

Chapter = 12

Circulation

CIRCULATORY SYSTEM:

"The circulatory system is made up of blood vessel that carry blood away from heart and towards the heat this system carries oxygen, nutrients and hormones to cells & moves waste product like".

TYPES OF CIRCULATORY SYSTEM:

The blood circulatory system is basically of two types:

A- Open circulatory System.

B- Close circulatory System.



OPEN CIRCULATORY SYSTEM:

In open types circulatory system blood flow through the internal organ directly by Haemocoel cavity.

Example: Arthropodes, Molluscs & Tunicates animals.

CLOSED TYPE CIRCULATORY SYSTEM:

In this system blood flow in blood vessels and distinct from the interstitial fluid.

Example : Some Molluscs (Octopus) & verterbrates.

DIFFERENCE BETWEEN OPEN CIRCULATORY SYSTEM AND CLOSED TYPE CIRCULATORY SYSTEM:

| OPEN TYPE CIURCULATORY SYSTEM | CLOSED TYPE CIRCULATORY SYSTEM |
|--|--|
| It is type of circulatory system where hemolymph bath the organs and tissues directly. | It is type of circulatory system where blood circulatory with in closed vessels. |
| Body tissues in direct contact with blood (hemolymph) | Body tissues are not in direct contact with blood. |
| Blood flow at low pressure. | Blood flow at high pressure. |
| Respiratory pigments are absent (hemolymph). | Respiratory pigment (Haemoglobin) is present in blood. |
| The blood directly pumped into the body cavity. | The blood is pumped by heart through the vessels. |
| Arthropods & Molluscs. | Annelids, Echinoderms, vertebrates. |

KINDS OF CLOSE TYPE CIRCULATORY SYSTEM:

Close type of circulatory system either two types:

- i. Single circuit circulation.
- ii. Double circuit circulation.

SINGLE CIRCUIT CIRCULATION:

In single circulation, the blood pumped by heart to the gills for oxygenation, the blood from the gills receive oxygen, & then it is supplied to the body, now deoxygenated blood back to the heart.

Example: Birds, Fish, Reptiles have single circulatory system.

DOUBLE CIRCUIT CIRCULATION:

In double circulation, heart receive oxygenated blood from lungs & supplied to all parts of body. It is called systemic system. From body deoxygenated blood is carried back to the heart, which pumps into lungs for oxygenation, it is called pulmonary system. This circuit is called double circuit plan. There are types of double circuit circulation.

a) INCOMPLETE DOUBLE CIRCULATION:

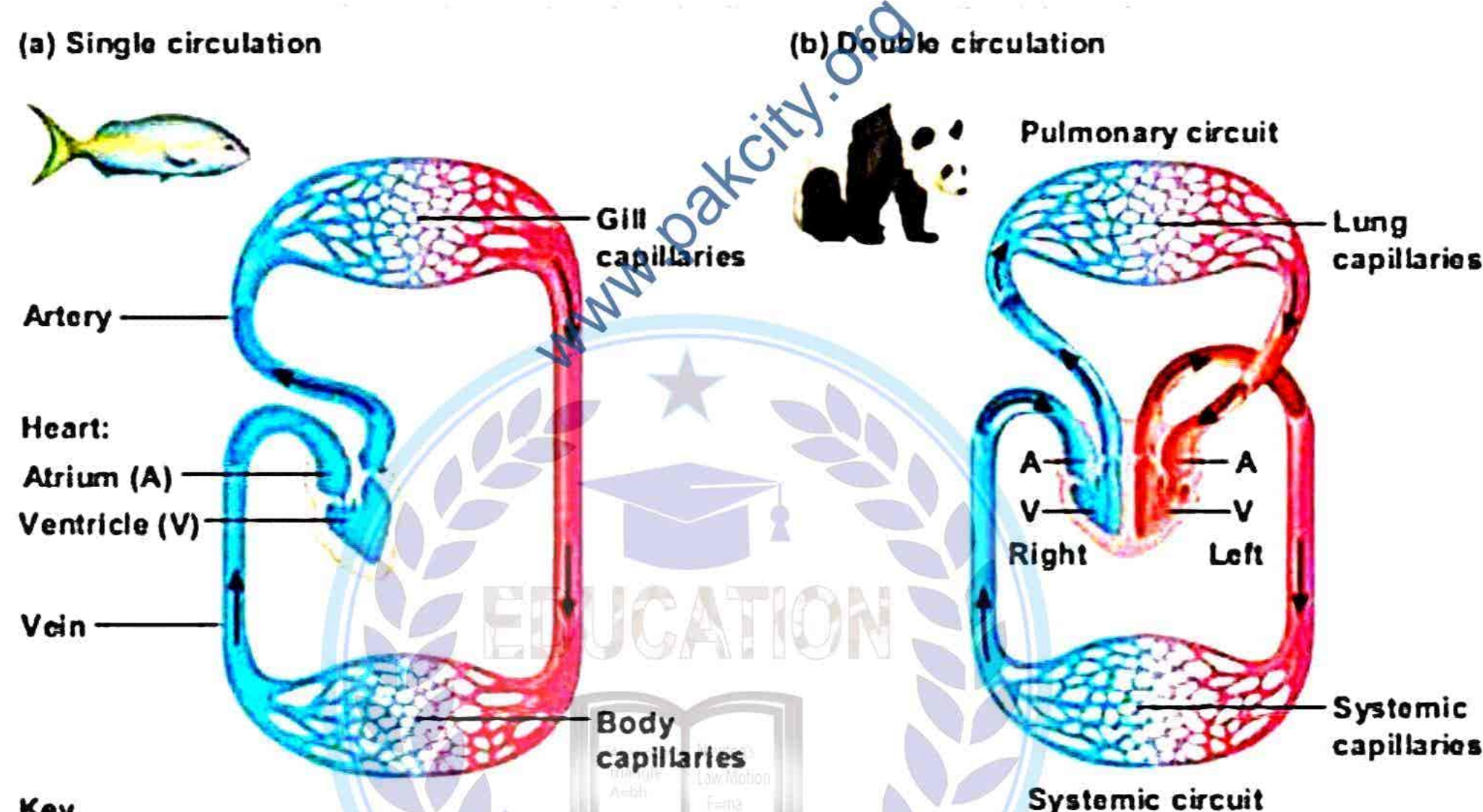
In amphibians and reptiles the heart consist of two atria & one ventricle. i.e. three chambered heart. The left atrium receive oxygenated blood from lungs & right atrium receive deoxygenated blood from different parts of the body.

The deoxygenated blood remain separate in atrium but when both blood enter in ventricle they are mixed together, this circulation is called incomplete double circulation.

b) COMPLETE DOUBLE CIRCULATION:

In birds and mammals the heart consist of two atria & two ventricles i.e. (Four chambered) heart. The left atrium receive oxygenated while right atrium receive deoxygenated blood from body.

The deoxygenated & oxygenated remain separate in atrium & when both blood enters in ventricles they remain quite separate from each other. This circulation is called Complete double circulation.



DIFFERENCE BETWEEN SINGLE CIRCUIT CIRCULATION AND DOUBLE CIRCUIT CIRCULATION

| SINGLE CIRCUIT CIRCULATION | DOUBLE CIRCUIT CIRCULATION |
|--|---|
| Blood flows through the heart only once. | The oxygenated blood from the lungs and deoxygenated blood from the body follow separate path without mixing up & flow twice through the heart. |
| Venous heart, as it receive only deoxygenated blood. | Arteriovenous heart, as it receive both oxygenated & deoxygenated blood. |
| Blood pressure is slow & pressure is slow. | Blood flow is fast & pressure is high. |
| Metabolic rate is low. | Metabolic rate is fast. |
| Fish, Birds, Reptiles. | Amphibians, Mammals. |

GENERAL CHARACTER OF CIRCULATORY SYSTEM:

All circulatory systems have three major components.

1. A fluid, blood that serves as a medium of transport.
2. A system of channels or vessels that conduct the blood throughout body.
3. A pump, the heart or modified blood vessel that keeps the blood circulating.



HUMAN HEART:

LAYERS OF HEART WALL:

Heart is hollow muscular organs present in the thoracic cavity. It is enclosed in double layer membrane, called pericardium. Its outer layer is parical layer (fibrous pericardium) & inner layer is visceral layer (Serous Layer) between these layers is a space which filled with a fluid called (Pericardial) fluid, which protect the heart from external jerks Pericardium is of three types:

Epicardium: It is outer layer of the wall of heart and formed by visceral layer.

Myocardium: It is muscular middle layer & its has excitable tissues and conducting system.

Endocardium: It is middle connecting Layers a Subendocardial layer.

The nest of heart composed of Subepicardial & Subendocardial Layers.

STRUCTURE OF HEART:

The heart of man consist of four chambered.

i. The heart of man consist of four chambers:

- a. Right Auricle.
- b. Left Auricle.
- c. Right Ventricle.
- d. Left Ventricle.

Right Auricle:

- i. It is an anterior part of heart and separated from left auricle by septum called inter-atrial septum.
- ii. It receives deoxygenated blood from precava and post cava.
- iii. The right auricle open into the right ventricle by an aperture called 'right atrial ventricula aperture'.
- iv. This aperture is guarded by tricuspid valve, which prevent the backward flow of blood.

Left Auricle:

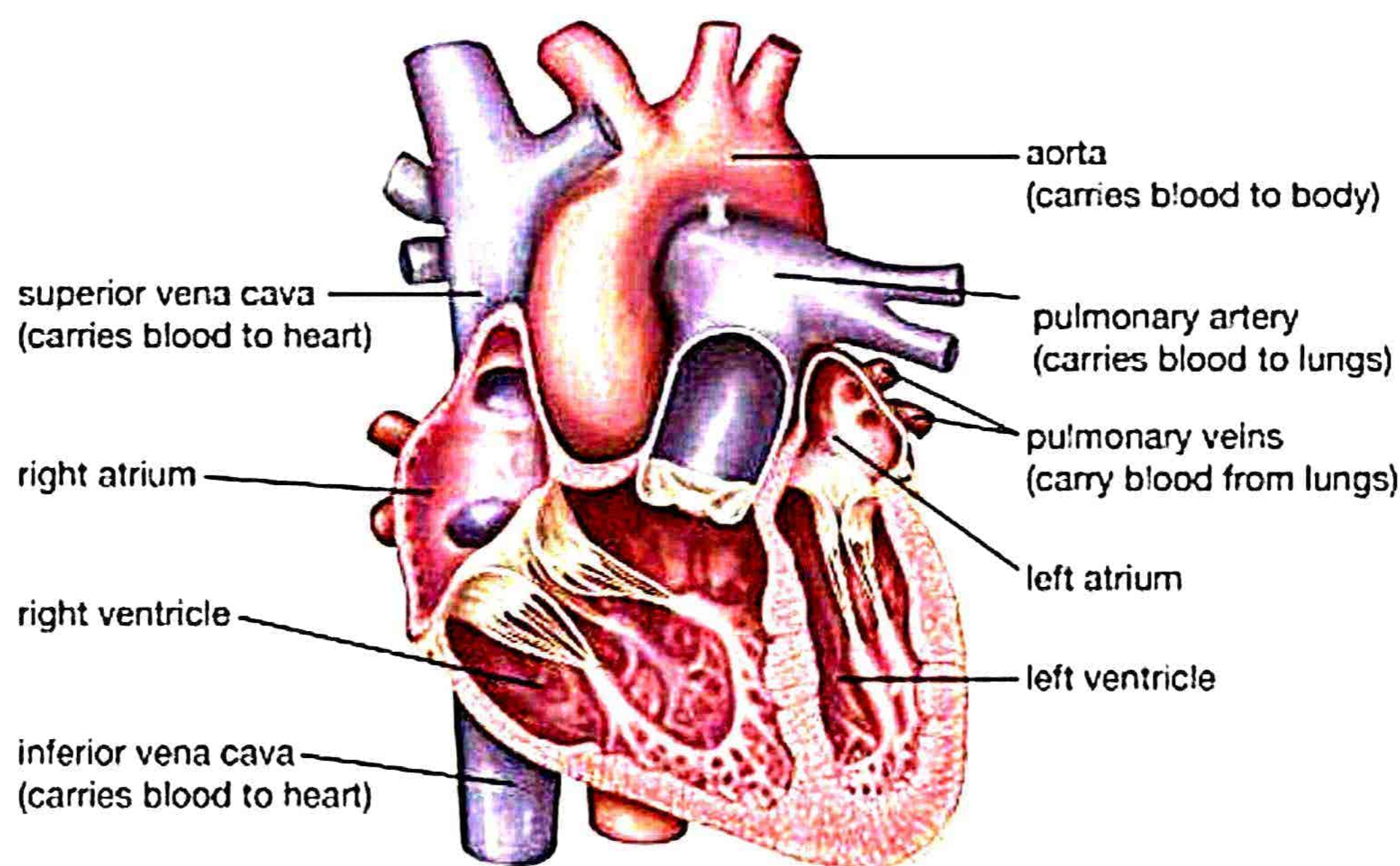
- i. It receive oxygenated blood from pulmonary vein which comes from lungs.
- ii. The left auricle open into the left ventricle by an aperture called 'left atrial ventricular aperture'.
- iii. This aperture is guarded by bicuspid valve which also prevent the backward flow of blood.

Right Ventricle:

- i. It is the posterior part of heart.
- li. Internally the walls of ventricles are attached to this and known as chordate dentine.
- lii. The dentine control the movement of valve.
- iv. Right ventricle transfer deoxygenated blood through pulmonary artery to the lungs.
- v. Its openings are controlled by semilunar valve.

LEFT AURICLE:

It receives oxygenated blood transfer through systemic arch to different parts of body.



PHASES OF HEART B:

- The heart work in a systematic way & Myogenic muscles involve the contraction of heart called heart beat.
- The alternating contracting and relaxation of heart beat is called Cardiac cycle. The period during which chambers of heart contract is called Systole & period during which chambers show expansion called diastole.
- When right atrium diastole it receive deoxygenated blood from different parts of body through venacava, while left atrium diastole receives oxygenated blood from lungs.
- When atria full of blood, they contract & transfer blood to both ventricles, this is called atrial systole.
- Right ventricle receive deoxygenated & left receive oxygenated blood. Now both ventricles contract at same time, it is called ventricular Systole.
- Normal resting heart rate of systole is 0.3 second & diastole about 0.5 second. A normal heart about 72 time in one minute, & the heart beat called heart sound.

LUB-DUB:

- During heart beat when the ventricles show systole, blood is forced against the closed atrioventricular valves, it produce first heart beat sound called LUB.
- After systole ventricles diastolic movement & in the pulmonary and systemic aorta high pressure is develop, it close the valve of both aorta, this process produce second sound called DUB.

SINO ARTRIAL MODE (S-A NODE):

- It is the specific region at the upper end of right atrium, close to the point entry of superior cava, called Sino atrial node (S-A Node)
- It produce electrical impulse and stimulates contraction of heart.
- The S-A Node takes part to start heart beat, so it is called Pace maker, It help in the contraction of atria by producing the wave of excitation, & also stimulates next wave of excitation.

ATRIO-VENTRICULAR NODE (A-V NODE):

- It is a region present in the right atrium just below SA Node.
- The excitation of A- V node are tranfered to ventricles by two bundles of muscles fibers, called bundle of His.

- These fibers connected to the wall of ventricle.
- The impulses are also propagated through a network of fibers called purkinji fibers By this excitation two ventricles contract.
- In the conduction of S-A Node & A Vinode delay of 0.15 second, so atrial systole is completed before ventricular systole.

BLOOD VESSELS:

The vessels through which blood flows area called vessels. These vessels carry blood from heart to body organs and bring back the blood from body parts to the heart.

The blood vessels are of two types:

- Arteries.
- Veins.



ARTERIES:

- Arteries transport blood away from the heart to the various parts of the body through capillaries.
- All arteries carry oxygenated blood except pulmonary artery.
- There are no valves in them except at the base of pulmonary trunk.
- Arteries have a high blood pressure.
- Wave of blood pressure or pulse due to heartbeat can be detected.
- Blood flow rapidly 400-500 mm per second in aorta and decreasing in arteries are asteroids.
- They have smaller bore and thick wall.
- Thick muscles layer and elastic fibers are present. The elasticity helps changing the pulsating flow of blood.
- Arteries consist of three layers. The outer layer is tunica externa, the middle layer is tunica media and inner layer is tunica interna.

VEINS:

- Collect blood from body through capillaries and transport towards heart.
- All veins carry deoxygenated blood except pulmonary veins.
- Valve are present only below the heart region of the body. These prevent the backward flow.
- Have a low blood pressure.
- No pulse.
- Rate of blood flow increases from smaller to larger one.
- Have larger bore with thin walls.
- Less elastic due to thin muscles.
- No exchange material.

CAPILLARIES:

- It link arteries with veins.
- These have a mixed oxygenated and deoxygenated blood.
- There are no valve.
- Falling pressure in these.
- No pulse.
- Blood flow slowest less than 1mm per second.
- Large bore wall with one cell thickness.
- No muscles of elastic fibers.
- Responsible for exchange of materials.
- The capillaries are externally narrow (7-9 μ in diameter).

STRUCTURE & FUNCTION OF VESSELS

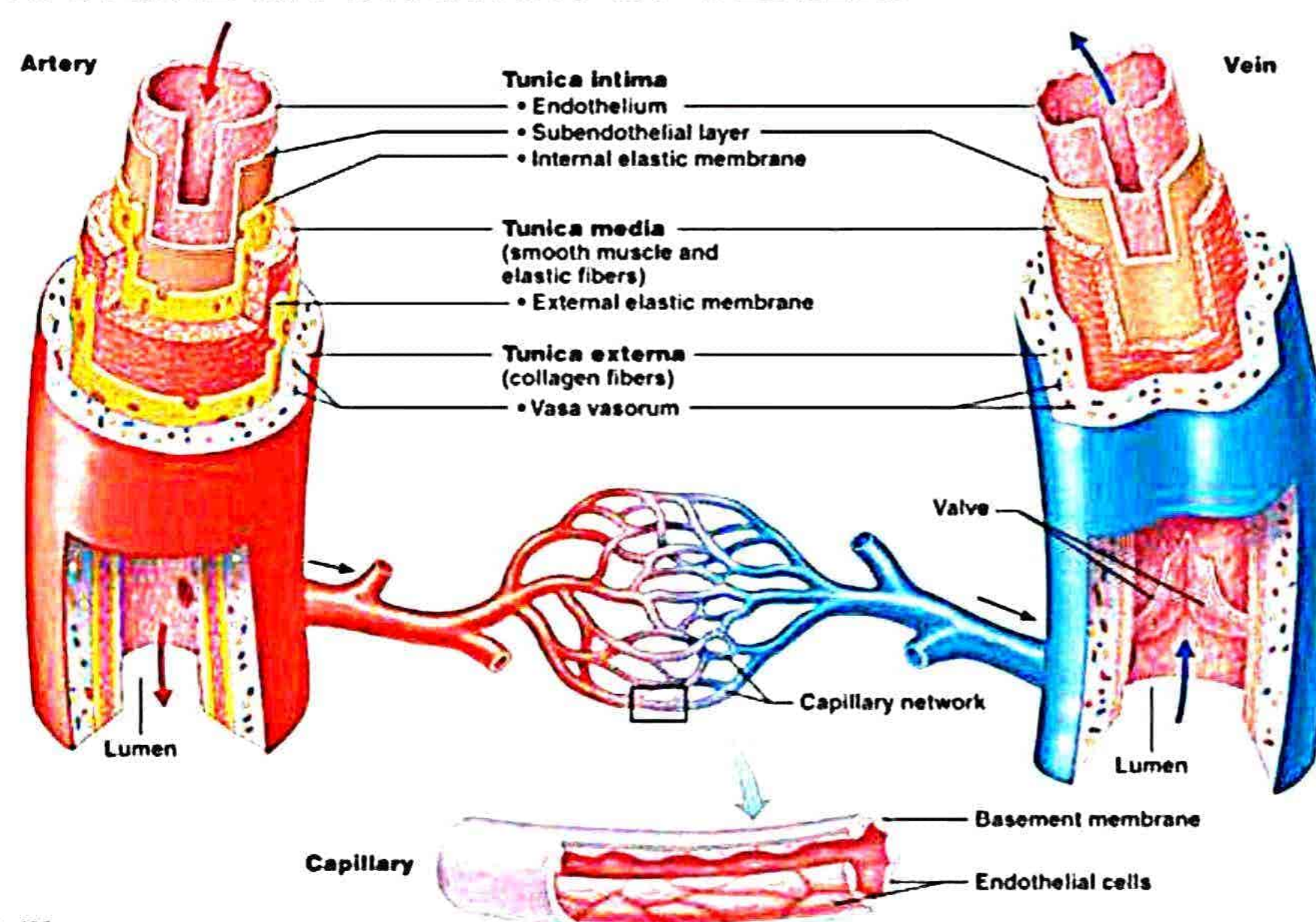


Fig 19.2

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CARDIO VASCULAR DISORDERS (CVD):

Disease of heart, blood vessels & blood circulation are generally termed as "Cardio-Vascular disorders.

Some of these disorders are as follow:

i) ATHERO SCLEROSIS:

Atherosclerosis is the disorder of blood vessels in which arterial wall (Intima) Loss its elasticity & the inner wall of arteries become narrow.

- The narrowing of blood vessels due to the formation of fatty lessons called atheromatous plaques.
- In such condition flow of blood is disturbed.
- These plaque consist of low density lipoprotein (LDL).

CAUSES:

The causes of atherosclerosis are:

- Smoking .
- Hypertension.
- male gender.
- Obesity.
- High cholesterol level in serum.
- Severe diabetes.
- Physical inactivity.
- Anxious or aggressive personality.
- Age factor.

ii. THROMBOUS FORMATION:

- The clotting of blood in the blood vessels is called thrombus formation, & the main cause is atherosclerotic plaque.
- These plaque damage the iner layer endothelium of blood vessels & initiate the process blood clot (Thrombous or embolous).
- By continuous process the inner cavity (Lumen) become narrow or blocked.

- This can reduce blood flow, & when it become stuck and severely blocks the flow of blood, this condition is called embolism.

HYPERTENSION:

- When the blood pressure is higher than the normal blood pressure, it is called hypertension.
- Under resting condition for women the mean arterial pressure is greatest than 160/95 or above, & for man 140/95 above is consider as hypertensive.
- It is consider as silent killer, continuous high blood pressure damages the lining of blood vessels, so heart muscles become weak, & its function become affected.



CAUSES:

Use of high amount of salts in food.

*Hereditary factor *Obesity * Smoking * Disorder of kidneys or adrenal glands

HYPOTENSION:

When mean arterial blood pressure lower than 90/60, it is consider Hypotensive. * Symptoms of flow blood pressure are fatigue, dizziness, nausea and lightheadness.

HEART PROBLEMS:

Cardio vascular disorders related to heart are called heart problems, some disorder are as follow.

ANGINA PECTORIS:

- Shortening, thickening & lengthening of the myocardium (Strain) on the heart may enlarge the heart & increasing resistance to blood flow.
- Heart muscles poorly supplied with blood; During exercise, Lack of sufficient oxygen to the heart can cause chest pain & move this pain in left arm, this condition is called Angina pectoris.

HEART ATTACK (MYOCARDIAL INFRACTION):

- When the blood vessels of heart are blocked either by thrombus or embolus.
- It causes death of the part of heart & continuous chest pain. It is called Myocardial infraction, commonly known as heart attack.

HEART FAILURE:

If heart do not supply proper blood to different organs of the body. This condition is identified as Heart failure.

CAUSES:

*Coronary artery disease *High blood pressure * High (LDL) cholesterol *Smoking *Diabetes.

CONGENITAL HEART PROBLEM:

The problem in structure of heart present from birth is called congenital heart problem.

- Baby with (Cyanosis) (blue baby), or rapid breathing, rapid heartbeat, heart wall & blood vessels are affected.

ANGIOGRAPHY:

Angiography is used to image of blood flow in vascular system by X-rays imaging.

- This technique is useful to locate blockage in the blood vessels.

TREATMENT OF CARDIOVASCULAR DISORDERS:**CORONARY BYPASS:**

Coronary artery bypass surgery creates a new path for blood to flow around blocked or partially blocked artery in the heart.

- In this surgery healthy vessel are taking from the chest or leg area. The vessel is connected below the blocked heart artery, & new pathway improves blood flow to the heart muscle.

ANGIO PLASTY:

- A medical procedure used to improve the blood flow through narrowed artery.
- A long thin tube (Catheter) is placed into blood vessel & balloon is used to stretch open a narrowed a blocked artery. The blood vessel should open & allow a healthy blood flow.

OPEN HEART SURGERY:

- It is a surgical procedure in which breast bone cracked open & providing direct access to heart.
- This surgery provide close monitoring & Immediate post operative support.

LYMPHATIC SYSTEM:

- Lymph is a tissue fluid, passes out from the walls of capillaries into the space surrounding the cells.
- It is obtained from the blood plasma, It is colorless & without protein.
- The lymph passes through a system of blind vessels called Lymphatic vessels & they form separate network & form Lymphatic System.

COMPONENTS:

- In addition to lymphatic vessels and lymph, this system also consist of lymph nodes, spleen, thymus, tonsils and some tissues of appendix and small intestine.

LYMPHATIC VESSELS:

A thin tube that carries lymph and white blood cells through the lymphatic system is called lymphatic vessels.

- It drains fluid (Lymph) that has leaked from the empties it back into the blood stream via Lymph node.

LYMPH NODES:

At certain point the lymph vessels contain special masses of connective tissues called Lymph node.

- In these nodes Lymphocytes are present. Many lymphatic vessels carry the Lymph into the Lymph node, when Lymph is filtered through the Lymph node the Lymphocytes & macrophages present here neutralized and kill microorganism.

LACTEALS:

Within the villi of small intestine Lymph vessels are called Lacteals.

- After absorbing digested fats, intestinal cells release fat globules, these globules do not diffuse in blood but can easily flow through lymph vessels called Lacteals. About 1% Lymphatic fluid produce from these globules.

FUNCTION OF LYMPHATIC SYSTEM:

The lymphatic system performs the following functions:

i. Drainage System:

The lymphatic vessels take part in the returning of water and plasma proteins back to the blood stream, which have leaked away from blood. Otherwise death may occur in 24 hours.

ii. Defence of the Body:

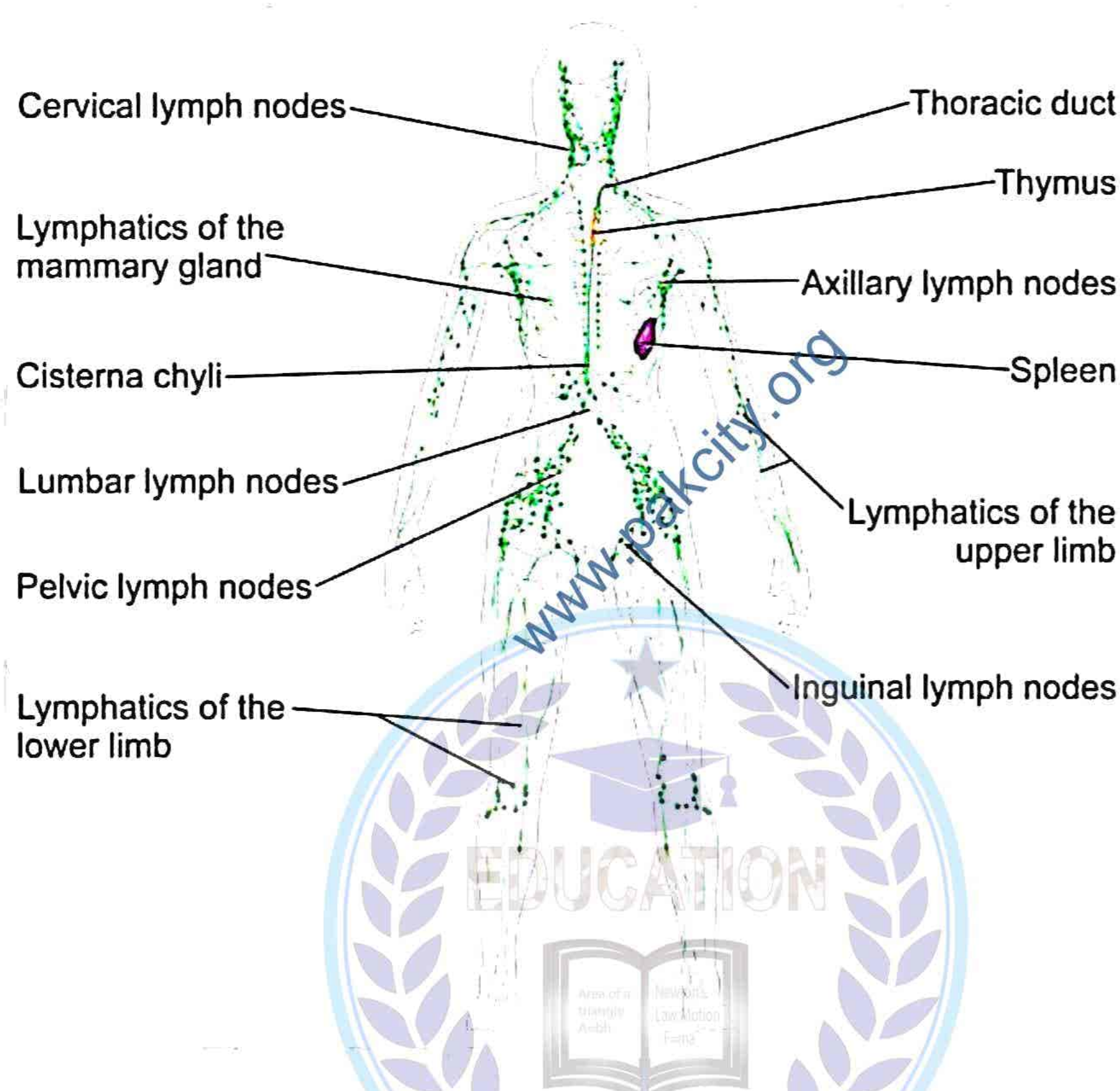
The lymphatic system helps to maintain the body resistance. The micro- organisms, foreign bodies and broken cells are removed by macrophages, found in the lymphatic nodes.

iii. Absorption and Delivery of Fats:

The lacteals of villi absorb digested fats, which are changed into droplet, after that these fats are returned back to the blood.

iv. Bathing of Tissues:

The lymphatic vessels bath the tissues and keep them moist.



BLOOD PRESSURE:

"The hydrostatic force of blood exerted on the wall of vessels is called Blood Pressure".

- Blood pressure is measured with Sphygmomanometer.
- Blood pressure is produced by ventricle Systole.
- The blood pressure is determined by cardiac output and by the diameter of arterioles.
- When constriction takes place in the walls of arterioles, when constriction takes place in the walls of arterioles. It is called vasoconstriction. It rises blood pressure.
- When the walls of arterioles are dilated, it is called Vasodilation. It falls the blood pressure.
- In normal healthy person during systole of ventricles is about 120mmHg & during diastole is about 80mmHg high.
- The difference b/w systolic & diastolic pressure is called pulse pressure.

BARORECEPTORS:

They are mechanoreceptors allowing relay information developed from blood pressure within autonomic nervous system.

There are two types of baroreceptors.

HIGH-PRESSURE ARTERIAL BARORECEPTORS:

They sense blood pressure & relay information to the nervous system and maintain proper blood pressure.

LOW-PRESSURE VOLUME BARORECEPTORS:

They are found in large veins and in the walls of atria of the heart, they involved to regulate the blood volume.

REGULATION OF BODY TEMPERATURE IN HOT & COLD WEATHER:

On the hot summer days arterioles in skin expand (Vasodilation) and supply more blood to skin capillaries to release heat to the outside and maintain body temperature. In cold days capillaries contract & maintain temperature inside the body that's why finger & toes can become frostbitten.

PRE-CAPILLARY SPHINCTER:

"They are the band or ring of smooth muscles, surrounds the junctions b/w arterioles & regulates the blood flow into capillaries".

FUNCTIONS (REGULATING BLOOD THROUGH CAPILLARIES):

- They are located at the junction of arterioles & open & close in response of local changes.
- When CO₂ lactic acid or other waste material accumulated in tissues they signal to increase blood flow. These signals produced by sphincter to increase blood flow through capillaries, & muscles become relaxed.

VASCULAR PATHWAY:

The vascular or circulatory system is made up of vessels that carry blood & lymph through the body.

It includes two major pathways.

- Pulmonary circulation.
- Systemic Circulation.

PULMONARY CIRCULATION:

- In pulmonary circulation first deoxygenated blood from whole body collect in the right atrium and then right ventricles which pump this deoxygenated blood into pulmonary subaorta to the lungs.
- Now blood oxygenated in lungs & return to the atrium through pulmonary veins.

SYSTEMIC CIRCULATION:

- Systemic circulation carries oxygenated blood from left ventricle by aorta & vena cava to the capillaries in the tissues of the body.
- Systemic consist of three major circuits.
 - Coronary circulation.
 - Hepatic circulation.
 - Renal circulation.

CORONARY CIRCULATION:

These arteries supply blood to the wall of the heart (Myocardium).

- They are present just above the surface of heart & divided into small arterioles & capillaries where they supply blood to venules & then cardiac veins & finally pour blood into right atrium.

HEPATIC PORTAL SYSTEM:

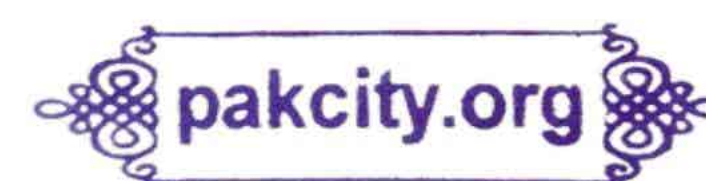
- This circulation found b/w small intestine and liver & begins and ends in capillaries.
- Blood from villi combine with hepatic portal vein & now this vein take blood from liver & pour into inferior vena cava of heart.



RENAL CIRCULATION:

- These are arteries axis from abdominal aorta enter into kidney & divided into branches which pass through medulla of kidney.
- Now from medulla they enter into cortex then glomerular & from here blood enter in the peritubular capillaries & vasa recta.
- From these network of capillaries the blood is drained through vein & leave the kidney in the form of single renal vein & finally empties into inferior vena cava of heart.



SHORT QUESTION & REASONS:**Q#1: Why double circulation is better than single circulation?**

Double circulation is better than single circulation b/c it supply blood with more O₂ to tissues and there is no change of mixing oxygenated and deoxygenated blood. Further more, double circulation take more energy and body remain more efficient.

Q#2: Why higher animals need circulatory system?

All living cell needs oxygen, nutrients and hormones and removes waste products like CO₂. In unicellular and lower multicellular organisms it is done by simple diffusion because all cells are in direct contact with the environment but in higher multicellular it is difficult to transport substances through the simple diffusion. Large, multicellular organisms have cells that are not in direct contact with the environment. A circulatory system is required to serve these functions.

Q#3: Why SA node is called pace maker of heart?

The S-A Node takes part to start heartbeat, so it is called Pace maker, It help in the contraction of atria by producing the wave of excitation, & also stimulates next wave of excitation.

Q#4: What are LUB and DUB sound?

During heart beat when the ventricles show systole, blood is forced against the closed trioventricular valves, it produce first heart beat sound called LUB.

After systole ventricles diastolic movement & in the pulmonary and systemic aorta high pressure is develop, it close the valve of both aorta, this process produce second sound called DUB.

Q#5: Why blood flow faster in arteries?

Blood flows faster in arteries because arteries have thick smooth muscle and connective tissue than the veins to handle or manage the higher blood pressure and speed of newly pumped blood. The veins are thin walled as the pressure and rate of flow are much lower.

Q#6: What is pulmonary circulation? Explain.

Pulmonary circulation is a type of blood circulation responsible for carrying deoxygenated blood away from the heart, and to the lungs, where it is oxygenated. The system then brings oxygenated blood back to the heart to be pumped throughout the body.

Q#7: Define systemic circulation.

In systemic circulation, the heart pumps the oxygenated blood through the arteries to every organ and tissue in the body, and then back again to the heart through a system of veins.

Q#8: Elaborate on coronary circulation and its significance.

The heart is a muscle, and it needs a constant supply of oxygenated blood to survive and work effectively. This is where coronary circulation fulfils this function through a network of arteries and veins in the heart. The coronary arteries supply oxygenated blood to the heart, and the cardiac veins drain the blood once it has been deoxygenated by the tissues of the heart.

Q#9: What is pericardium? Explain its function.

The pericardium is a fibrous membrane that envelops the heart. It also serves a protective function by producing a serous fluid, which lubricates the heart and prevents friction between the surrounding organs. Furthermore, the pericardium also holds the heart in its position and provides a hollow space for the heart to expand and contract.



Q#10: Explain the three layers of the heart wall.

The heart wall is made up of 3 layers, namely:

Epicardium: It is outer layer of the wall of heart and formed by visceral layer.

Myocardium: It is muscular middle layer & it has excitable tissues and conducting system.

Endocardium: It is middle connecting layers a Subendocardial layer.

The nest of heart composed of Subepicardial & Subendocardial layers.

Q#11: Explain the three major blood vessels of the human body.

The blood vessels comprise:

- **Veins** - It supplies deoxygenated blood to the heart via inferior and superior vena cava eventually draining into the right atrium.
- **Capillaries** - They are minuscule, tube-like vessels which form a network between the arteries and veins.
- **Arteries** - These are muscular-walled tubes responsible for supplying oxygenated blood away from the heart to all other parts of the body.

Q#12: What is the function of the heart valves? Provide examples of various valves.

Valves are flaps of tissues that are present in cardiac chambers between the veins. They prevent the backflow of blood. Examples include the atrioventricular valves, tricuspid valves, mitral valves and the semilunar valves.

Q#13: What is meant by myocardial infarction?

When the blood vessels of heart are blocked either by thrombus or embolus.

It causes death of the part of heart & continuous chest pain. It is called Myocardial infarction, commonly known as heart attack.

Q14: Why capillaries have single layer of endothelium?

The capillaries are single layer of endothelium, due to which very little resistance to the diffusion of dissolved substance in or out side.

Q15: Why circulatory system of arthropods is called open type?

In arthropods & molluscs blood flow in haemocoel cavity & directly bathes the internal organ, blood is supplied directly to body tissues, that's why their circulatory system is called open type circulatory system.

Q#16: How pre-Capillaries sphincter help to relax muscles when they are fatigue?

When CO₂ lactic acid or other waste material accumulated in tissues they signal to increase blood flow. These signals produce by sphincter to increase blood flow through capillaries, & muscles become relax.

Q#17: What are the two major circulation pathways of blood?

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Systemic consist of three major circuit.

- i. Coronary circulation
- ii. Hepatic circulation
- iii. Renal circulation.

Q#18: Write down the general characteristics of circulatory system?

GENERAL CHARACTER OF CIRCULATORY SYSTEM:

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3. A pump, the heart or modified blood vessel that keeps the blood circulating.

