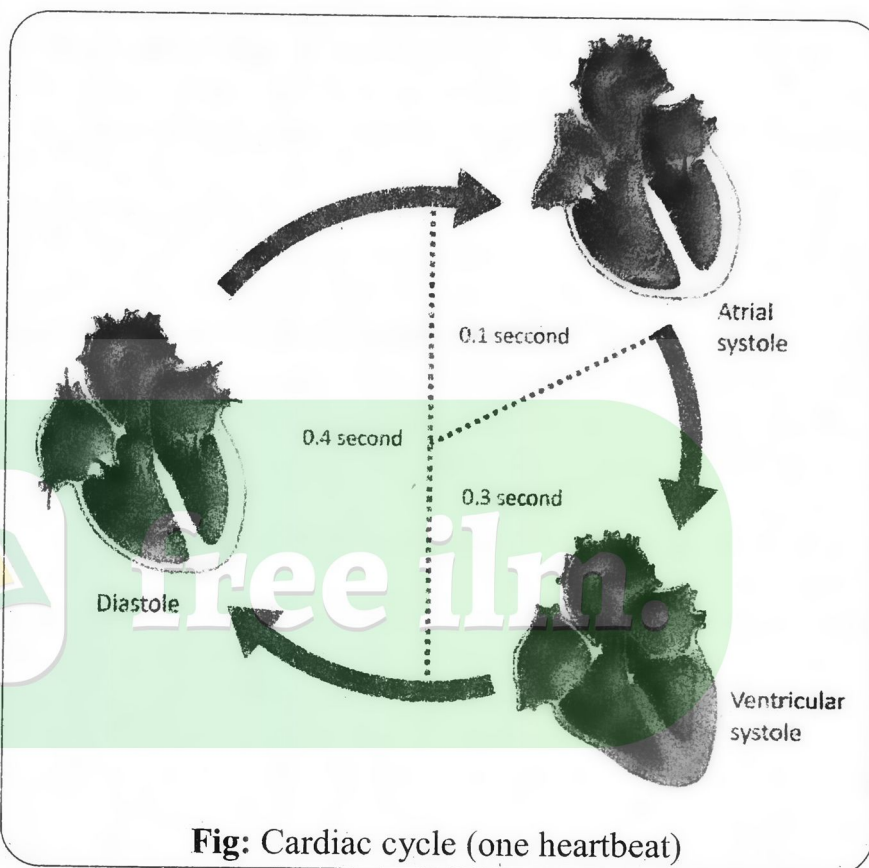


Fig: Cardiac cycle (one heartbeat)

- (i) **Sinoatrial Node (SA – node):** The sinoatrial node consists of a small cluster of cardiac muscle cells. It is embedded in the upper wall of right atrium. The pumping of heart is initiated by the Sinoatrial Node (SA node) or pacemaker. Heartbeat starts when SA node sends electrical impulses to the walls of atria. It causes both atria to contract simultaneously.
- (ii) **Atrioventricular node (AV – node):** AV-node is made of small cluster of cardiac muscle cells. It lies at the lower portion of interatrial septum. It receives the impulses from SA-node and propagates to ventricles through bundle of his.
- (iii) **Bundle of His/AV – Bundle:** It is a group of specialized fibres that transmit electrical impulses from AV-node to the left and right AV- bundle branches. It is located in interventricular septum, descending to inner rate the ventricles.
- (iv) **Purkinje Fibres:** These are the network of fibres formed by sub divisions of AV-bundles that spread throughout the ventricles, causing them to contract upon receiving nerve impulses from AV-node through AV-bundle.

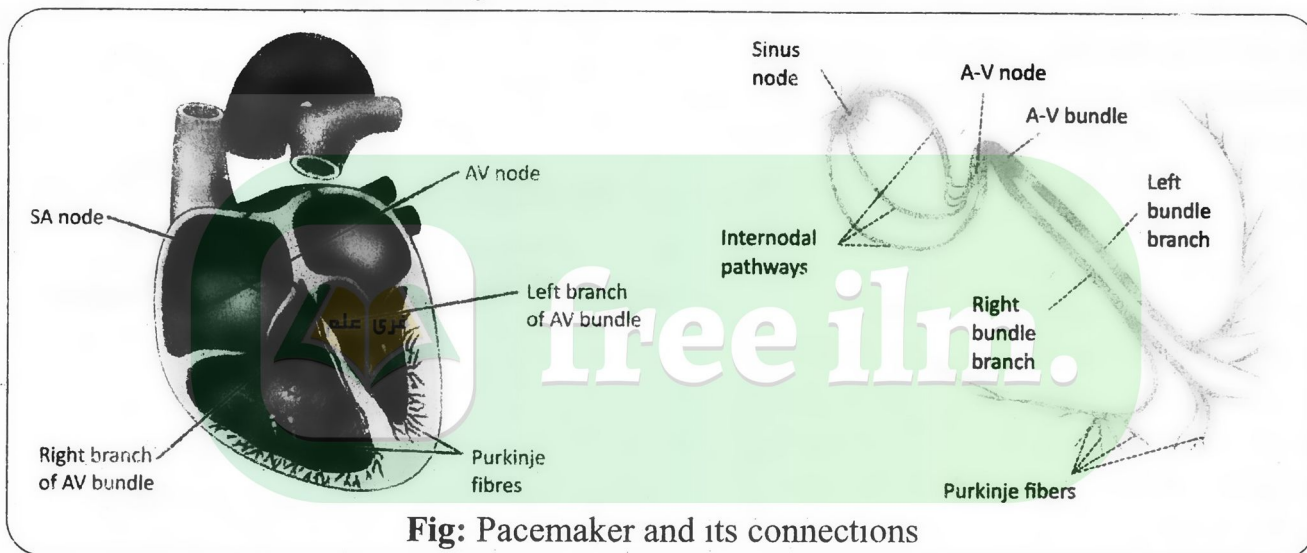


Fig: Pacemaker and its connections

Stimulation of these fibres causes the ventricles to contract almost simultaneously.

- **Delay of conductance:** There is a **delay of about 0.15 second** in conductance of impulses from the **SA node** to **AV node**, permitting atrial systole to be completed before ventricular systole begins.
- **Blockage in flow of electrical impulses:** If there is some blockage in the flow of the electrical impulses, or if the impulses initiated by SA node are weak; it may delay the rhythmicity of heartbeat or stop it.
- **Cure of blockage:** In such patients of weak SA node, **artificial pacemaker** is used. It is a battery – operated device that is surgically transplanted near the AV node. It emits electrical signals that trigger normal heartbeats.

Control of heart rate

The heart of an average adult beats about **70 times per minute**. It pumps the entire blood volume (**about 5 litres**) every minute. The normal speed of heartbeat is made and maintained by **pacemaker** and **AV node**.

Role of Brain in controlling heart rate: Brain also exerts some influence on heart rate.

- For example, **during fever and exercise**, the control centre in brain sends nerve signals to both the pacemaker and the AV node, making them to increase the heart rate. It is to cope with the situation.

- In contrast, when we are **asleep or at rest**, the brain's control centre slows down the activity of pacemaker and AV node.

Q5. What is ECG? How does it work? Describe the main components of ECG wave form along with their clinical significances?

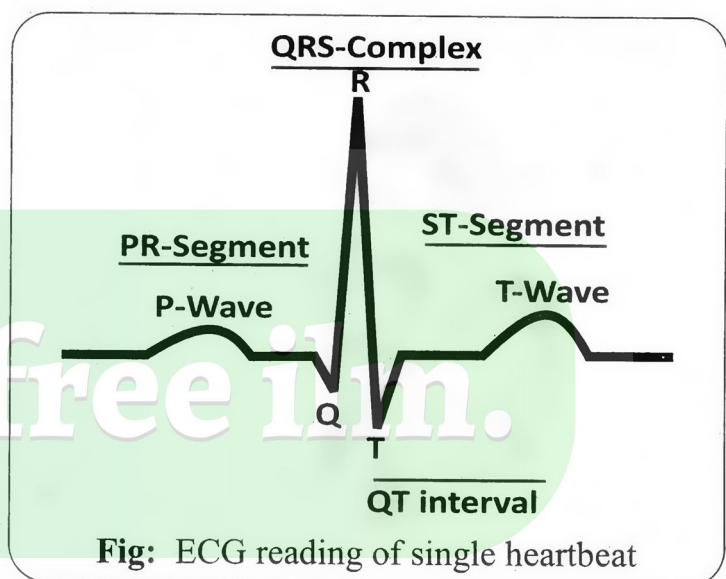
Ans. Electrocardiogram

The recording of electrical potentials, generated by the currents of cardiac impulses, is known as electrocardiogram (ECG).

When cardiac impulse passes over the surface of heart, a minute electrical current is generated. This current spreads into the tissues surrounding heart. This minute electrical current also travels to the surface of body from here these electrical potentials are recorded using ECG machine.

Electrocardiograph

In ECG, the electrical potentials generated by cardiac impulses current are measured and recorded. For this purpose, electrodes are placed on skin on the opposite sides of heart. The electrodes are attached to a machine called electrocardiograph that records electrical potentials generated by this current. ECG helps to diagnose the abnormalities in conduction system of heart. ECG shows the following waves of electrical impulses produced at specific events of cardiac cycle.



1. **P wave:** It shows beginning of atrial depolarization, initiated by SA node. It causes atrial contraction.
 - **Abnormalities:** Irregular or absent P waves may indicate arrhythmia (lack of rhythmicity).
2. **PR segment:** It shows the completion of atrial depolarization. It is usually 0.12 to 0.20 seconds.
 - **Abnormalities:** A prolonged PR indicates a first-degree heart block.
3. **QRS:** It shows the beginning of depolarization of ventricles. Atrial repolarization also occurs during this phase.
 - **Abnormalities:** Abnormalities in the QRS complex may indicate **bundle branch block**, ventricular tachycardia (faster rate of contraction), or other ventricular abnormalities.
4. **ST segment:** It shows the completion of depolarization of ventricles.
 - **Abnormalities:** It can be depressed in ischemia (decreased flow of blood and oxygen to heart muscles) and elevated in myocardial infarction. This segment ordinarily lasts about **0.08 second**.

5. **T wave:** It represents the beginning of repolarization of ventricles.
- **Abnormalities:** T wave abnormalities may indicate electrolyte disturbance. The hyper acute T wave shows the earliest findings of acute myocardial infarction.
6. **QT interval:** The QT interval is from the beginning of the QRS complex to the end of the T wave. A normal QT interval is usually about 0.40 seconds, it represents the time taken by ventricles to depolarize and then repolarize.
- **Abnormalities:** Deviation in QT interval usually increase the risk of arrhythmias.

BLOOD VESSELS

Q6. Describe the detailed structure of arteries veins and capillaries.

Ans. Blood Vessels

Arteries, veins and capillaries are the main blood vessels in human circulatory system.

1. Arteries

Arteries are the blood vessels which carry **blood away from heart** to different parts of body. All arteries carry oxygenated blood, except pulmonary arteries. The central core of artery is lumen.

- **Walls of arteries:** The walls of arteries are made up of three layers.
 - Tunica externa or adventitia:** It is the **Outer layer** of arteries made of connective and elastic tissue.
 - Tunica media:** It is the **middle layer** of arteries made of thick muscular tissue and elastic fibres. Middle layer is important and it can withstand higher blood pressure during ventricular systole.
 - Tunica intima:** It is the **Inner layer** of arteries made of thin layer of endothelial cells.
- **Arterioles:** Arterioles are the sub-divisions of arteries, which leads to capillaries. Arterioles divide repeatedly until they form a dense network of very fine branches i.e., capillaries.

2. Capillaries

These vessels are formed by the division of arterioles. Capillaries join to form venules. Capillaries penetrate all tissues and have approach to the cellular level.

- **Walls of capillaries:** The walls of capillaries are made of a single layer of **endothelial cells**. The internal diameter of a capillary is about **8 micrometres**.
- **Function of capillaries:** Capillaries are the sites where **materials are exchanged** between blood and body tissues by diffusion or active transport. Water and diffusible substances can pass through capillary walls.



Fig: Structure of artery

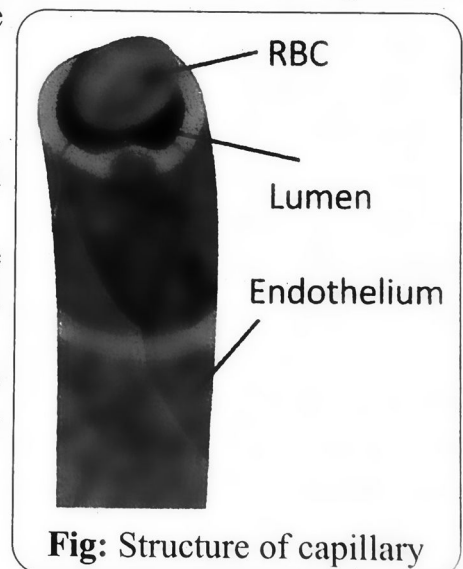


Fig: Structure of capillary

Materials pass through the endothelial cells or through the intercellular spaces of capillary wall. Some materials are also taken up by the cell of capillary wall by **endocytosis**. The capillary wall cells then pass these materials to the other side by **exocytosis**.

Interstitial fluid: The pressure within capillaries causes a continuous leakage of fluid from the blood plasma into tissues. This fluid, known as interstitial fluid consists of water with dissolved nutrients, hormones, gases, wastes and small proteins. Large proteins, RBCs and platelets remain within capillaries. But some WBCs can squeeze out through the intercellular spaces of capillary wall.

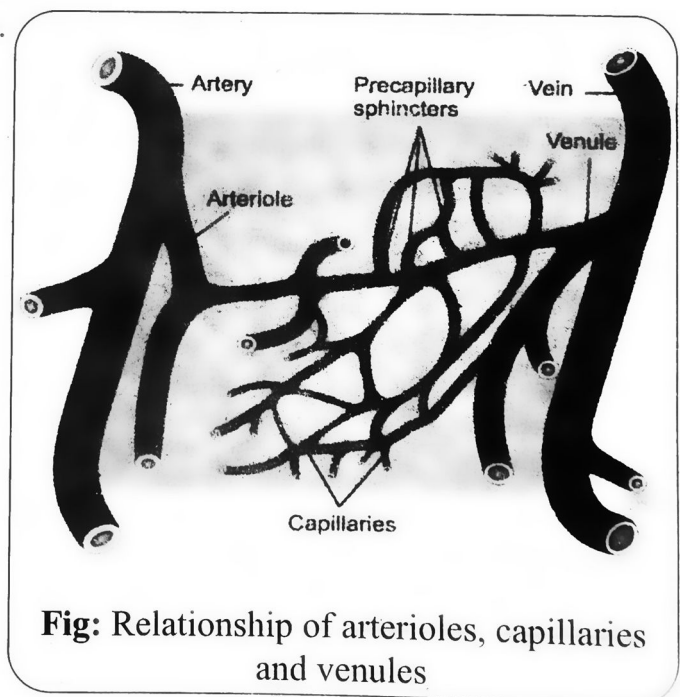
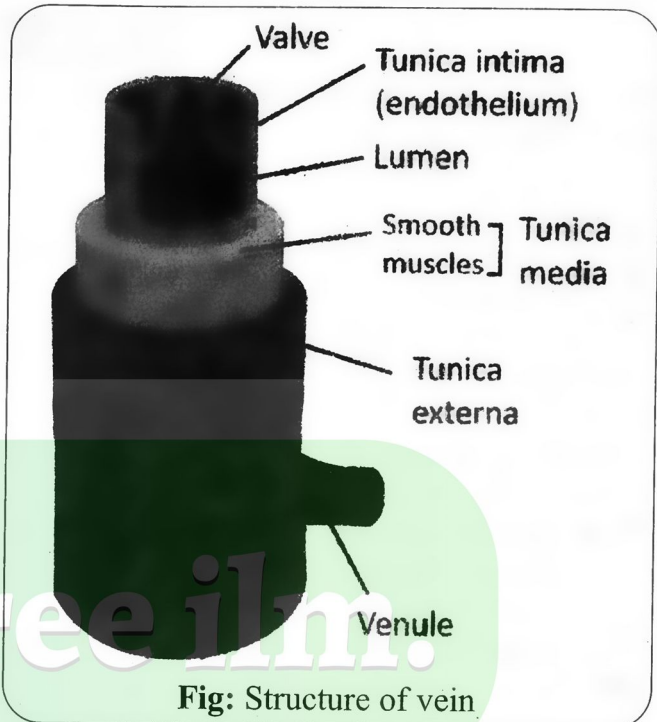
3. Veins

The blood vessels carry blood from different parts of the body towards heart. All veins carry deoxygenated blood except pulmonary veins.

Walls of veins: The wall of veins has same three layers as are present in arteries.

- **Tunica externa (adventitia):** It is the **outer layer** of veins, made of connective and elastic tissue.
- **Tunica media:** It is the **middle layer** of veins, relatively thin and only slightly muscular, with few elastic fibres.
- **Tunica intima:** It is the **inner layer** of veins, made of thin layer of endothelial cells.
- The middle layer of veins is relatively thinner than that of arteries because veins do not have to withstand high blood pressure.
- Semilunar valves are present in veins to prevent the back flow of blood, as it is moving towards heart.
- The pressure generated by the contraction of surrounding muscles presses veins and assists in the return of blood towards heart.

Relationship of arterioles, capillaries and venules: Smaller veins join to form larger veins and ultimately from vena cavae (inferior vena cava and superior vena cava), which pour blood into the right atrium of heart. Pulmonary veins from lungs empty in left atrium.



Q7. Describe the role of precapillary sphincters in regulating the flow of blood through capillaries.

Ans. Regulation of Blood Flow in Capillaries

The amount of blood flowing in capillaries is controlled by constricting or dilating the capillaries.

Capillaries do not have smooth muscles in their wall, so the diameter of a capillary is controlled by some other factors, such as by nervous stimulation, as well as by chemicals.

Nervous stimulation can constrict capillaries and certain **chemicals** such as histamine can dilate them. Some capillaries are connected with arterioles and venules through loops of other capillaries.

When the tissues suffer from hypoxia (that is low supply of oxygen) or need more nutrients the diameter of the capillaries is increased by vasodilators.

The entry of each loop is guarded by a ring of muscles called a pre-capillary sphincter. These sphincters regulate the amount of blood flowing through capillaries, as they are made up of smooth muscles, that contract or relax to change the diameter of capillaries.

When the body needs oxygen and nutrients the precapillary sphincters are allowed to relax, in order to increase blood flow to capillaries.

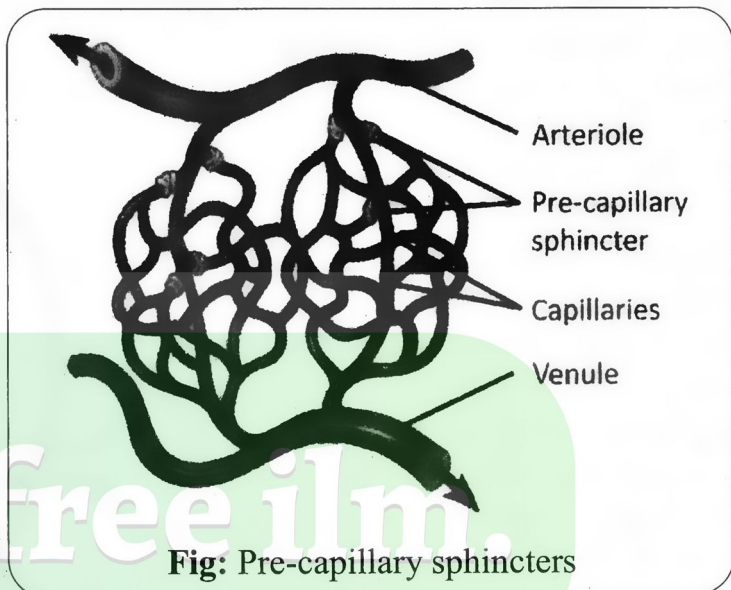


Fig: Pre-capillary sphincters

When the body is at rest or asleep, the precapillary sphincters constrict under the effect of nervous stimulation to reduce the flow of blood towards tissues.

Q8. How the flow of blood is regulated in arterioles? How it is related to metabolic activity in a cell?

Ans. Vasoconstriction in Arterioles: In the walls of arterioles, there are more circular muscles than elastic tissue. The contraction of the circular muscles of arterioles is under the control of nervous and endocrine systems. When these muscles contract, arterioles are constricted. It is called **vasoconstriction**. It reduces the flow of blood in arterioles.

Vasodilation in Arterioles: When these muscles are relaxed, arterioles are dilated. It is called **vasodilation** and it increases blood flow in them.

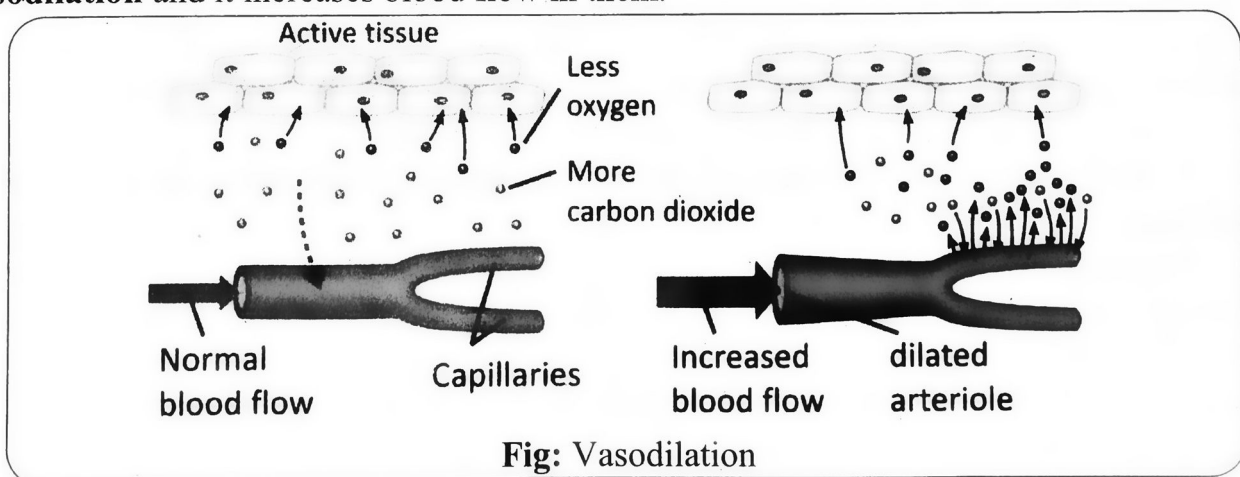


Fig: Vasodilation

Regulation of blood flow and metabolic activity of tissues

Vasoconstriction and vasodilation happen in response to changes in metabolic activity of tissues.

For example, when **metabolic activity in a tissue rises**, oxygen decrease and carbon dioxide increases in its interstitial fluid. In its response, the circular muscles of the arterioles in that tissue relax (vasodilation). It increases blood flow in these arterioles and also in capillaries. The increase blood flow supplies more oxygen and removes more carbon dioxide. Similarly, decreased metabolic activity causes vasoconstriction of arterioles.

Q9. Write the components of pulmonary circulation?

Ans. Pulmonary Circulation

Blood circulation from heart to lungs and from lungs back to heart is called pulmonary circulation.

At the level of heart:

Pulmonary circulation supplies deoxygenated blood to lungs and returns oxygenated blood to heart. A big artery i.e. pulmonary trunk carries deoxygenated blood from the right ventricle of heart. **Pulmonary trunk** divides into right and left pulmonary arteries which carry deoxygenated blood to the right and left lungs.

At the level of lungs:

Inside each lung, the pulmonary artery divides and makes pulmonary arterioles and lung capillaries in lung capillaries, blood is

oxygenated. Lung capillaries join to form pulmonary venules, which join to form pulmonary vein. Left and right pulmonary veins from lungs open in left atrium.

Q10. Define systematic circulation. What are main components of systematic circulation.

Ans. Coronary Circulation

Definition: The systemic circulation supplies oxygenated blood to all the cells, tissues and organs of the body (except lungs) and returns deoxygenated blood to heart. The heart walls are supplied with blood through a small portion of the systemic circulation. It consists of following components.

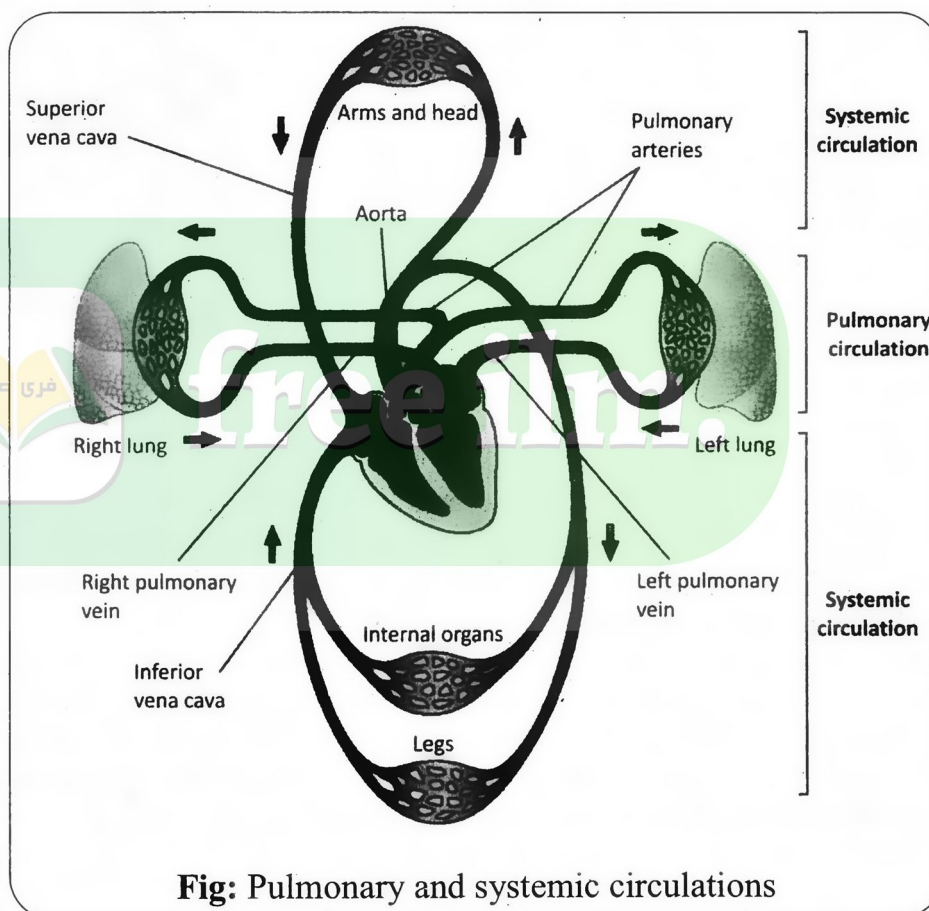
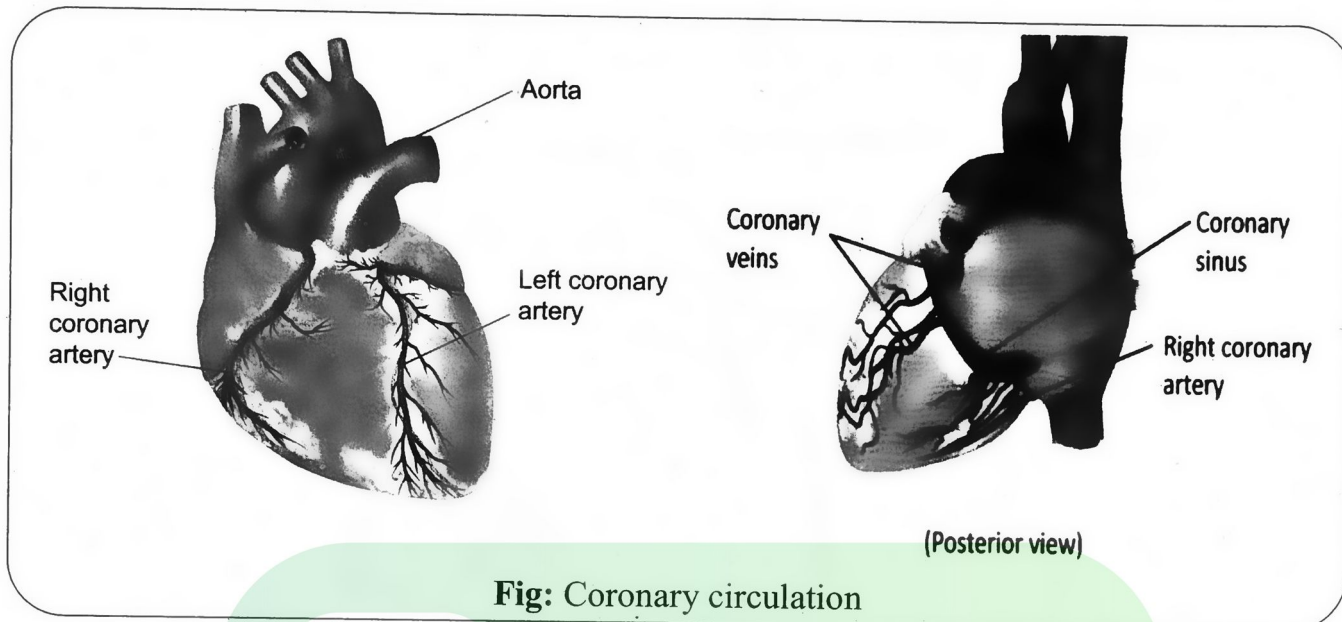


Fig: Pulmonary and systemic circulations

Two **coronary arteries** i.e., right and left coronary arteries arise from aorta, near its origin. These arteries divide into many smaller arteries, arterioles and then into capillaries. After supplying oxygenated blood to heart muscles, the capillaries unite to form venules which make many **coronary veins**.



The coronary veins join to form a **coronary sinus** which opens in right atrium. Small coronary veins drain directly into right atrium.

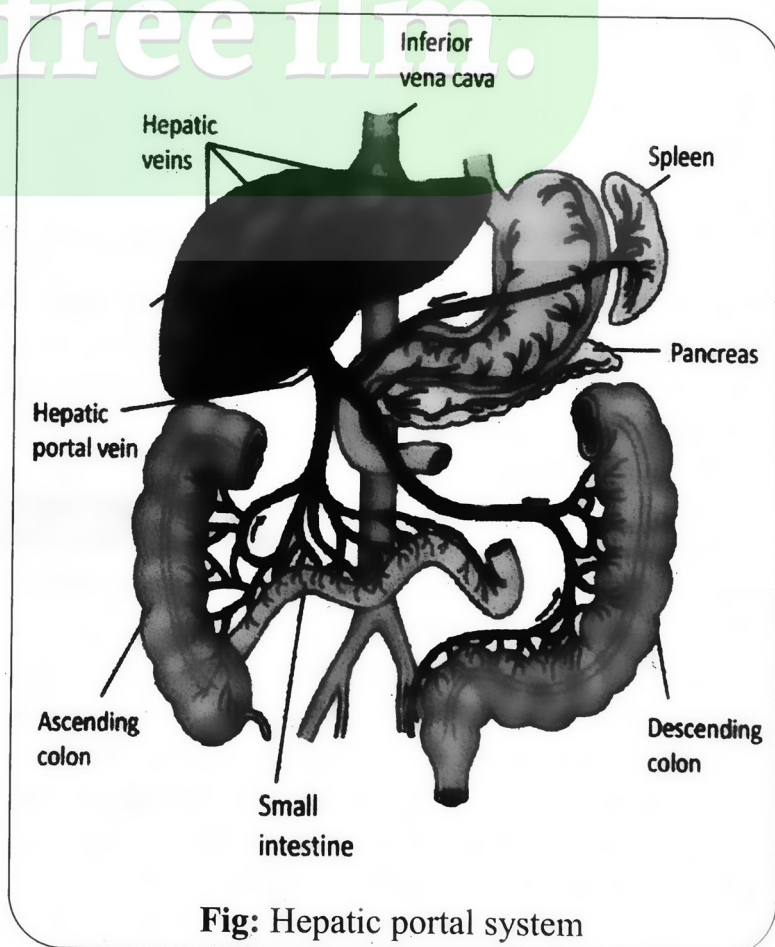
Hepatic Portal Circulation

A portal system is a circulation in which veins end in capillaries.

In hepatic portal system, a large **hepatic portal vein** collects blood from spleen and alimentary canal and take it to liver. The blood from liver is taken to heart through **hepatic veins**.

The blood that comes from alimentary canal to liver contains substances that are absorbed from small intestine.

Purpose of hepatic portal circulation: These substances pass through liver before going to heart liver **removes harmful substances** from blood and absorbs nutrients for storage before sending this blood to heart. Hepatic portal system **extends from the lower portion** of oesophagus to the upper part of **anal canal**.



Renal Circulation

It is another important component of the systemic circulation. Right and left **renal arteries** carry oxygenated blood to the right and left kidneys.

Inside the kidney, each renal artery divides repeatedly to make smaller arteries which branch into several **afferent arterioles**, and supply blood to nephrons (units of kidney). Each afferent arteriole divides to make the capillaries of glomeruli.

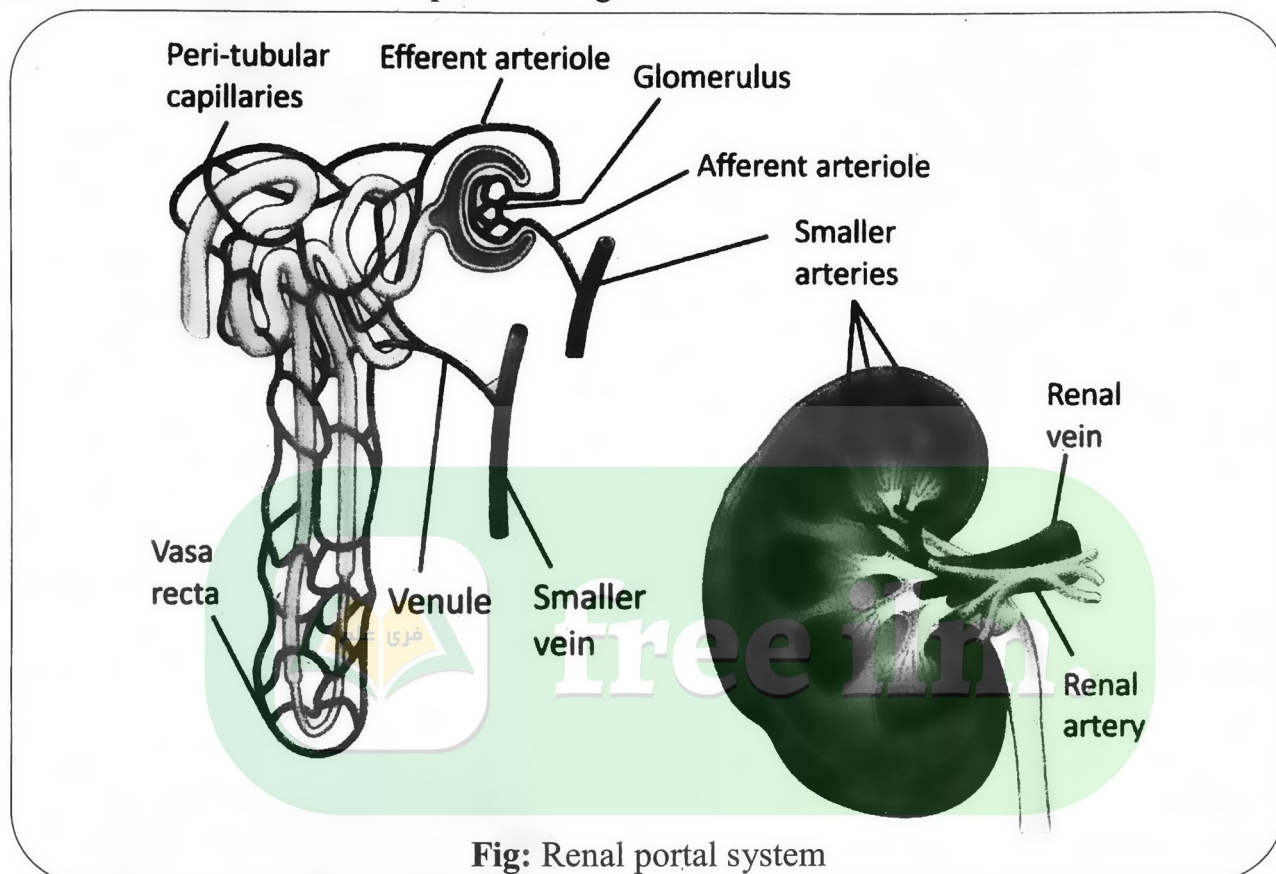


Fig: Renal portal system

The capillaries of glomeruli unite to make **efferent arteriole**, which divides to make two sets of capillaries i.e., (i) **peri-tubular capillaries** (around nephron tubule in cortical portion of kidney in cortical nephrons), and (ii) **vasa recta** (around nephron tubule in the medulla of kidney in juxtamedullary nephrons). These capillaries unite to form venules that converge and make smaller veins. The smaller veins unit to form a **renal vein**.

BLOOD PRESSURE

Q11. Define blood pressure, explain systolic and diastolic pressures?

Ans. Blood Pressure

Blood pressure is the measure of force exerted by blood against the inner walls of blood vessels. This force keeps blood flowing from heart to the entire capillary network in body. Although such a pressure occurs throughout the vascular system, the term blood pressure most commonly refers to **systemic arterial blood pressure**. Blood pressure is highest in aorta and then gradually reduces in systemic arteries. The walls of arteries are elastic. The flow of blood creates rhythmical throbbing of arteries, which is called as **pulse**. The pulse can be felt in wrist (radial pulse), thighs (femoral pulse) side of neck (carotid pulse), with the help of index and middle fingers.

Component of blood pressure

There are two main components of blood pressure.

(i) Systolic pressure

(ii) Diastolic pressure

(i) **Systolic pressure:** The maximum pressure during ventricular systole or ventricular contraction is called systolic pressure. When ventricles contract (ventricular systole), heart forces blood into pulmonary arteries and aorta. As a result, the pressure in these arteries rises sharply. Systolic pressure in a normal young adult is **120 mm Hg**.

(ii) **Diastolic pressure:** The lowest pressure that remains in arteries before the next ventricular contraction, or the blood pressure when the heart muscles are relaxed, is called diastolic pressure. Arterial blood pressure rises and falls corresponding to the phases of cardiac cycle. When ventricles relax (diastole), the arterial pressure drops. Diastolic pressure in a normal young adult is **80 mm Hg**.

Expression of blood pressure: Conventionally, the readings of blood pressure are expressed as **120/80**. The instrument **sphygmomanometer** is used for the manual measurement of systolic and diastolic blood pressures. In this instrument, rise and fall in mercury column shows the readings of blood pressure.

Q12. Elaborate the mechanism of short term and long term regulation of blood pressure?

Ans. Role of baroreceptors / pressure receptors in short term regulation

Location of pressure receptors: Pressure receptors, known as **baroreceptors** are present in **carotid arteries** (arteries that supply blood to the head region and brain) and **aortic arch** (portion of artery that bends between the ascending and descending aorta).

During low blood pressure: When blood pressure falls, baroreceptors activate sensory neurons that send information to brain. The control centre in brain reacts by increasing the rate and force of contraction of heart, and by causing vasoconstriction in arterioles. Both these changes restore blood pressure to normal.

Long Term Regulation

Role of hormones: The long-term regulation of blood pressure is done through **hormones**. Certain hormones regulate the volume of blood by affecting the **reabsorption of water and salts in kidneys**.

Decreased blood volume and pressure: When there is a decrease in blood volume and blood pressure, special receptor presents in brain create thirst. They also **stimulate posterior pituitary** gland to secrete antidiuretic hormone (**ADH**). ADH stimulates kidneys to retain

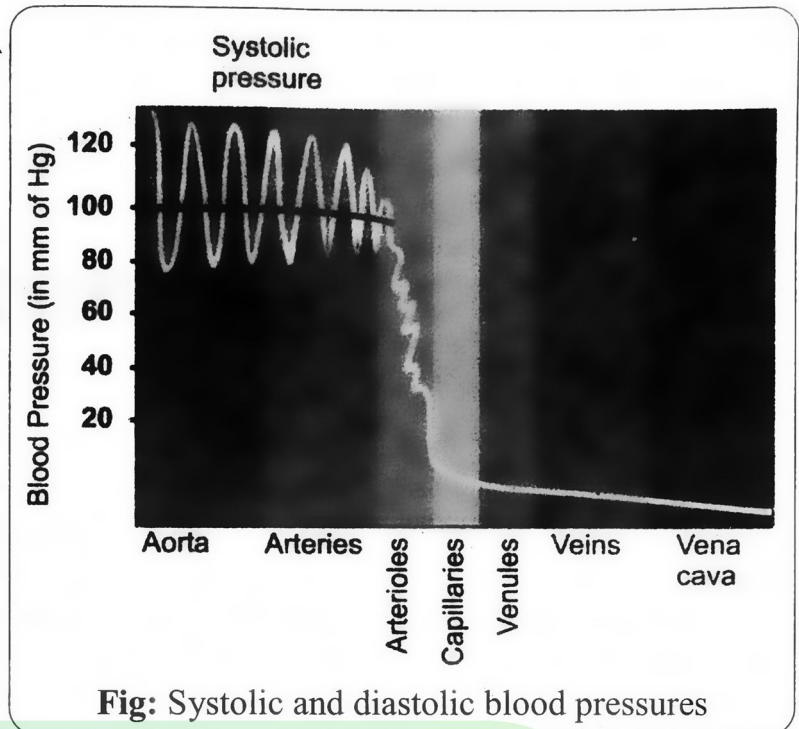


Fig: Systolic and diastolic blood pressures

more water in blood, excreting less in urine. It restores the blood volume and ultimately blood pressure. ADH also constricts arterioles, which raises arterial blood pressure.

Role of heart: The **walls of right atrium** contain endocrine cells that secrete **atrial natriuretic hormone** (ANH). When there is stretching of the atrium by an increased blood volume, the right atrium secretes ANH. It speeds up the excretion of salts and water through urine, which lowers the blood volume and pressure.

CARDIOVASCULAR DISORDERS

Q13. Briefly describe atherosclerosis, arteriosclerosis and thromboembolism in terms of causes and effects?

Ans.

1. Atherosclerosis

Atherosclerosis means deposition of materials within arteries.

Causes: Various materials may accumulate in arteries e.g., fatty materials, abnormal accounts of smooth muscle cells, cholesterol, fibrin and cellular debris of various kinds. All these build-ups impair the proper functioning of arteries. The accumulation of **cholesterol** is thought to be the prime contributor to atherosclerosis.

Effects: Atherosclerosis can lead to **heart attacks**, because it causes the **narrowing** of arteries and increases the risk of the formation of **thrombus (thrombosis)**.

2. Arteriosclerosis

Arteriosclerosis means **hardening of arterial** walls.

Causes: It occurs when calcium is deposited in arterial walls. The blood flows through these arteries is restricted and arteries cannot expand normally.

Effects: This forces the heart to work harder. Severe atherosclerosis usually leads to arteriosclerosis.

3. Thrombosis

Thrombosis is the **formation of thrombus**. Thrombus is a solid mass or plug of blood constituents (clot) in a blood vessel. This mass may block (wholly or only in part) the vessel.

Causes: Thrombus formation may be due to; (i) **irritation** or infection of lining of blood vessels, (ii) **reduced rate** of blood flow, due to long periods of inactivity, or (iii) **pneumonia**, tuberculosis, emphysema etc.

Effects: Thrombosis blocks the blood flow to organs. A thrombosis in coronary arteries causes heart attack. Similarly, a thrombus in the vessels of brain causes stroke.

A thrombus may be dislodged and carried to some other locations in the circulatory system.

★ Such a thrombus is called **embolus** and this phenomenon is called **thromboembolism**.

Q14. Describe the procedure of angiography in detail. / Which diagnostic tests are performed to locate cardiovascular diseases?

Ans. Various diagnostic tests are performed on cardiovascular patients to locate the exact problem and to measure the severity of disease. The important tests are **ECG** and **angiography**.

1. Angiography

- Coronary angiography is an **x-ray examination** of blood vessels or chambers of heart. In order to create the x-ray pictures, a physician guides a small tube-like device called

catheter through the large arteries of body. When the **tip of catheter** reaches the opening of coronary arteries, a **special fluid** (called a contrast medium or dye) is injected in catheter. This fluid is visible in x-ray machine.

- Pictures (**angiograms**) of fluid in coronary artery are obtained. If clots are present in the lumen of a coronary artery, the artery appears narrow.
- By changing the diagnostic catheter to a guiding catheter, physicians can also pass an instrument into coronary artery through the catheter. The most commonly used instruments are **guide wires** and **balloon dilation catheters**.



Fig: An angiogram showing blood flow in coronary arteries

Q15. Co-relate angina pectoris and heart attack (myocardial infarction). Write a note on angina pectoris, heart attack and heart failure.

Ans. Angina pectoris: Blockage of coronary arteries is usually due to **gradual build-up** of lipids (especially **cholesterol**) in the **inner wall** of coronary artery. If such conditions persist, chest pain, called angina pectoris can result during periods of stress or physical exertion. Angina indicates that oxygen demands are greater than its delivery and a heart attack may occur in future.

Myocardial infarction: Coronary arteries supply oxygen and nutrients to cardiac muscles. If **blood flow is blocked** in coronary arteries, it results in **insufficient supply of blood** to one or more parts of cardiac muscle. If heart **muscles die** due to supply of oxygen and nutrients, the condition is known as myocardial infarction (heart attack).

★ **Recovery from a heart attack** is possible if the damaged portion of heart is small enough that the other blood vessels in heart can enlarge their capacity and resupply the damaged tissues.

- If lifestyle changes and medication haven't relieved the symptoms or if the narrowed coronary arteries are at imminent risk of a heart attack, **coronary bypass surgery** or **angioplasty** is performed.

Q16. Define open heart surgery. Outline the main principles of coronary bypass, angioplasty and Stenting.

Ans. Open heart surgery

★ The **open or beating-heart surgery** is done when heart is still beating which include bypass surgery, valvular replacement, heart transplants etc.

1. **Coronary Bypass:** Open heart surgery is one of the most common and effective procedures to compensate the blockage of blood to cardiac muscles. In this surgery, surgeon takes a **healthy blood vessel** from leg, arm, chest or abdomen of the patient. He

attaches the ends of blood vessel above and below the blocked coronary artery. So, blood is bypassed around the damaged or blocked area.

Post-Operative care

Coronary bypass surgery doesn't cure the underlying disease process i.e., atherosclerosis or coronary artery disease, one should follow post-operative care to minimize its recurrence by making changes in lifestyles.

- **Lifestyle changes** especially **smoking cessation** is crucial to reduce the chance of future blockages and heart attacks, even after successful bypass surgery.

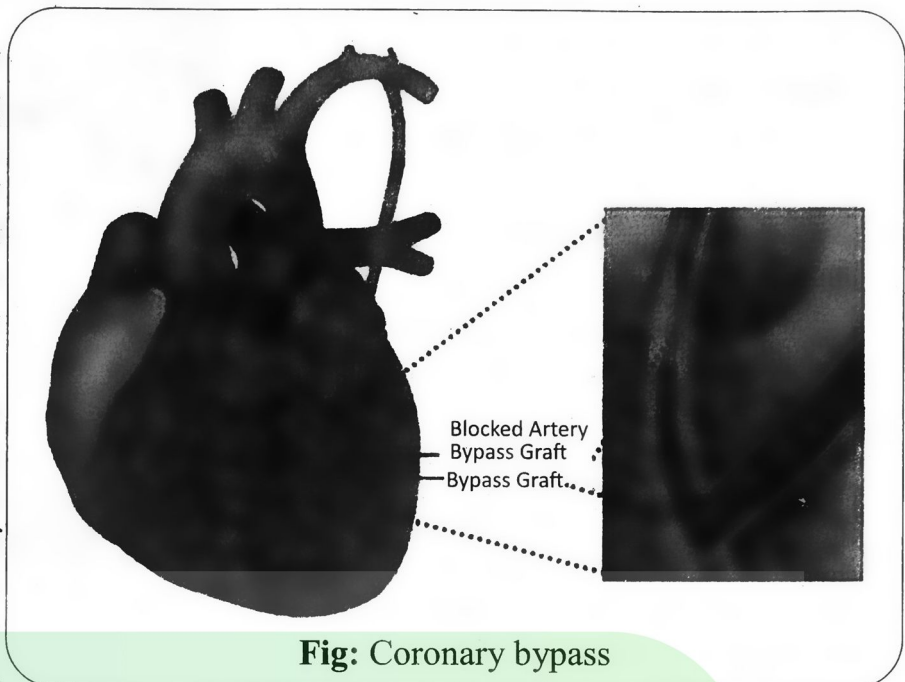


Fig: Coronary bypass

- **Reducing** certain types of **fat** in diet, increasing **physical activity**, and controlling **high blood pressure, diabetes** and other risk factors for heart disease.

2. **Angioplasty:** Angioplasty is an invasive procedure that **opens a blocked or narrowed artery**. During an angioplasty, a small wire called a **catheter**, under x-ray guidance, is passed through the narrowed coronary artery. A small sausage-shaped balloon is then advanced over the wire into the narrowed section of artery. The **balloon** is then **inflated** to dilate the narrowed section of the artery. Once the artery is dilated, a small amount of dye is injected to confirm the successful dilatation.

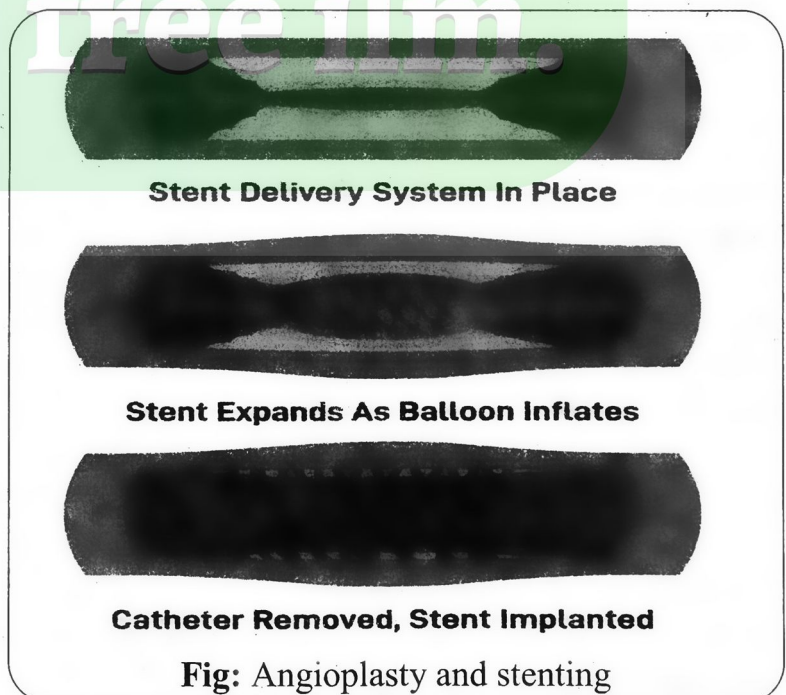


Fig: Angioplasty and stenting

3. **Stenting:** Stenting may also be done during angioplasty. A **stent** is an expandable stainless steel mesh tube, mounted on balloon catheter.

- When stent/balloon is positioned within the narrow artery, the balloon is inflated during angioplasty.

- The inflated balloon expands the stent and the artery. The balloon is removed and the stent remains in place. The stent supports the artery walls and keeps the artery open and dilated.

Q17. Define hypertension and describe the factors that regulate blood pressure and can lead to hypertension and hypotension. / Define hypertension and hypotension alongwith their causes. Describe the organ damage due to hypertension.

Ans. (A) Hypertension

It is a medical condition in which a person suffers from a chronic (long lasting) consistent elevated level of blood pressure above **140/90mmHg**.

Causes: Any **abnormality in nervous or hormonal** mechanisms of blood pressure regulation may cause hypertension.

- Other causes of hypertension include **stress, obesity, high salt intake, and smoking**.
- There may also be **hereditary reasons** of hypertension.

Organ Damage due to Hypertension

1. **Brain haemorrhage:** Whenever blood pressure is chronically elevated, there is an increased chance of the **rupture of blood vessels**. When this occurs in brain, it is called brain haemorrhage. It damages the delicate structure of brain leading to loss of functioning corresponding structures.
2. **Congestive heart failure:** Hypertension also weakens cardiac muscles. If hypertension is prolonged, heart is **unable to pump** effectively and blood flow cannot be maintained to meet needs of tissues. In such conditions, **blood may be retained in heart and lungs**. It is called congestive heart failure.
3. **Damage to kidneys:** Hypertension can also damage the nephrons of kidneys. It leads to further retention of salts and water in blood and therefore further accelerating hypertension.

(B) Hypotension: Hypotension or low blood pressure is a condition in which the force of blood against the walls of arteries falls below **90/60mmHg**.

Causes

- **Medical conditions:** e.g., bradycardia (slow heart rate), heart failure, valve disease.
- **Endocrine disorders:** Hypothyroidism, hypoglycaemia.
- **Blood loss:** Trauma, surgery, internal bleeding.
- **Dehydration:** from vomiting diarrhoea, insufficient fluid intake.

LYMPHATIC SYSTEM OF HUMAN

Q18. Describe the structure and role of lymph capillaries, lymph vessels and lymph ducts? / Describe the components, role and functions of lymphatic system.

Ans. Lymphatic System of Human

In humans, in addition to the blood circulatory system, there is another system responsible for the transport of materials. It also returns the materials from tissues to blood. This system is called **lymphatic system**.

Components of lymphatic system: It consists of lymph vessels, lymphoid masses, lymph nodes and lymph-the fluid which flows in the system.

Description of lymphatic system

Lymphatic system begins with small vessels called **lymph capillaries** which have blind endings in extracellular fluid (interstitial fluid). Pressure of the interstitial fluid forces it to enter into lymph capillaries.

- When interstitial fluid enters lymph capillaries, it is called **lymph**.
- Lymph capillaries join to form larger **lymphatic vessels** (or lymphatics or lymph vessels).
- Lymph vessels join to form larger **lymph ducts**. There are **two main lymph ducts** i.e., right lymphatic duct and thoracic duct. These vessels open into right and left **subclavian veins** (veins that drain blood from the arms and shoulder to the heart) respectively. The flow of lymph is always from body tissues **towards thoracic duct**.
- **Maintenance of lymph flow:** It is maintained by the activity of **skeletal muscles**, movement of **viscera** and **breathing** movements. The valves present in lymph vessels prevent the back flow of lymph.
- ★ The branches of lymph capillaries in villi are called **lacteals**. Fatty acids and glycerol are absorbed into the epithelial cells of villi where they form triglycerides. The triglycerides are coated with proteins to form **chylomicrons**, which enter the lacteals of villi.

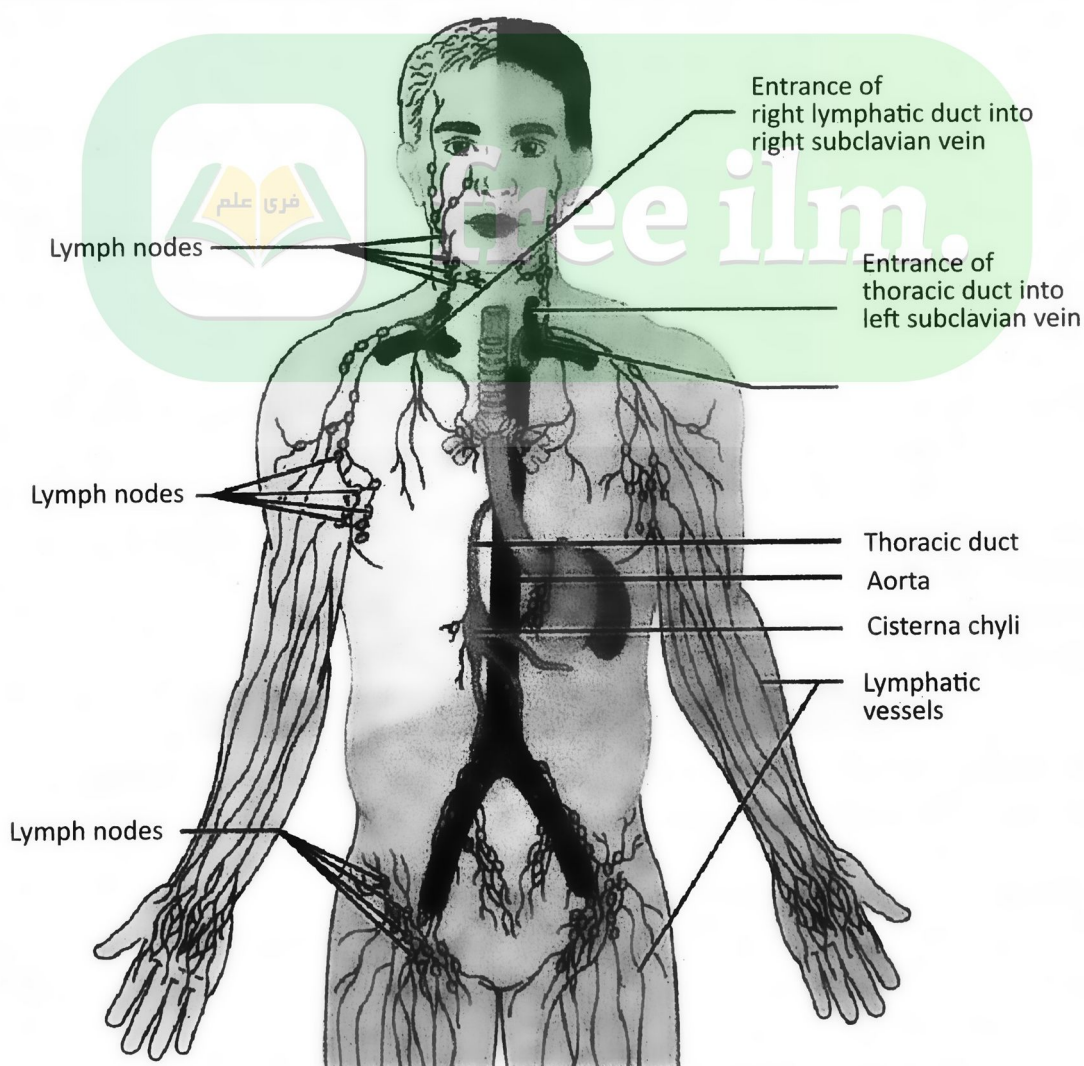


Fig: Human lymphatic system

Lymph Nodes

At certain spots, the lymph vessels have masses of connective tissue where lymphocytes are present. These are **lymph nodes**. Several **afferent lymph vessels** (which bring lymph towards node) enter a lymph node and the lymph is drained by a **single efferent lymph vessel** (which take lymph away from the node).

Lymph nodes are present in the neck region, axilla and groin areas of man.

Lymphoid masses: In addition to lymph nodes, several **lymphoid masses** are present in different areas e.g., in the mucosa and submucosa of **alimentary canal** (digestive system). The larger lymphoid masses are **spleen, thymus, tonsils** and **adenoids**. These produce lymphocytes (a type of WBCs).

Functions of the Lymphatic System

- Lymphatic system **returns the excess fluid** and dissolved proteins and other substances to blood.
- In an average person, about **three litres more fluid leaves blood capillaries** daily. But it is absorbed by lymphatic capillaries and **returned to bloodstream**, before the blood enters heart.
- Lymphatic system also helps to **defend body against foreign invaders**. Lymph nodes filter lymph. They have lymphocytes and macrophages that destroy bacteria and viruses present in lymph.
- **Spleen filters blood through** its macrophages and lymphocytes that destroy foreign particles and aged RBCs. Spleen also functions to store RBCs.

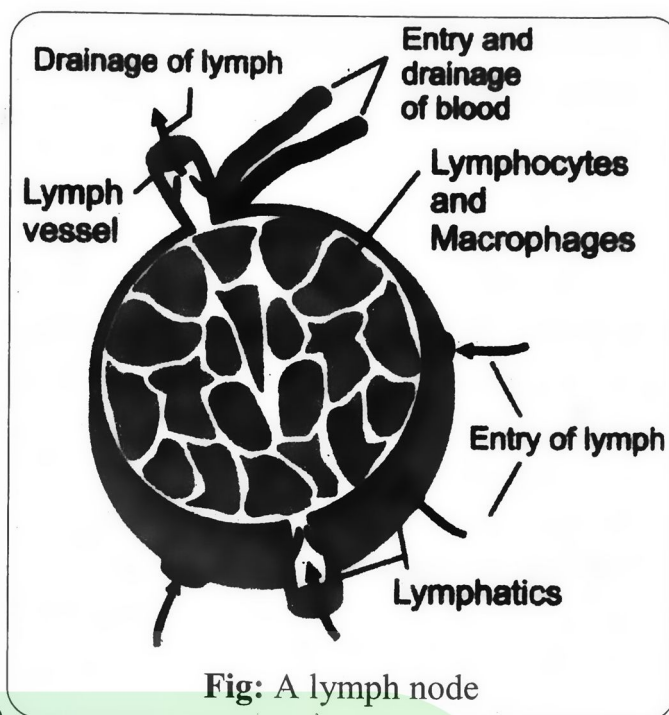


Fig: A lymph node