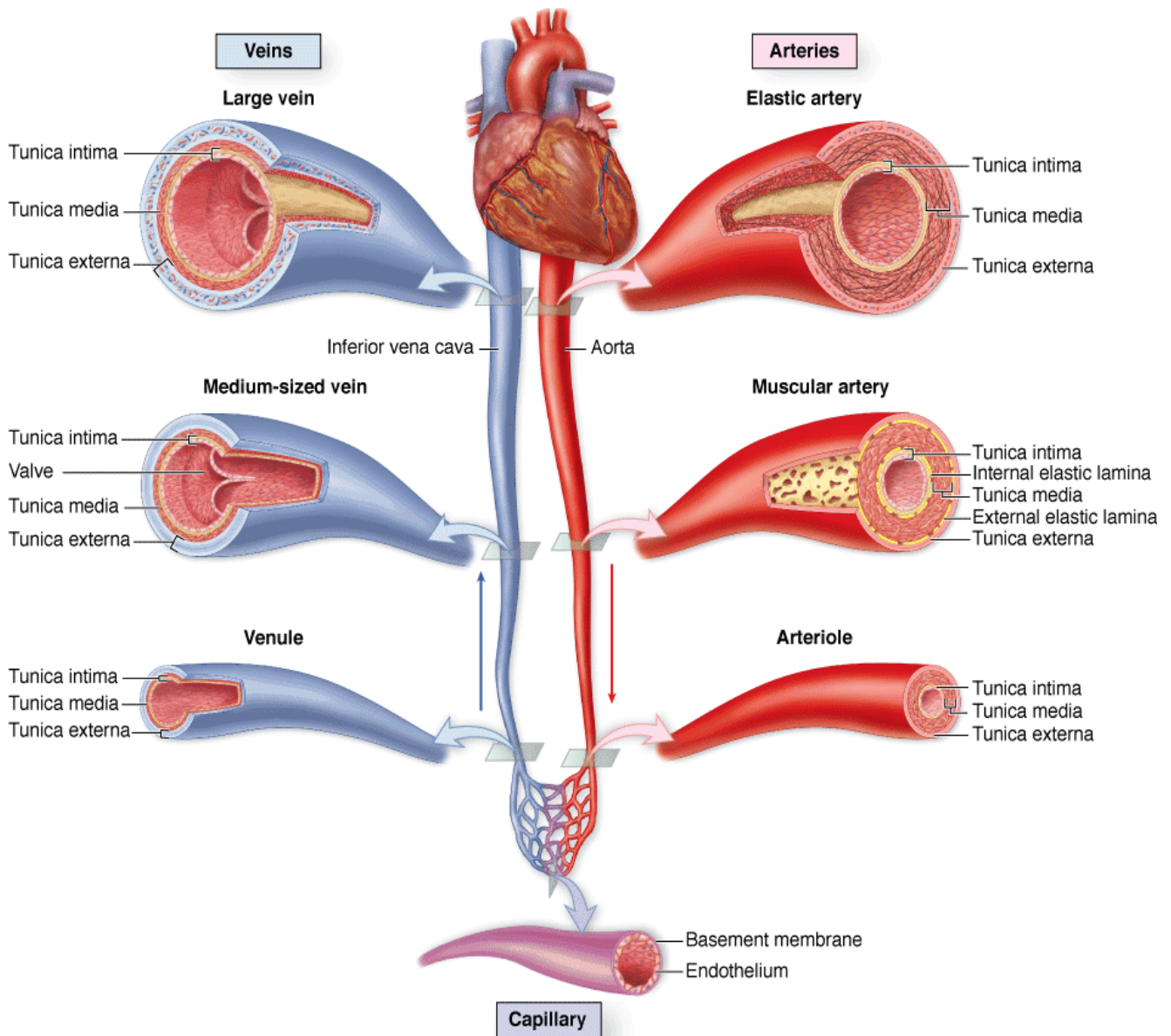


THE CIRCULATORY SYSTEM

- **Cardiovascular system**
- **Lymphatic vascular system**

The cardiovascular system consists of the heart , arteries, capillaries and veins.



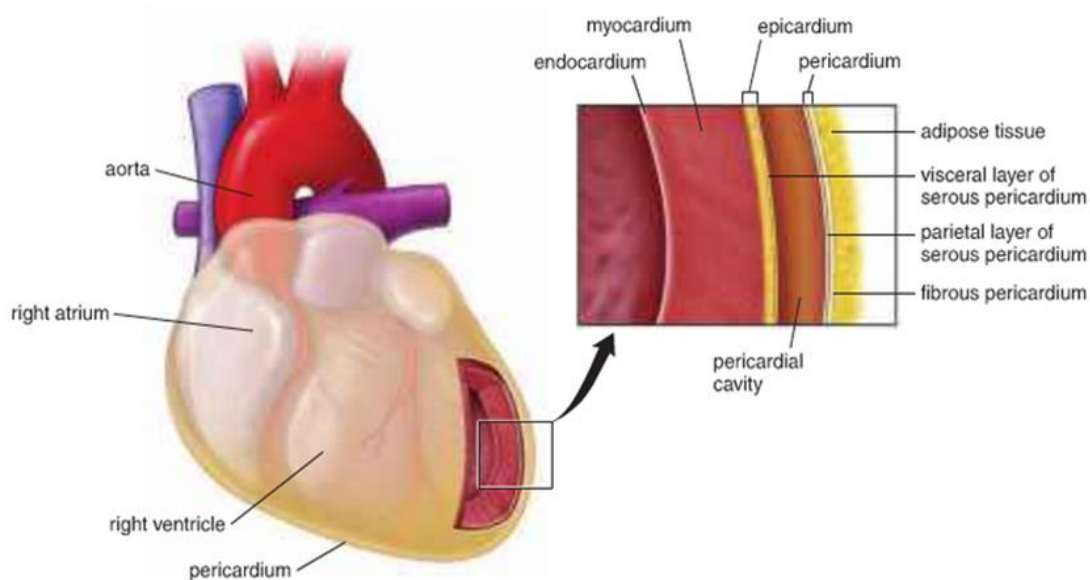
Histology

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HEART

Cardiac muscle in the four chambers of the heart wall contracts rhythmically. The walls of all four heart chambers consist of three major layers: the internal **endocardium**; the middle **myocardium**; and the external **epicardium**.



- The endocardium

Inner layer of the heart lines the atria and ventricles and covers the heart valves vessels, has three sublayers:

- Endothelium - innermost portion a simple squamous epithelium.
- Middle layer of the endocardium is mix of connective tissue and smooth muscle.
- Subendocardial Layer - outer layer of the endocardium is loose connective tissue joining the endocardium and myocardium.

-The myocardium

Is the middle layer (thickest layer) of the heart wall and contains the cardiac muscle with its fibers arranged spirally around each heart chamber.

- Cardiac muscle cells in the myocardium are arranged in strands whose ends attach to the dense connective tissue.
- Loose FECT holds bundles of cardiac muscle cells, fibers together and contains numerous blood vessels.

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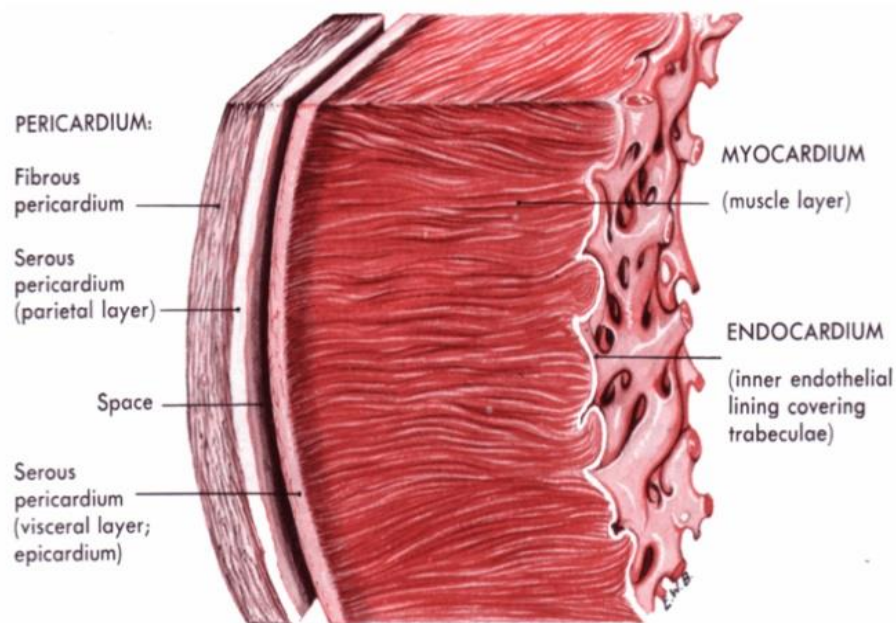
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-The epicardium

- Is the outer layer of the heart wall (simple squamous mesothelium) supported by a layer of loose connective tissue containing blood vessels and nerves.
- The epicardium corresponds to the visceral layer of the **pericardium** (the membrane surrounding the heart).

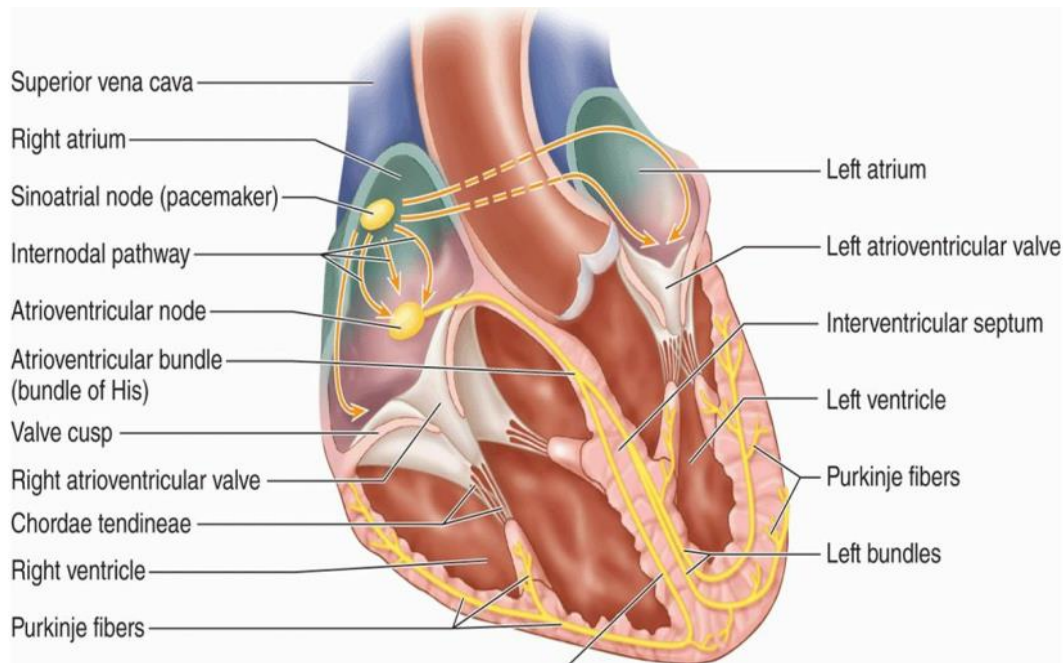
The **pericardium** is a two-layered connective tissue sac that encloses the heart. The **fibrous** pericardium is the **outer** layer, and the **serous** pericardium is the **inner** layer. The space between the two layers is the **pericardial cavity**, that contains serous fluid, this facilitates the pumping action of the heart.

The **epicardium functions** to protect the inner heart layers and also assists in the production of pericardial fluid.



Within the subendocardial layer and adjacent myocardium, modified cardiac muscle cells make up the impulse conducting system of the heart. This system consists of two nodes of specialized myocardial tissue in the right atrium: the **sinoatrial (SA) node** and the **atrioventricular (AV) node**, followed by the **AV bundle (of His)**.

At the apex of the heart, the bundles branch further into a subendocardial conducting network of myofibers called **Purkinje fibers**. These are pale-staining fibers, larger than the adjacent contractile muscle fibers, with sparse, peripheral myofibrils and much glycogen.



TISSUES OF THE VASCULAR WALL

Walls of all blood vessels except capillaries contain **smooth muscle** and **connective tissue** in addition to the **endothelial** lining. The amount and arrangement of these tissues in vessels are influenced by **mechanical factors, blood pressure, and metabolic factors reflecting the local needs of tissues**.

1- The endothelium is a specialized epithelium that acts as a semipermeable barrier between two internal compartments: the blood plasma and the interstitial tissue fluid. Vascular endothelial cells are squamous, polygonal .

Besides their key role in **metabolite exchanges between blood and tissues**, endothelial cells have several other functions:

-The endothelium presents a **nonthrombogenic surface** on which blood will not clot and actively secretes agents that control local clot formation.

-The cells regulate local **vascular tone and blood flow** by secreting various factors that stimulate smooth muscle contraction or relaxation.

- Endothelium has several roles in **inflammation and local immune responses**. Endothelial cells also secrete various factors called interleukins that affect the activity of local white blood cells during inflammation.

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- Under various conditions endothelial cells **secrete various growth factors**, as vascular endothelial growth factor (VEGF).

2- Smooth muscle fibers occur in the walls of all vessels larger than capillaries and are arranged helically in layers. In arterioles and small arteries, the smooth muscle cells are connected by many more gap junctions and permit vasoconstriction and vasodilation which are of key importance in regulating the blood pressure.

3- Connective tissue components are present in vascular walls in variable amounts and proportions based on local functional requirements.

- **Collagen fibers** are found in the subendothelial layer, between the smooth muscle layers, and in the outer covering.

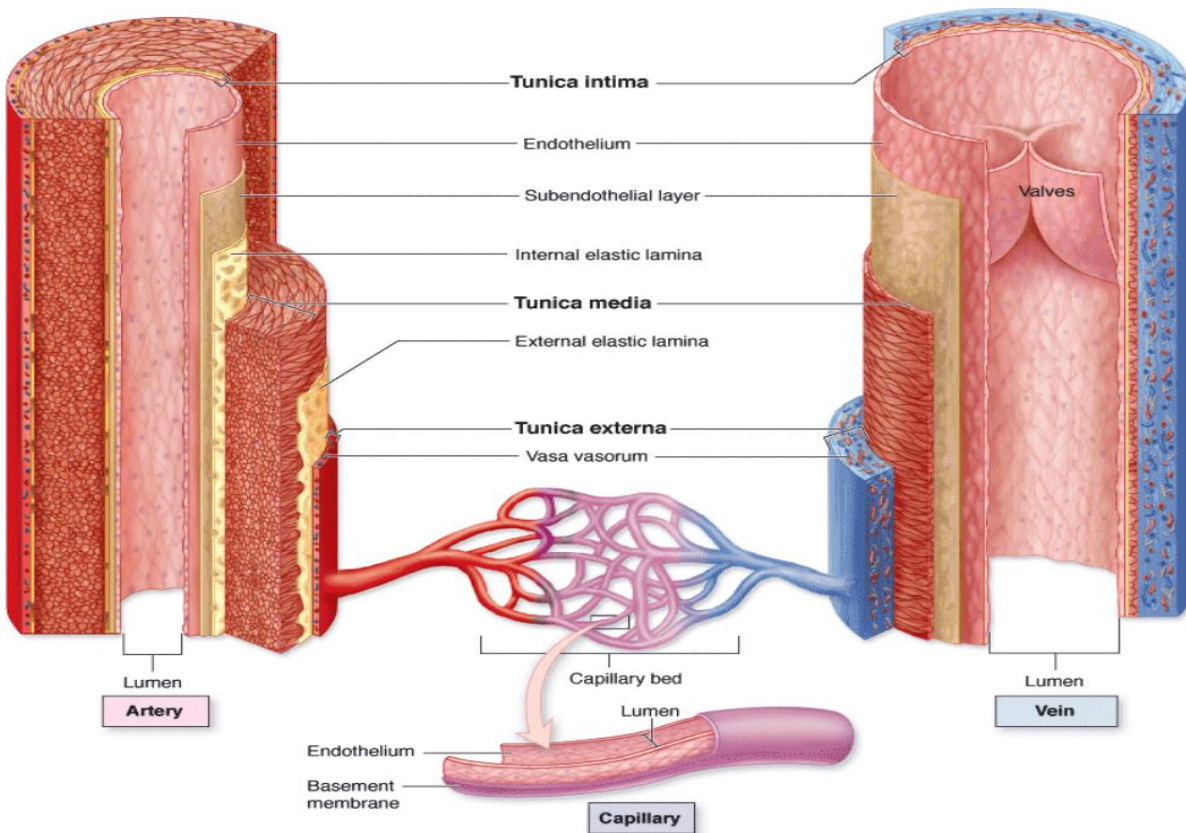
- **Elastic fibers** provide the resiliency required for the vascular wall to expand under pressure.

However, all of these larger vessels have walls with **three concentric layers, or tunics** :

- **The tunica intima** consists of the endothelium and a thin subendothelial layer of loose connective tissue sometimes containing smooth muscle fibers. **In arteries** the intima includes a prominent limiting layer, the **internal elastic lamina**

- **The tunica media** the middle layer consists chiefly of concentric layers of helically arranged smooth muscle cells. Interposed among the muscle fibers are variable amounts of elastic fibers and elastic lamellae and reticular fibers all of which are produced by the smooth muscle cells. In **arteries**, the media may have a **thin external elastic lamina**, separating it from the outermost tunic.

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



Elastic Arteries

Are the aorta, the pulmonary artery, and their largest branches; these large vessels are also called conducting arteries because their major role is to carry blood to smaller arteries. the most prominent feature of elastic arteries is:

-**The intima** is well developed, with many smooth muscle cells in the subendothelial connective tissue. The **internal elastic lamina** is not easily discerned because it is similar to the elastic laminae of the next layer.

- **The thick media** in which elastic lamellae, alternate with layers of smooth muscle fibers.

-**The adventitia** is much thinner than the media.

The numerous elastic laminae of these arteries contribute to their important function of making blood flow more uniform.

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Muscular Arteries

The muscular arteries distribute blood to the organs and help regulate blood pressure by contracting or relaxing the smooth muscle in the media.

-**The intima** has a very thin subendothelial layer and a prominent internal elastic lamina.

-**The media** may contain up to 40 layers of large smooth muscle cells interspersed with a variable number of elastic lamellae (depending on the size of the vessel). 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 adventitia.

Arterioles

The smallest arteries branch as arterioles:

-**The subendothelial** layer is very thin, elastic laminae are absent,

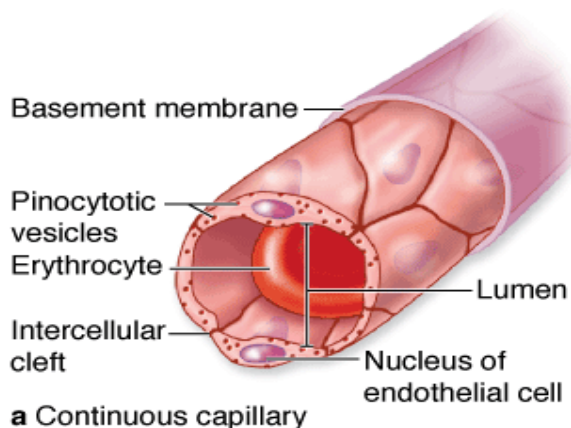
-**The media** consists of the circularly arranged smooth muscle cells (only one or two smooth muscle layers).

- In both small arteries and arterioles, **the adventitia** is very thin and inconspicuous.

Capillaries

Capillaries are composed of a single layer of endothelial cells rolled up as a tube . Capillaries permit and regulate metabolic exchange between blood and surrounding tissues. Capillaries are generally grouped into three histologic types, depending on the **continuity of the endothelial cells and the external lamina**.

1- **The continuous, or somatic, capillaries** are characterized by the absence of fenestrae in their wall. They are found in all types of muscle tissue, connective tissue, exocrine glands, and nervous tissue.

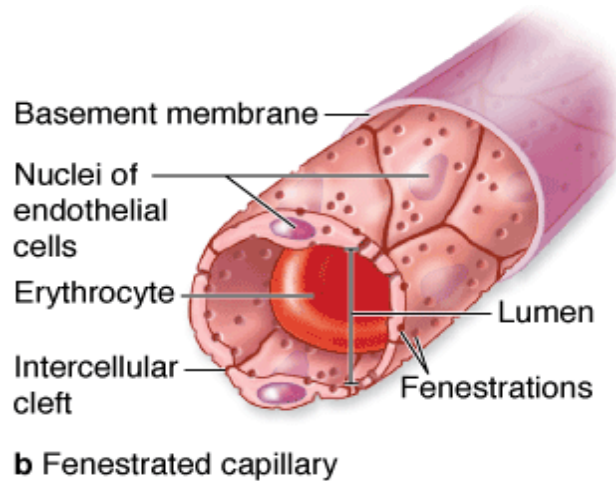


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2- **The fenestrated, or visceral, capillaries** are characterized by the presence of several circular openings in the endothelium membrane called **fenestrae**. Fenestrae are limited by the cell membrane. The basal lamina of the fenestrated capillaries is continuous. Found in organs with rapid interchange of substances between tissues and the blood, such as the kidneys, intestine, choroid plexus, and endocrine glands.

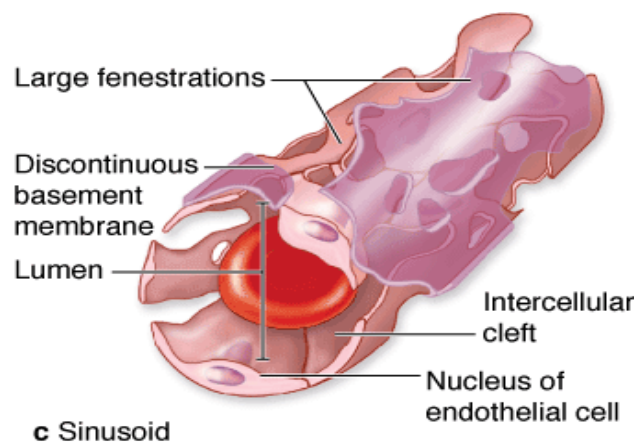


3. **The discontinuous or sinusoidal capillaries**, the third type, have the following characteristics:

- The endothelial cells form a discontinuous layer and are separated from one another by wide spaces.

- The basal lamina is discontinuous

Sinusoidal capillaries are found mainly in the liver and in hematopoietic organs such as the bone marrow and spleen.



Postcapillary Venules

The transition from capillaries to venules occurs gradually. The immediate postcapillary venules (pericytic venules) are characterized by the presence of **pericytes**. The tunica intima of these vessels is composed of endothelium and a very thin subendothelial layer. The media of these venules may contain only contractile pericytes .

Venules

Postcapillary venules converge into larger collecting venules . The venules become surrounded by a 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

Veins carry blood back to the heart from microvasculature all over the body. Blood entering veins is under very low pressure and moves toward the heart by contraction of smooth muscle fibers in the media and by external compressions from surrounding muscles and other organs. Most veins are small or medium veins.

- **The intima** usually has a thin subendothelial layer,
- **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 close to the heart, are the large veins.

- the well-developed intima,
- The media is relatively thin, with alternating layers of smooth muscle and connective tissue.
- The adventitial layer is thicker than the media in large veins and frequently contains longitudinal bundles of smooth muscle.
- Both the media and adventitia contain elastic fibers, but internal and external elastic laminae are not present. Medium and large veins have **valves** consisting of paired folds of the intima projecting across 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.