Circulatory System

Lec. 12

Part 1

Histology

Second year

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The Circulatory System

- The blood vascular system consists of the heart, major arteries, arterioles, capillaries, venules, and veins. The main function of this system is to deliver oxygenated blood to cells and tissues and to return venous blood to the lungs for gaseous exchange.

Types of Arteries

There are three types of arteries in the body: elastic arteries, muscular arteries, and arterioles.

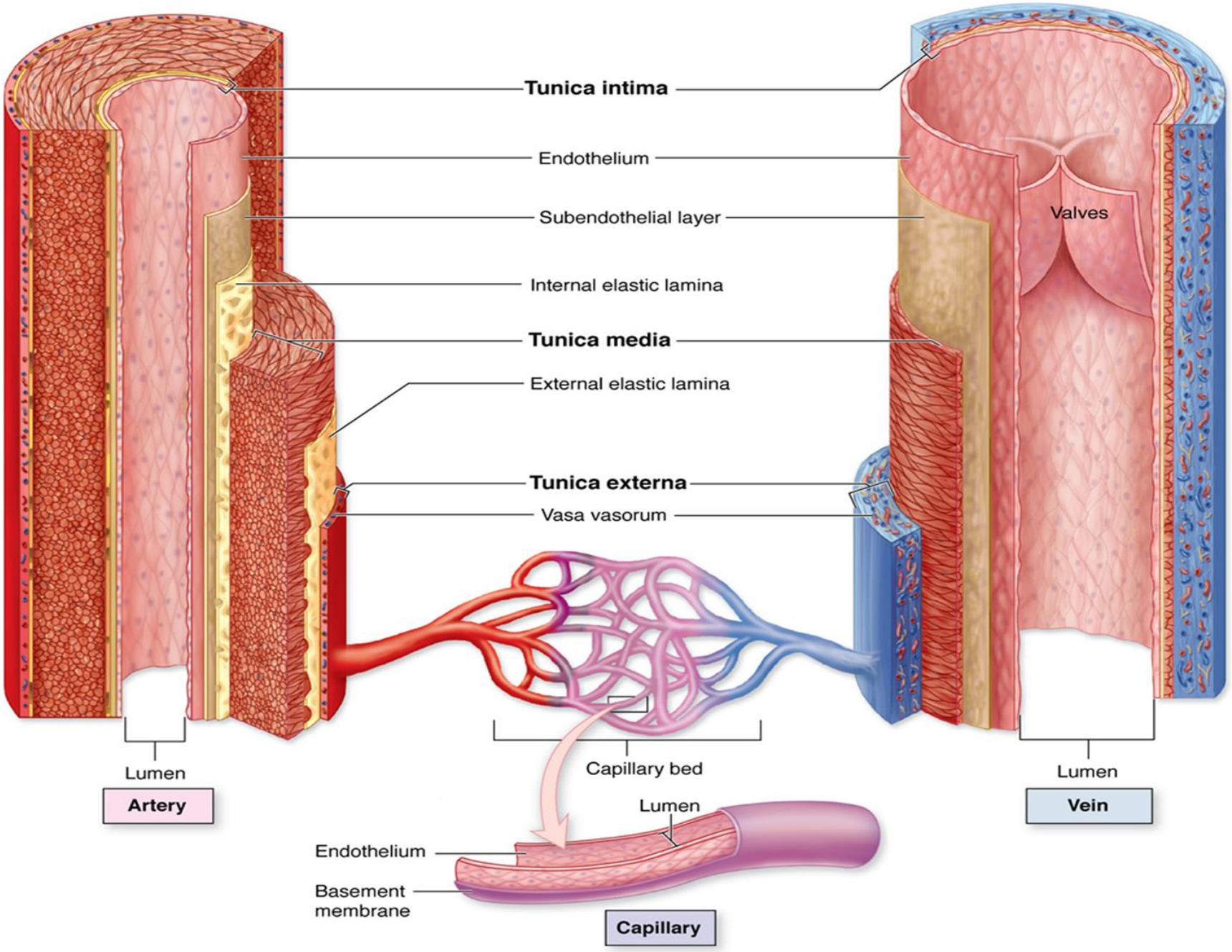
Arteries that leave the heart to distribute the oxygenated blood exhibit progressive branching. With each branching, the luminal diameters of the arteries gradually decrease, until the smallest vessel, the capillary, is formed.

Elastic arteries are the largest blood vessels in the body and include the pulmonary trunk and aorta with their major branches, the brachiocephalic, common carotid, subclavian, vertebral, pulmonary, and common iliac arteries. The walls of these vessels are primarily composed of elastic connective tissue fibers. These fibers provide great resilience and flexibility during blood flow.

The large elastic arteries branch and become medium-sized muscular arteries, the most numerous vessels in the body. In contrast to the walls of elastic arteries, those of muscular arteries contain greater amounts of smooth muscle fibers. Arterioles are the smallest branches of the arterial system. Their walls consist of one to five layers of smooth muscle fibers. Arterioles deliver blood to the smallest blood vessels, the capillaries. Capillaries connect arterioles with the smallest veins or venules.

Structure of Arteries

The wall of a typical artery contains three concentric layers or tunics. The innermost layer is the **tunica intima**. This layer consists of a simple squamous epithelium, called endothelium in the vascular system, and the underlying subendothelial connective tissue. The middle layer is the **tunica media**, composed primarily of smooth muscle fibers. Interspersed among the smooth muscle cells are variable amounts of elastic and reticular fibers. In these arteries, smooth muscles produce the extracellular matrix. The outermost layer is the **tunica adventitia,** composed primarily of collagen and elastic connective tissue fibers; adventitia consists primarily of collagen type I. The walls of some muscular arteries also exhibit two thin, wavy bands of elastic fibers. The internal elastic lamina is located between the tunica intima and the tunica media; this layer is not seen in smaller arteries. The external elastic lamina is located on the periphery of the muscular tunica media and is primarily seen in large muscular arteries.


Tunica intima
Endothelium
Subendothelial layer
Internal elastic lamina
Tunica media
External elastic lamina
Tunica externa
Vasa vasorum
Valves
Lumen
Artery
Capillary bed
Lumen
Vein
Lumen
Endothelium
Basement membrane
Capillary

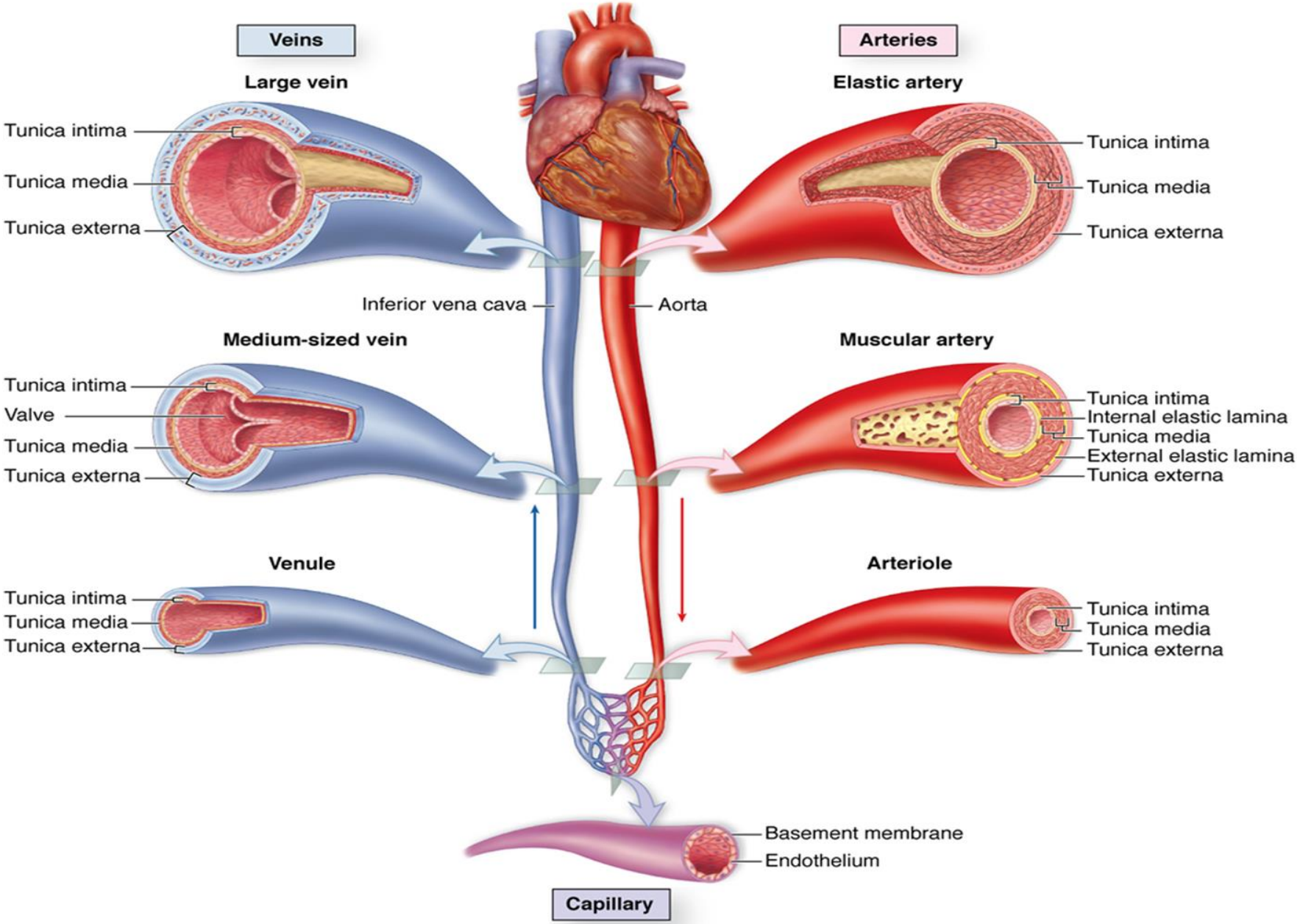
Structure of Veins

Capillaries unite to form larger blood vessels called venules; venules usually accompany arterioles.

The venous blood initially flows into smaller postcapillary venules and then into veins of increasing size. The veins are classified as small, medium, and large. Compared with arteries, veins typically are more numerous and have thinner walls, larger diameters, and greater structural variation.

Small-sized and medium-sized veins, particularly in the extremities, have valves. Because of the low blood pressure in the veins, blood flow to the heart in the veins is slow and can even back up. The presence of valves in veins assists venous blood flow by preventing backflow. When blood flows toward the heart, pressure in the veins forces the valves to open. As the blood begins to flow backward, the valve flaps close the lumen and prevent backflow of blood. Venous blood between the valves in the extremities flows toward the heart as a result of contraction of muscles that surround the veins. Valves are absent in veins of the central nervous system, the inferior and superior venae cavae, and viscera.

The walls of the veins, like the arteries, also exhibit three layers or tunics. However, the muscular layer is much less prominent. The tunica intima in large veins exhibits a prominent endothelium and subendothelial connective tissue. In large veins, the muscular tunica media is thin, and the smooth muscles intermix with connective tissue fibers. In large veins, the tunica adventitia is the thickest and best-developed layer of the three tunics. Longitudinal bundles of smooth muscle fibers are common in the connective tissue of this layer.


Veins
Large vein
Tunica intima
Tunica media
Tunica externa
Medium-sized vein
Tunica intima
Valve
Tunica media
Tunica externa
Venule
Tunica intima
Tunica media
Tunica externa
Arteries
Elastic artery
Tunica intima
Tunica media
Tunica externa
Muscular artery
Tunica intima
Internal elastic lamina
Tunica media
External elastic lamina
Tunica externa
Arteriole
Tunica intima
Tunica media
Tunica externa
Inferior vena cava
Aorta
Basement membrane
Endothelium
Capillary

Vasa Vasorum

The walls of larger arteries and veins are too thick to receive nourishment by direct diffusion from their lumina. As a result, these walls are supplied by their own small blood vessels called the vasa vasorum (vessels of the vessel). The vasa vasorum allows for exchange of nutrients and metabolites with cells in the tunica adventitia and tunica media.

Types of Capillaries

Capillaries are the smallest blood vessels. Their average diameter is about 8 µm, which is about the size of an erythrocyte (red blood cell). There are three types of capillaries: **continuous capillaries, fenestrated capillaries, and sinusoids.** These structural variations in capillaries allow for different types of metabolic exchange between blood and the surrounding tissues. Continuous capillaries are the most common. They are found in **muscle, connective tissue, nervous tissue, skin, respiratory organs, and exocrine glands**. In these capillaries, the endothelial cells are joined and form an uninterrupted, solid endothelial lining.

Fenestrated capillaries are characterized by large openings or fenestrations (pores) in the cytoplasm of endothelial cells designed for a rapid exchange of molecules between blood and tissues. Fenestrated capillaries are found in **endocrine tissues and glands, small intestine, and kidney glomeruli**.

Sinusoidal (discontinuous) capillaries are blood vessels that exhibit irregular, tortuous paths. Their much wider diameters slow down the flow of blood. Endothelial cell junctions are rare in sinusoidal capillaries, and wide gaps exist between individual endothelial cells. Also, because a basement membrane underlying the endothelium is either incomplete or absent, a direct exchange of molecules occurs between blood contents and cells. Sinusoidal capillaries are found in the **liver, spleen, and bone marrow**

The Lymph Vascular System

The lymphatic system consists of lymph capillaries and lymph vessels. This system starts as blind-ending tubules or lymphatic capillaries in the connective tissue of different organs. These vessels collect the excess interstitial fluid (lymph) from the tissues and return it to the venous blood via the large lymph vessels, the **thoracic duct and right lymphatic duct**. Also, to allow greater permeability, the endothelium in lymph capillaries and vessels is extremely thin. The structure of larger lymph vessels is similar to that of veins except that their walls are much thinner.

Lymph movement in the lymphatic vessels is similar to that of blood movement; that is, the contractions of surrounding skeletal muscles forces the lymph to move forward. Also, the lymph vessels contain more valves to prevent a backflow of collected lymph. Lymph vessels are found in all tissues except the central nervous system, cartilage, bone and bone marrow, thymus, placenta, and teeth.