The University of Jordan
Faculty Of Medicine

Histology of Cardiovascular system

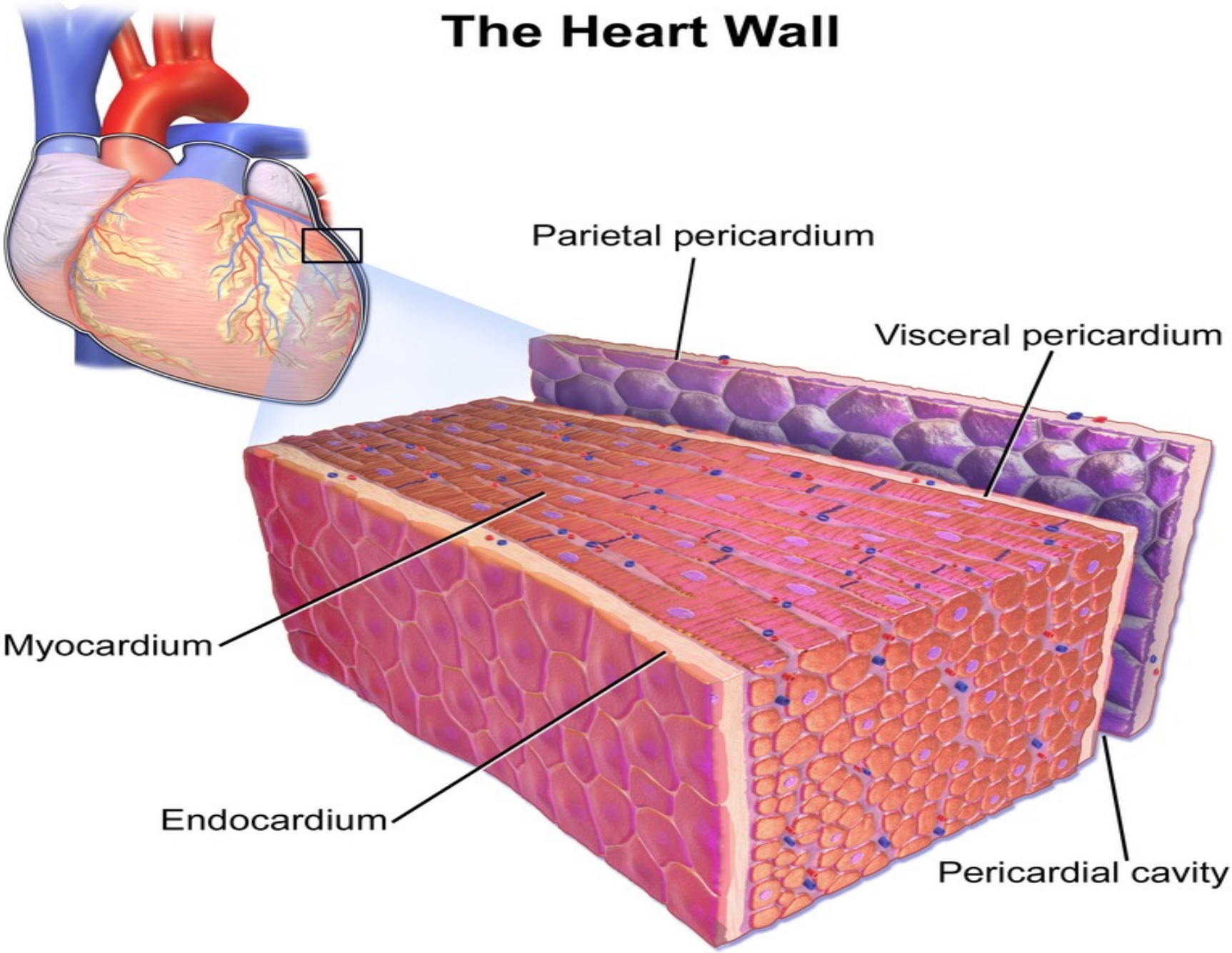
Dr. Ahmed Salman

Associate professor of anatomy & embryology

Layers of wall of heart chambers

- Endocardium (internal)
- Myocardium (middle)
- Epicardium (external)

The Heart Wall

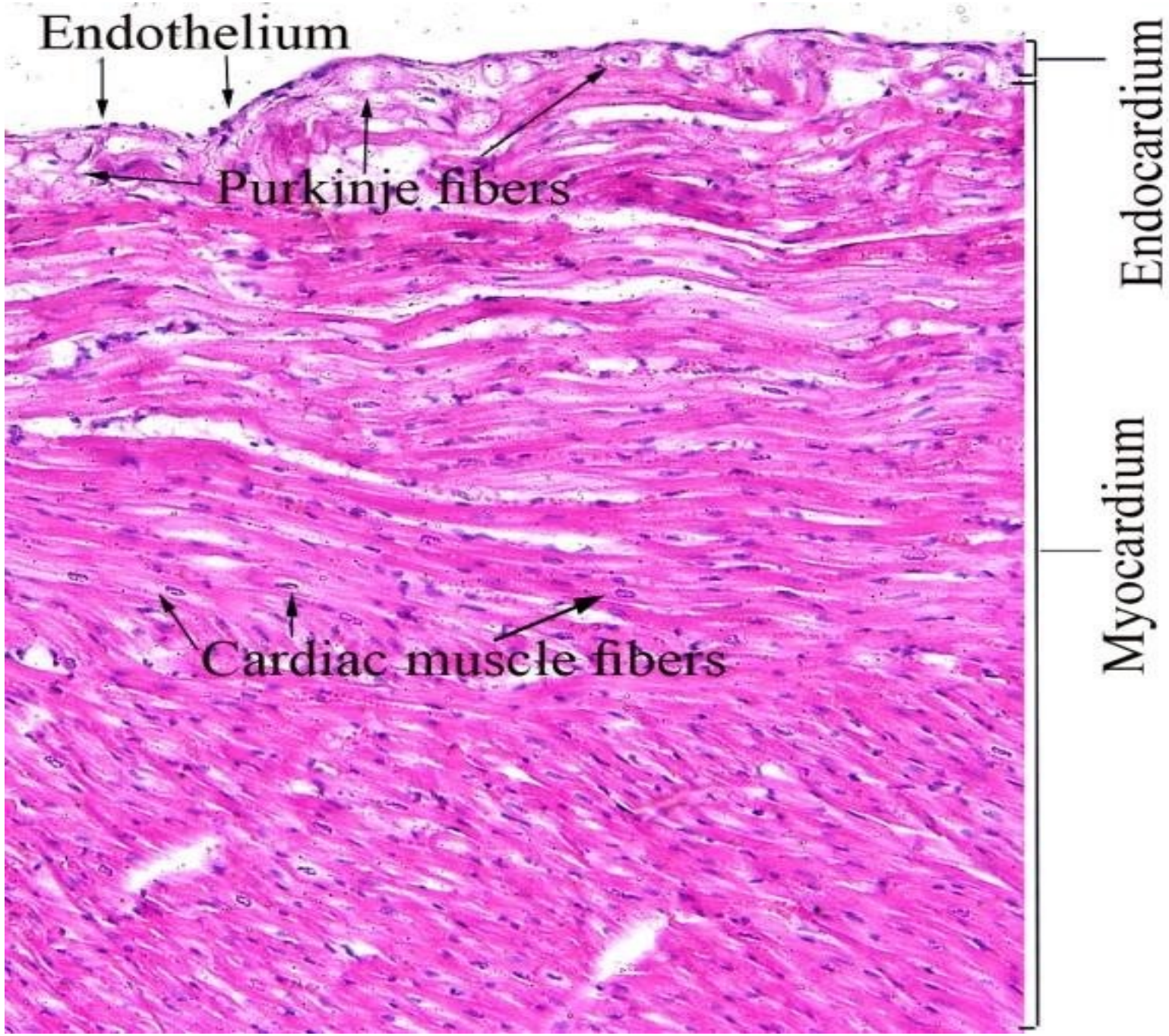


Endocardium

The **endocardium** consists of:

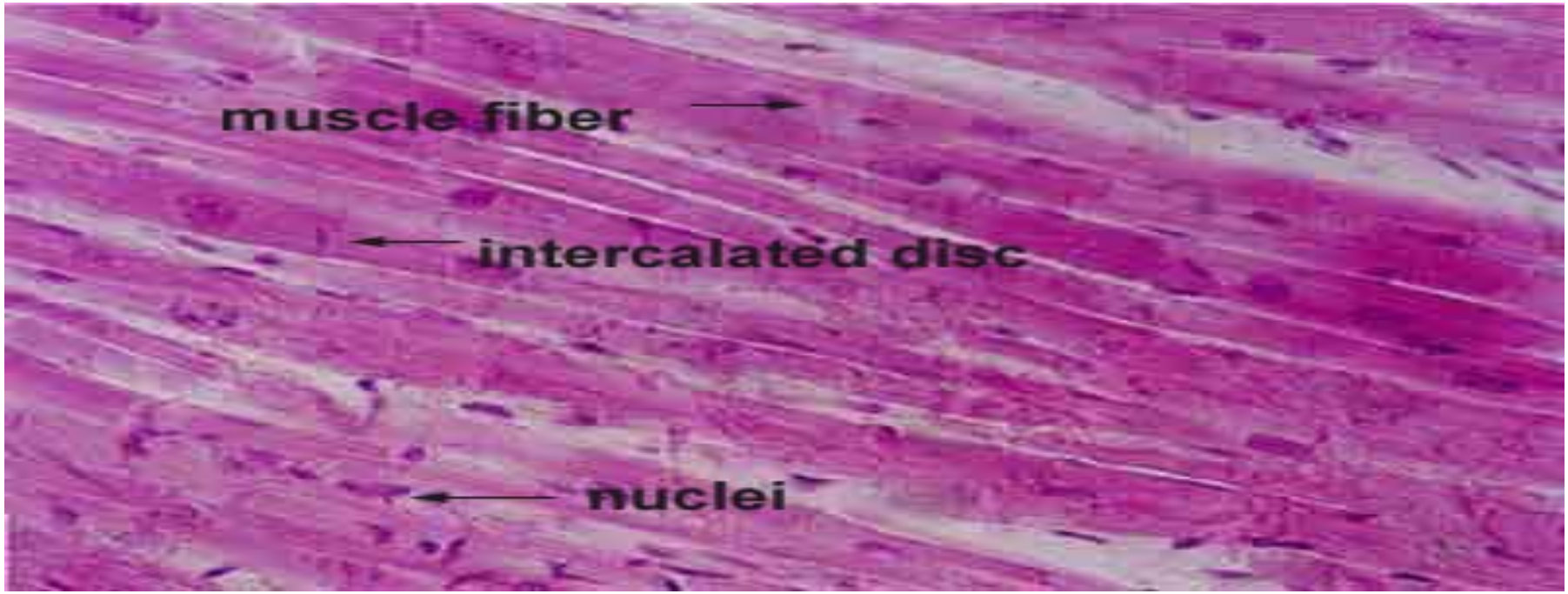
- A thin inner layer of endothelium
- A middle myoelastic layer of smooth muscle fibers and connective tissue
- A deep layer of connective tissue called the **subendocardial layer** that merges with the myocardium.

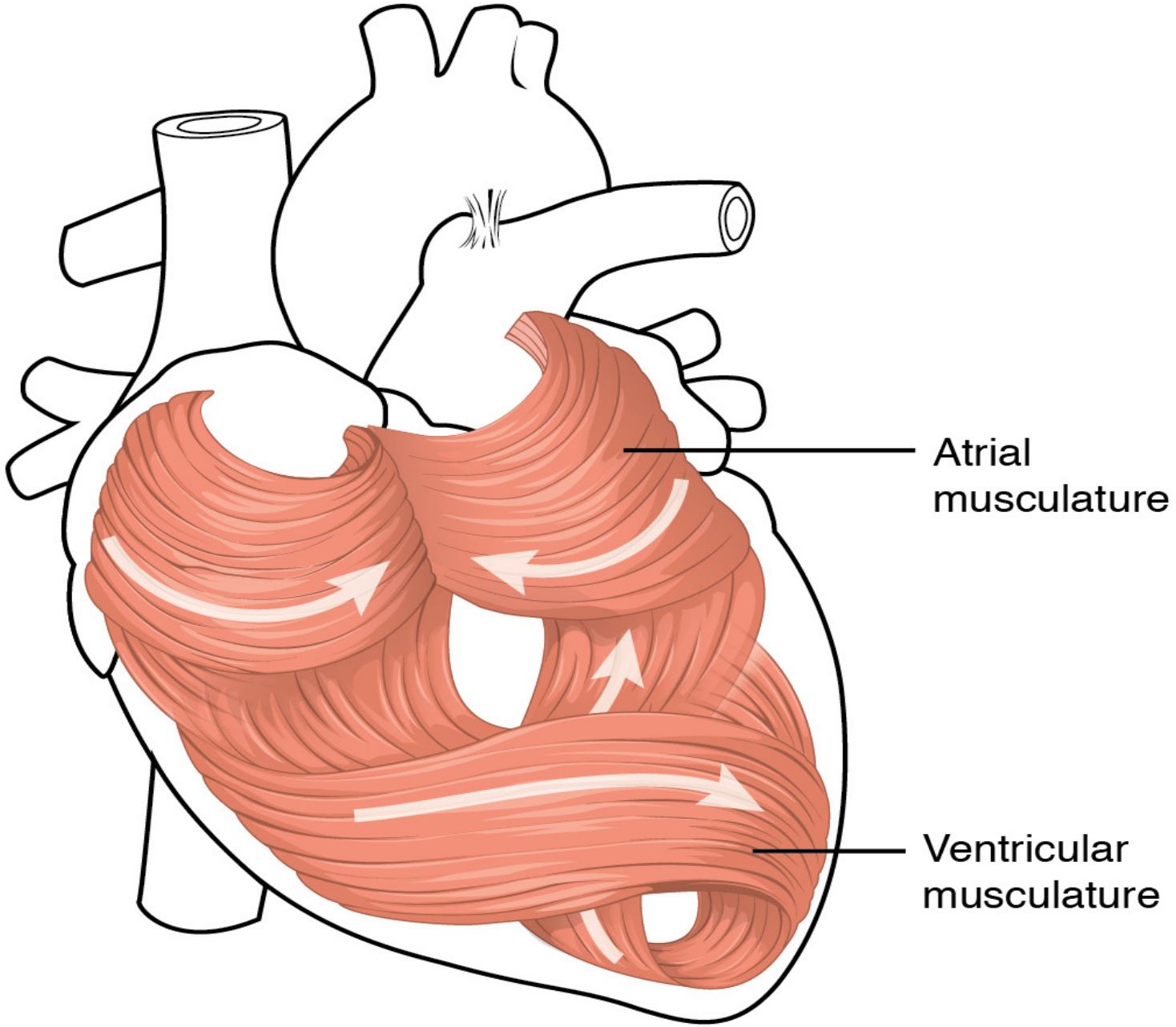
- Branches of the heart's conducting system , are also located in the subendocardial layer.


Endothelium
Purkinje fibers
Cardiac muscle fibers
Endocardium
Myocardium

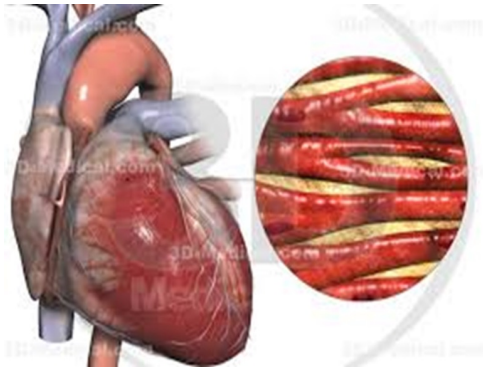
Myocardium

- The thickest layer, the **myocardium**, consists mainly of cardiac muscle with its fibers arranged spirally around each heart chamber.
- Because strong force is required to pump blood through the systemic and pulmonary circulations, the myocardium is much thicker in the walls of the ventricles, particularly the left, than in the atrial walls

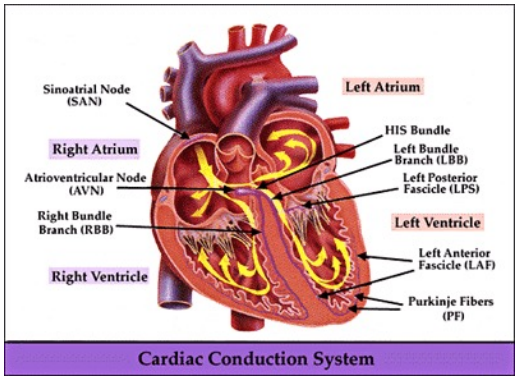



Atrial
musculature
Ventricular
musculature

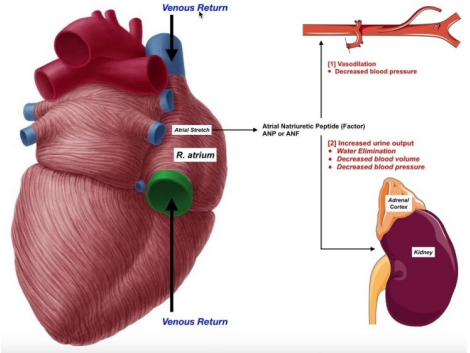
Cardiac Muscle Functions



1. Contraction (Ordinary fibers)
2. Conduction (Conducting System)
3. Secretion Atrial Natriuretic Peptide (ANP)



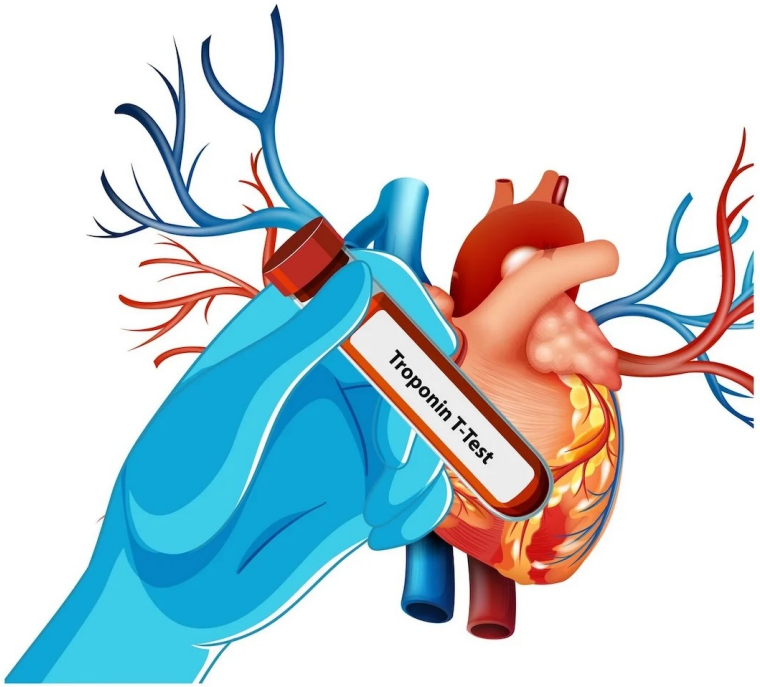
N.B: Main function of ANP is causing a reduction in expanded extracellular fluid (ECF) volume by Increases Glomerular Filtration Rate (GFR) and increasing renal sodium excretion.

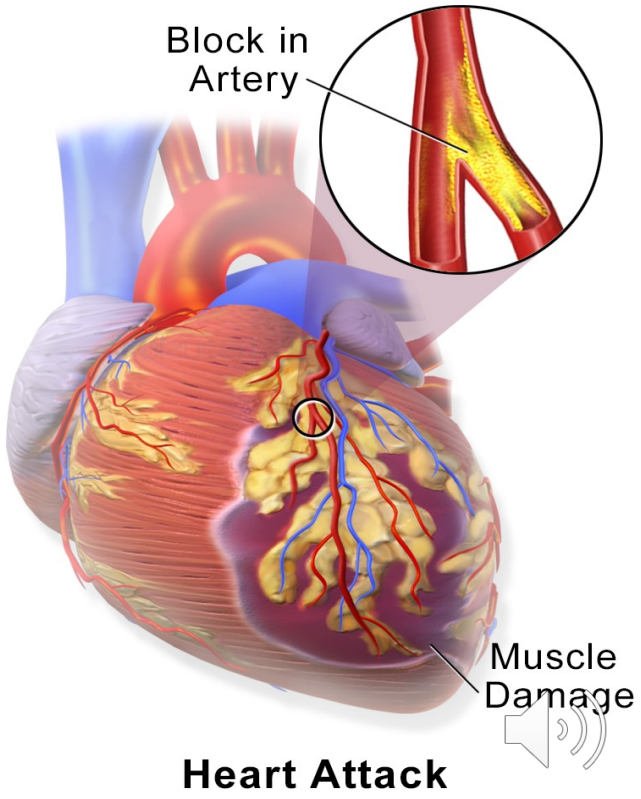


During myocardial infarction, ischemic injury causes cardiomyocyte necrosis, damage of cell membranes and leakage of :-

1- Cardiac troponin I (cTnI)
2- Cardiac troponin T (cTnT)

Cardiac troponins are released from injured cardiomyocytes; they are not actively secreted hormones.





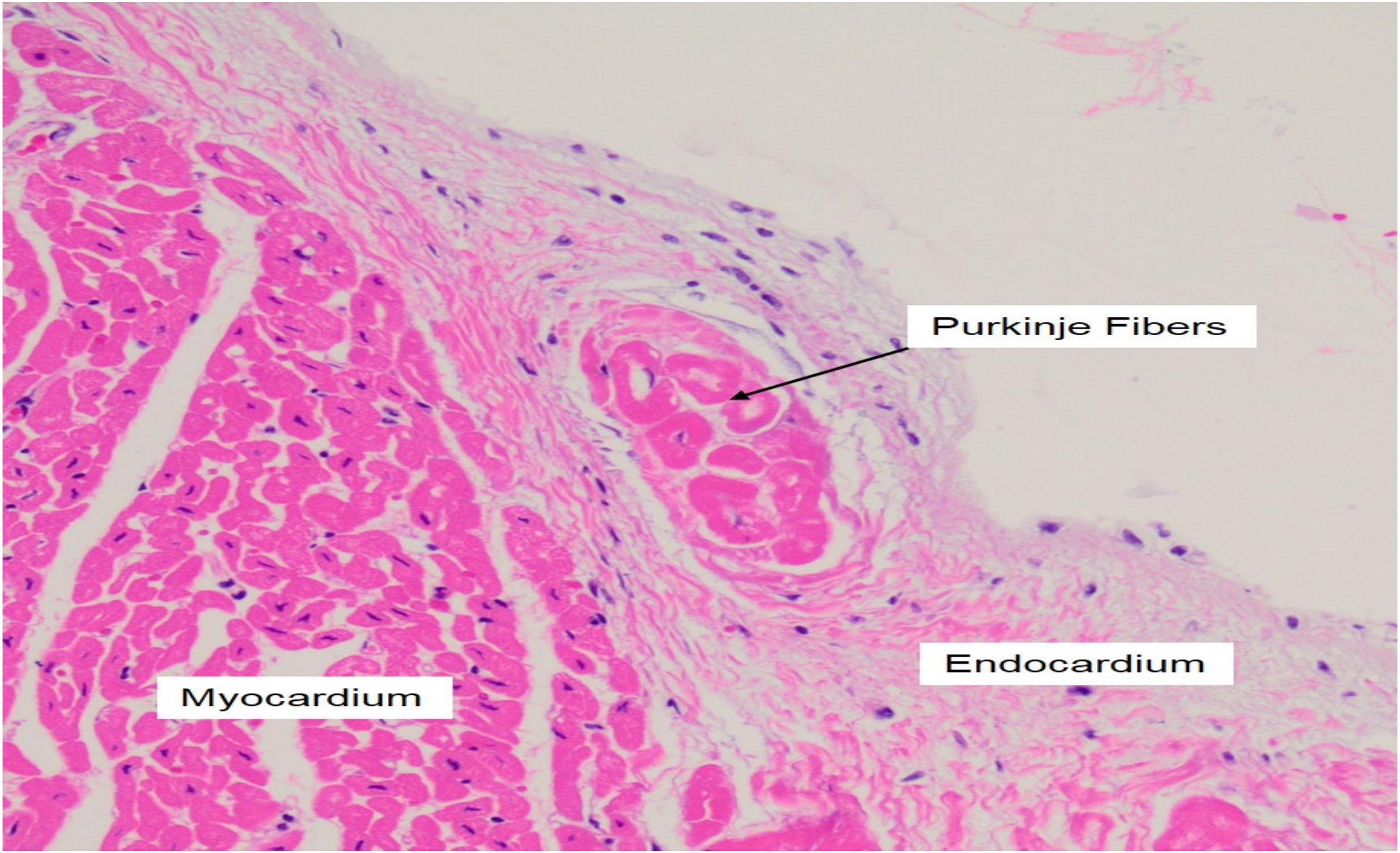
Purkinje fibers

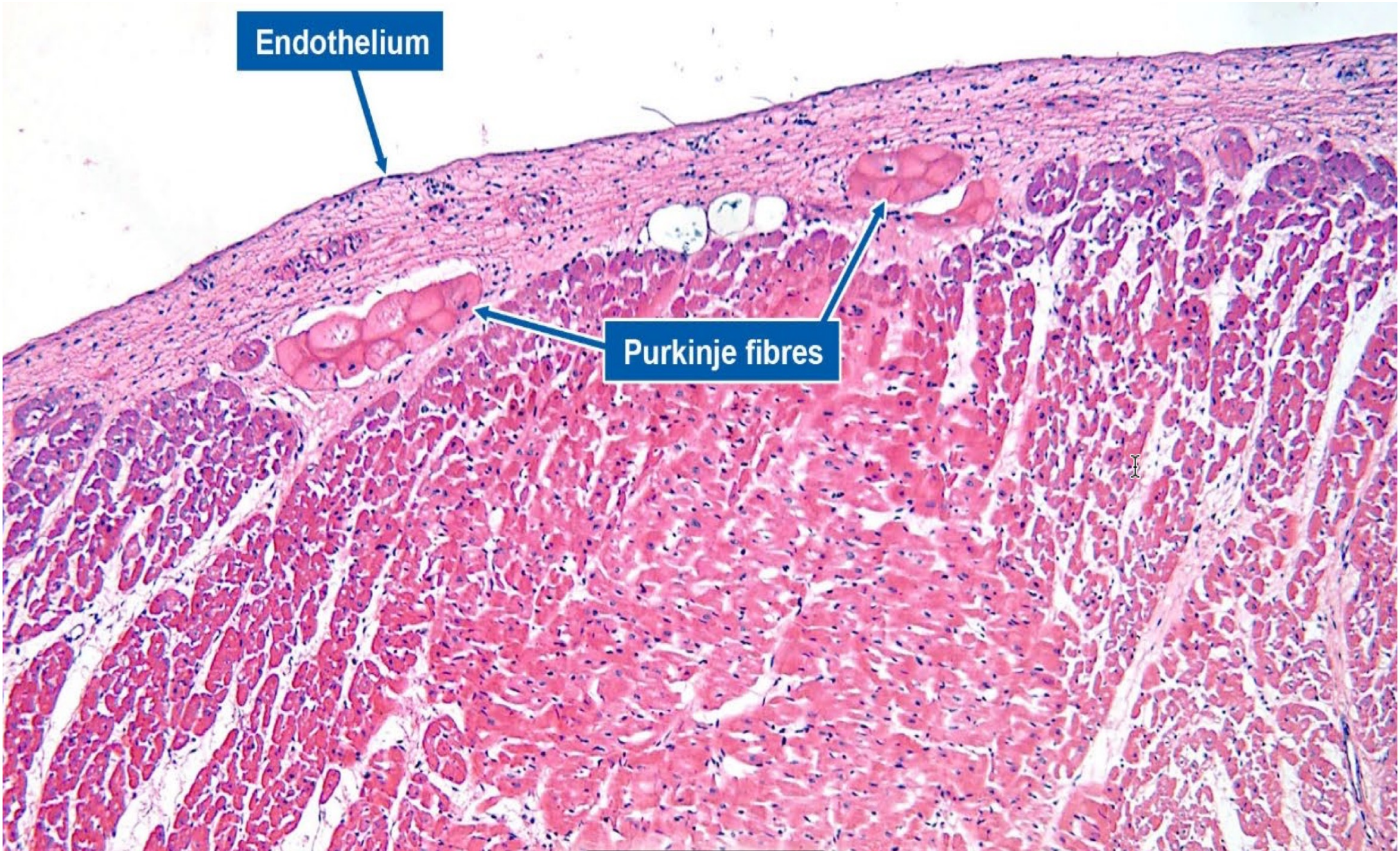
Purkinje fibers are cardiac muscle fibers specialized for electrical conduction.

They are pale-staining fibers, larger than the adjacent contractile muscle fibers

- Arranged in groups
- Larger and paler than cardiac muscles
- Vacuolated
- Few myofibrils
- Fewer interacted disc
- Rich nerve supply

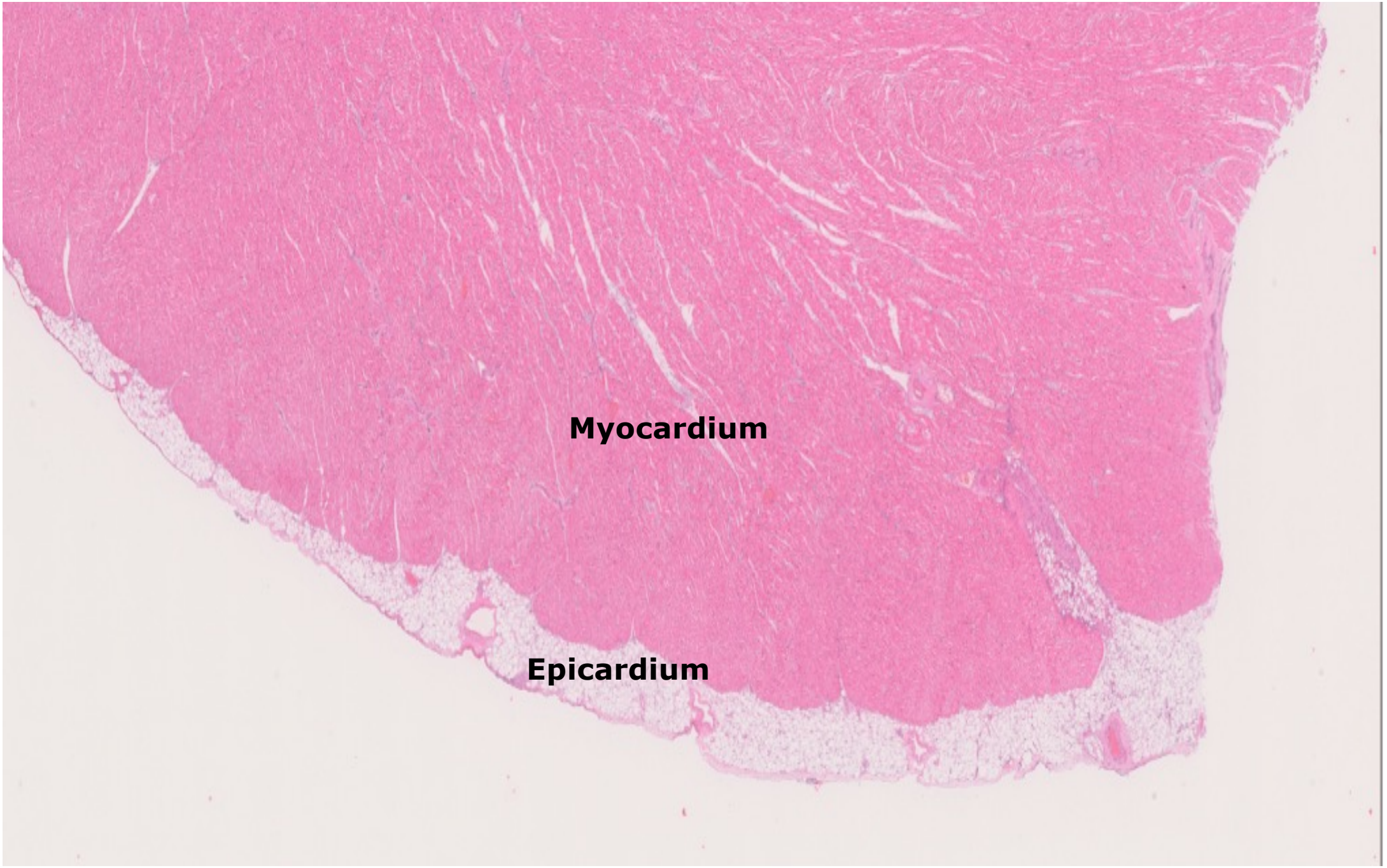
➢ Purkinje fibers mingle distally with contractile fibers of both ventricles and trigger waves of contraction through both ventricles simultaneously.


Purkinje Fibers
Endocardium
Myocardium


Endothelium
Purkinje fibres

Epicardium

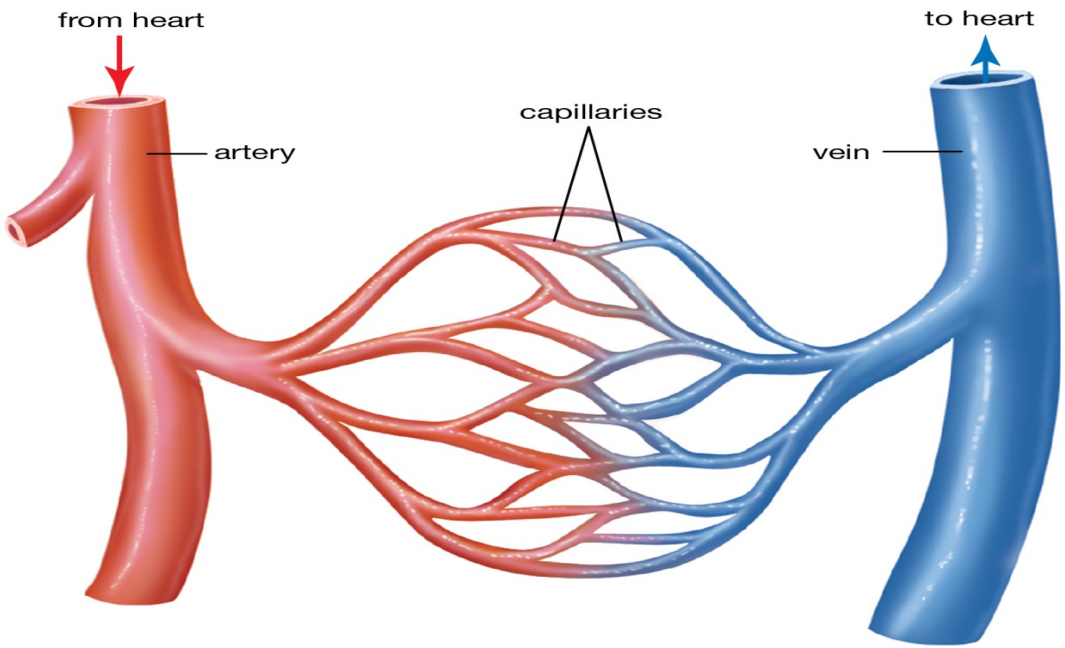
- The **epicardium** is a simple squamous **mesothelium** supported by a layer of loose connective tissue containing blood vessels and nerves.
- The epicardium corresponds to the **visceral layer of the pericardium**.
- Where the large vessels enter and leave the heart, the epicardium is reflected back as the **parietal layer** lining the pericardium.
- Friction within the pericardium is prevented by lubricant fluid produced by both layers of serous mesothelial cells.

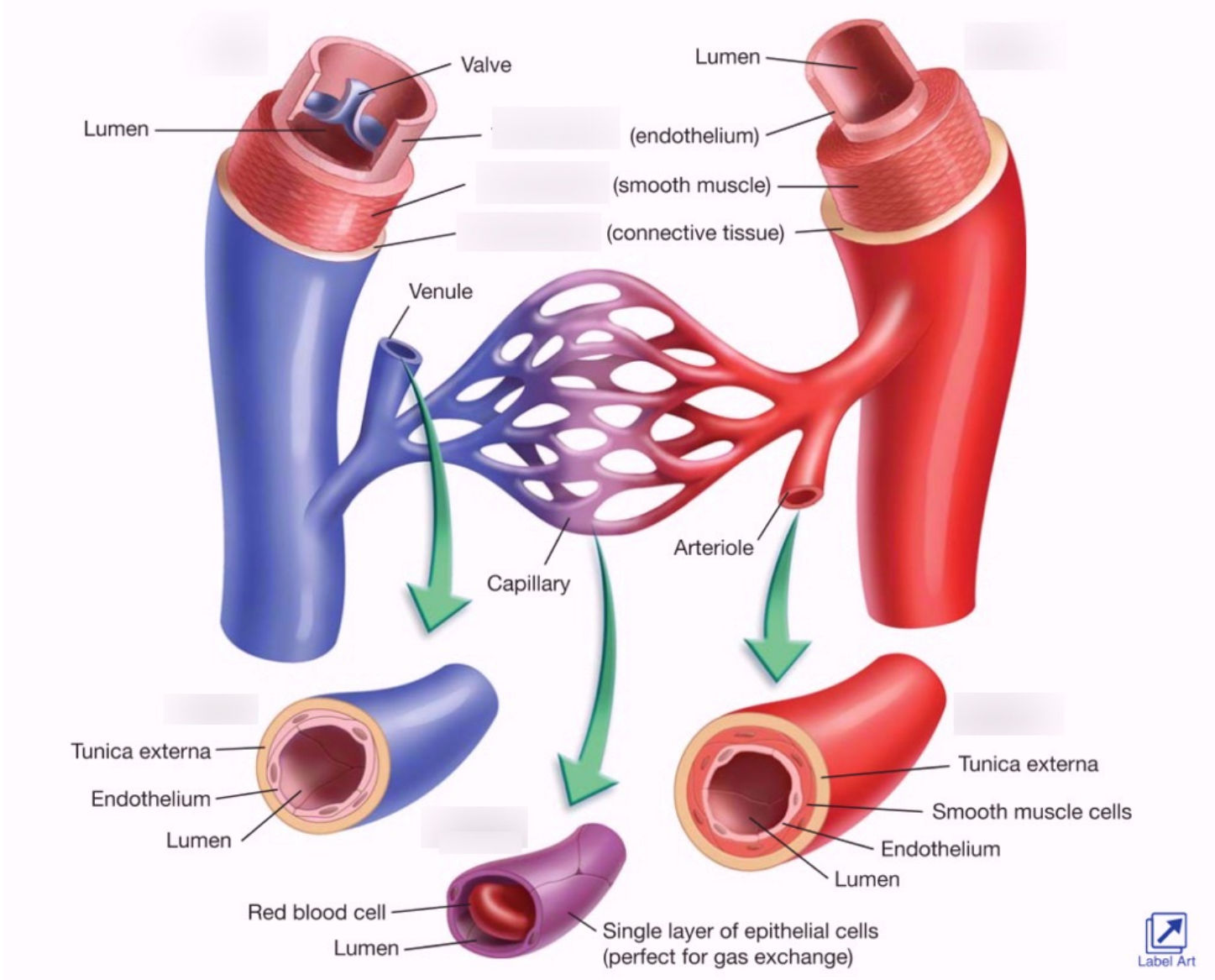

Myocardium
Epicardium

Classification of Blood Vessels

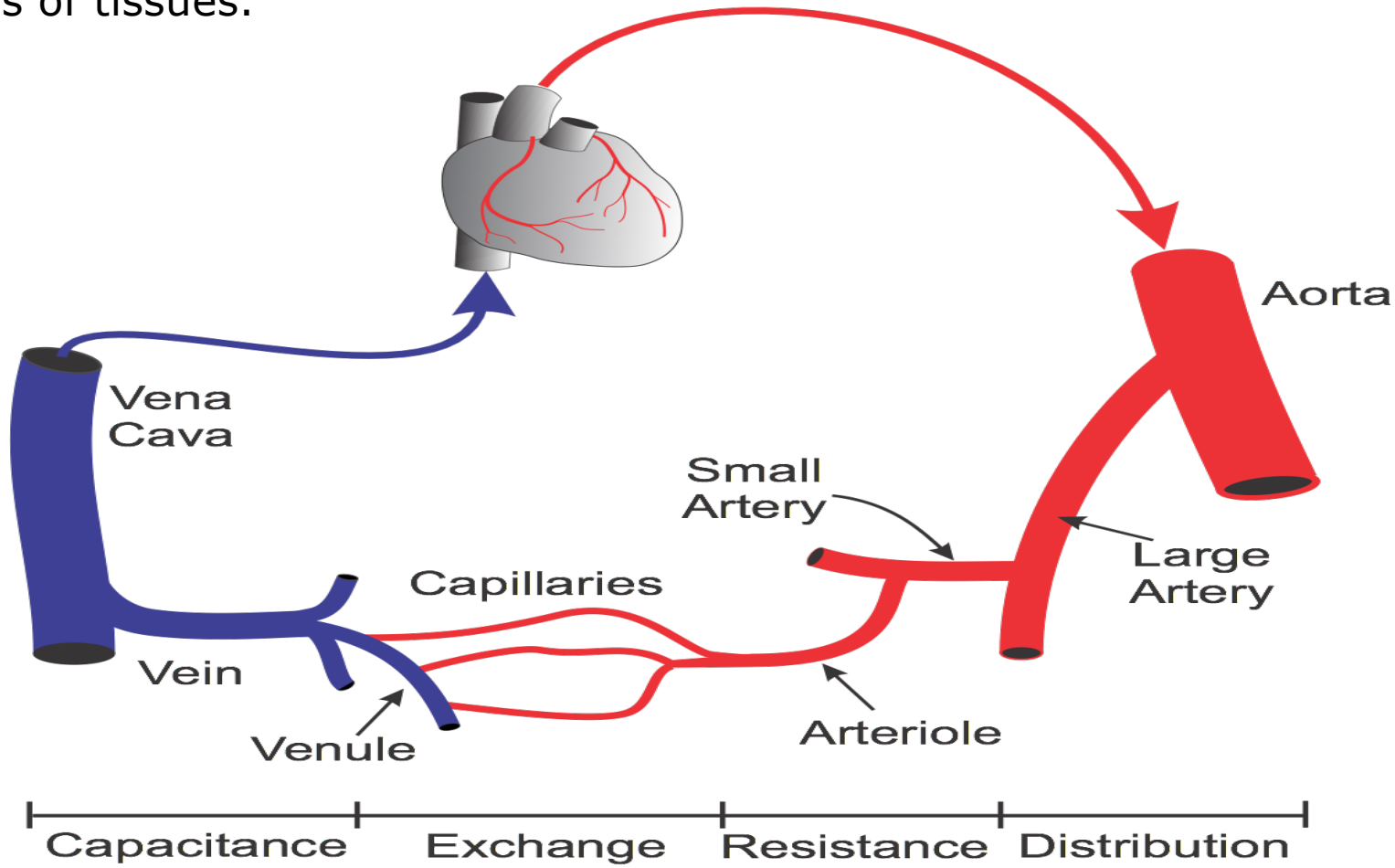


- There are 3 Major Types of **Blood Vessels**: ***Arteries***, ***Veins*** and ***Capillaries***.
- **Blood vessels** flow **blood** throughout the body.
- ***Arteries*** transport **blood** away from the heart.
- ***Veins*** return **blood** back toward the heart.
- ***Capillaries*** surround body cells and tissues to deliver and absorb oxygen, nutrients, and other substances.




Valve
Lumen
Lumen
(endothelium)
(smooth muscle)
(connective tissue)
Venule
Capillary
Arteriole
Tunica externa
Endothelium
Lumen
Red blood cell
Lumen
Single layer of epithelial cells
(perfect for gas exchange)
Tunica externa
Smooth muscle cells
Endothelium
Lumen
Label Art

- 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**, primarily blood pressure, and **metabolic factors** reflecting the local needs of tissues.

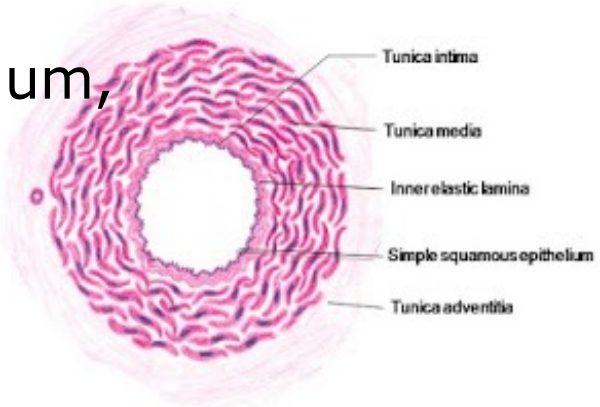


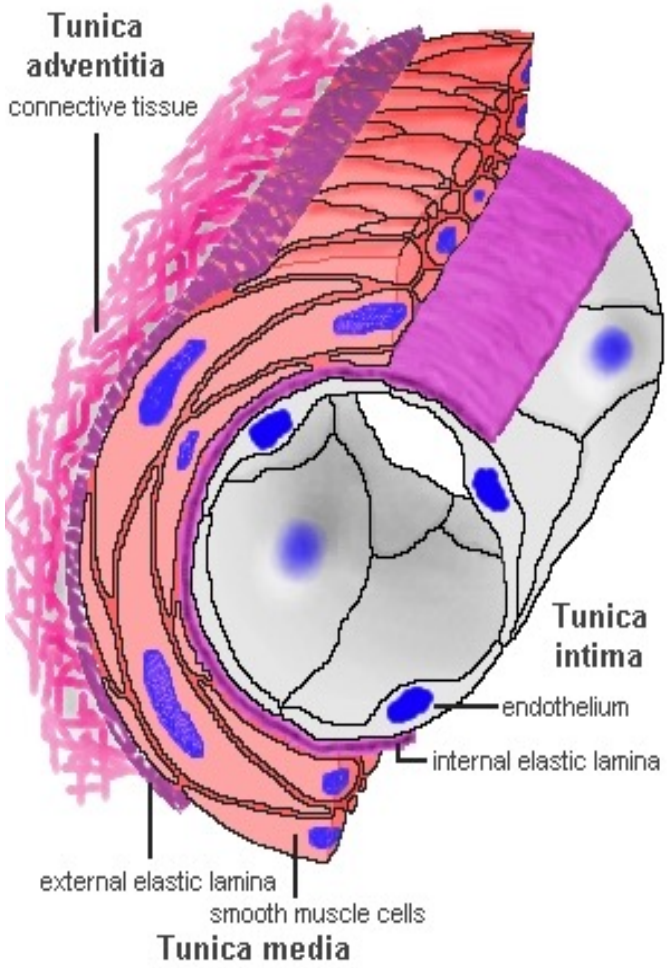
General Histological Characteristics of Blood Vessels

The wall of a blood vessel consists of ***3 layers*** from the lumen outward are:

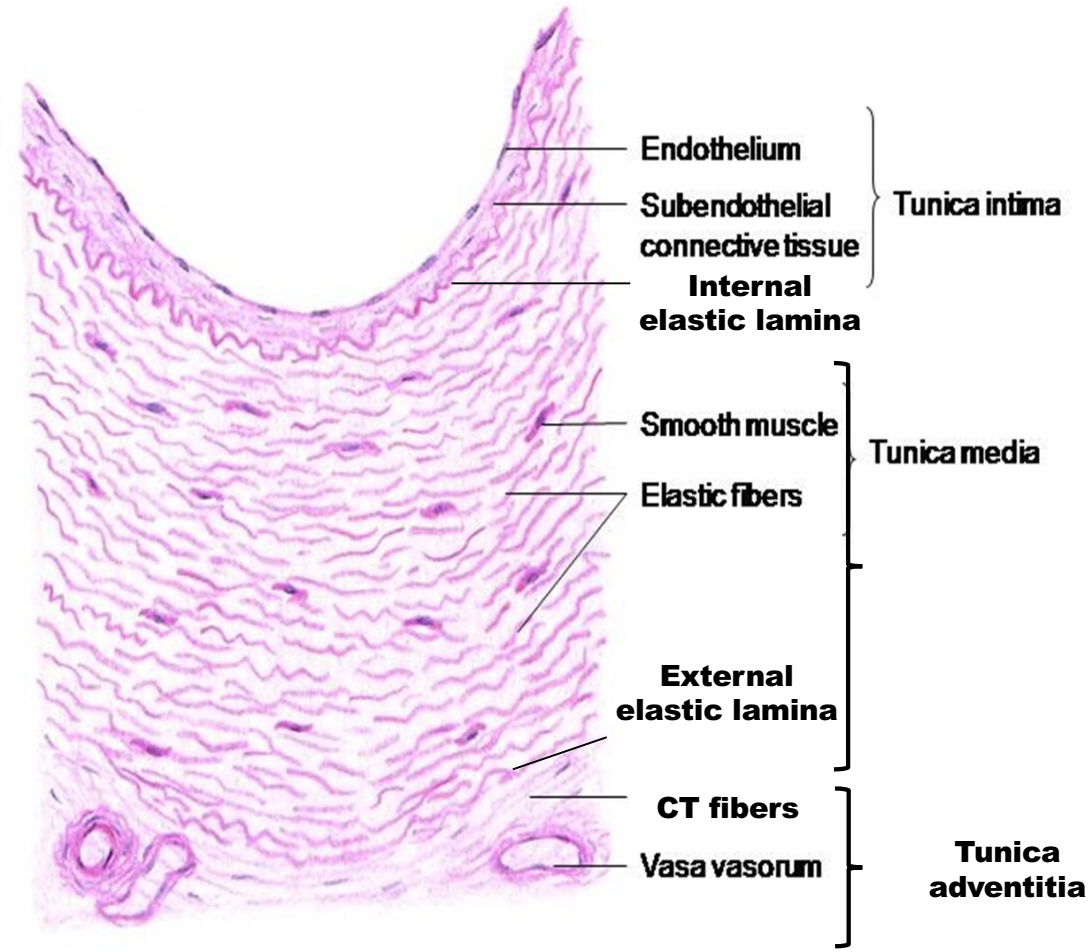
1. **Tunica intima**
2. **Tunica media**
3. **Tunica adventitia**

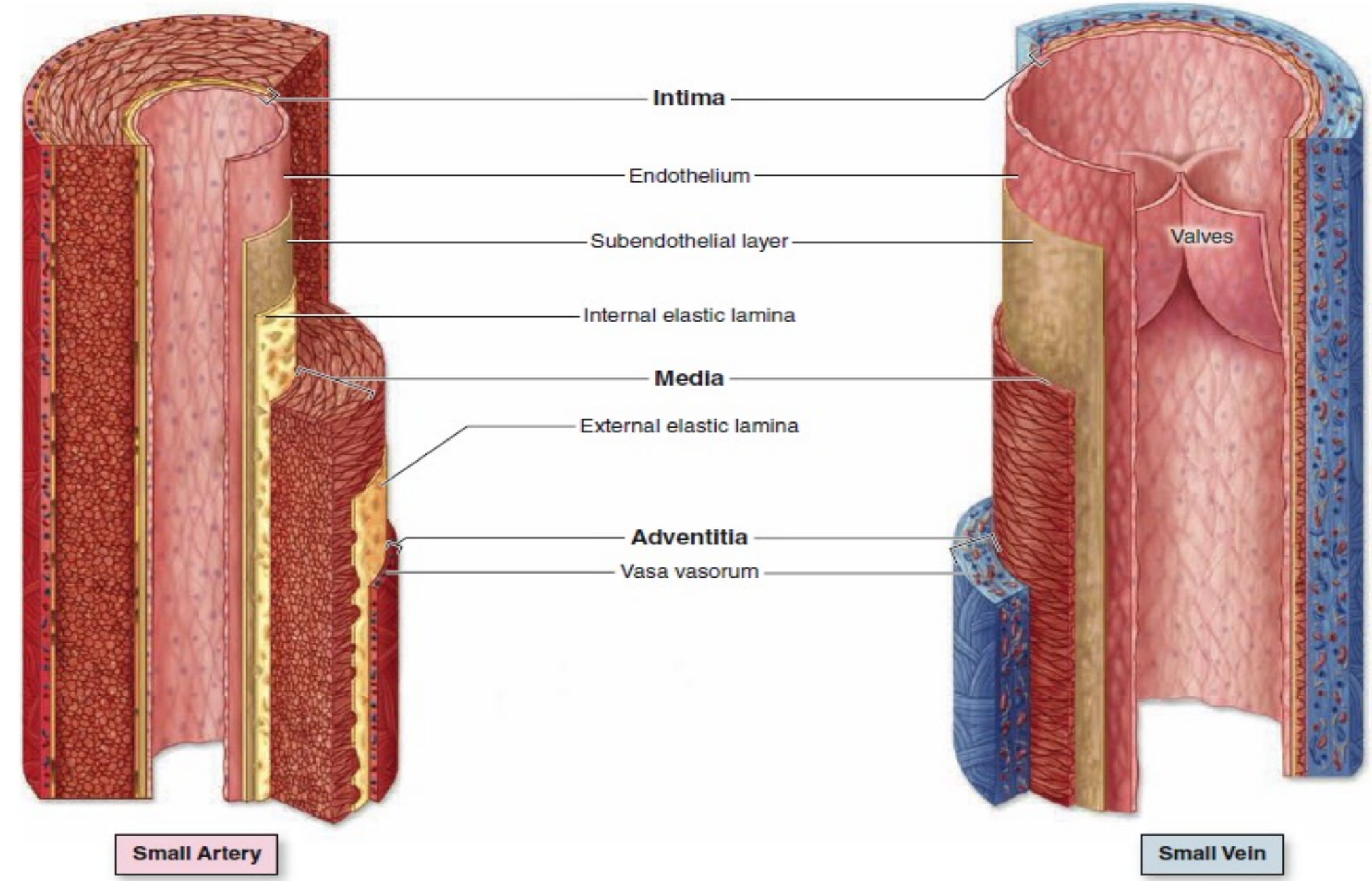
which correspond roughly to the heart's endocardium, myocardium, and epicardium.





Histological Structure of Blood Vessels




Intima
Endothelium
Subendothelial layer
Internal elastic lamina
Media
External elastic lamina
Adventitia
Vasa vasorum
Valves
Small Artery
Small Vein

1-Tunica intima

The innermost coat & consists of:

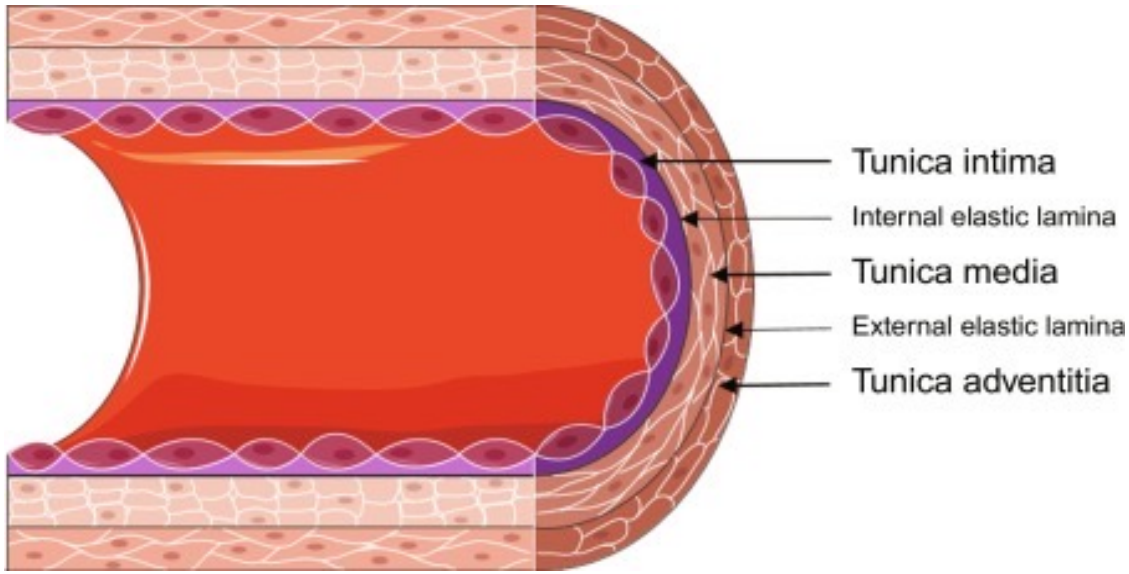
a- **Endothelium:** a simple squamous epithelium that provides a smooth surface for blood flow.

b- **Sub-endothelial layer**: It consists of loose connective tissue.

c- **Internal elastic lamina**: The most external component.

It composed of elastin, with holes allowing better diffusion of substances from blood deeper into the wall.

The elastic lamina prevent complete occlusions of the vessels during contraction.



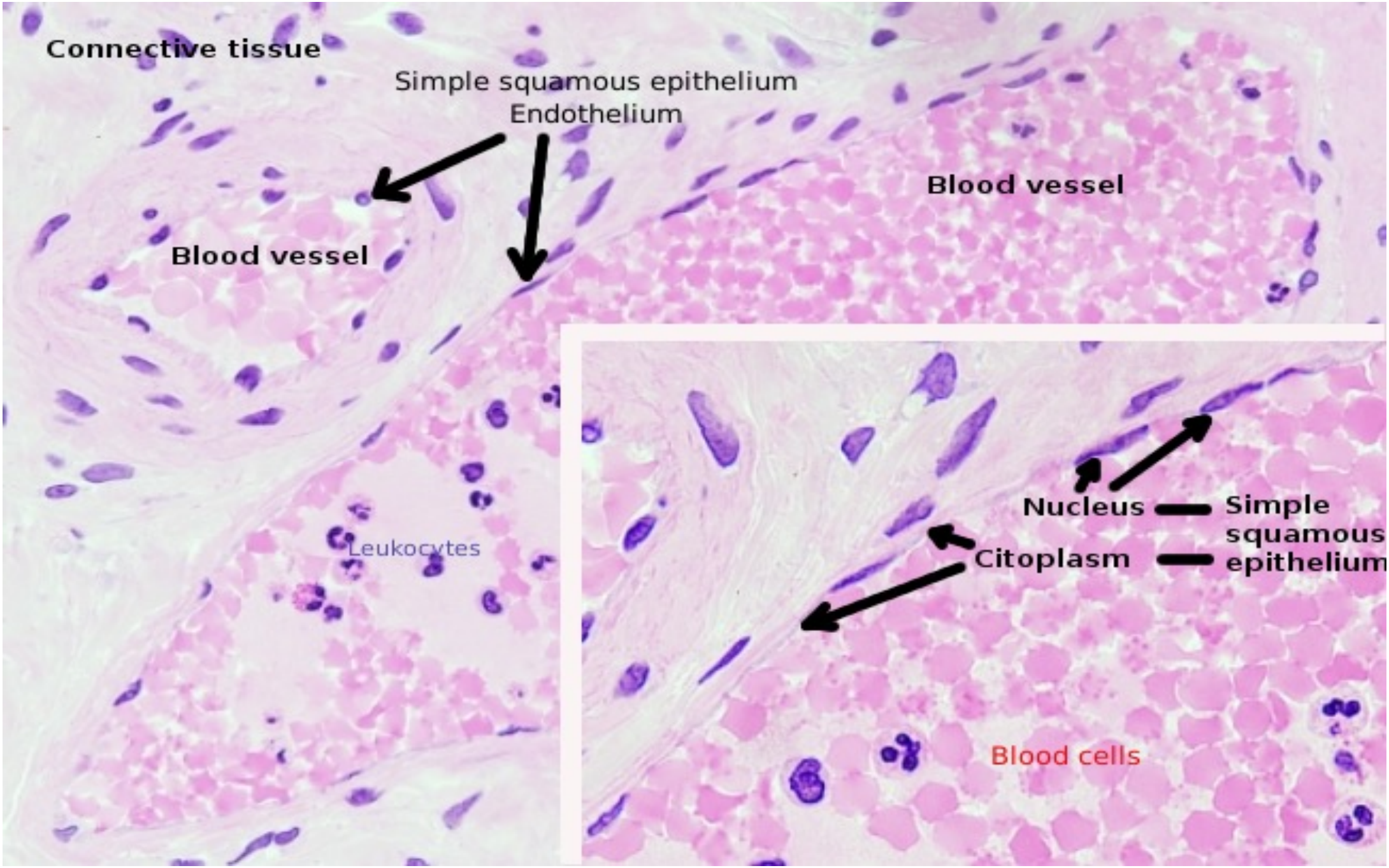
Endothelium

- The internal surface of all components of the blood and lymphatic systems is lined by a simple squamous epithelium called **endothelium**.

- Vascular endothelial cells are squamous, polygonal, and elongated with the long axis in the direction of blood flow

- The **endothelium** is a specialized epithelium that acts as a semipermeable barrier between two major internal compartments: the blood and the interstitial tissue fluid.

- Endothelium with its basal lamina is highly differentiated to mediate and actively monitor the bidirectional exchange of molecules by simple and active diffusion, receptor-mediated endocytosis and transcytosis


Connective tissue
Simple squamous epithelium
Endothelium
Blood vessel
Blood vessel
Leukocytes
Nucleus
Simple squamous epithelium
Citoplasm
Blood cells

Functions of Endothelium

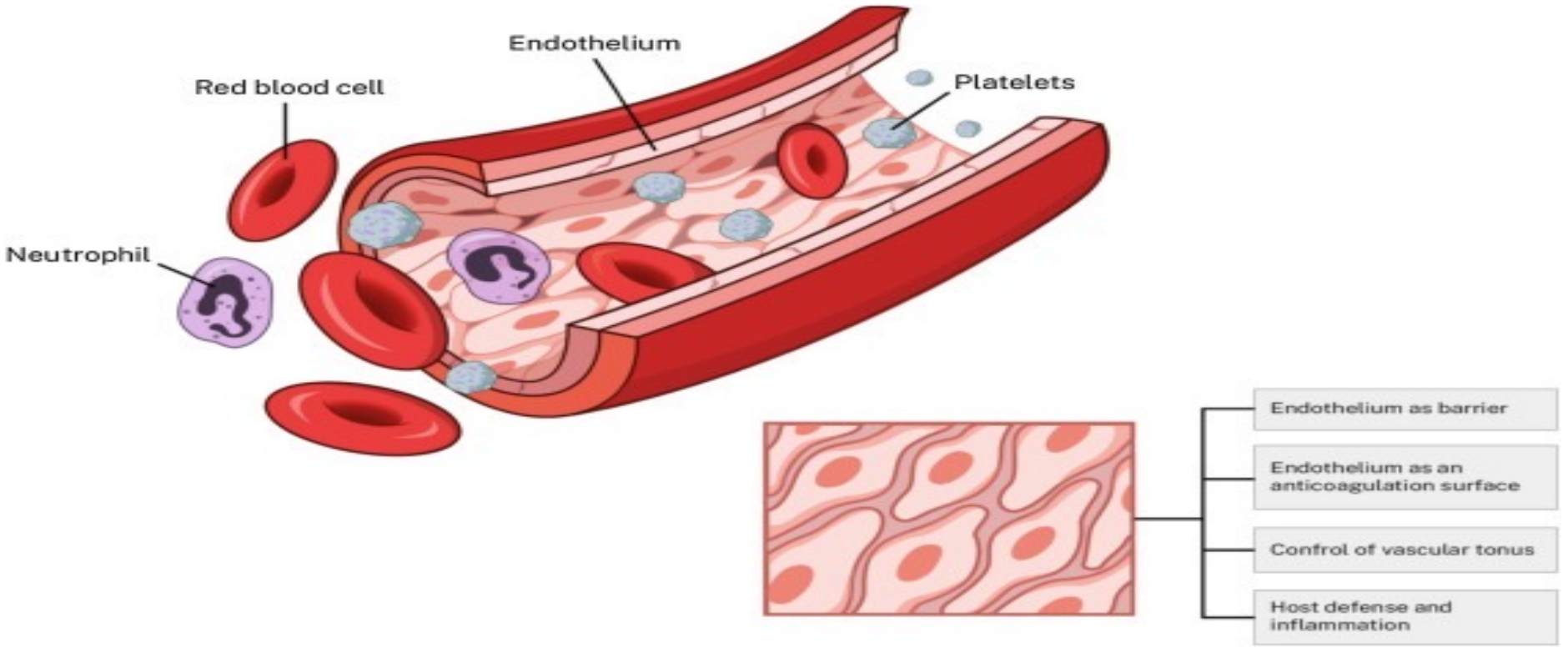
1. **Selective permeability:** Controls the movement of water, ions, proteins, and other molecules.
2. **Transport:** Facilitates molecule transport by endocytosis, exocytosis, and transcytosis.
3. **Regulation of vascular tone:**

   Nitric oxide (NO) → vasodilation.

   Endothelin → vasoconstriction.
4. **Anticoagulant function:** prevents unwanted platelet aggregation and thrombosis.
5. **Inflammatory response:** Regulates leukocyte adhesion and migration into tissues.
6. **Angiogenesis:** Participates in the formation of new blood vessels.
7. **Hemostasis:** Helps regulate coagulation and fibrinolysis.

Endothelial dysfunction is associated with:

- Atherosclerosis.
- Hypertension.
- Thrombosis.
- Increased vascular permeability.



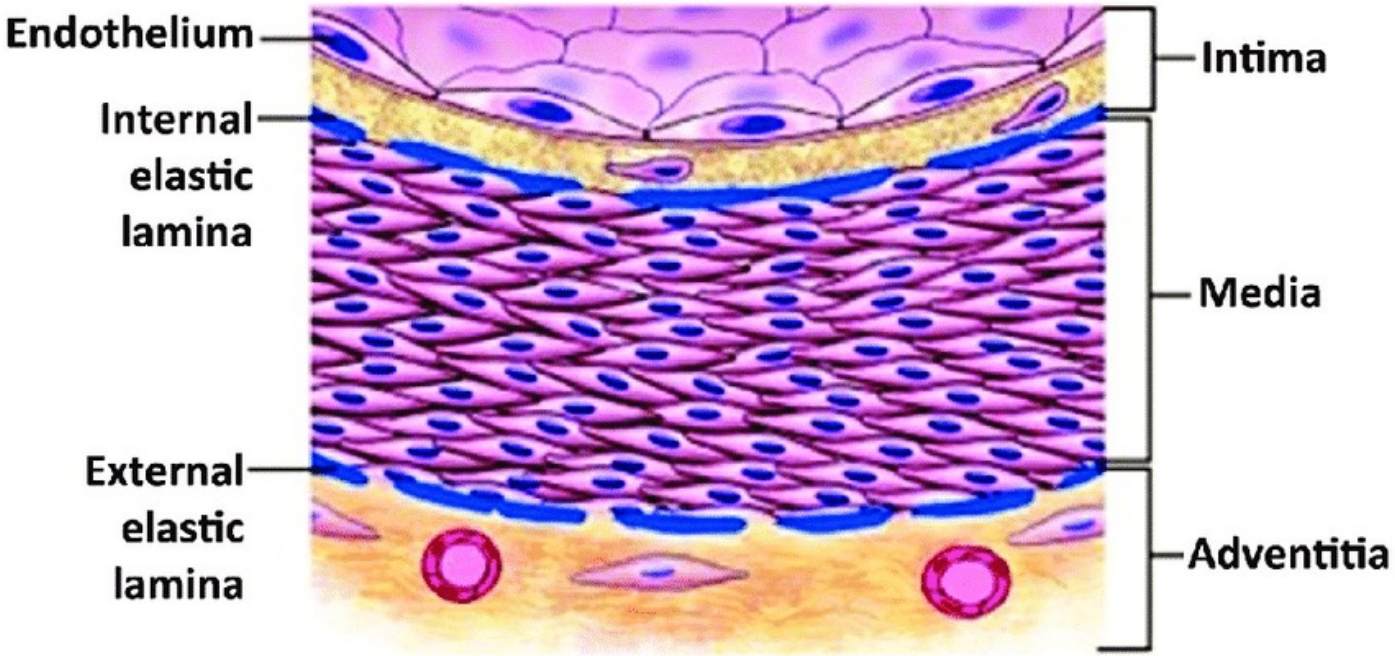
2-Tunica media

The middle coat & consists of:

a- **Smooth muscle fibers**: circularly arranged.

b- **Variable amounts of elastin**, **collagen**, **proteoglycan** and **glycoprotein** between the smooth muscle cells.

c- **External elastic lamina**: In arteries only, the tunica media has a thin external elastic lamina, which separates it from the next layer.



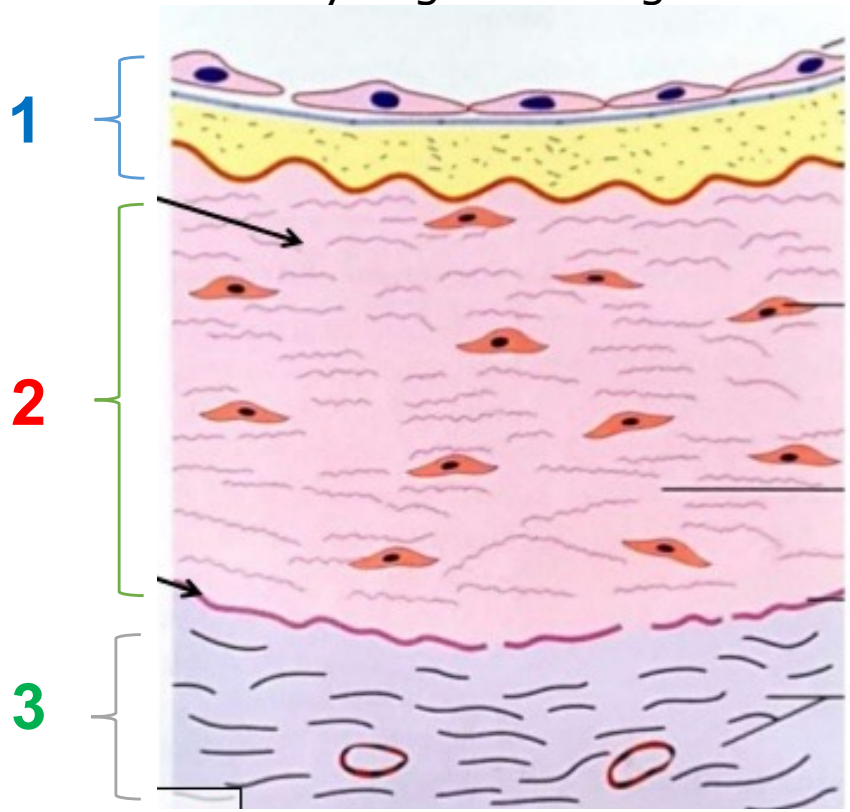
3-Tunica adventitia

The outermost coat & consists of:

a- **Few elastic fibers**

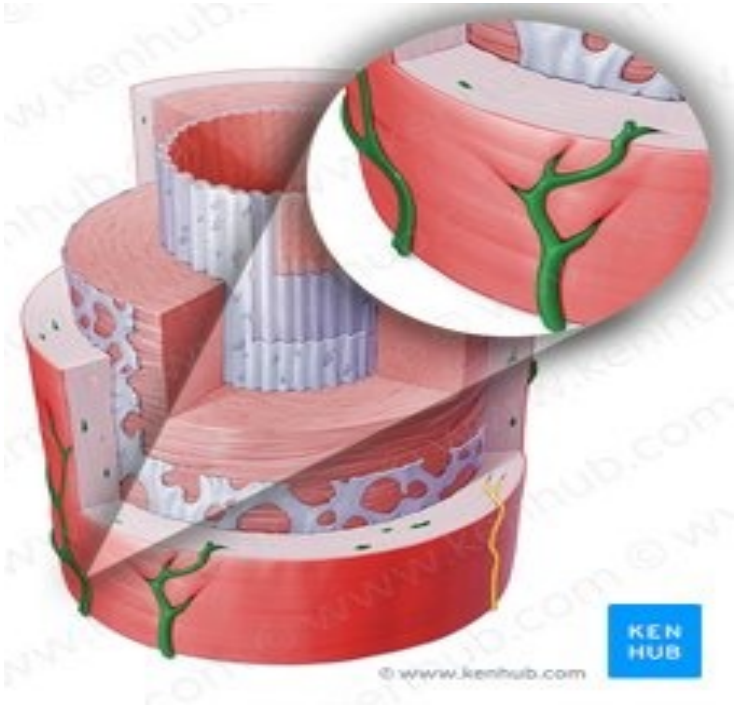
b- It contains **vasa vasorum,** which are tiny blood vessels that supply tunica adventitia and periphery of the media.

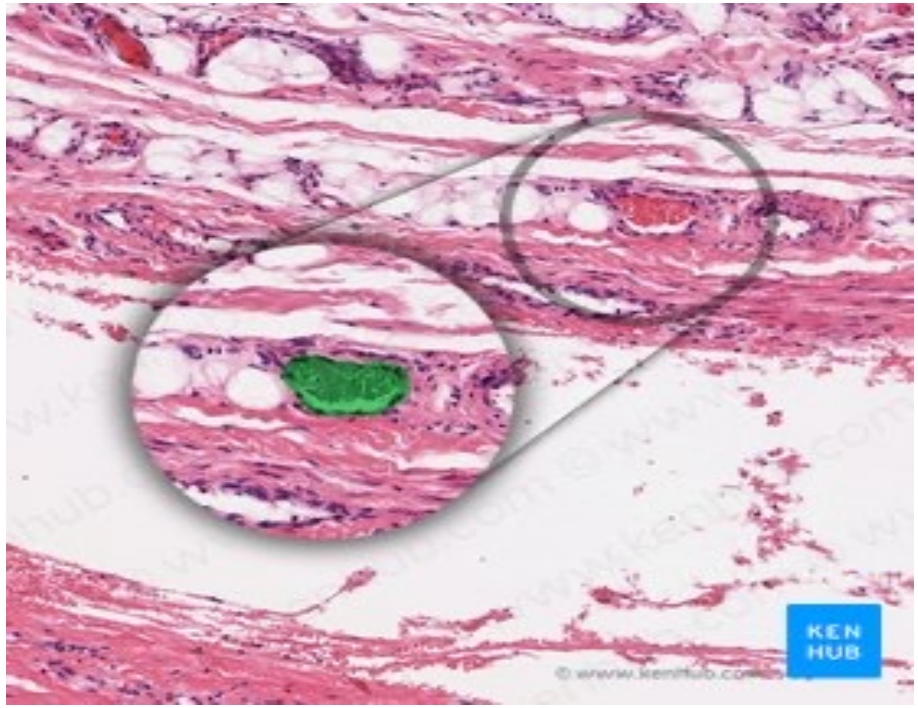
c- It becomes **continuous with the connective tissue** of the nearby organ through which the vessels runs.



Vasa Vasorum

1. Large vessels usually have **vasa vasorum** (“vessels of the vessel”)
2. The vasa vasorum are required to provide metabolites to cells in those larger vessels tunics , because the wall is too thick to be nourished solely by diffusion from the blood in the lumen.
3. Large veins have more vasa vasorum than arteries as it carry deoxygenated blood

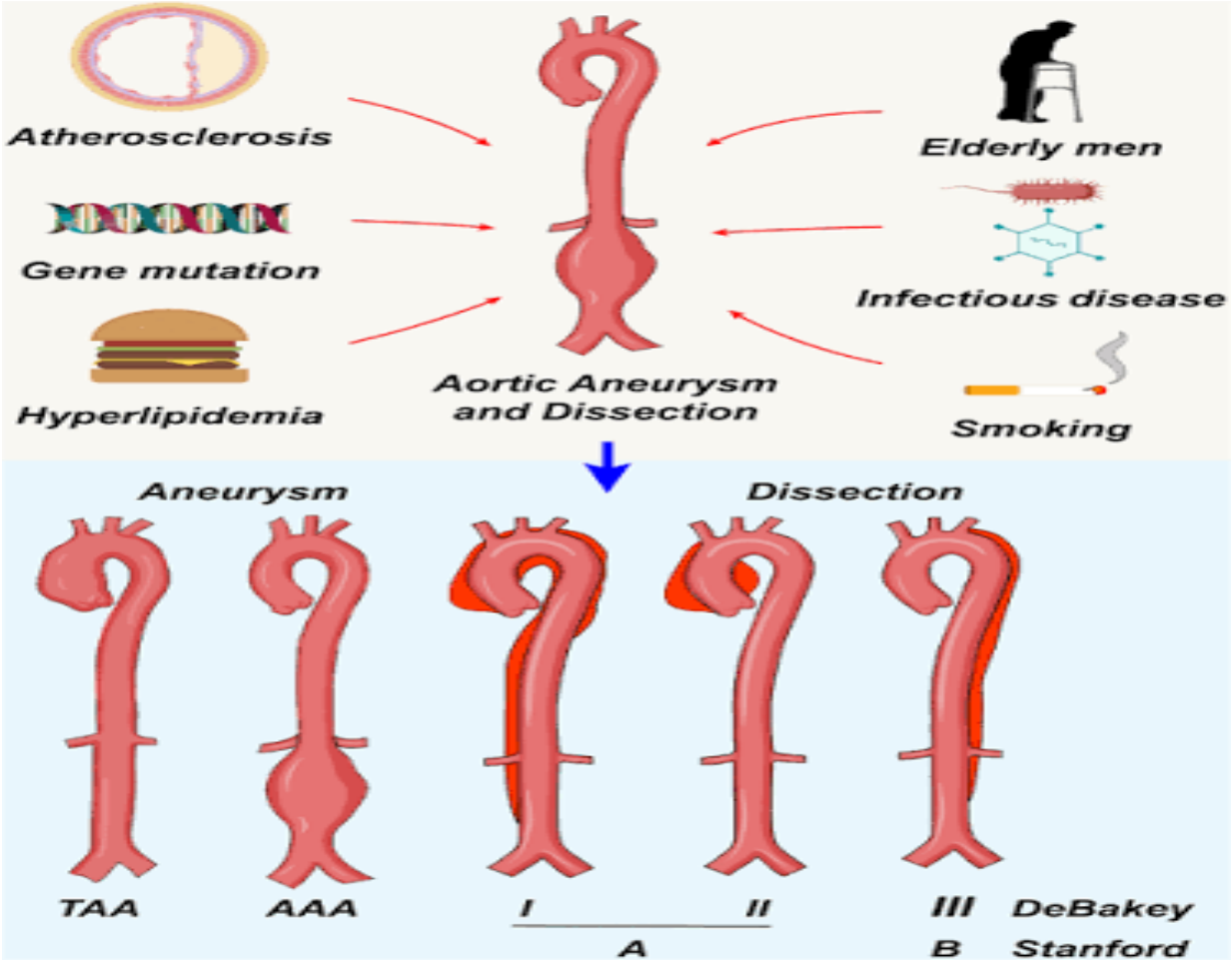




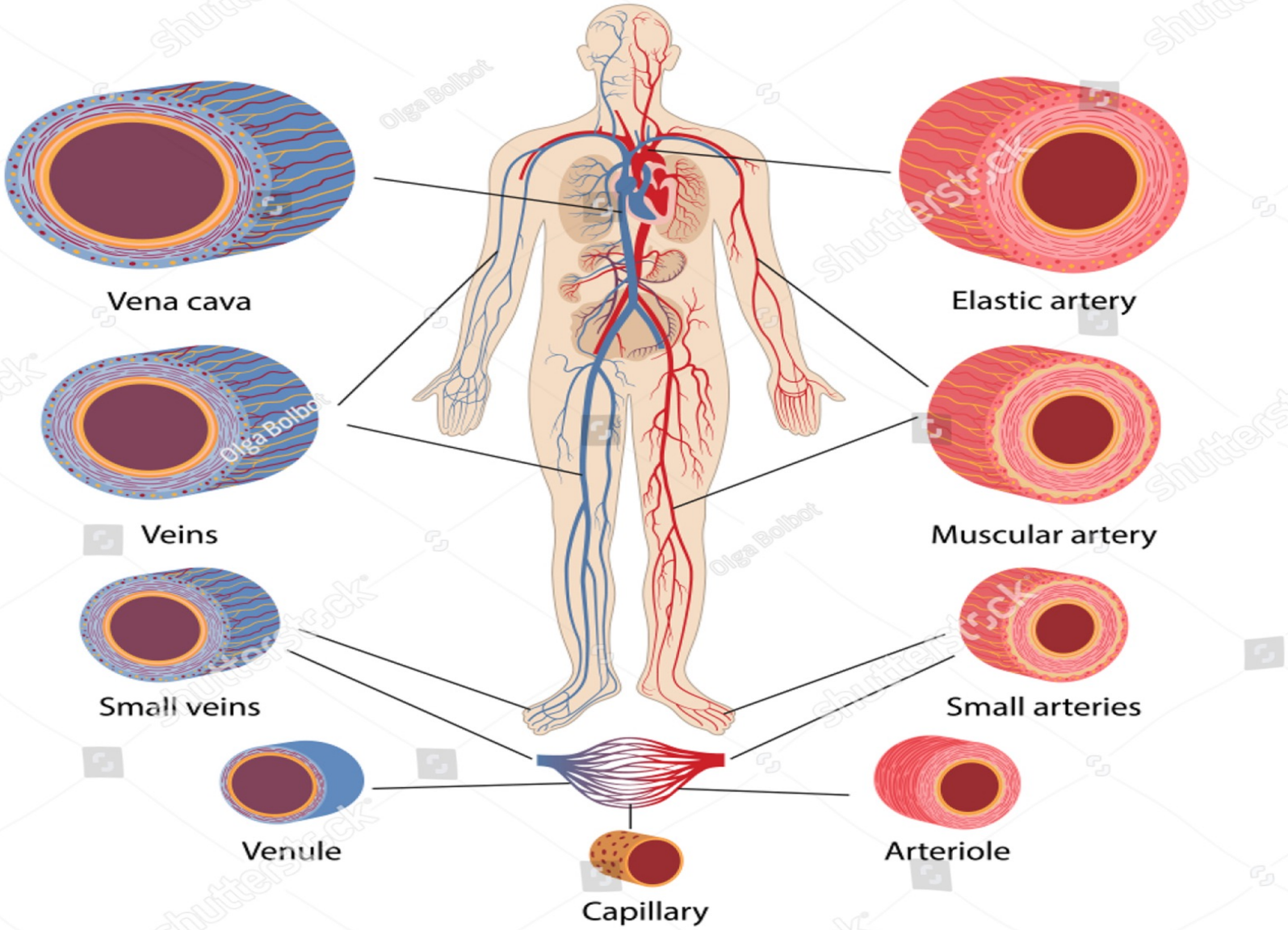
Aortic Aneurysm Pathogenesis:

Iñ large elastic arteries, luminal diffusion nourishes only the inner third of the media, while the outer two-thirds rely on the **vasa vasorum**.

Hypertension-induced hyalinization of the vasa vasorum causes medial ischemia,smooth muscle loss, and **thoracic/abdominal aortic aneurysms**.



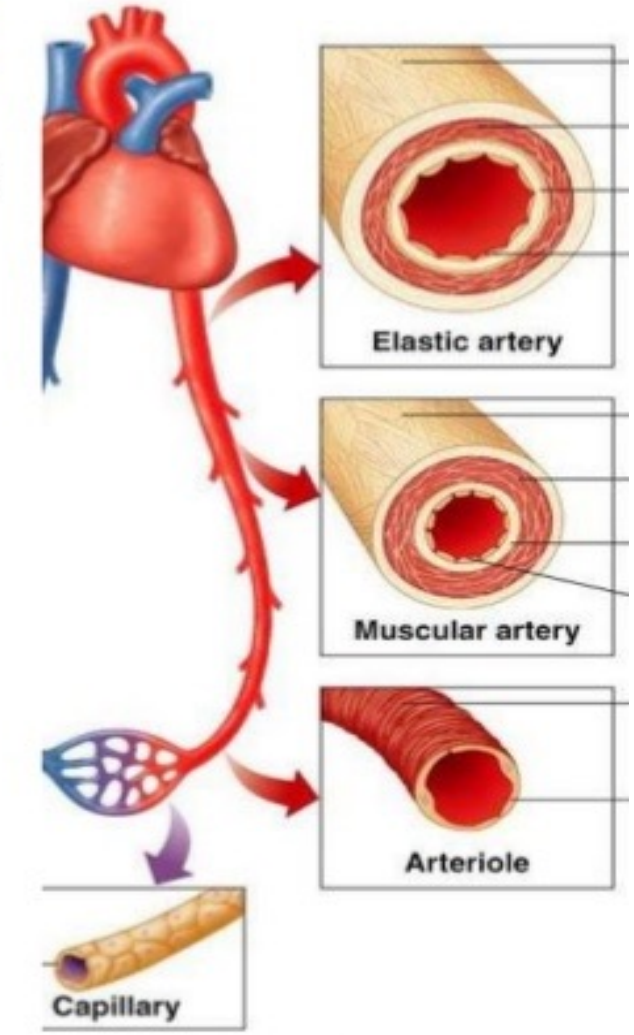
Blood vessels types

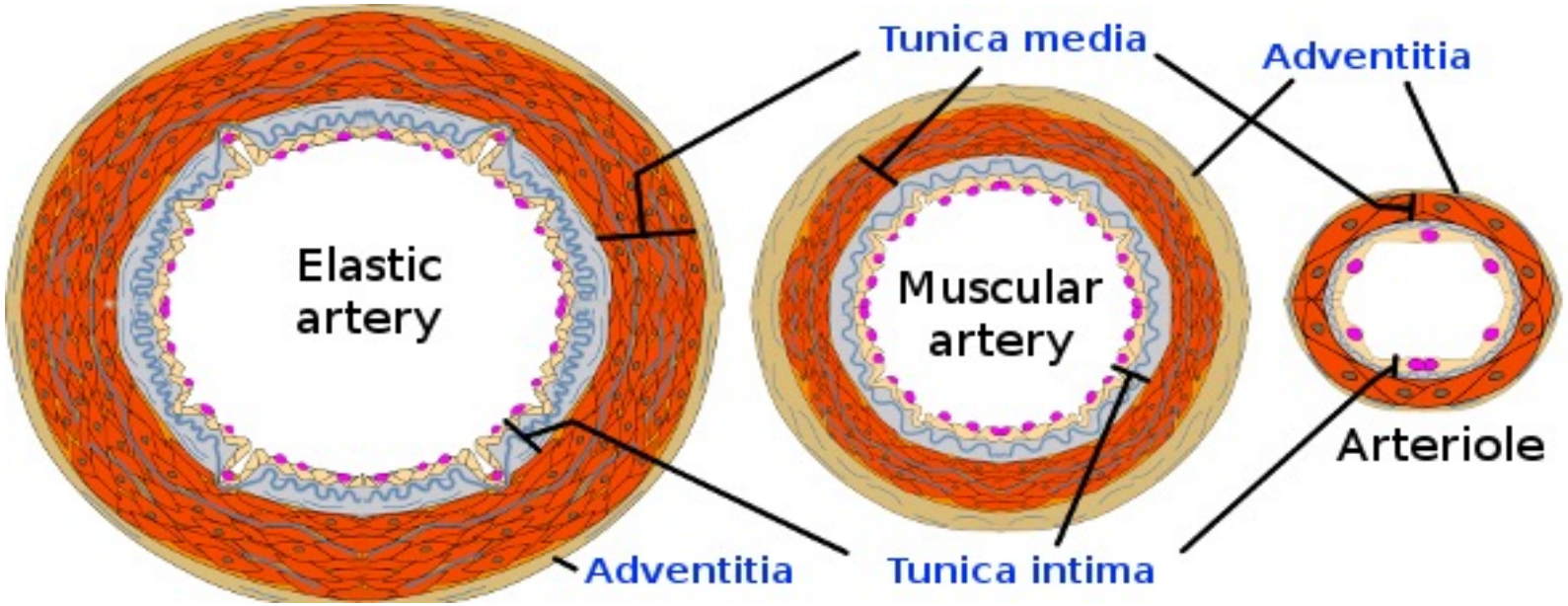


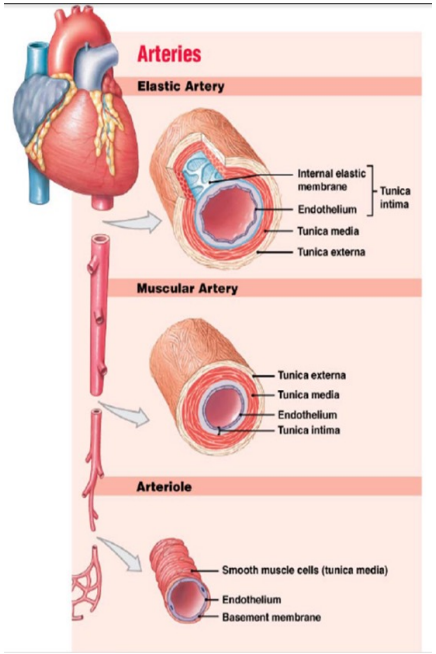
Arteries

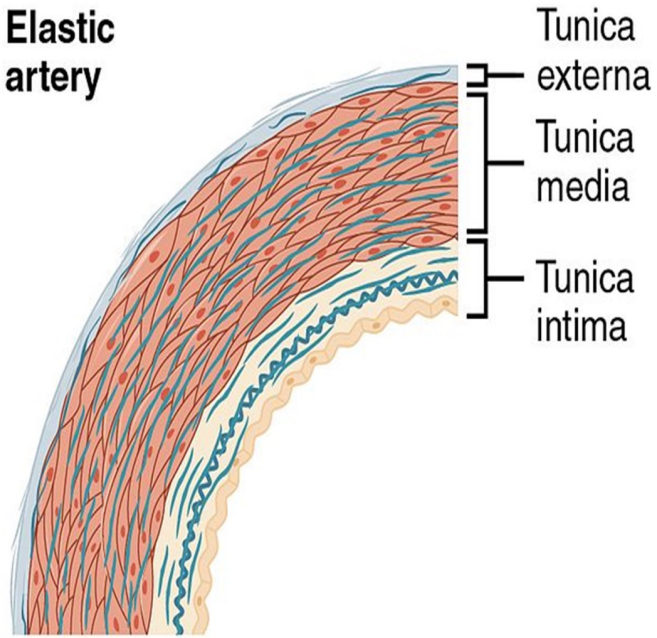
They are classified into 3 types according to their structure & size:

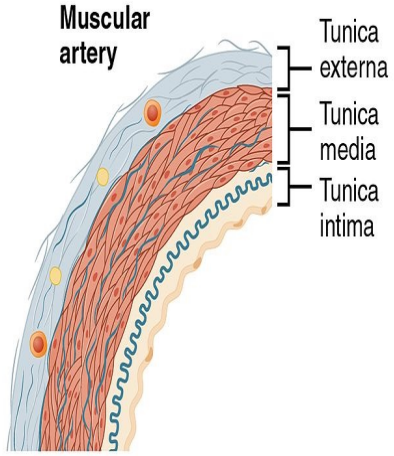
1. ***Large (elastic)*** *arteries.*
2. ***Medium sized (muscular)*** *arteries.*
3. ***Small*** *arteries* ***(arterioles)***

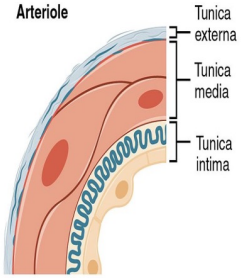



Tunica media
Adventitia
Elastic artery
Muscular artery
Arteriole
Adventitia
Tunica intima


Arteries
Elastic Artery
Internal elastic membrane
Endothelium
Tunica media
Tunica externa
Tunica intima
Muscular Artery
Tunica externa
Tunica media
Endothelium
Tunica intima
Arteriole
Smooth muscle cells (tunica media)
Endothelium
Basement membrane

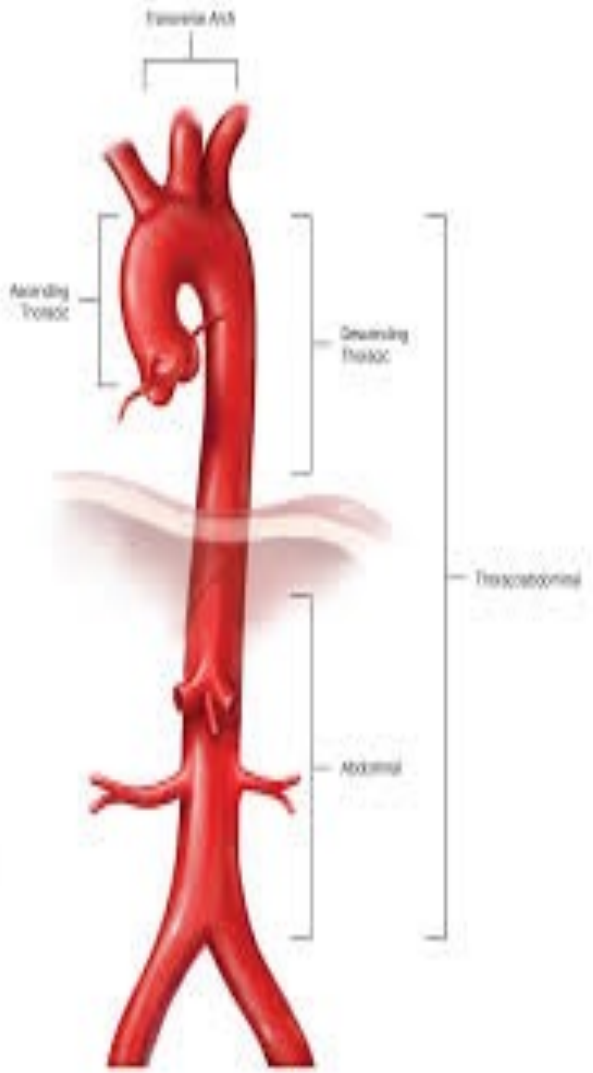

Elastic artery
Tunica externa
Tunica media
Tunica intima


Muscular artery
Tunica externa
Tunica media
Tunica intima


Arteriole
Tunica externa
Tunica media
Tunica intima

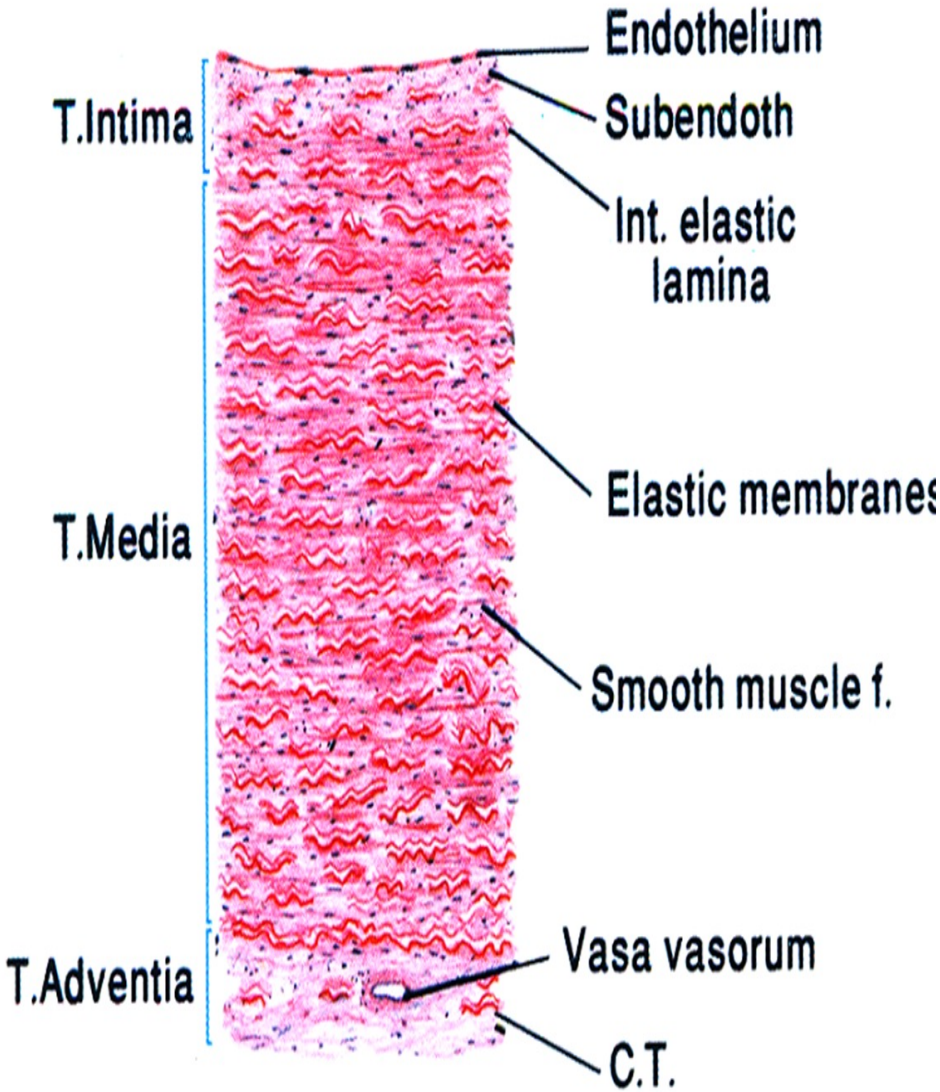
1- Large (Elastic) or Conducting Arteries

- It is called conducting arteries because their major role is to carry blood to smaller arteries.
- It is called **elastic** ,due to **large amount of elastic lamina** in their **media.**
- They have **thick walls** and **wide lumen**.
- These need to be elastic because when the heart contracts, and ejects blood into these arteries, the walls **stretch** to accommodate the blood surge.
- Between heart contractions, the elastic walls **recoil** to maintain the blood pressure and continuing to move blood even when ventricles are relaxed
- Examples: **the aorta** & its largest main branches, **common carotid artery** **and** **common iliac artery**

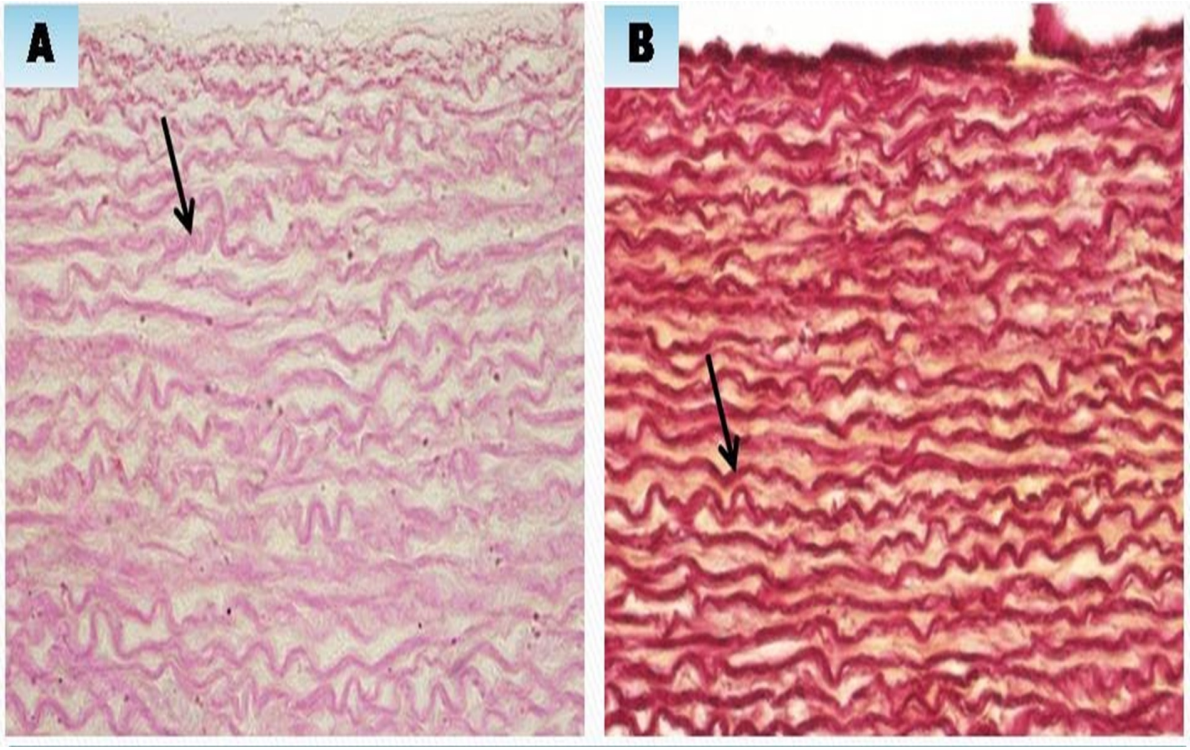


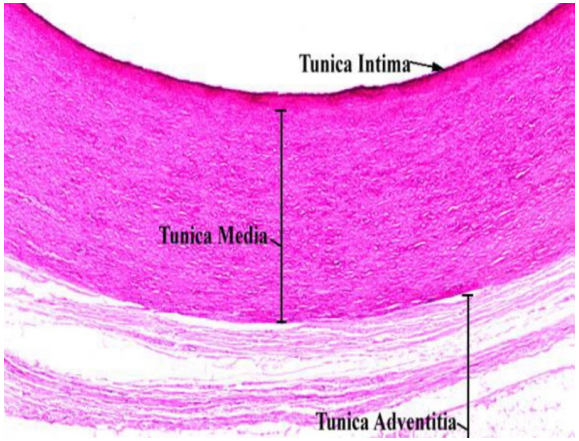
Aorta

- **Tunica intima**: ***thin***
  1. **Endothelium**
  2. **Subendothelial layer** contains some smooth muscle, elastic fibers, collagen fibers
  3. **Internal elastic lamina** : it is present but **indistinct** as it merges with the elastic membranes in tunica media
- **Tunica media :** ***very thick***
  1. Formed of **40 - 60 distinct, concentrically arranged elastic laminae**, it is the main component of tunica media
  2. Between elastic lamina, **fibroblasts**, **elastic fibers**, **collagen fibers** and **few smooth muscle cells.**
- **Tunica adventitia**: ***thin***
  1. consists mainly of **collagen fibers**, blood vessels (**vasa vasorum**), **nerves**; **some elastic fibers** & **fibroblasts**.



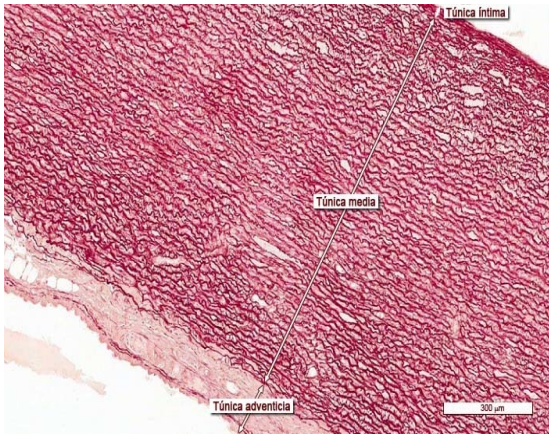
Structure of the Aorta



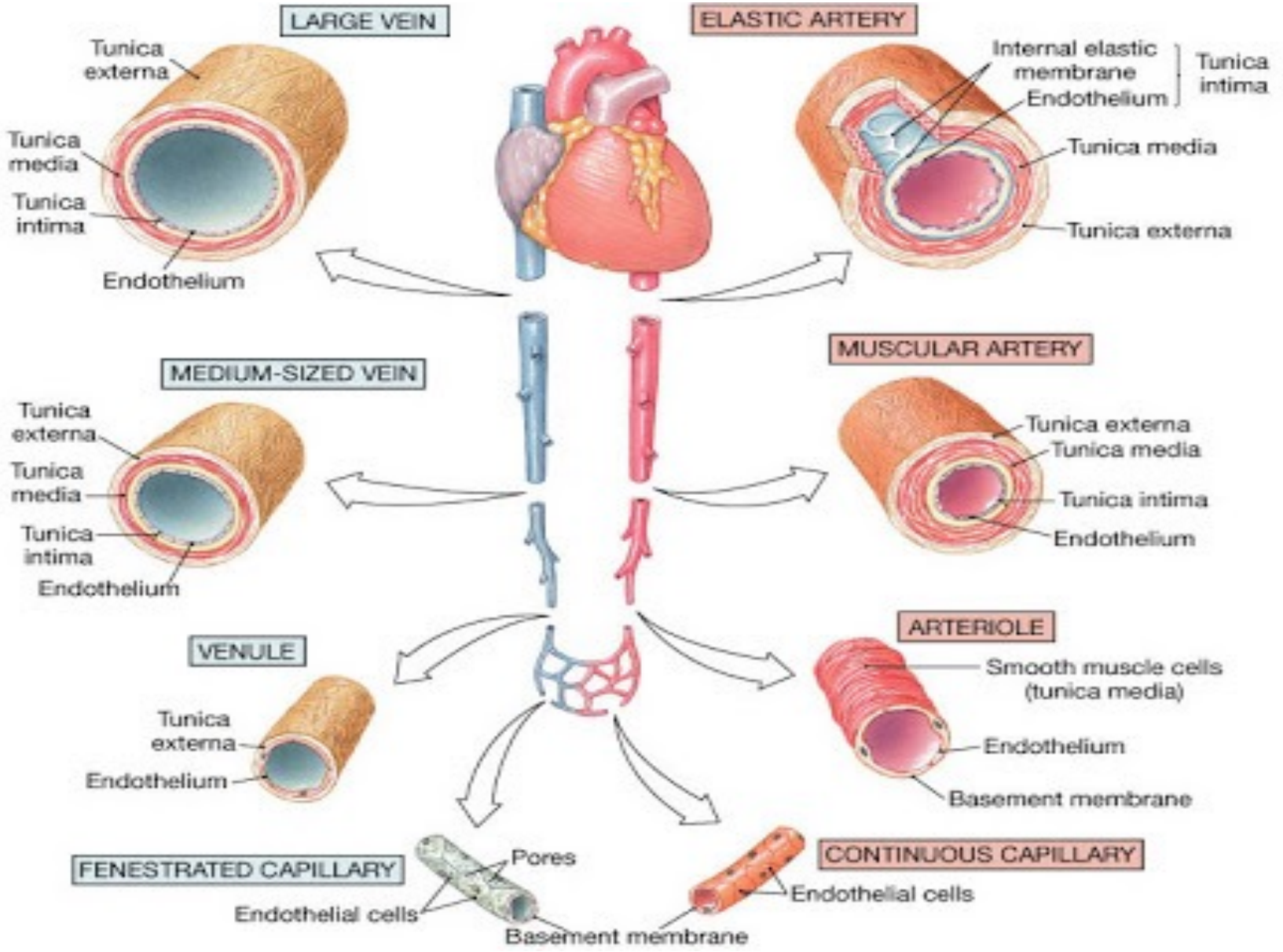


Hx & E

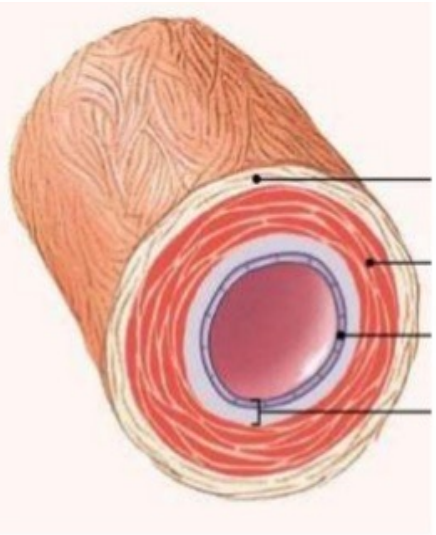
Orcein



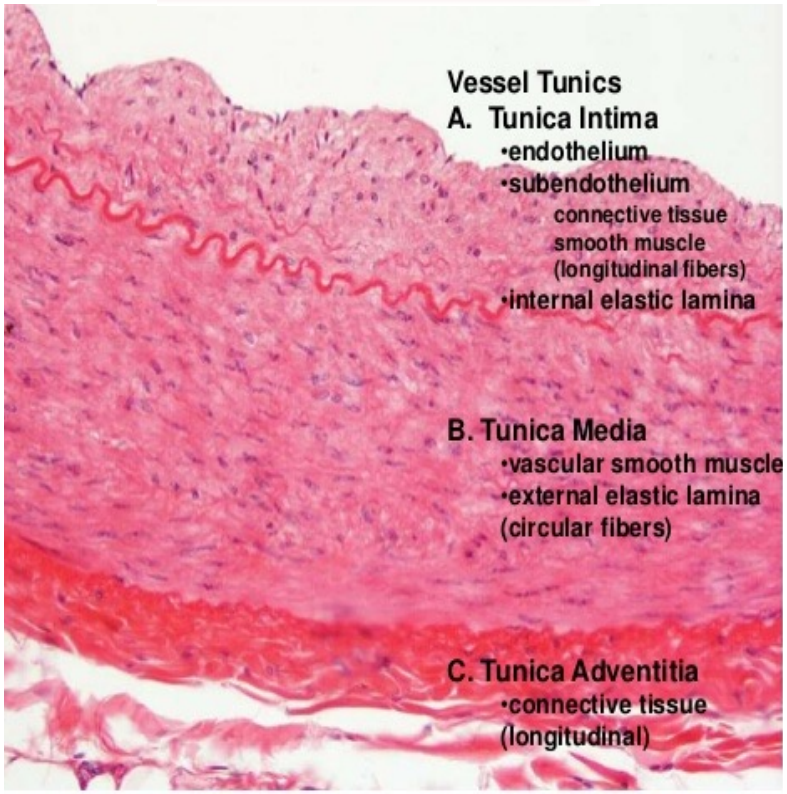
Medium sized A & V



Medium sized (Muscular) or distributing arteries



- They are called **distributing arteries**, distribute blood to the organs and help regulate blood pressure by contracting or relaxing the smooth muscle in the media.
- They are called muscular arteries as they consist of **smooth muscle in their media**
- As **ulnar** and **radial** arteries.
- They have **thick wall** and **narrow lumen.**
- The arterial walls are thick because they need to be able to **withstand (maintain) arterial blood pressure.**



Structure of Medium Sized Artery

- **Tunica intima**: **thin**

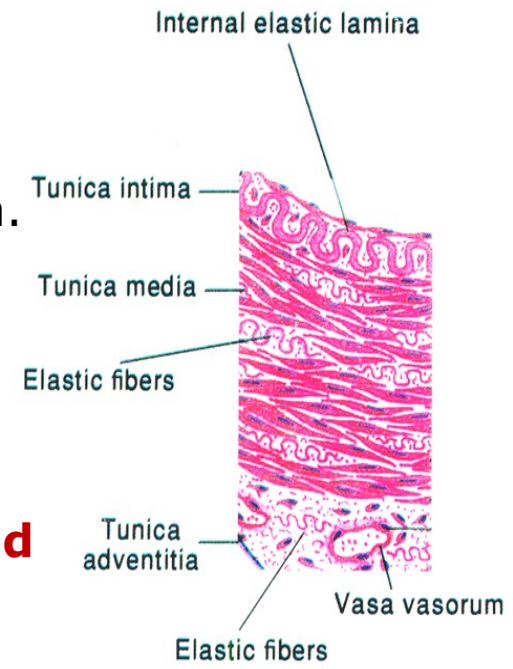
- Endothelium: simple squamous epithelium resting on a basal lamina.
- Subendothelium layer
- Internal elastic lamina: is **prominent.**

- **Tunica media** : **thick**

- It consists mainly of **concentric layers of circularly arranged smooth muscle** cells (up to 40 layers) .
- Variable amount of reticular and elastic fibers.
-The inter-cellular matrix contains proteoglycans and glycoproteins.
- External elastic lamina: is **present**.

- **Tunica adventitia :** **thick**

-This forms about half the thickness of the media.
-It consists of collagen fibers , elastic fibers, fibroblasts and adipose cells and nerves.

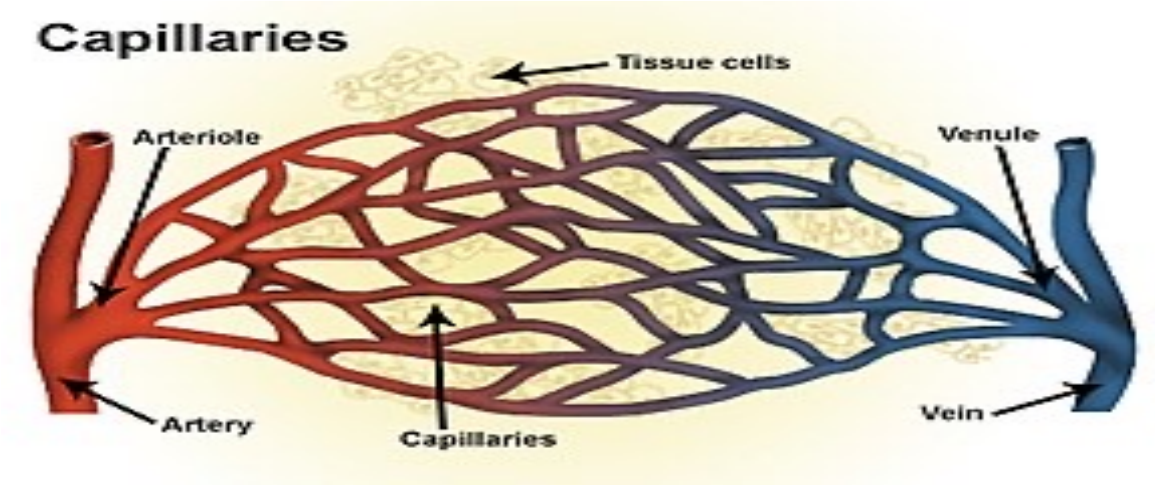


Medium sized artery (T.S.) H&E&

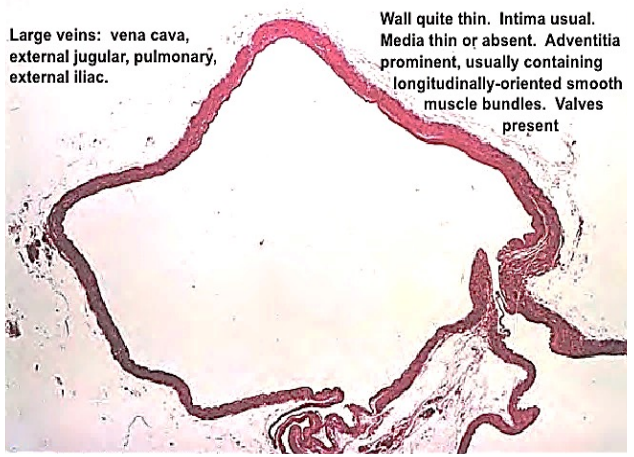


Arterioles

- The smallest arteries branch as **arterioles**, which have only one or two smooth muscle layers; these indicate the beginning of an organ's **microvasculature.**
- Arterioles are generally less than 0.1 mm in diameter, with lumens approximately as wide as the wall is thick.
- The subendothelial layer is very thin.
- **Elastic lamina is absent.**
- The media consists of the circularly arranged smooth muscle cells.
- **The adventitia is very thin.**
- These vessels are the major determinants of systemic blood pressure.



Large veins



Inferior Vena Cava

1. **It has a very wide lumen with many valves.**
2. **Structure:**

❖ **Tunica intima:**

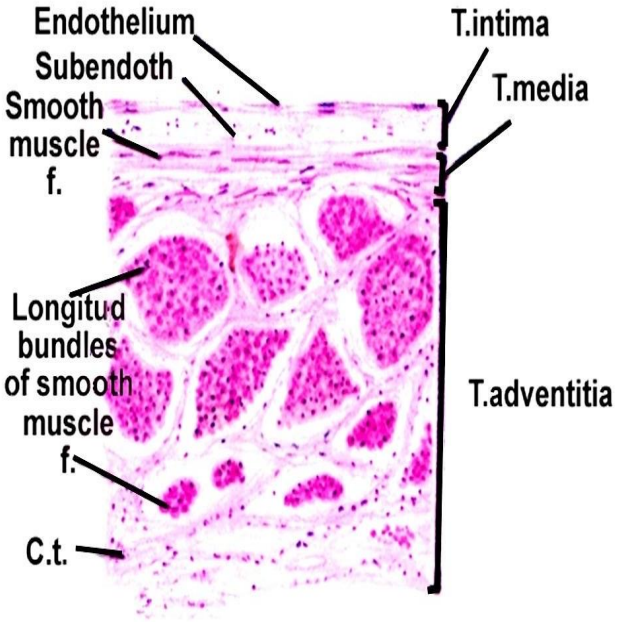
- Endothelium: endothelial cells resting on a basal lamina.
- Sub-endothelium: is **thick** and contain collagenous and elastic fibers.
- Internal elastic lamina: is **absent.**

❖ **Tunica media:**

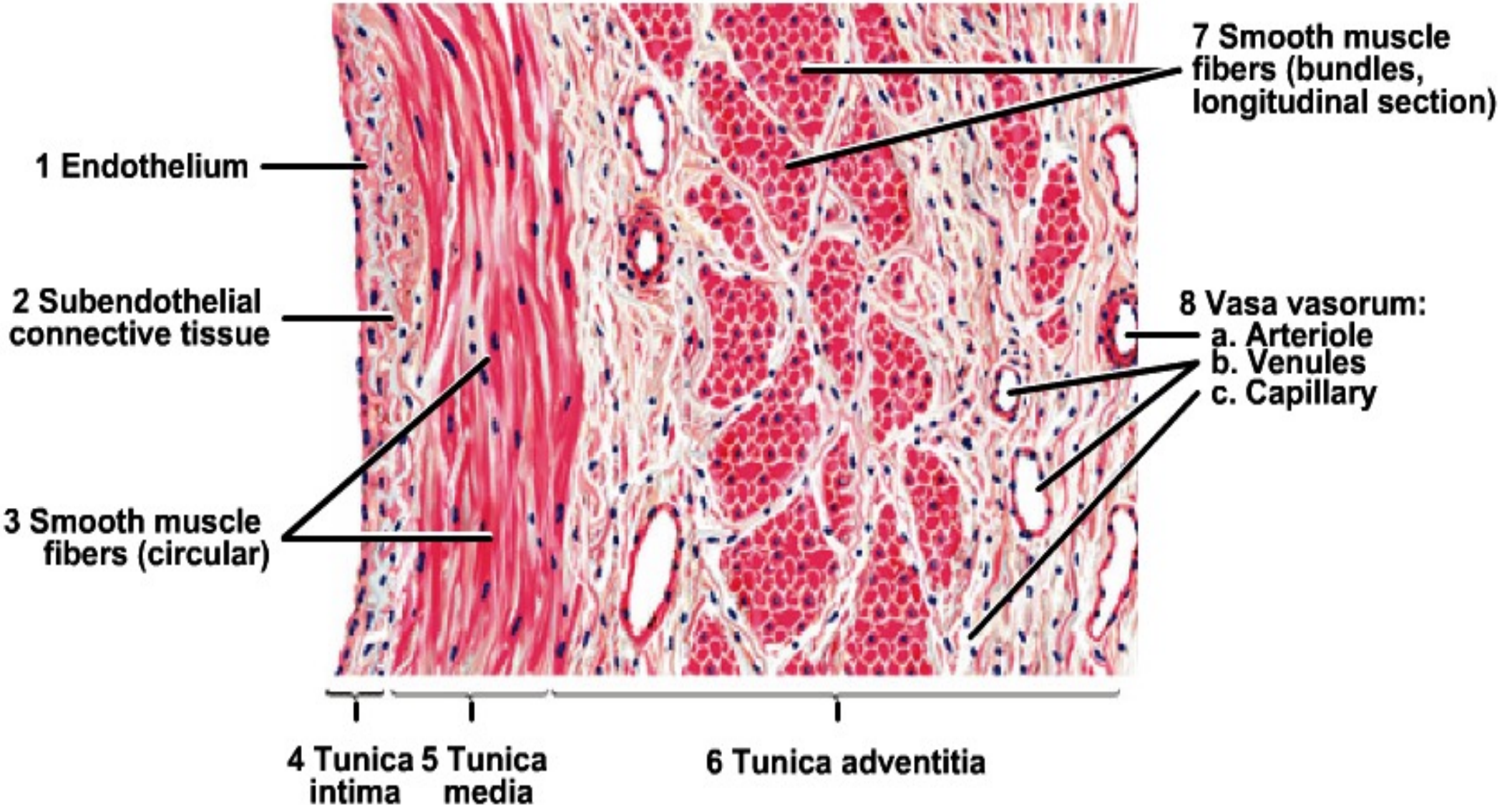
- is thin, consisting of few smooth muscles cells and **abundant C.T.**
- **No external elastic lamina**.

❖ **Tunica adventitia:**

- is thick and contains **longitudinal smooth muscle bundles** that strengthen the wall to prevent excessive distension .
- Abundant **vasa vasorum** and lymphatics are present .
- **Valves (**Endothelium + core of CT) are present.



INFERIOR VENA CAVA (T.S.)

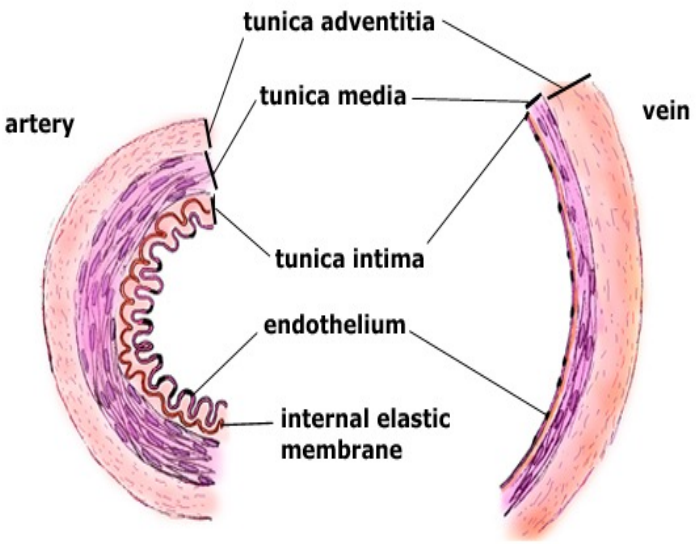


WALL OF LARGE VEIN (T.S)

Medium sized A

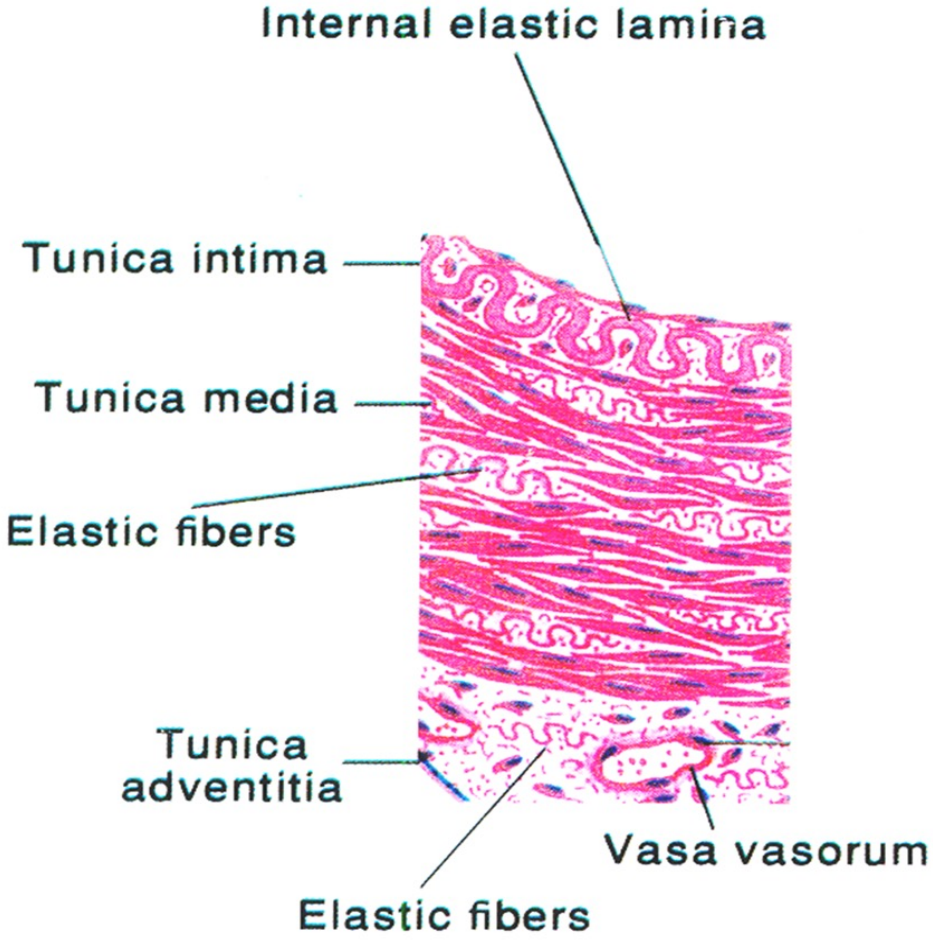
- Thick wall
- Narrow lumen
- T intima: thicker
- T media: thicker
- Internal elastic L: present
- T adventitia: thinner
- Valves: absent



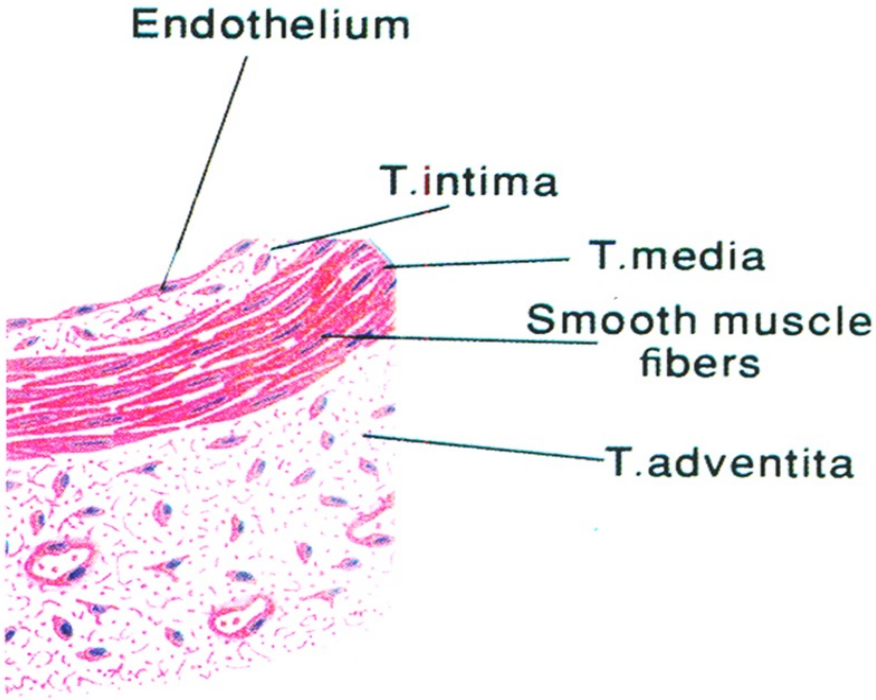


Medium sized V

- Thin wall
- Wide lumen
- T intima: thinner
- T media: thinner
- Internal elastic L: absent
- T adventitia: thicker
- Valves: present



Medium sized artery (T.S.) H&E&



Medium sized vein (T.S.) H&E

Capillaries

- Smallest blood vessels
- Average diameter – **8 µm**
- Thin-walled & form plexus which spread throughout the tissue & continuous with
  - Smallest arteriole at one end
  - Smallest venules at other end
- **Site of exchange of gases, nutrients and metabolic wastes**
- Abundant in tissue with high metabolic rate like
  - Kidney, liver and cardiac muscle

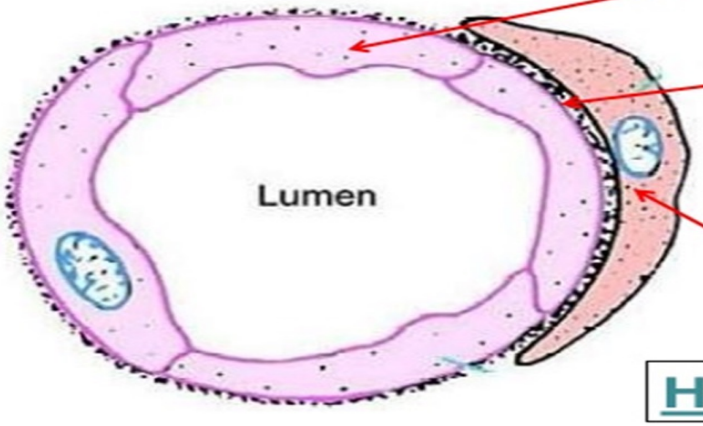


Capillaries

- Capillaries are composed of the simple layer of **endothelial cells** rolled up as a tube surrounded by basement membrane.
- The nuclei of endothelial cells are oval and bulge into the lumen of capillaries
- The average diameter of capillaries varies from 4 to 10 μm, which allows transit of blood cells only one at a time.
- It surrounded by pericytes which are cells present at intervals along the walls of capillaries
- Capillaries are generally grouped into three histologic types, depending on the continuity of the endothelial cells and their basement membrane. These are continuous, fenestrated and discontinuous.

Structure of Capillaries

The capillary wall is formed by



Single layer of endothelial cells

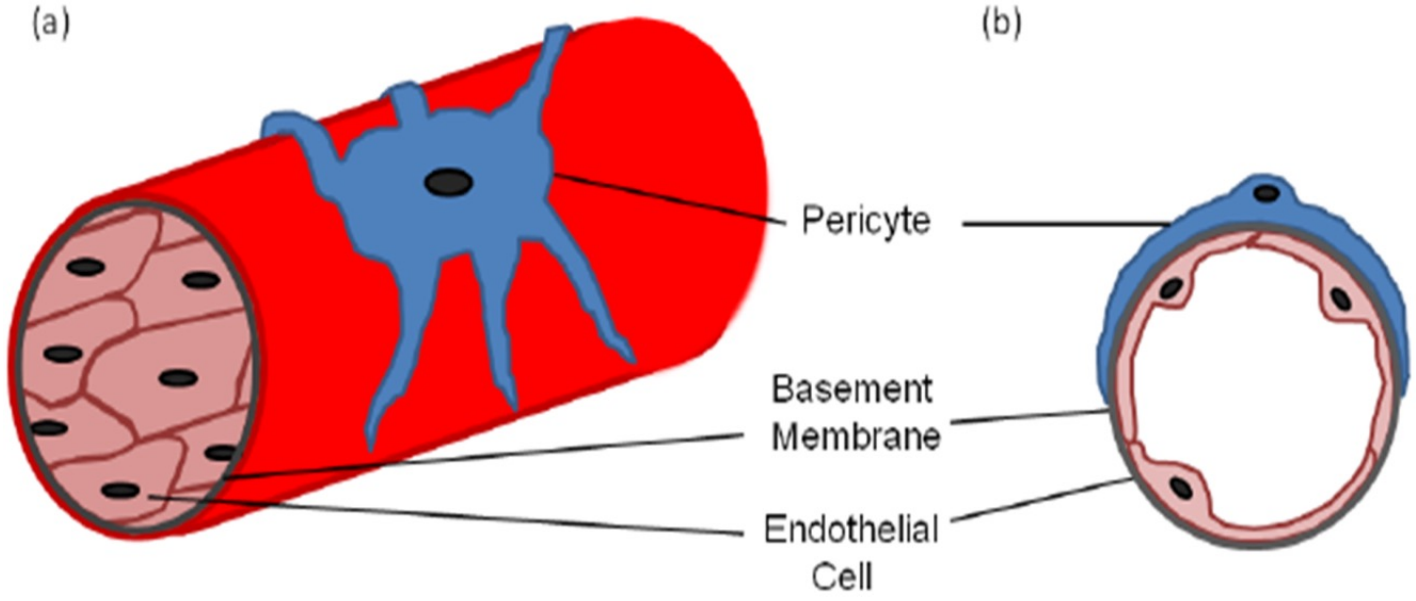
Glycoprotein layer of Basal lamina

Out side the basal lamina- **Contractile cells** wrapped around the capillaries

Pericytes

Has only Tunica Intima

Lacks T Media and therefore no smooth muscle cells



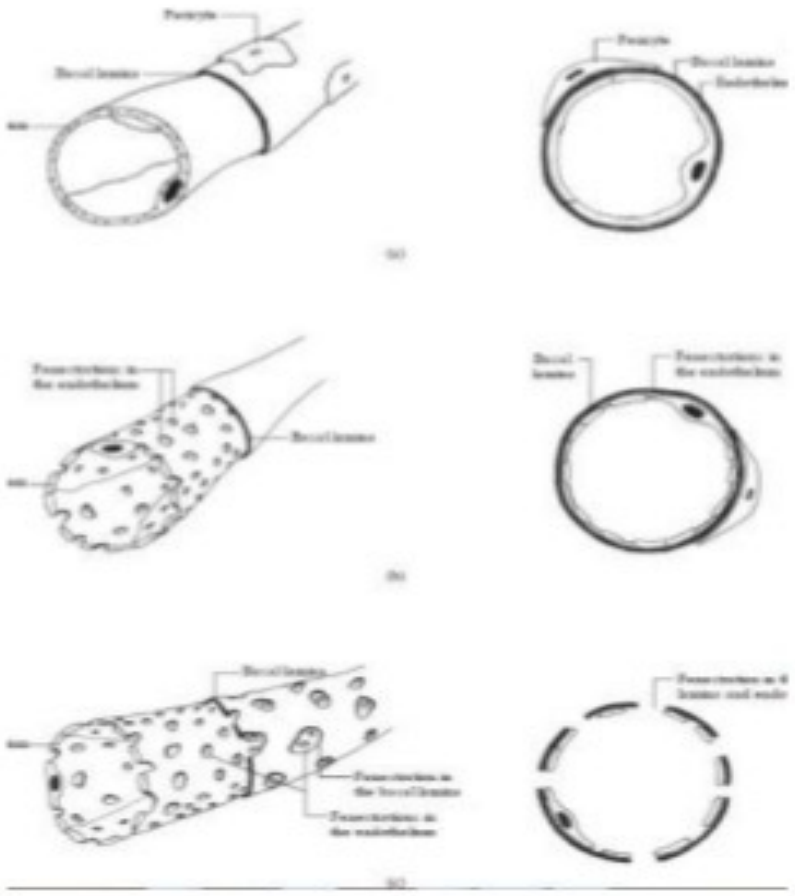
Types of Capillaries

- According to the appearance under the electron microscope, there are **3 types of capillaries**:

1. Continuous
2. Fenestrated

} **6-10 µm D**

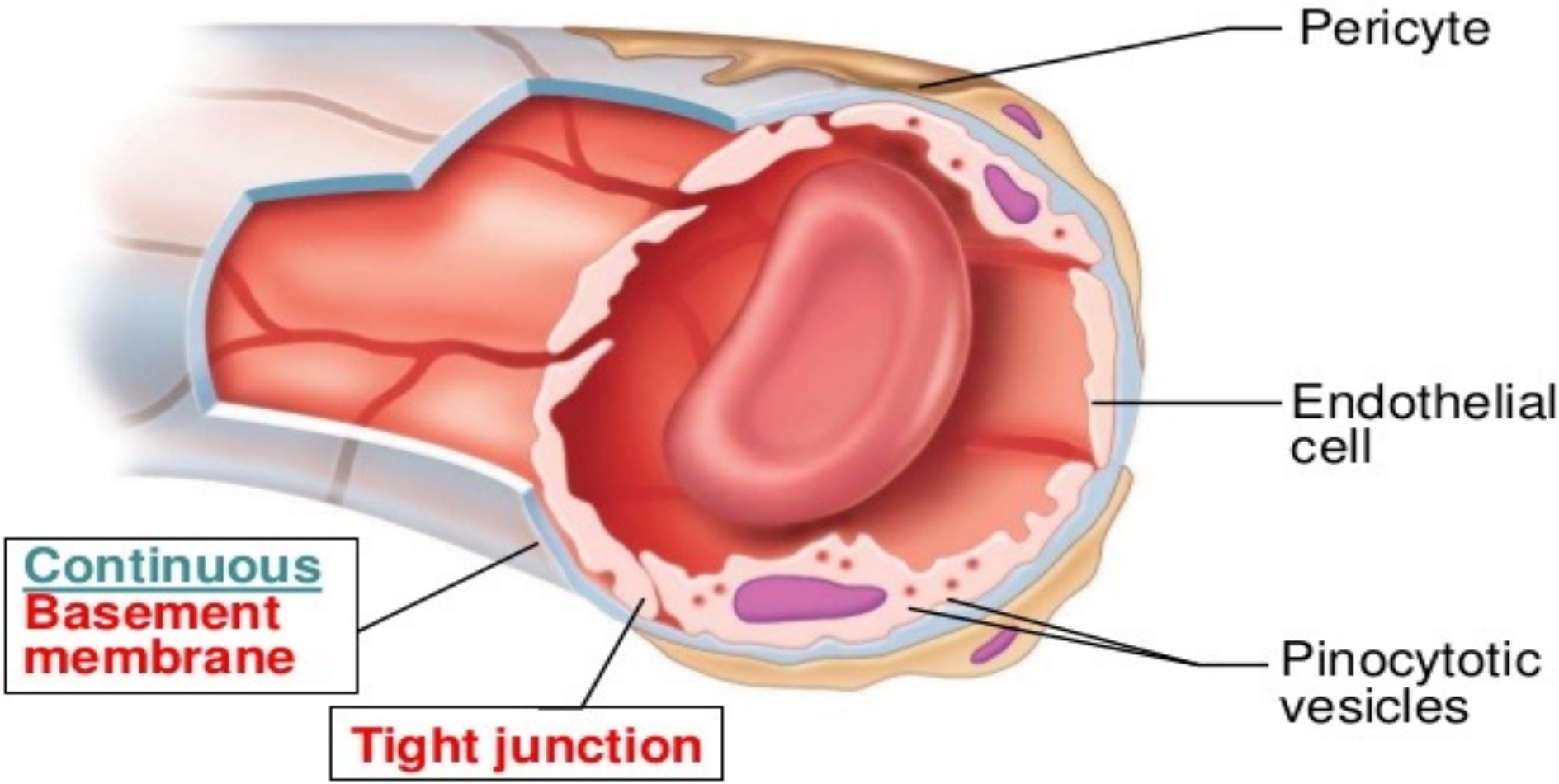
3. Sinusoidal – **30-40 µm D**



Continuous Capillaries

- **Continuous capillaries** have many tight, well-developed occluding junctions between slightly overlapping endothelial cells, which provide for continuity along the endothelium and well-regulated metabolic exchange across the cells.
- This is the most common type of capillary and is found in muscle, connective tissue, lungs, exocrine glands, and nervous tissue..

Continuous Capillaries



(a)

Least permeable, and most common

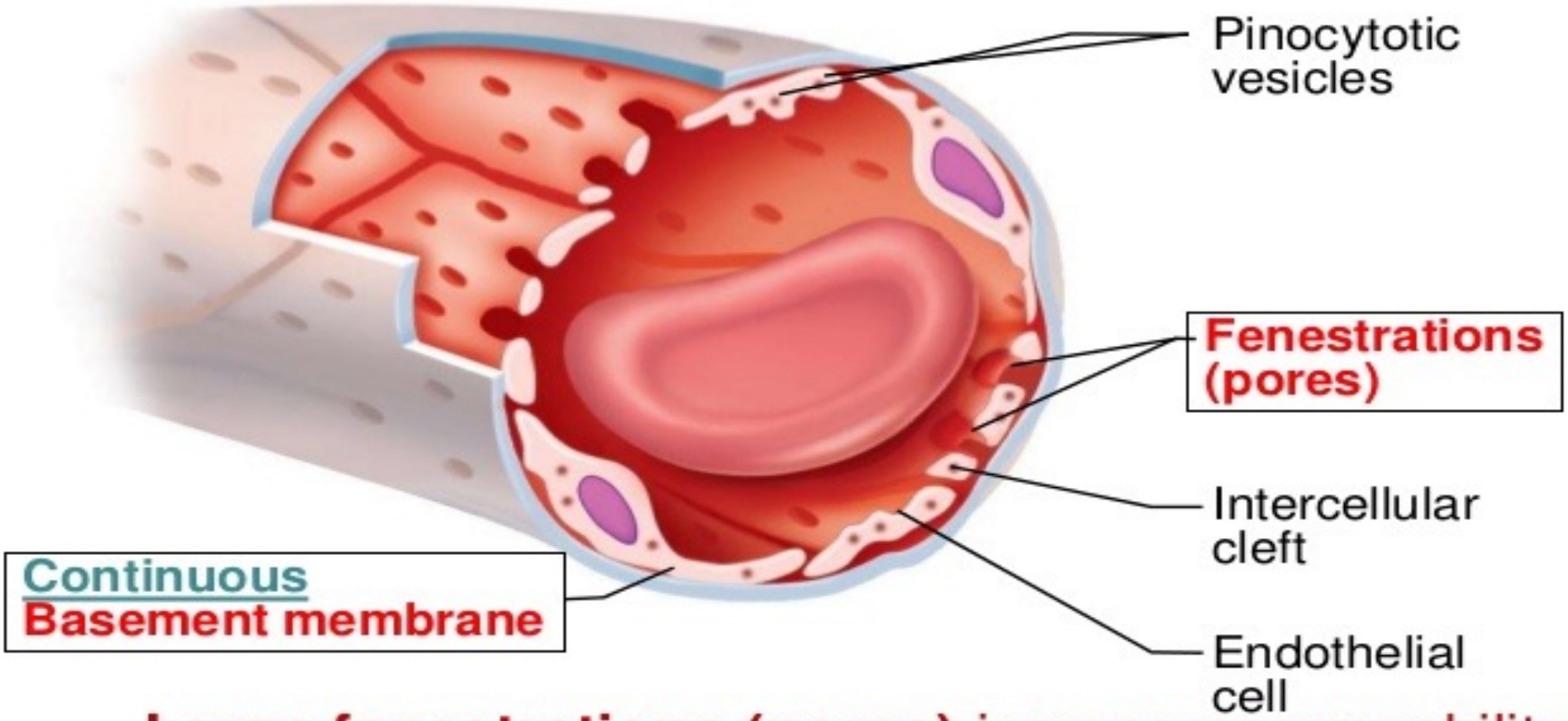
E.G., skin, muscle, nervous tissues, etc…

Fenestrated Capillaries

- **Fenestrated capillaries** have a sieve like structure that allows more extensive molecular exchange across the endothelium.
- The endothelial cells are penetrated by numerous small circular openings or fenestrations (L. *fenestra*, perforation).
- Some fenestrations are covered by very thin diaphragms of proteoglycans
- The basement membrane however is continuous and covers the fenestrations.
- Fenestrated capillaries are found in organs with rapid interchange of substances between tissues and the blood, such as the kidneys, intestine and endocrine glands.



Fenestrated Capillaries



Large fenestrations (pores) increase permeability

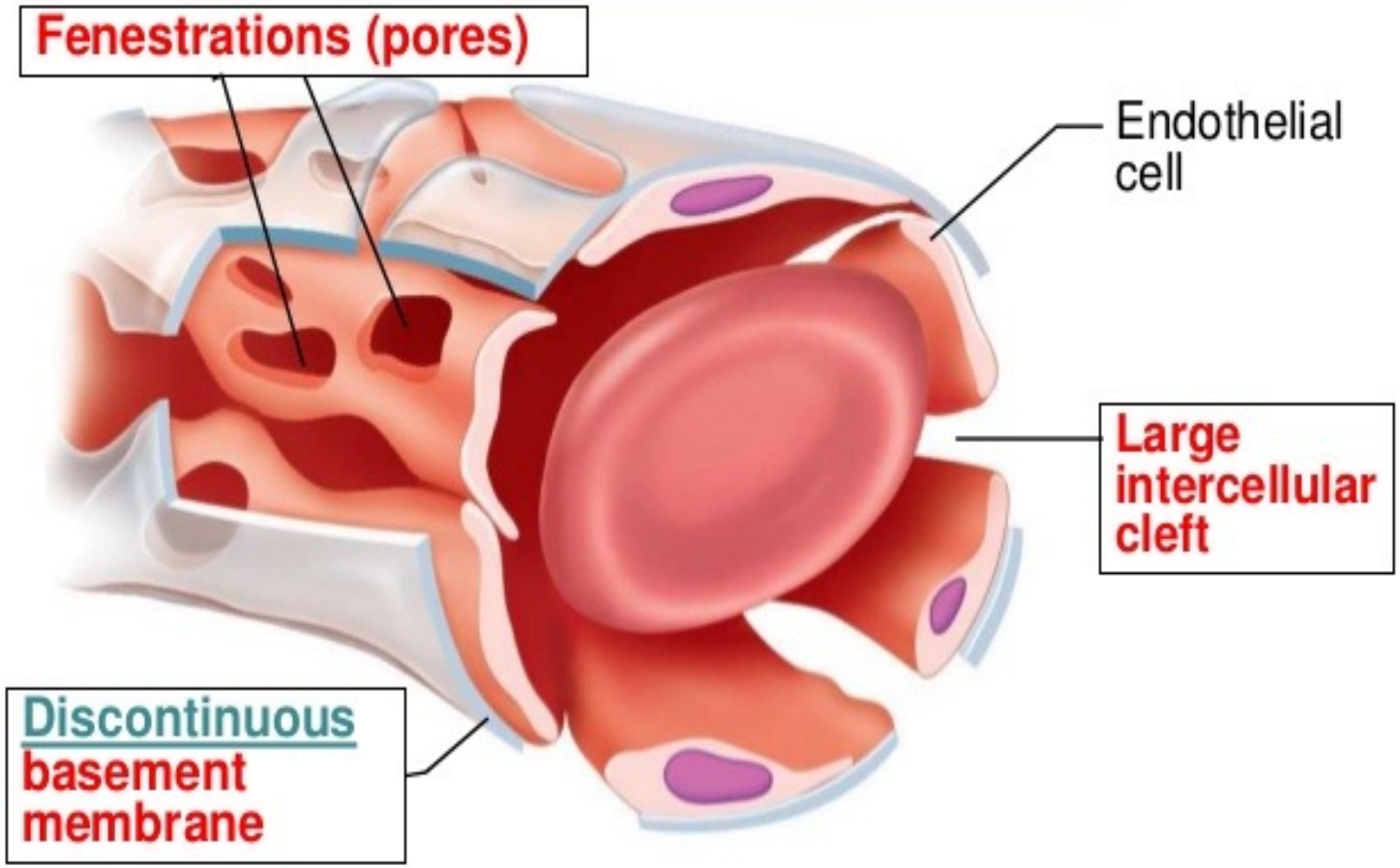
(b) Occurs in areas of active absorption or filtration

E.G., kidney, small intestine, endocrine glands etc…

Discontinuous capillaries

- **Discontinuous capillaries**, commonly called **sinusoids**, permit maximal exchange of macromolecules as well as allow easier movement of cells between tissues and blood.
- The endothelium here has large perforations without diaphragms and irregular intercellular clefts, forming a discontinuous layer with spaces between and through the cells.
- Unlike other capillaries sinusoids also have highly discontinuous basement membranes and much larger diameters, which slows blood flow.
- Sinusoidal capillaries of this type are found in the liver, spleen and bone marrow.

Sinusoidal Capillaries

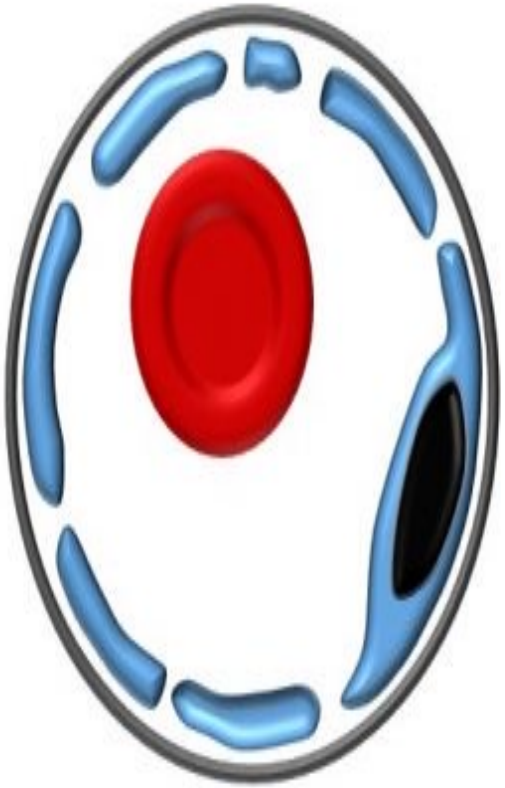


(c) **Most permeable. Occurs in special locations**

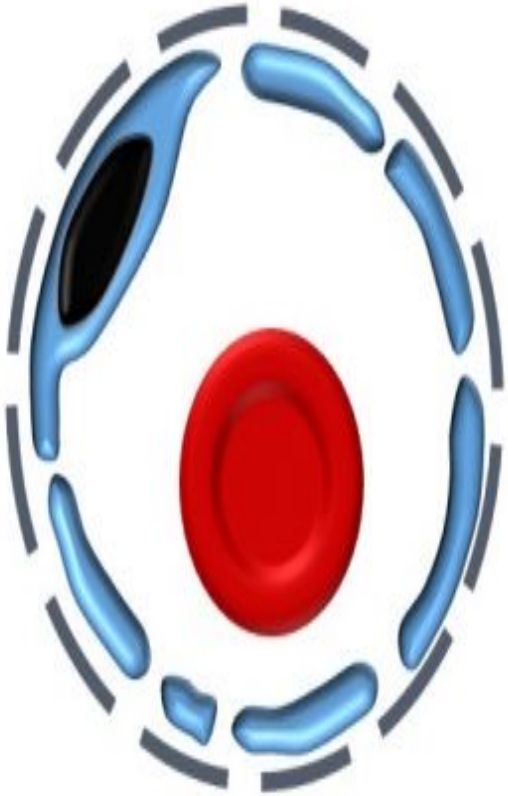
E.G., liver, bone marrow, spleen



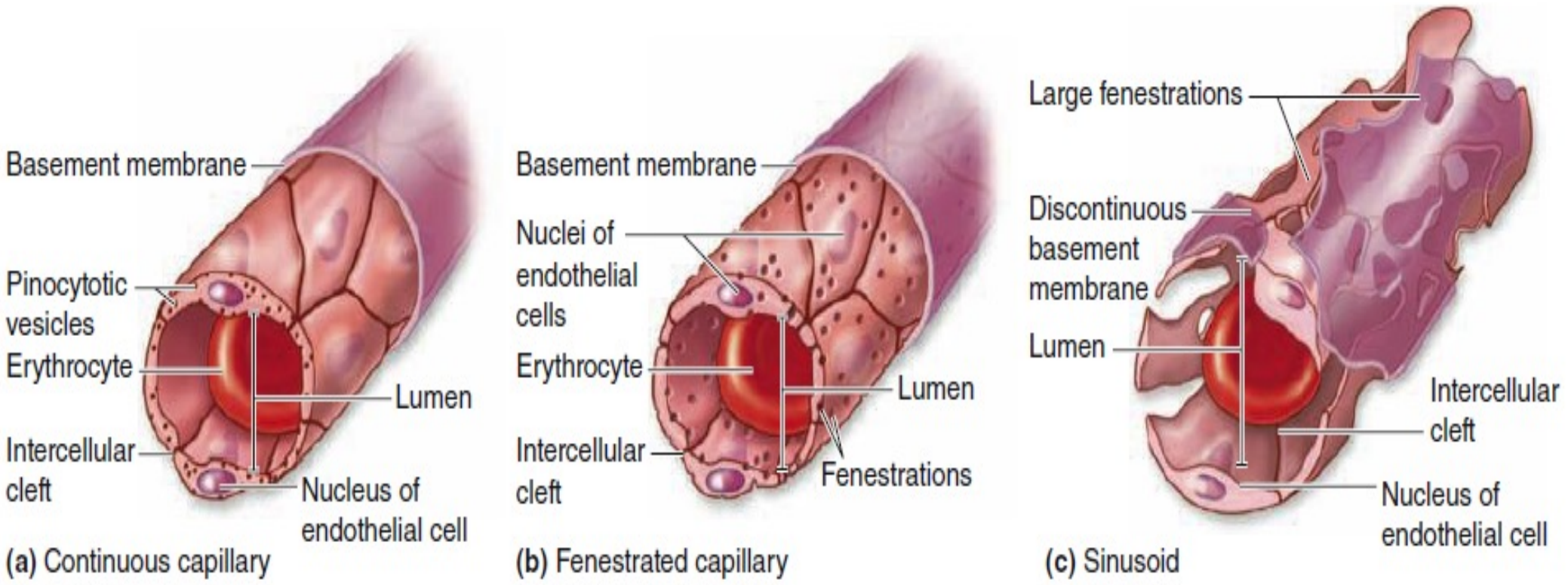
Continuous



Fenestrated



Sinusoidal
(Discontinuous)


Basement membrane
Pinocytotic vesicles
Erythrocyte
Lumen
Intercellular cleft
Nucleus of endothelial cell
(a) Continuous capillary
Basement membrane
Nuclei of endothelial cells
Erythrocyte
Lumen
Intercellular cleft
Fenestrations
(b) Fenestrated capillary
Large fenestrations
Discontinuous basement membrane
Lumen
Intercellular cleft
Nucleus of endothelial cell
(c) Sinusoid


THANK YOU