

(vi) Blood Vessels

Blood Vessel definition: The blood vessels are part of the circulatory system and function to transport blood throughout the body. The most important types, arteries, veins and capillaries, carry blood away from or towards the heart, respectively. All blood vessels have the same basic structure.

Structure: The central opening or cavity of a blood vessel, the lumen, is surrounded by a wall consisting of three layers:

Tunica intima: It is the inner layer facing the blood. It is composed of an innermost layer of endothelium (simple squamous epithelium) surrounded by variable amounts of connective tissues.

Tunica media: The middle layer, is composed of smooth muscle with variable amounts of elastic fibers.

Tunica adventitia or externa: The outer layer, is composed of connective tissue serosa, areolar tissues, elastic tissues, nerves and vasa vasorum in case of large vessels i-e large arteries (aorta) & veins (venacava).

The cardiovascular system consists of three kinds of blood vessels that form a closed system of passageways:

Artery: It carry blood away from the heart. The three kinds of arteries are categorized by size and function:

- i. Elastic arteries (conducting arteries) are the largest arteries and include the aorta and other nearby branches. The tunica media of elastic arteries contains a large amount of elastic connective tissue,

which enables the artery to expand as blood enters the lumen from the contracting heart. During relaxation of the heart, the elastic wall of the artery recoils to its original position, forcing blood forward and smoothing the jerky discharge of blood from the heart.

- ii. Muscular arteries (conducting arteries) branch from elastic arteries and distribute blood to the various body regions. Abundant smooth muscle in the thick tunica media allows these arteries to regulate blood flow by **vasoconstriction** (narrowing of the lumen) or **vasodilation** (widening of the lumen). Most of the arteries in the body are muscular arteries.

Arterioles: Arterioles are small, nearly microscopic blood vessels that branch from muscular arteries. Most arterioles have all three tunics present in their walls, with considerable smooth muscle in the tunica media. The smallest arterioles consist of endothelium surrounded by a single layer of smooth muscle. Arterioles regulate the flow of blood into capillaries by vasoconstriction and vasodilation.

Capillaries: These are microscopic blood vessels with extremely thin walls. Only the tunica intima is present in these walls, and some walls consist exclusively of a single layer of endothelium. Capillaries penetrate most body tissues with dense interweaving networks called capillary beds. The thin walls of capillaries allow the diffusion of oxygen and nutrients out of the capillaries, while allowing carbon dioxide and wastes into the capillaries.

Below is a list of the different types of capillaries:

- Meta arterioles (precapillaries) are the blood vessels between arterioles and venules. Although meta arterioles pass through capillary beds with capillaries, they are not true capillaries because meta arterioles, like arterioles, have smooth muscle present in the tunica media. The smooth muscle of a meta arteriole allows it to act as a shunt to regulate blood flow into the true capillaries that branch from it. The thoroughfare channel, the tail end of the meta arteriole that connects to the venule, lacks smooth muscle.
- True capillaries form the bulk of the capillary bed. They branch away from a meta arteriole at its arteriole end and return to merge with the meta arteriole at its venule end (thoroughfare channel). Some true capillaries connect directly from an arteriole to a meta arteriole or venule. Although the walls of true capillaries lack muscle fibers, they possess a ring of smooth muscle called a precapillary sphincter where they emerge from the meta arteriole. The precapillary sphincter regulates blood flow through the capillary. There are three types of true capillaries:
- Continuous capillaries have continuous, unbroken walls consisting of cells that are connected by tight junctions. Most capillaries are of this type.
- Fenestrated capillaries have continuous walls between endothelial cells, but the cells have numerous pores (fenestrations) that increase their permeability. These capillaries are found in the kidneys, lining the small intestine, and in other areas where a high transfer rate of substances into or out of the capillary is required.
- Sinusoidal capillaries (sinusoids) have large gaps between endothelial cells that permit the passage of blood cells. These capillaries are found in the bone marrow, spleen, and liver.

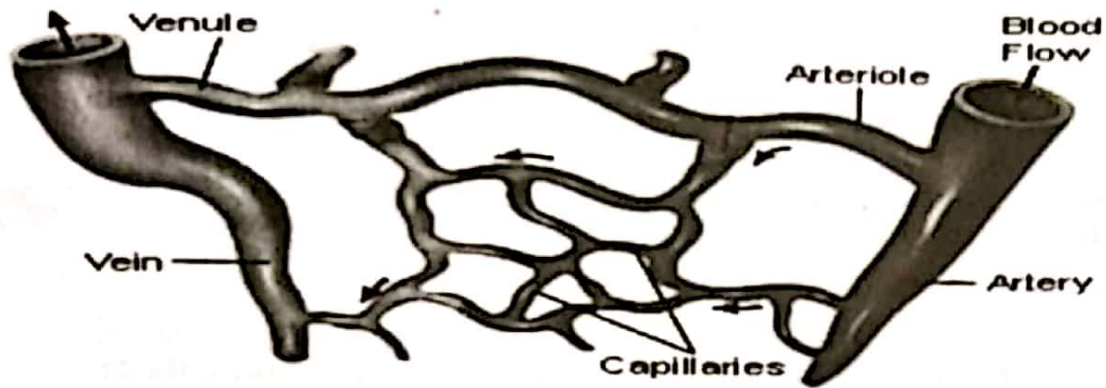
Vein: It carry blood toward the heart. The three kinds of veins are listed here in the sequence they occur regarding the flow of blood back to the heart:

Post capillary venules: the smallest veins, form when capillaries merge as they exit a capillary bed. Much like capillaries, they are very porous, but with scattered smooth muscle fibers in the tunica media.

Venules: It form when post capillary venules join. Although the walls of larger venules contain all three layers, they are still porous enough to allow white blood cells to pass.

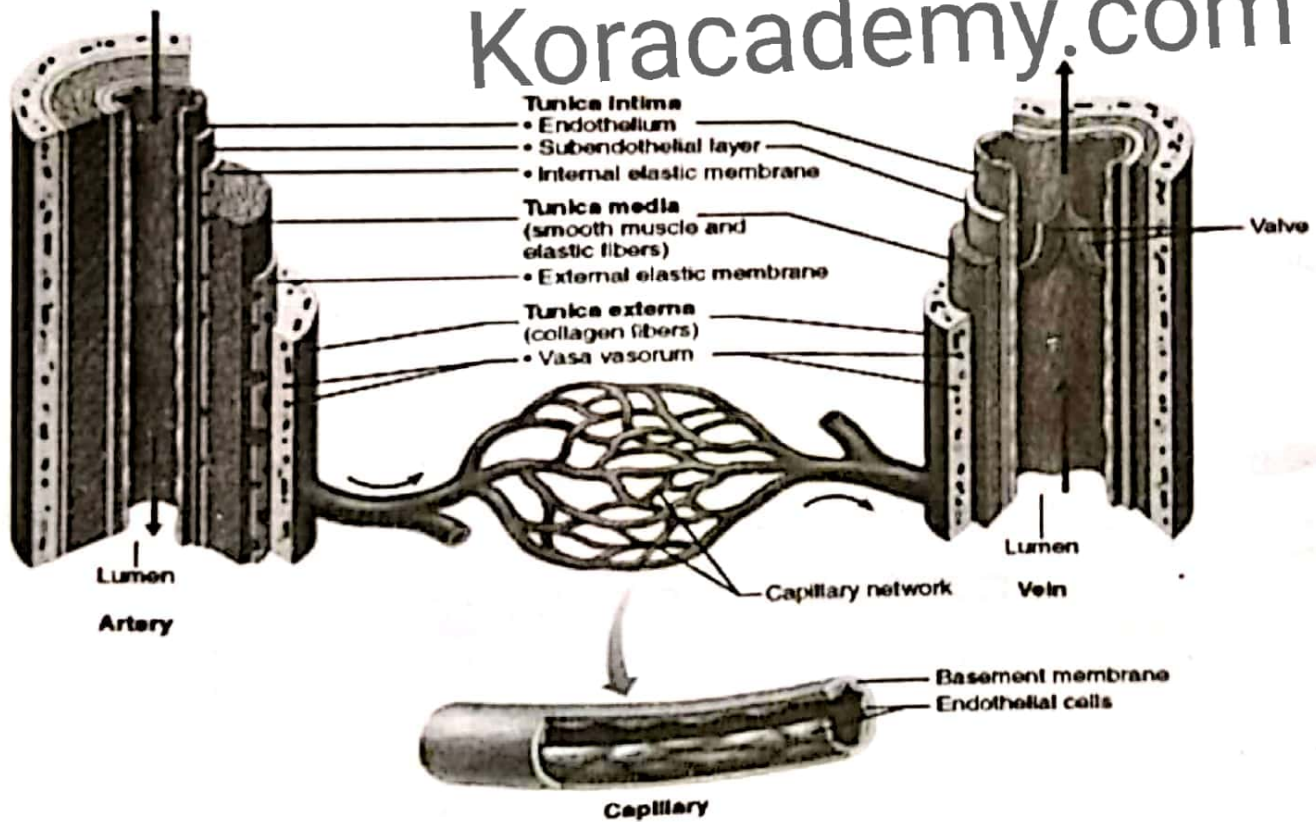
Veins: These have walls with all three layers, but the tunica intima and tunica media are much thinner than in similarly sized arteries. Few elastic or muscle fibers are present. The wall consists primarily of a well-developed tunica adventitia. Many veins, especially those in the limbs, have valves, formed from folds of the tunica intima that prevent the backflow of blood. If these valves fail to close properly, varicose (enlarged & twisted) veins may occur.

heart → artery → arteriole → capillary → venule → vein → heart



Blood flow through vessels

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Blood vessels

Features of human circulatory system

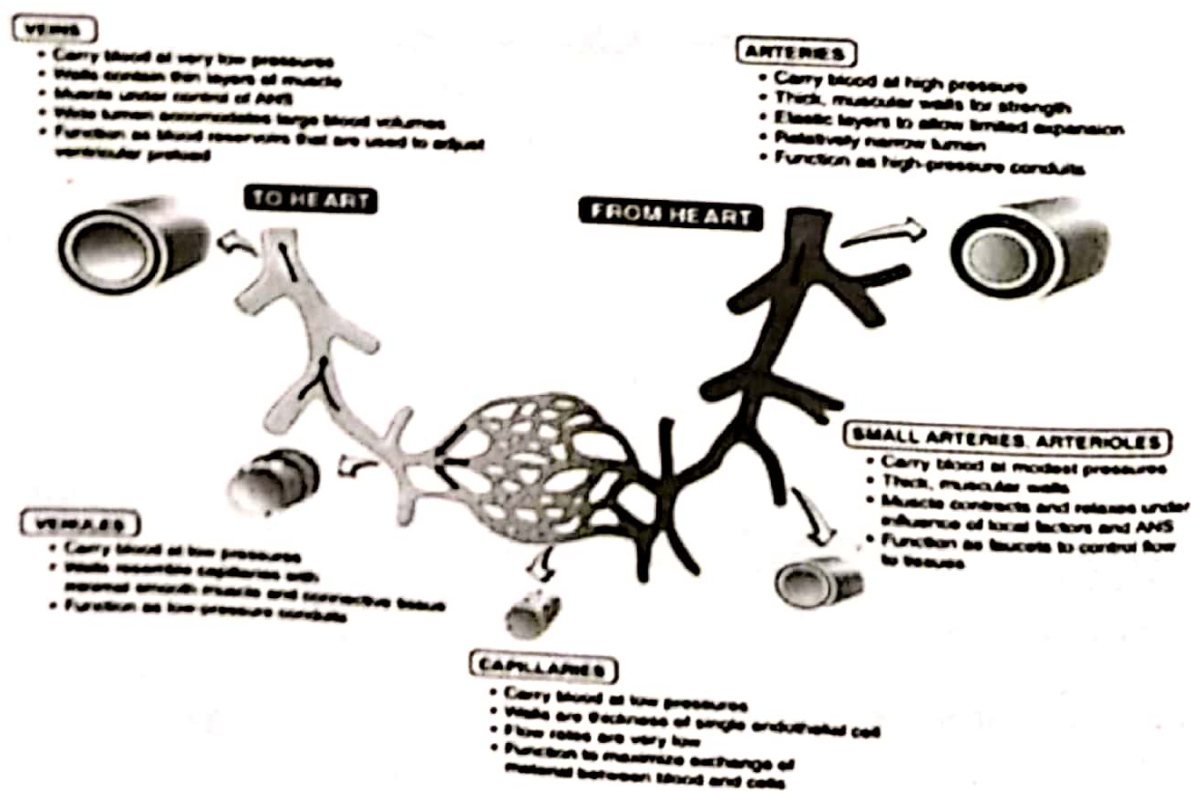
- i. **Total length of vessels:** The approximate length of human blood vessels is about 60,000 miles (96561km).
- ii. **Total surface area of blood vessels:** The total surface area of human blood vessels is 800-1000 square meters which is roughly three time greater than surface area of tennis court.
- iii. **Total blood volume:** The total volume of blood in adult is 5-6 liters.

- iv. **Blood in blood vessels:** If the major vessels and heart is filled with blood then capillaries are unable to receive blood. Thus blood is supplied to various parts according to its needs,
- ❖ At any given time, only 5-10 % capillaries are filled with blood but all the times all parts of body are supplied with blood.
 - ❖ Capillaries to heart, brain, liver and kidney carry nutrients rich blood but supply of blood varies to other parts according to their need.
 - ❖ Body heat regulation is carried by skin for which blood supply to skin is increased or decreased to conserve heat.
 - ❖ Blood supply to heart and skeletal muscles is increased during exercise but blood supply to brain is unchanged.

➤ Exchange of materials

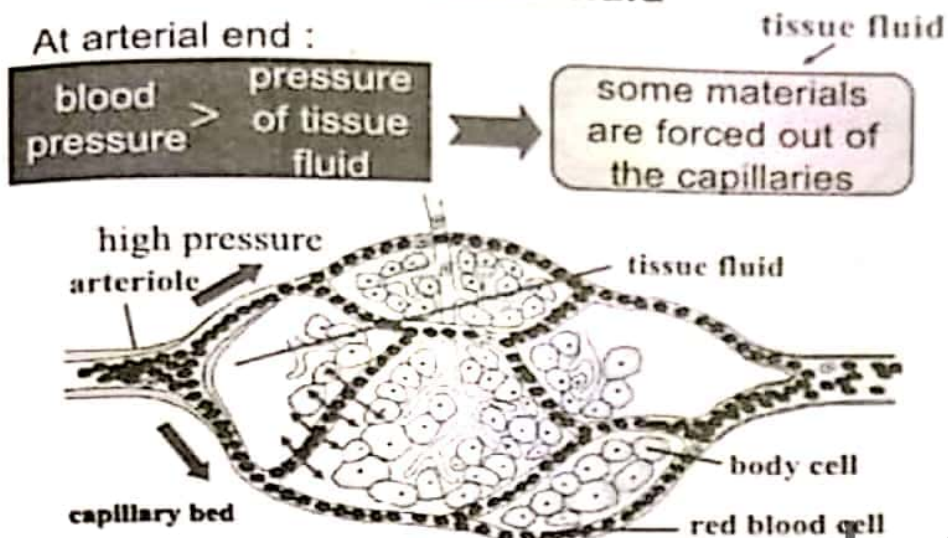
When heart muscles are contracted, blood is pumped into aorta arteries, arterioles, capillaries to reach each & every part of body. The coronary artery to heart and carotid artery to brain carry full loaded blood and varies to other parts from time to time. Blood speed is highest in aorta, decreases in arteries and become slowest in capillaries

In aorta speed of blood is 425 mm /sec while in capillaries it reaches to 1 mm/sec. The change in speed is due to change in cross section area. Aorta pressure is comparatively low while speed is high than arteries and finally pressure is highest in capillaries thus speed of blood in capillaries is slowest to provide more time for exchange of materials. Capillaries carry blood loaded with nutrients and O_2 to the tissues. When capillaries reach to tissues then 90% blood plasma beside R.B.Cs filtered out of capillaries into tissues intercellular spaces forming a fluid called tissue fluid which is nutrients rich. The nutrients and O_2 diffused into cells while wastes & CO_2 diffuse out of the cells into tissue fluid. In this way exchange occur. After exchange 70 % tissue fluid is reabsorbed into venule blood capillaries and 20 % tissue fluid is left outside in intercellular spaces which is termed as lymph.



Formation of the tissue fluid

At arterial end :



Control of blood flow in capillaries

The flow of blood in capillaries is adjusted by two mechanism

- (i) **Pre-Capillary sphincter:** It is a band of smooth muscles surrounding arterioles & regulating blood flow into capillary bed. It is usually present at the region where capillaries arise from arterioles. The contraction of pre-Capillary sphincter causes reduction or blockage of blood flow into capillaries while relaxation of sphincter causes increase in blood flow. In some cases pre- Capillary sphincter fails to control blood flow due to which accumulation of tissue fluid occur which causes blood flow enormously and causes swelling of tissue known as edema or watering of tissue.

- (ii) **Vasomotor nerves & local chemical condition:** It also regulates blood flow in capillaries.

Blood Pressure: Pressure exerted by blood against the walls of vessels during blood flow. It is measured by sphygmomanometer in mm Hg. It is of two types systolic pressure, which is due to the contraction of left ventricle i-e 120 mm Hg & diastolic pressure which is due to the relaxation of left ventricle i-e 80 mm Hg normally.

Blood Pressure in Artery: In artery blood pressure is higher due to heart beating i-e 120/80 mm Hg.

Blood Pressure in Vein: The average blood pressure in veins is 20 mm Hg. It is maintained by the following factors.

- Presence of valves
- Muscles massage
- Respiratory pressure
- Cardiac pumping pressure in the body cavity etc.