The Circulatory system

The circulatory system includes both the blood and lymphatic vascular systems. **The blood vascular system** is composed of the following structures:

- The **heart,** an organ whose function is to pump the blood.
- The **arteries,** a series of efferent vessels that become smaller as they branch, and whose function is to carry the blood, with its nutrients and oxygen, to the tissues.
- The **capillaries**, the smallest blood vessels, constituting a complex network of thin tubules that branch profusely in almost every organ and through whose walls the interchange between blood and tissues takes
- The **veins**, which result from the convergence of capillaries into a system of larger channels that continue enlarging as they approach the heart, toward which they convey the blood to be pumped again.

The **lymphatic vascular system**, begins with the **lymphatic capillaries**, which are closed-ended tubules that merge to form blood vascular system emptying into the large veins near the heart. One of the functions of the lymphatic system is to return the fluid of the tissue spaces to the blood. The internal surface of all components of the blood and lymphatic systems is lined by a single layer of a squamous epithelium, called endothelium.

The circulatory system is considered to consist of the **macrovasculature**, vessels that are more than 0.1 mm in diameter (large arterioles, muscular and elastic arteries, and muscular veins), and the **microvasculature** (arterioles, capillaries, and postcapillary venules) visible only with a microscope .The microvasculature is particularly important functionally, being the site of interchanges between blood and the surrounding tissues both under normal conditions and during inflammatory processes.

➢ HEART

The heart is a muscular organ chat contracts rhythmically, pumping the blood through the circulatory system . The right and left **ventricles** pump

blood to the lungs and the rest of the body respectively; right and left **atria** receive blood from of the body and the pulmonary veins respectively. The walls of all four heart chambers consist of three major layers or tunics: the internal endocardium; the middle myocardium; and the external epicardium.

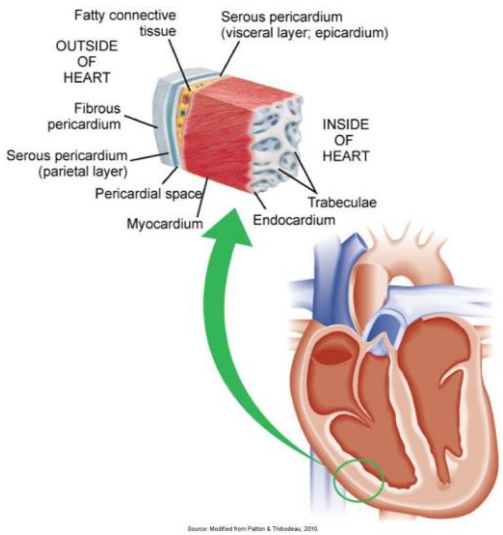
The **endocardium** consists of a single layer of squamous endothelial cells on a thin layer of loose connective tissue containing elastic and collagen fibers as well as some smooth muscle cells. Connecting this subendothelial layer to the myocardium is additional connective tissue (often called the **subendocardial layer**) containing veins, nerves, and branches of the impulseconducting system of the heart .

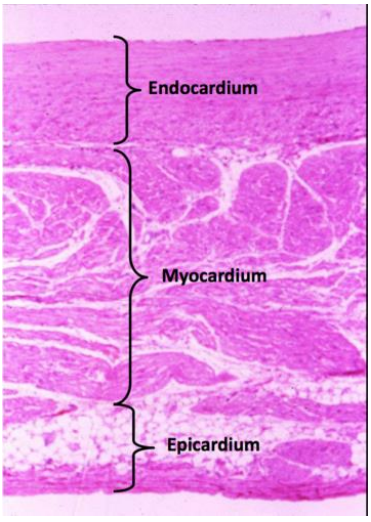
The **myocardium** is the thickest of the tunics and consists of cardiac muscle cells arranged in layers that surround the heart chambers in a complex spiral.

the myocardium is much thicker in the ventricles than in the atria.

The heart is covered externally by simple squamous epithelium (mesothelium) supported by a thin layer of connective tissue that constitutes the **epicardium.** A subepicardial layer of loose connective tissue contains veins, nerves, and many adipocytes . The epicardium corresponds to the visceral layer of the **pericardium**, the serous membrane in which the heart lies. In the space between the pericardium's visceral layer (epicardium) and its parietal layer is a small amount of lubricant fluid that facilitates the hearts movements. P SEP

The cardiac valves consist of a central core of dense fibrous connective tissue (containing both collagen and elastic fibers), lined on both sides by endothelial layers.





TISSUES OF THE VASCULAR WALL

"Walls of larger blood vessels contain three basic structural components: a simple squamous **endothelium**, **smooth muscle,** and **connective tissue** with elastic elements in addition to collagen.
The amount and arrangement of these tissues in vessels are influenced by **mechanical factors,** primarily blood pressure, and **metabolic factors** reflecting local needs of tissues.

STRUCTURAL PLAN OF BLOOD VESSELS

Blood vessels are usually composed of the following layers, or tunics (L. tunica, coat).

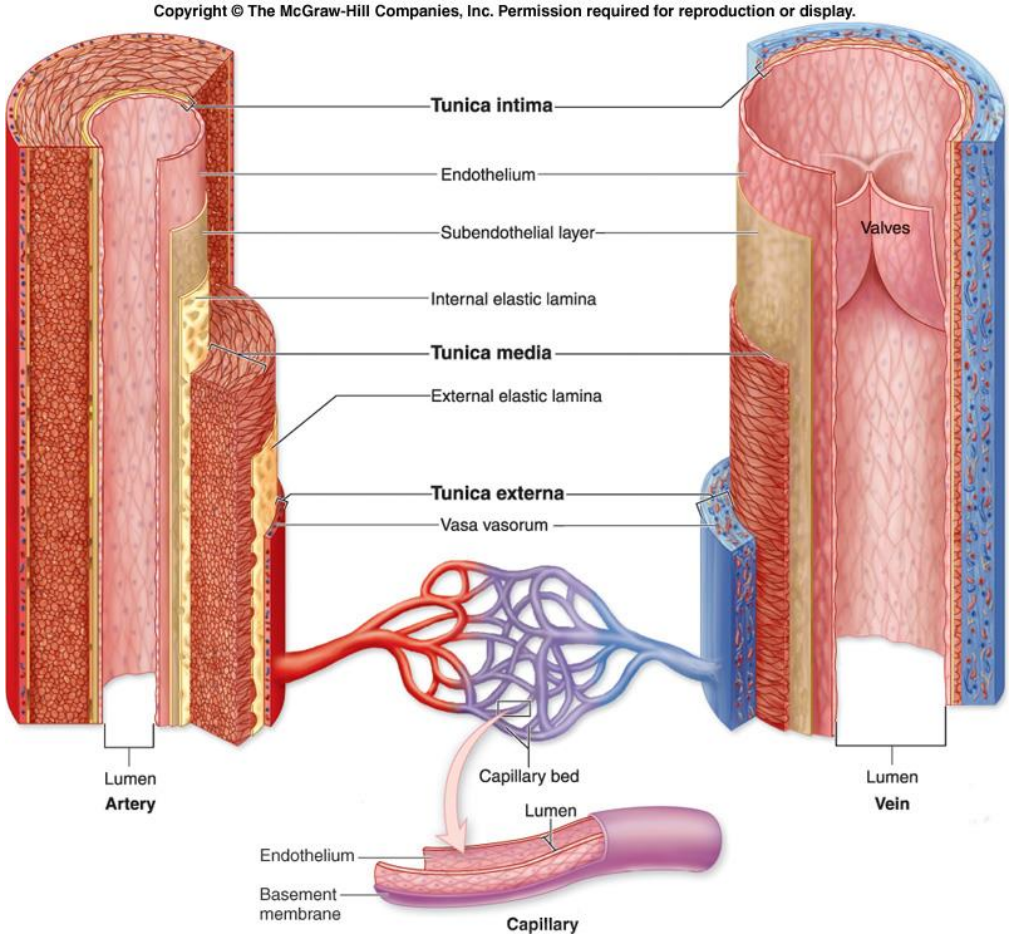
The **tunica intima** has one layer of endothelial cells supported by a thin subendothelial layer of loose connective tissue with occasional smooth muscle cells. In arteries, the intima is separated from the media by an **internal elastic lamina**, the most external component of the intima. This lamina, composed of elastin, has holes (fenestrae) that allow the diffusion of substances to nourish cells deep in the vessel wall. As a result of the loss of blood pressure and contraction of the vessel at death, the tunica intima of arteries may have a slightly folded appearance in tissue sections .

The **tunica media**, the middle layer, consists chiefly of concentric layers of helically arranged smooth muscle cells . Interposed among the smooth muscle cells are variable amounts of elastic fibers and lamellae, reticular fibers of collagen type III, proteoglycans, and glycoproteins, all of which is produced by these cells. In arteries, the media has a thinner **external elastic lamina**, which separates it from the tunica adventitia.

The **tunica adventitia** or tunica externa consists principally of type I collagen and elastic fibers . This adventitial layer is gradually continuous with the stromal connective tissue of the organ through which the blood vessel runs.

Large vessels usually have **vasa vasorum** (Vessels of the vessel") , which consist of arterioles, capillaries, and venules in the tunica adventitia and the outer part of the media .The vasa vasorum provide metabolites to cells of those layers, since in larger vessels the wall is too thick to be nourished, solely by diffusion from the blood in the lumen. Luminal blood alone does provide nutrients and oxygen for cells of the tunica intima. Since they carry deoxygenatecf blood, large veins typically have more vasa vasorum than arteries.

Larger vessels are supplied with a network of unmyelinated sympathetic nerve fibers (**vasomotor nerves**) whose neurotransmitter is norepinephrine .

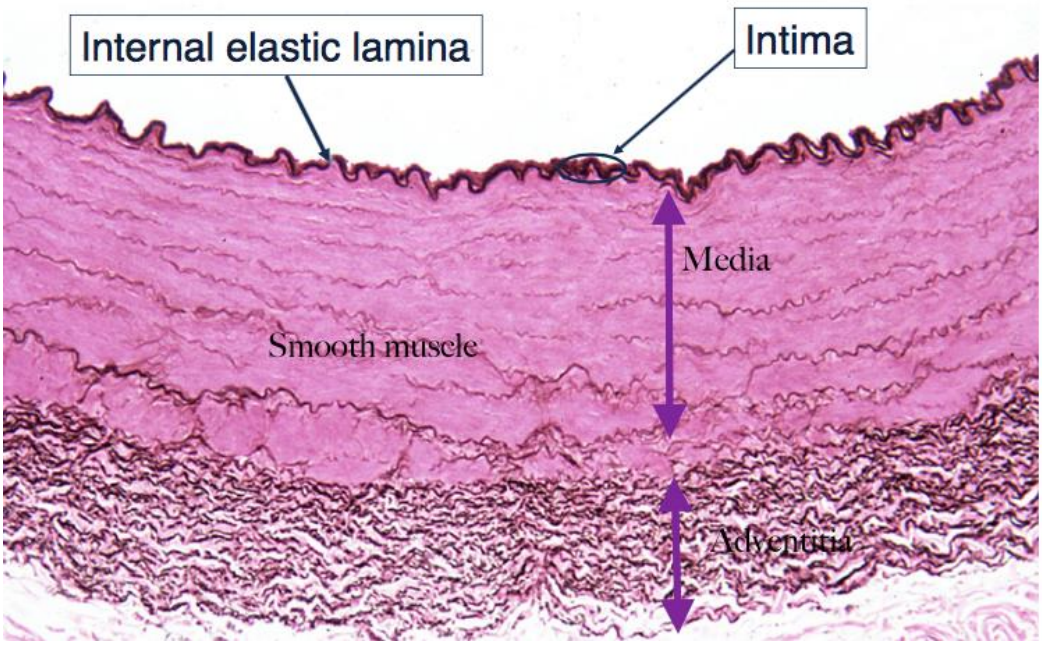


- **Arteries**

Large Elastic Arteries

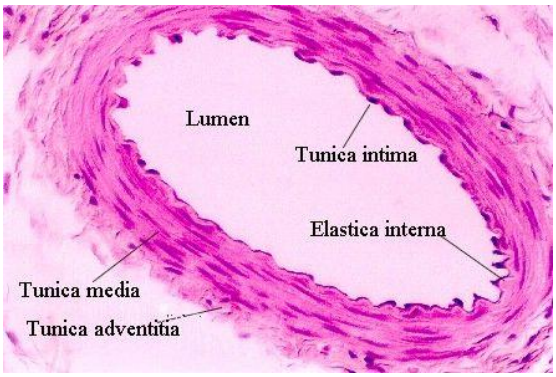
Large elastic arteries help to stabilize the blood flow. The elastic arteries include the aorta and its large branches. Freshly dissected, they have a yellowish color from the elastin in the media. The intima is thicker than the corresponding tunic of a muscular artery. An internal elastic lamina, although present, may not be easily discerned, since it is similar to the elastic laminae of the next layer . The media consists of elastic fibers and a series of concentrically arranged, perforated elastic laminae whose number increases with age (there are about 40 in the newborn, 70 in the adult). Between the elastic laminae are smooth muscle cells, reticular fibers, proteoglycans, and glycoproteins. The tunica adventitia is relatively underdeveloped.

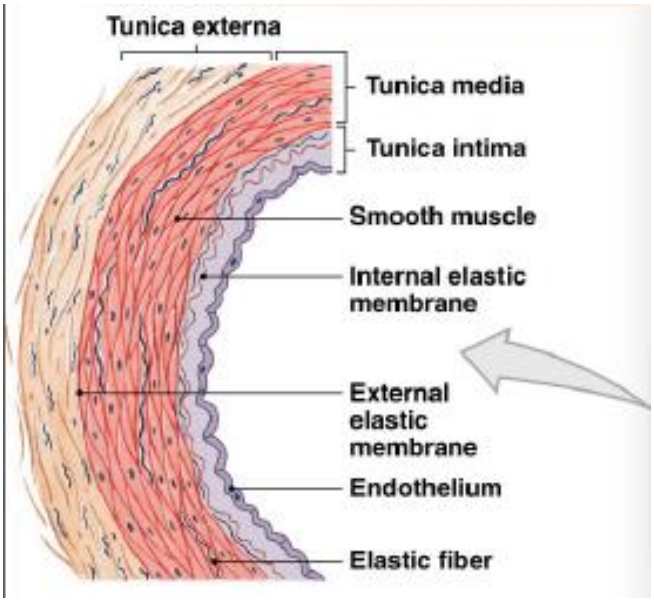
The several elastic laminae contribute to the important function of making blood flow more uniform. During ventricular contraction **(systole),** the elastic laminae of large arteries are stretched, reducing the force of the pressure somewhat. During ventricular relaxation **(diastole),** ventricular pressure drops to a low level, but the elastic rebound of large arteries helps to maintain arterial pressure. As a consequence, arterial pressure and blood velocity decrease and become less variable as the distance from the heart increases.



- **Muscular Arteries**

Mt muscular arteries can control blood flow to organs by contracting or relaxing the smooth muscle cells of the tunica media. The intima has a very thin subendothelial layer and the internal elastic lamina, the most external component of the intima, is prominent . The tunica media may contain up to 40 layers of more prominent smooth muscle cells which are intermingled with a variable number of elastic lamellae (depending on the size of the vessel) as well as reticular fibers and proteoglycans. An external elastic lamina, the last component of the media, is present only in the larger muscular arteries. The adventitia consists of connective tissue. Lymphatic capillaries, vasa vasorum, and nerves are also found in the advenritia and these structures may penetrate to the outer part of the media.

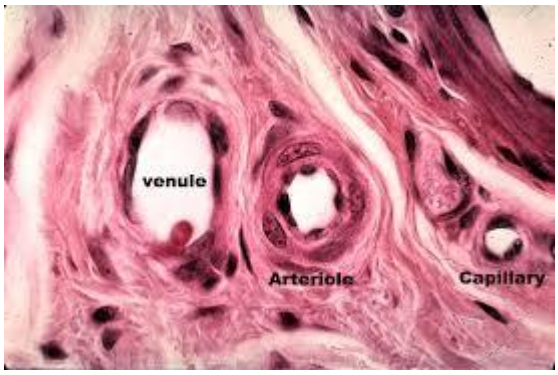


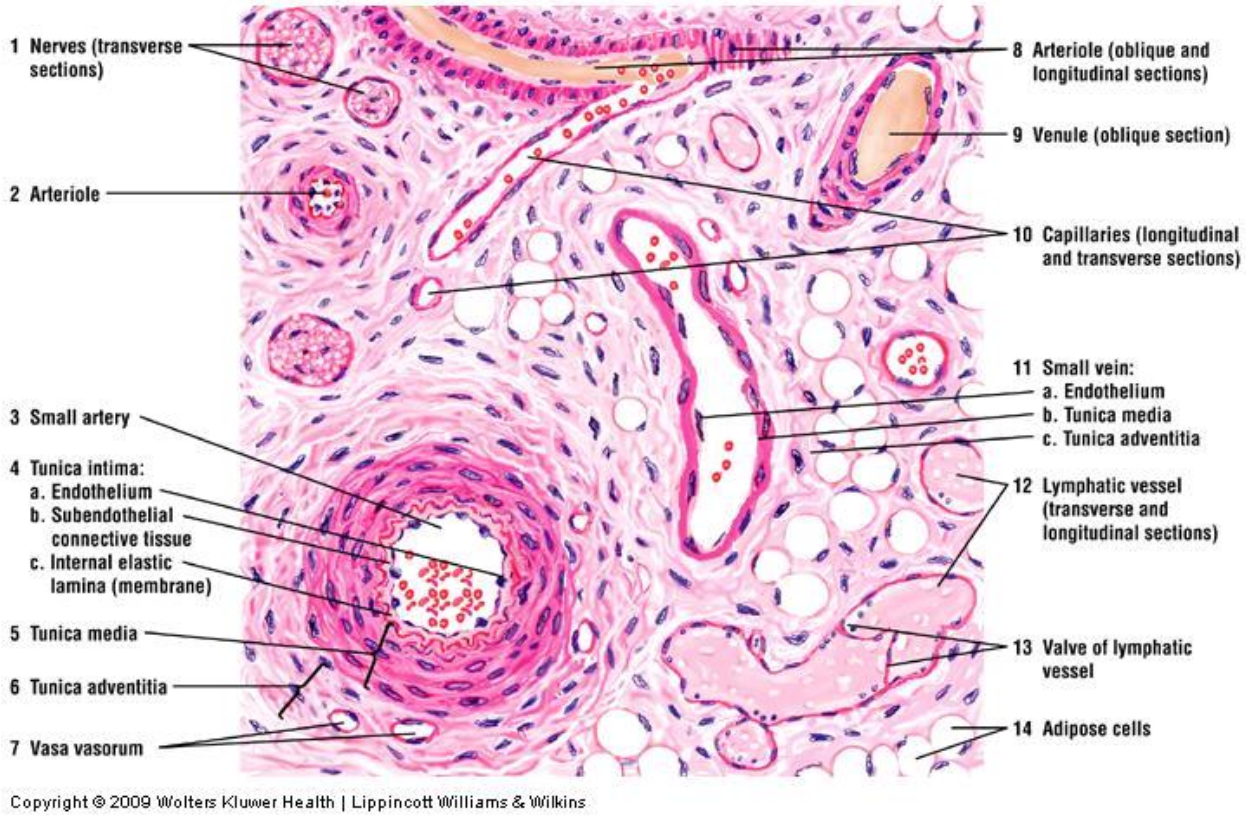


- **Arteriols**

Muscular arteries branch repeatedly into smaller and smaller arteries, until reaching a size with only two or three medial layers of muscle. The smallest arteries branch as arterioles, which have one or two smooth muscle layers and indicate the beginning of an organs miaovasculature (Figure 11-13) where achanges between blood and tissue fluid occur. Arterioles are generally less than 0.5 mm in diameter, with lumens approximately as wide as the wall is thick (Figures 11-2 and 11-14”). The

subendothelial layer is very thin, the elastic laminae are absent and the media is generally composed of circularly arranged smooth muscle cells. In both small arteries and arterioles, the tunica adventitia is very thin and inconspicuous.





- **Capillaries**

Capillaries permit different levels of metabolic exchange between blood and surrounding tissues. They are composed of a single layer of **endothelial cells** rolled up in the form of a tube. The average diameter of capillaries varies from 5 to 10 um. and their individual length is usually not more than 50 um. Altogether capillaries comprise over 90% of all blood vessels in the body, With a total length of nearly 96,000 km (60,000 miles).

- **Venules**

The transition from capillaries to venules occurs gradually. The immediate **postcapillary venules** are similar structurally to capillaries, with pericytes, but range in diameter from 15 to 20 um. Postcapillary venules participate in the exchanges between the blood and the tissues and, , are the primary site at which white blood cells leave the circulation at sites of

infection or tissue damage. These venules converge into larger **collecting venules** which have more contractile cells. With greater size the venules become surrounded by recognizable tunica media with two or three smooth muscle layers and are called **muscular venules**. A characteristic feature of all venules is the large diameter of the lumen compared to the overall thinness of the wall.

Veins

Blood entering veins is under very low pressure and moves toward the heart by contraction of the tunica media and external compressions surrounding muscles and other organs. Valves project from the tunica intima to prevent back-flow of blood. Most veins are **small** or **medium veins**, with diameters less than one centimeter. Such veins are usually located in parallel with corresponding muscular arteries. The intima usually has a thin subendothelial layer and the media consists of small bundles of smooth muscle cells intermixed with reticular fibers and a delicate network of elastic fibers. The collagenous adventitial layer is well-developed.

The big venous trunks, paired with elastic arteries close heart, are **large veins** . Large veins have a well-developed tunica intima, but the tunica media is relatively thin, with few layers of smooth muscle and abundant connective tissue. The adventitial layer is thick in large veins and frequently contains Iongitudinal bundles of smooth muscle. Both the media and adventitia contain elastic fibers, but elastic laminae like those of arteries are not present.

Most veins have valves, but these are most prominent in large veins. Valves consist of paired semilunar folds of the tunica intima projecting across part of the lumen . They are rich in elastic fibers and are lined on both sides by endothelium. The valves, which are especially numerous in veins of the legs, help keep the flow of venous blood directed toward the heart.