Circulatory system

The circulatory system is composed of two separate but connected components: the blood vascular system (**cardiovascular system**) that transports blood and the **lymphatic vascular system** that collects and returns excess extracellular fluid (lymph) to the blood vascular system.

Blood vascular system

It consisting of the heart and blood vessels, functions in propelling and transporting blood and its various constituents throughout the body. Blood vessels are composed of three concentric layers: tunica intima, tunica media, and tunica adventitia

• The **tunica intima** is composed of a continuous sheet of simple squamous endothelial cells lining the lumen and of various amounts of subendothelial connective tissue.

• The **tunica media**, usually the thickest of the three layers in the arterial leg of the circulatory system, is composed of circularly arranged smooth muscle cells and fibroelastic connective tissue, whose elastic content increases greatly with the size of the vessel.

• The **tunica adventitia** is the outermost layer of the vessel wall, consisting of fibroelastic connective tissue.

In larger vessels, the tunica adventitia houses **vasa vasorum**, small blood vessels that supply the tunica adventitia and media of that vessel. In the venous leg of the circulatory system, it is the tunica adventitia that is the thickest of the three layers. The blood vascular system is subdivided into the pulmonary and systemic circuits, which originate from the right and left sides of the heart, respectively.

• The **pulmonary circuit** takes oxygen-poor blood to the lungs to become oxygenated and returns it to the left side of the heart.

• The oxygen-rich blood is propelled via the **systemic circuit** to the remainder of the body to be returned to the right side of the heart, completing the cycle.

Heart

The heart is a four-chambered organ composed of two atria and two ventricles. The atria, subsequent to receiving blood from the pulmonary veins, venae cavae, and coronary sinus, discharge it into the ventricles. Contractions of the ventricles then propel the blood either from the right ventricle into the pulmonary trunk for distribution to the lungs or from the left ventricle into the aorta for distribution to the remainder of the body. Although the walls of the ventricles are thicker than those of the atria, these chambers possess common characteristics in that they are composed of three layers: epicardium, myocardium, and endocardium.

Epicardium, the outermost layer, is covered by a simple squamous mesothelium deep to which is a fibroelastic connective tissue. The deepest aspect of the epicardium is composed of adipose tissue that houses nerves and the coronary vessels. most of the wall of the heart is composed of **myocardium**, consisting of bundles of cardiac muscle that are attached to the thick collagenous connective tissue skeleton of the heart. The **endocardium** forms the lining of the atria and ventricles and is composed of a simple squamous endothelium as well as a subendothelial fibroelastic connective tissue. The endocardium participates in the formation of the heart valves, which control the direction of blood flow through the heart. **Atrioventricular valves** between the atria and ventricles prevent regurgitation of blood into the atria. Similarly, **semilunar valves** located in the pulmonary trunk and the aorta prevent regurgitation of blood from these vessels back into their respective ventricles. The closing of these valves is responsible for the sounds associated with the heartbeat. Additionally, some cardiac muscle fibers are modified and specialized to regulate the sequence of atrial and ventricular contractions. These are the sinoatrial and atrioventricular nodes and the bundle of His and Purkinje fibers. The **sinoatrial node** (**SA node**), the pacemaker

of the heart, is located at the junction of the superior vena cava and the right atrium. The SA node generates impulses that result in the contraction of the atrial muscles; blood from the atria then enters the ventricles.

Arteries

Arteries, by definition, conduct blood away from the heart; they are classified into three categories: elastic (also known as conducting or large), muscular (also known as distributing or medium), and arterioles

• **Elastic arteries**, such as the aorta, receive blood directly from the heart and consequently are the largest of the arteries.

• **Muscular arteries** comprise most of the named arteries of the body and supply blood to various organs. Their tunica media is composed mostly of many layers of smooth muscle cells. Both elastic and muscular arteries are supplied by **vasa vasorum**

• **Arterioles** regulate blood pressure and the distribution of blood to capillary beds via vasoconstriction and vasodilatation of vessel walls

• **Metarterioles** are the terminal ends of the arterioles, and they are characterized by the presence of incomplete rings of smooth muscle cells (**precapillary sphincters**) that encircle the origins of the capillaries. Metarterioles form the arterial (proximal) end of a **central channel**, and they are responsible for delivering blood into the capillary bed. The venous (distal) end of the central channel, known as a **thoroughfare channel**, is responsible for draining blood from the capillary bed and delivering it into venules.

• **Arteriovenous anastomoses** are direct connections between arteries and venules, and they also function in having blood bypass the capillary bed. These shunts function in **thermoregulation** and blood pressure control.

• **Capillaries** are very small vessels that consist of a single layer of endothelial cells surrounded by a basal lamina and occasional **pericytes** , but these vessels possess no smooth muscle cells; therefore, they do not exhibit vasomotor activities. Capillaries exhibit **selective permeability**, and they, along with venules, are responsible for the exchange of gases, metabolites, and other substances between the bloodstream and the tissues of the body. Capillaries are composed of highly attenuated **endothelial cells** that form narrow vascular channels 8 to 10 mm in diameter and are usually less than 1 mm long. There are three types of capillaries: continuous, fenestrated, and sinusoidal .

1..Continuous capillaries lack fenestrae, display only occasional pinocytotic vesicles, and possess a continuous basal lamina. They are present in regions such as peripheral nerve fibers, skeletal muscle, lungs, and thymus.

2..Fenestrated capillaries are penetrated by relatively large diaphragm-covered pores. These cells also possess pinocytotic vesicles and are enveloped by a continuous basal lamina. Fenestrated capillaries are located in endocrine glands, pancreas, and lamina propria of the intestines, and they also constitute the glomeruli of the kidneys, although their fenestrae are not covered by a diaphragm.

3..Sinusoidal capillaries (also known as **sinusoids, discontinuous capillaries)** are much larger than their fenestrated or continuous counterparts. They are enveloped by a discontinuous basal lamina, and their endothelial cells do not possess pinocytotic vesicles. The intercellular junctions of their endothelial cells display gaps, thus permitting leakage of material into and out of these vessels. Frequently, macrophages are associated with sinusoidal capillaries. Sinusoidal capillaries are located in the liver, spleen, lymph nodes, bone marrow, and the suprarenal cortex.

Veins

Veins conduct blood away from body tissues and back to the heart . Generally, the diameters of veins are larger than those of corresponding arteries; however, veins are thinner walled, since they do not bear high blood pressures. Veins also possess three

concentric, more or less definite layers: **tunica intima**, **tunica media**, and **tunica adventitia**. Furthermore, veins have fewer layers of smooth muscle cells in their tunica media than do arteries. Finally, many veins possess valves that act to prevent regurgitation of blood. Three categories of veins exist: **small**, **medium**, and **large** . The smallest of the **veins**, **venules**, especially **postcapillary venules**, are also responsible for the exchange of materials. Postcapillary venules have **pericytes** instead of a tunica media, and their walls are more permeable than those of venules and even of capillaries.

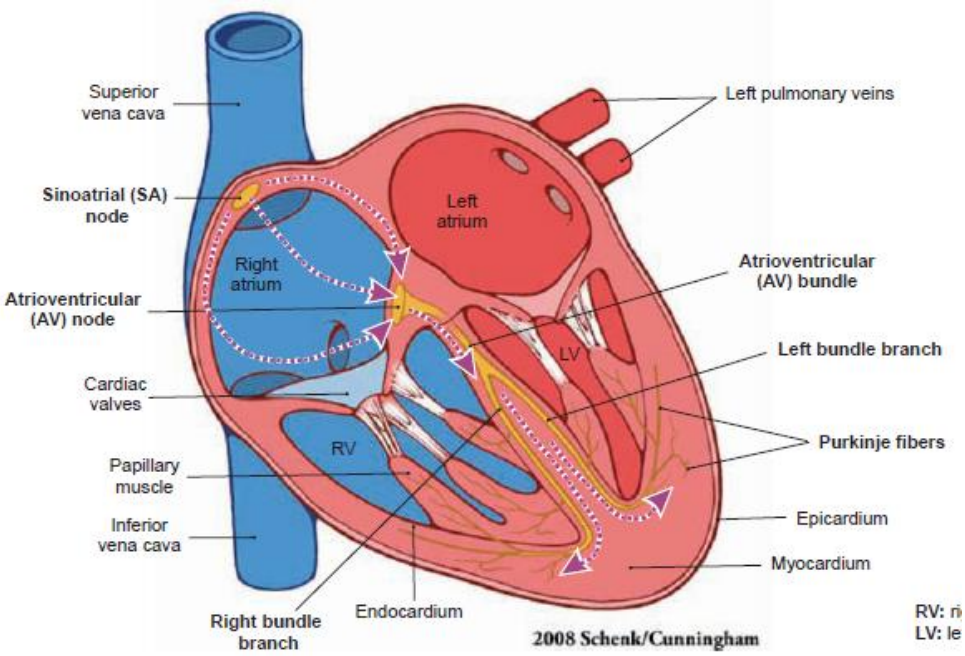
• **Medium veins** receive blood from most of the body, including the upper and lower extremities. They also possess three layers. Tunica intima frequently forms valves, especially in the lower extremities, to counteract the gravitational forces and avert the backflow of blood. Tunica media is slender and houses only a loosely organized network of smooth muscle cells interspersed with fibroblasts and type I collagen fibers .Tunica adventitia is the thickest of the three layers consisting mostly of elastic fibers and type I collagen bundles arranged parallel to the longitudinal axis of the vein. Occasional smooth muscle cells are also present in the adventitia.

• **Large veins**, such as the venae cavae, pulmonary, and renal veins, are more than 1 cm in diameter. As the venae cavae and pulmonary veins approach the heart, they exhibit the presence of cardiac muscle cells in their adventitia. Most of the large veins (except for those in the lower extremities) possess no smooth muscle cells in their tunica media instead those cells are located in their tunica adventitia .The tunica intima of large veins are rich in elastic fibers and fibroblasts .The walls of these large veins are supplied by slender vessels derived from the vasa vasorum located in their adventitia.

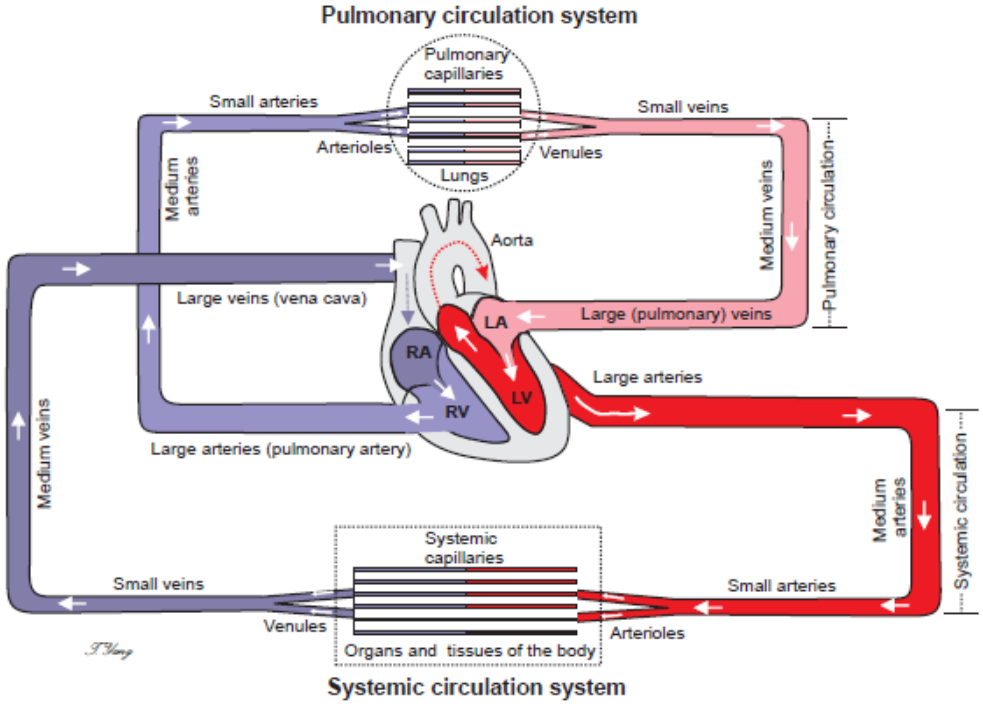
Lymph vascular system

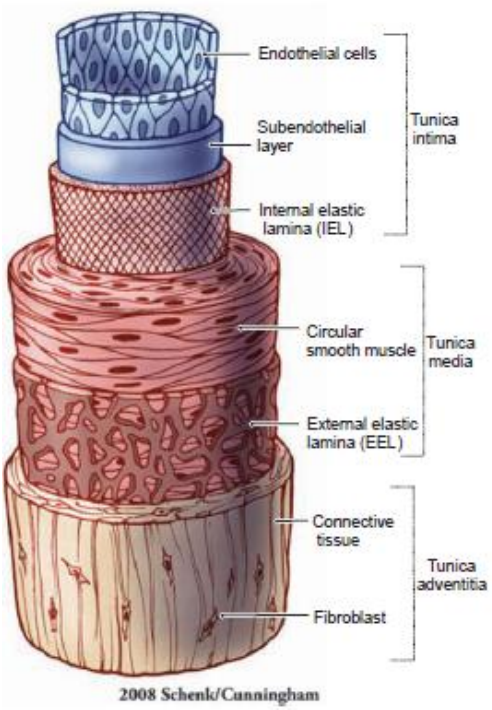
Excess extracellular fluid, which does not enter the venous return system at the level of the capillary bed or venule, gains entry into **lymphatic capillaries**, blindly ending

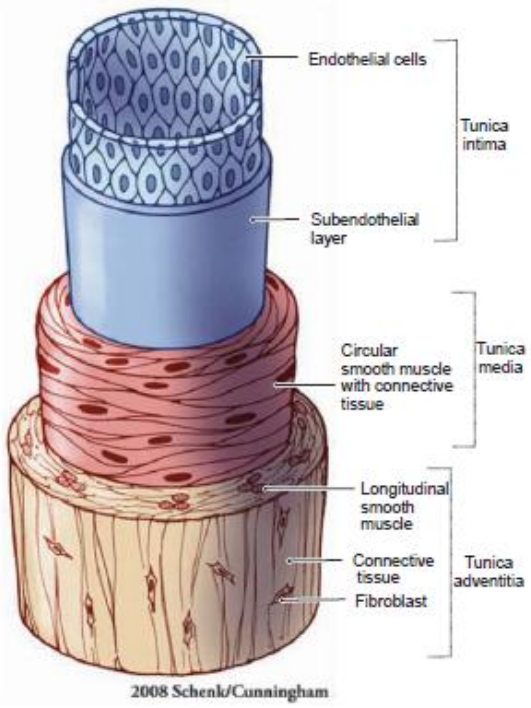
thin vessels of the lymph vascular system. Subsequent to passing through chains of lymph nodes and larger lymph vessels, the fluid known as lymph enters the blood vascular system at the root of the neck.



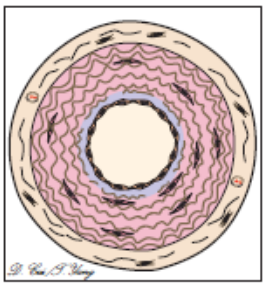
The Cardiovascular System



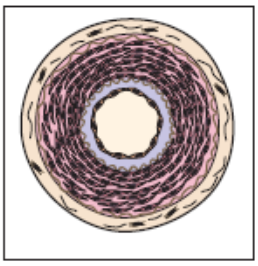




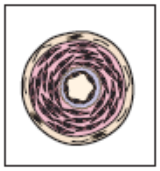
Large artery
(elastic artery)



Medium artery
(muscular artery)

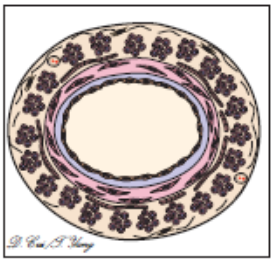


Small artery

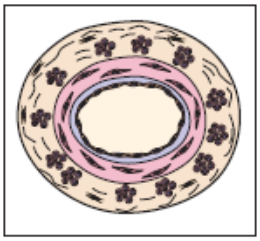


Arteriole

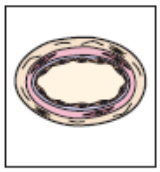
Large vein



Medium vein

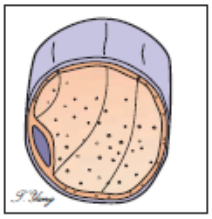


Small vein



Venule

Continuous capillary



Fenestrated capillary

Discontinuous (sinusoidal)
capillary