



Histology of Cardiovascular system

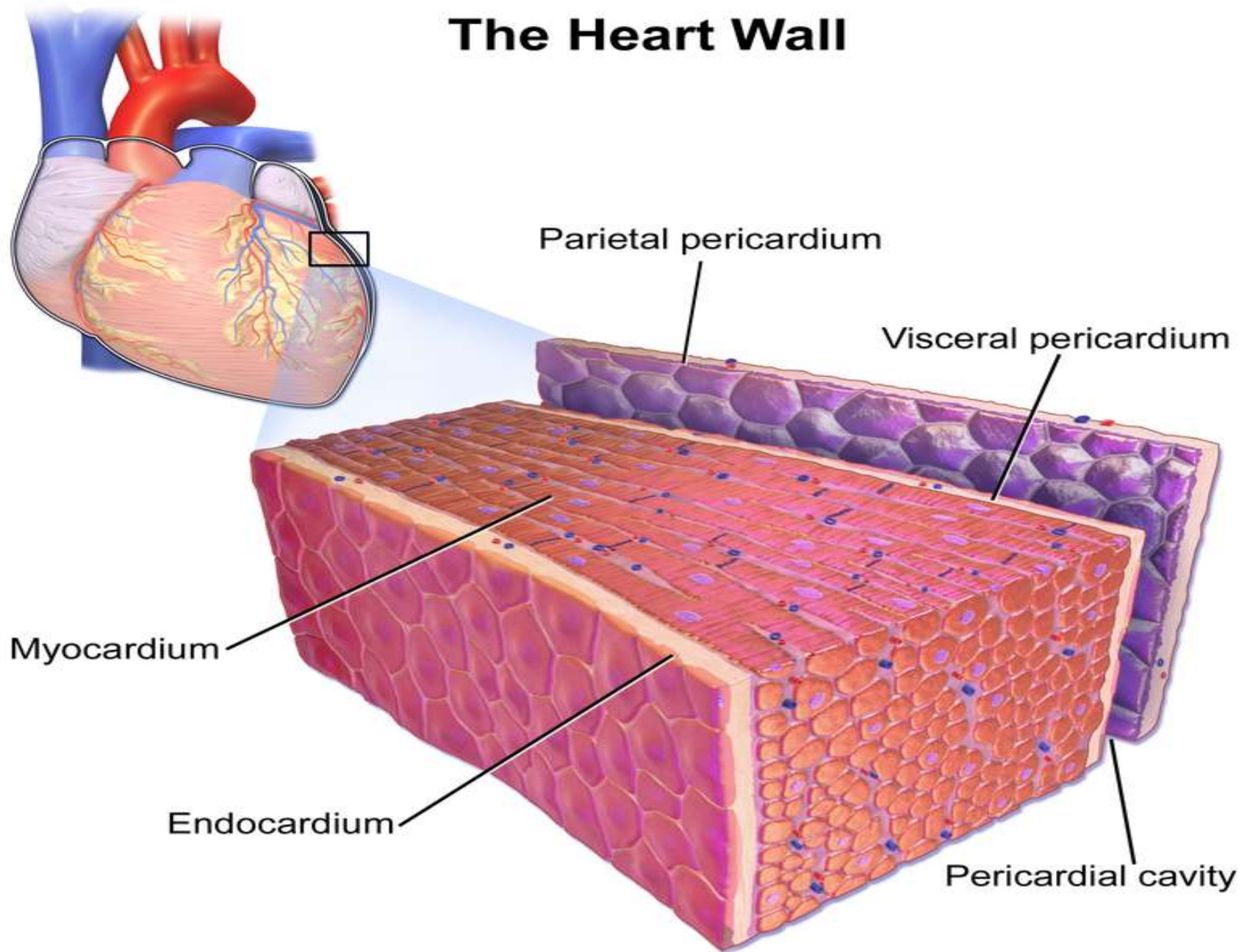
Dr. Ahmed Salman

Associate professor of anatomy & embryology

Layers of wall of heart chambers

- ❖ Endocardium (internal) *endothelium layer, under it we have subendocardial layer.*
- ❖ Myocardium (middle) *ما في عاده*
- ❖ Epicardium (external) *Mesothelium.*

The Heart Wall

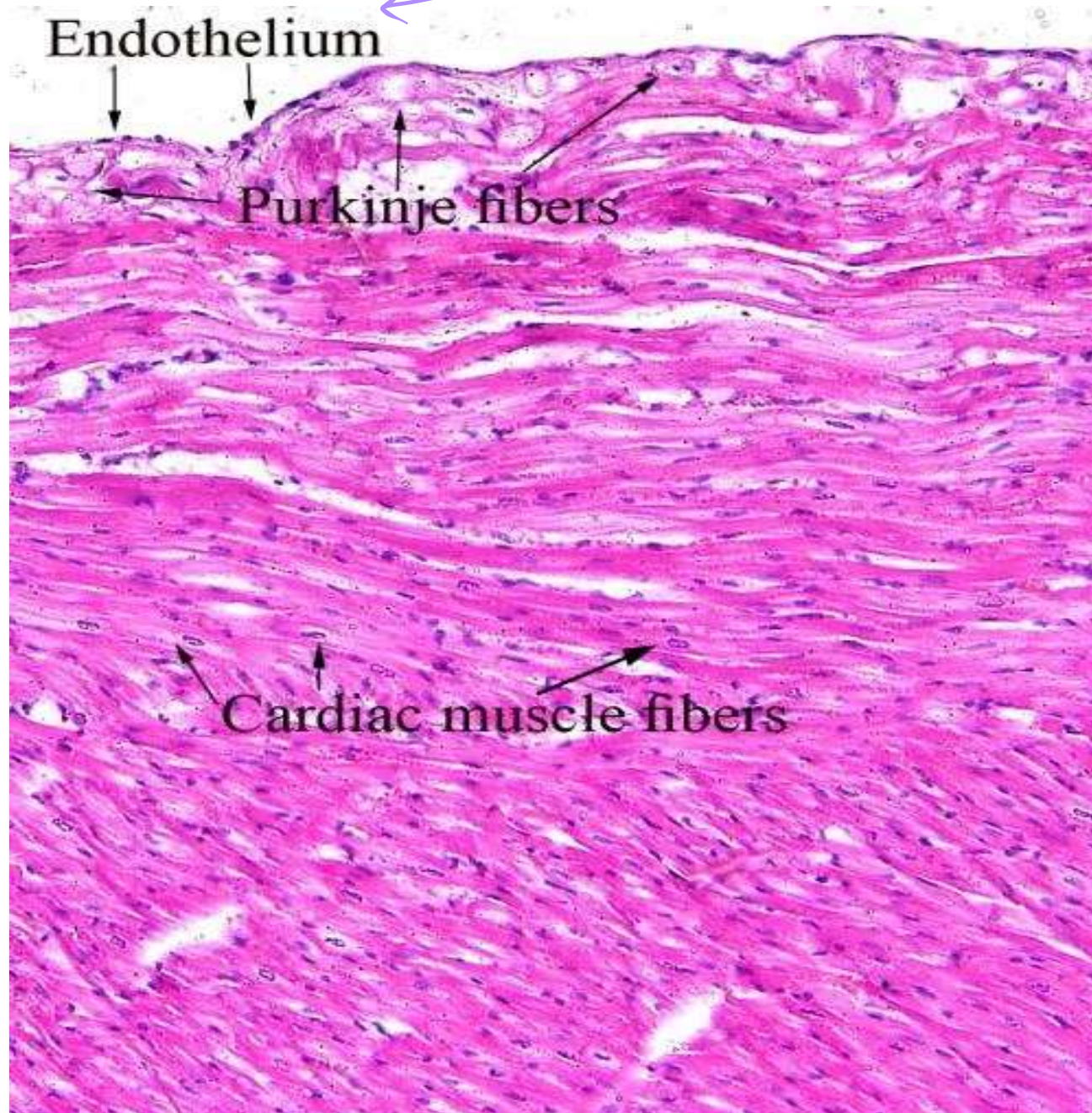


Endocardium

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.

Purkinje



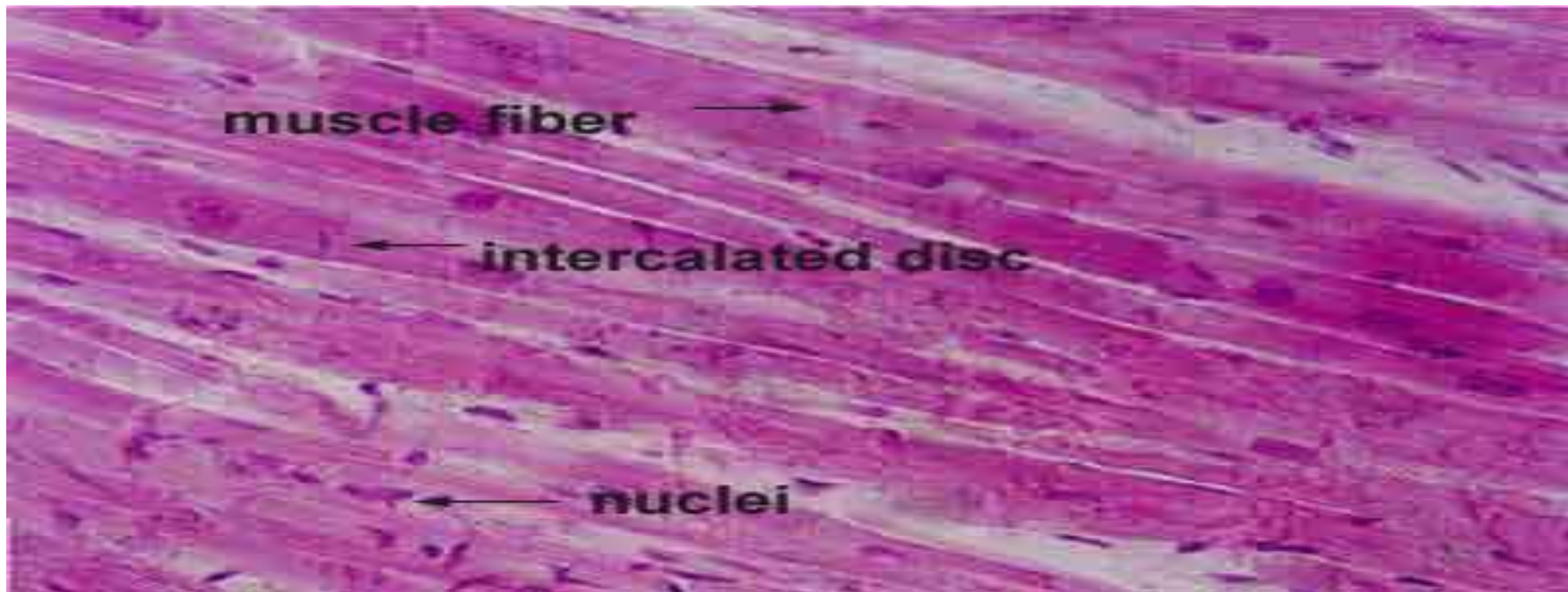
Endocardium

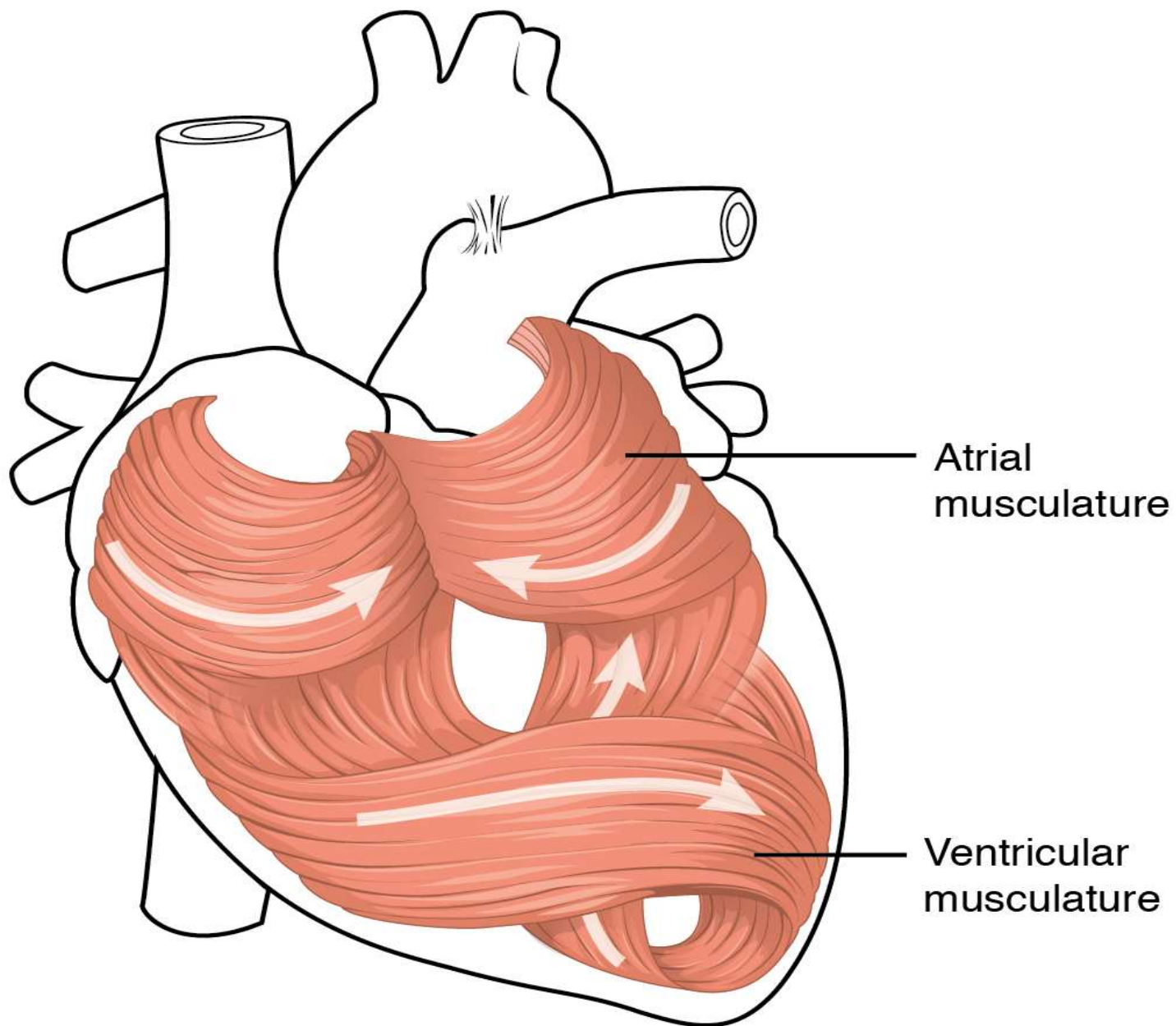
between them we have
subendocardium layer
which contains Purkinje fibers

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





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 increasing renal sodium excretion.

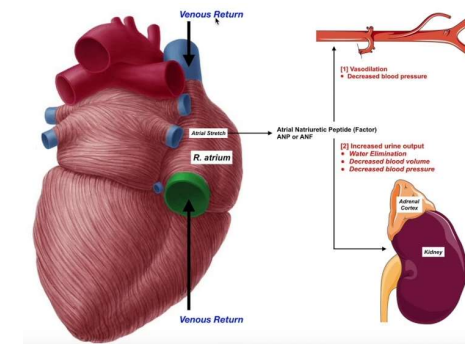
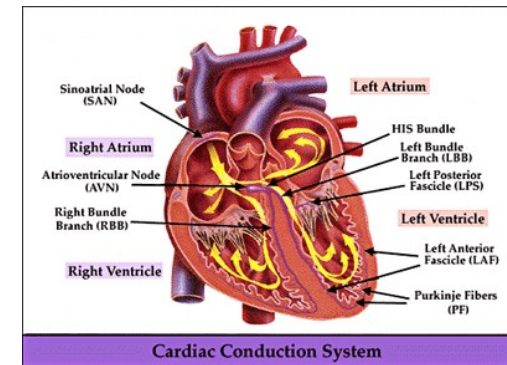
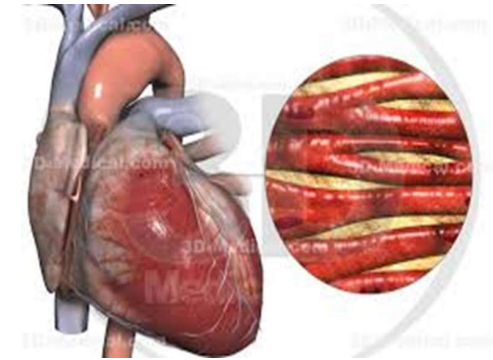
لما يصير تمدد بالأذين بسبب ازدياد حجم الدم (atrial myocytes) هو هرمون يُفرَز من خلايا الأذين ANP وظيفته الأساسية:

زيادة إخراج الصوديوم من الكلى (Natriuresis)

ولما يطلع الصوديوم → تطلع المي معه

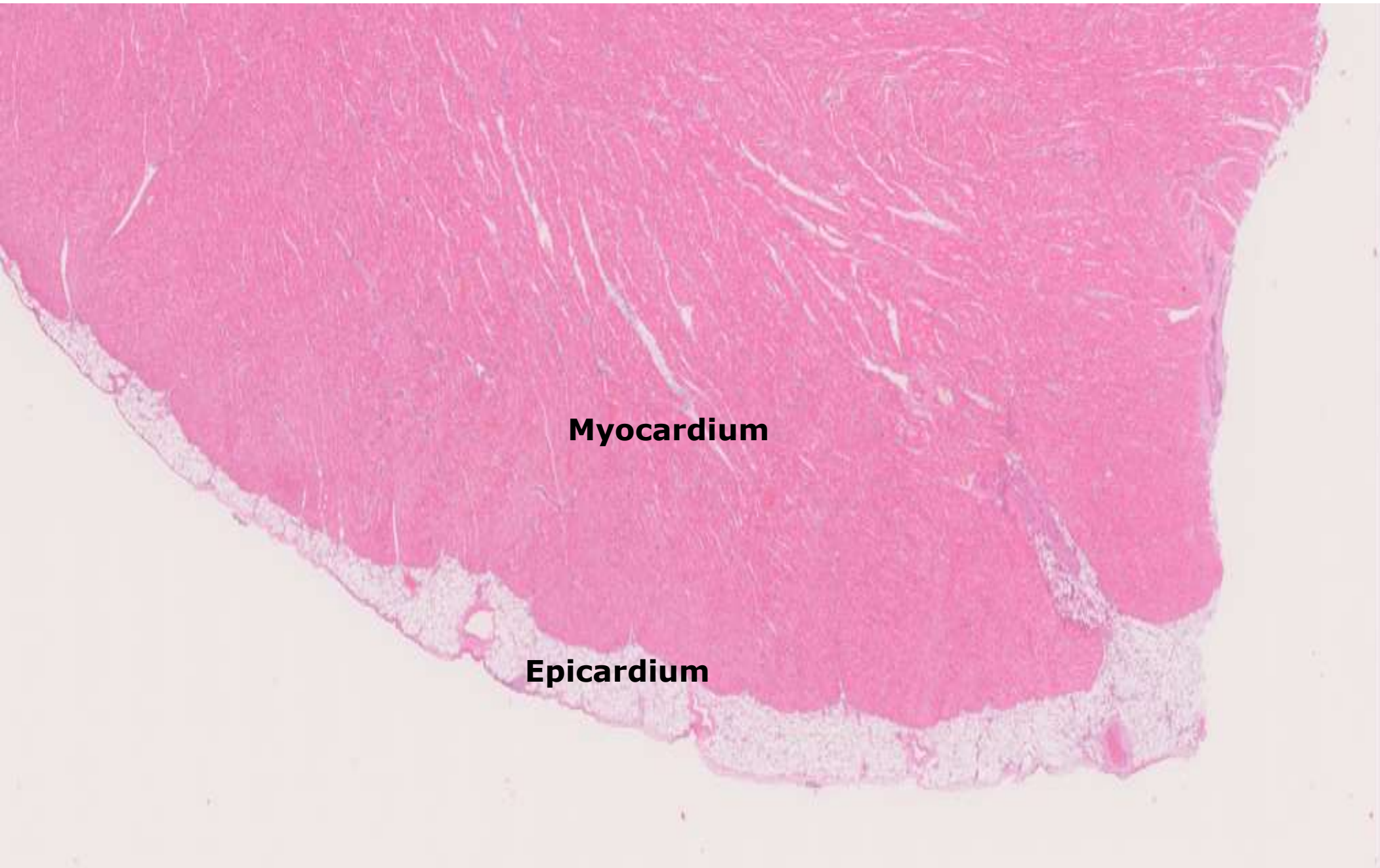
ف يقل حجم الـ ECF ويقل الضغط

يعني ANP هو هرمون يحارب ارتفاع السوائل والضغط عن طريق إنه يخلي الكلى تفرز صوديوم أكثر.



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.

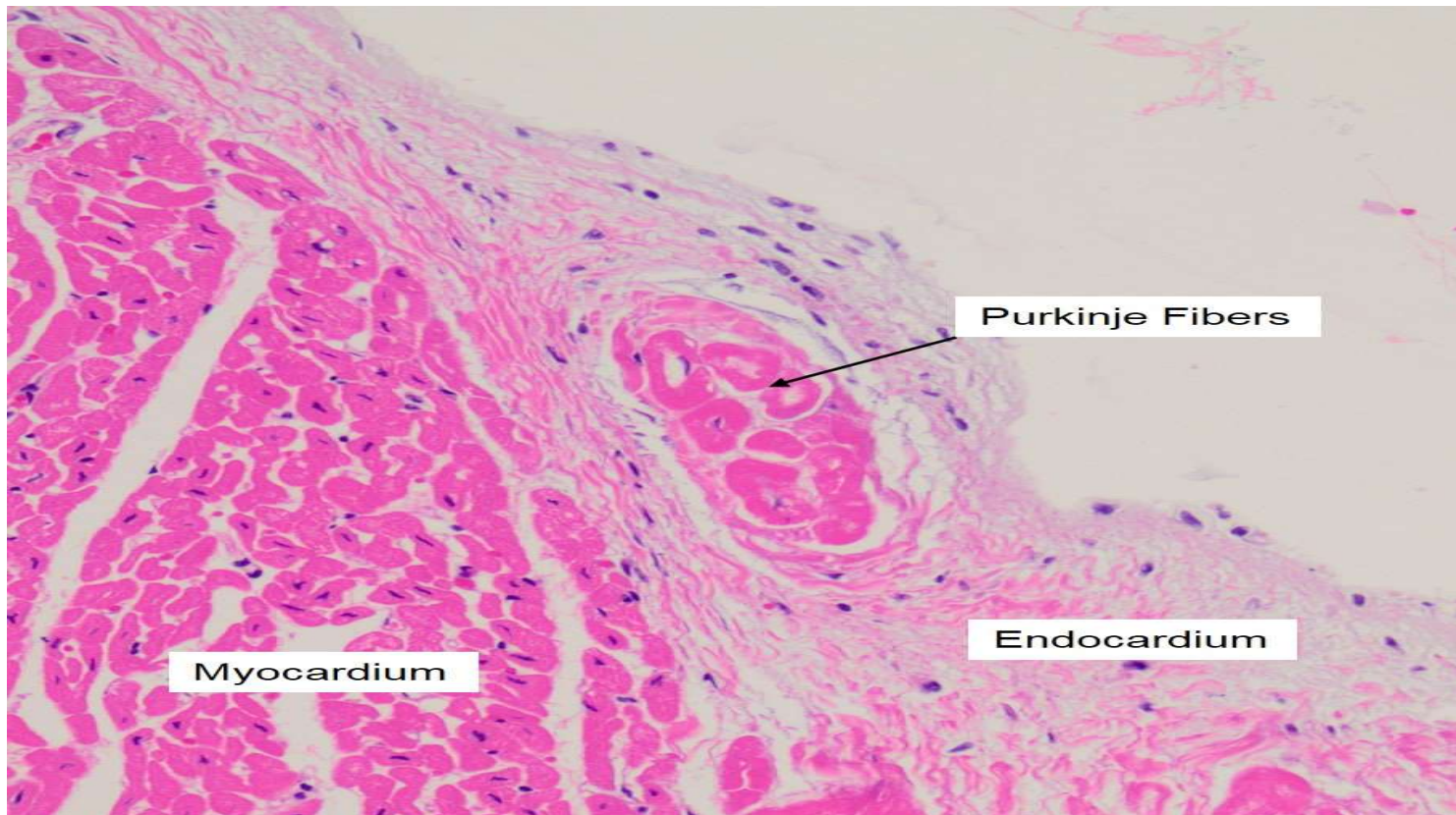


Myocardium

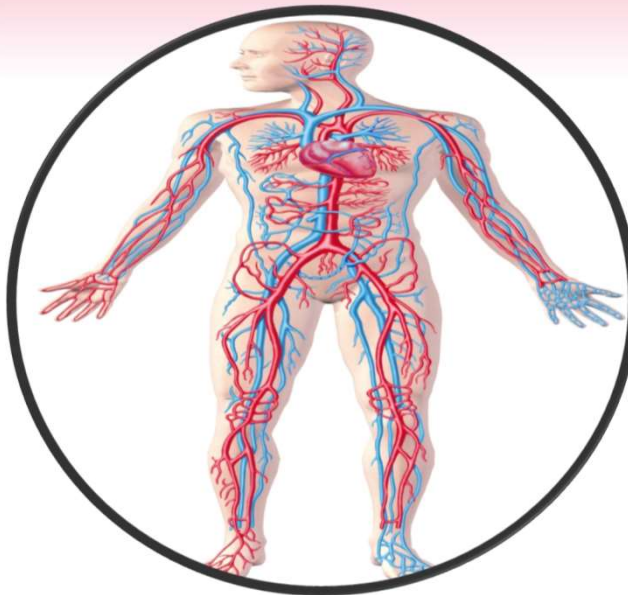
Epicardium

Purkinje fibers = Considered as modified Cardiac muscle

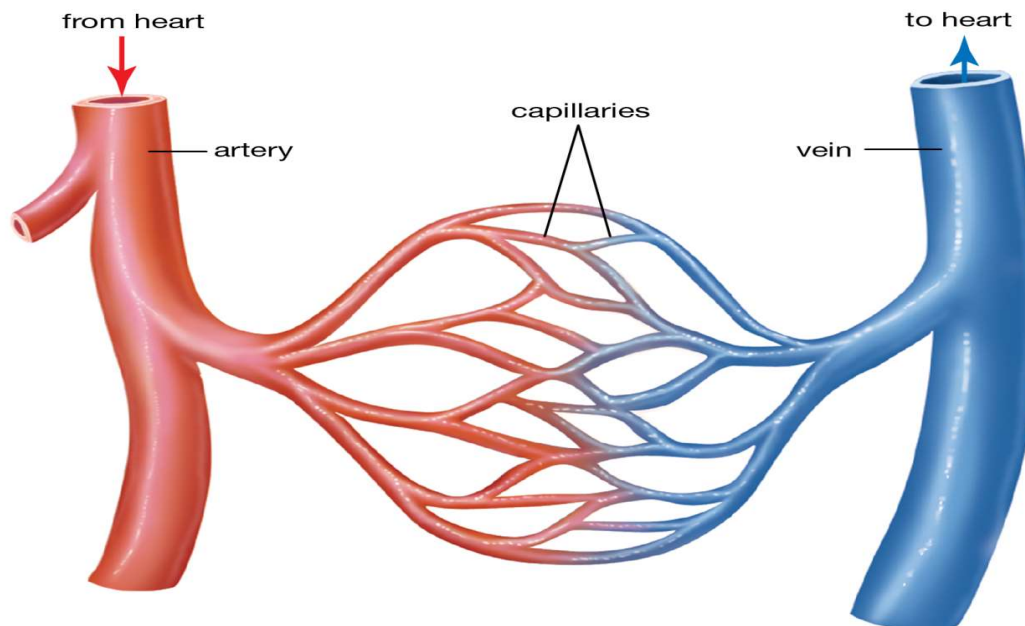
- **Purkinje fibers** are pale-staining fibers, larger than the adjacent contractile muscle fibers, with sparse, peripheral myofibrils and much glycogen.
- Purkinje fibers mingle distally with contractile fibers of both ventricles and trigger waves of contraction through both ventricles simultaneously.

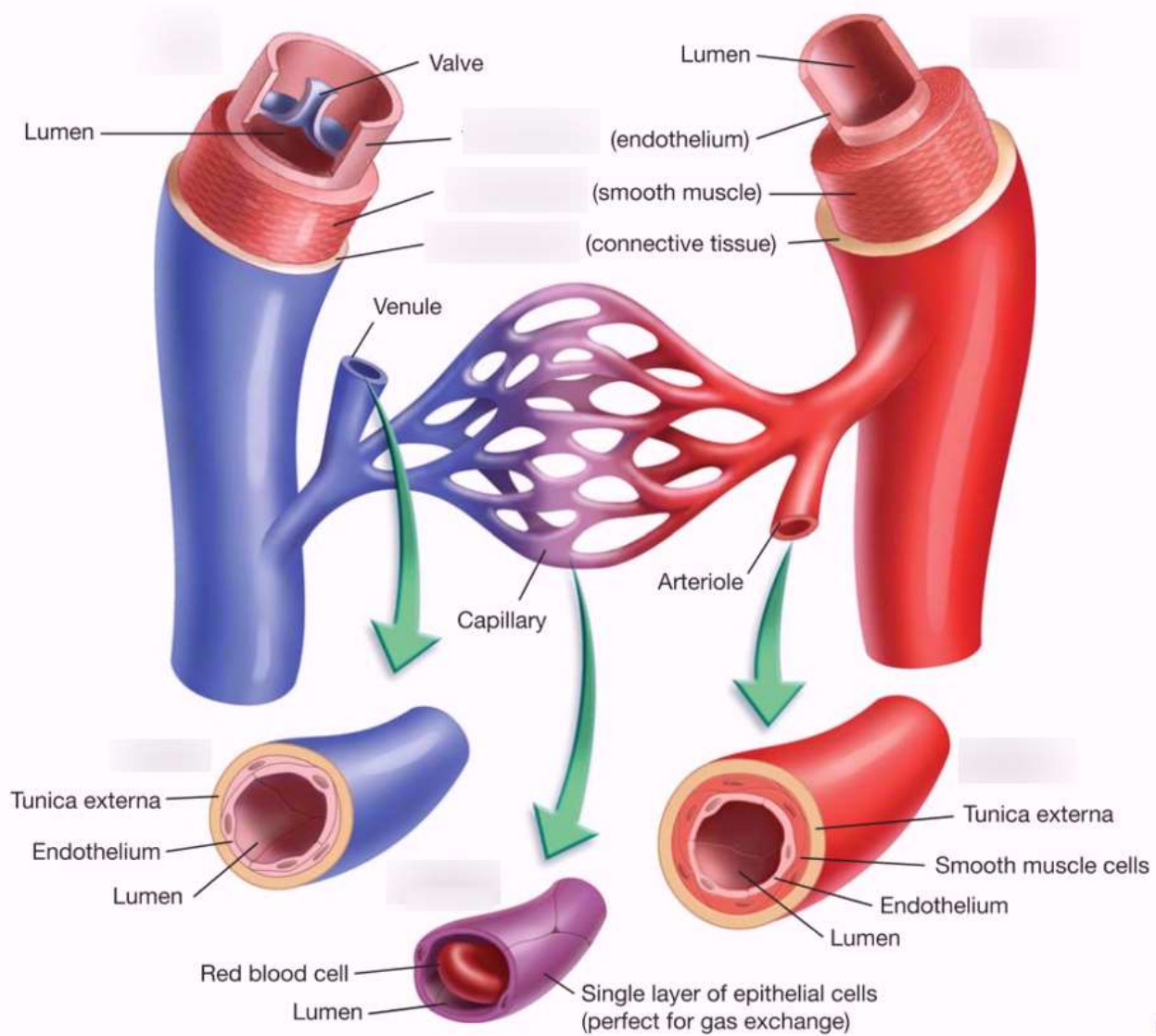


Classification of Blood Vessels

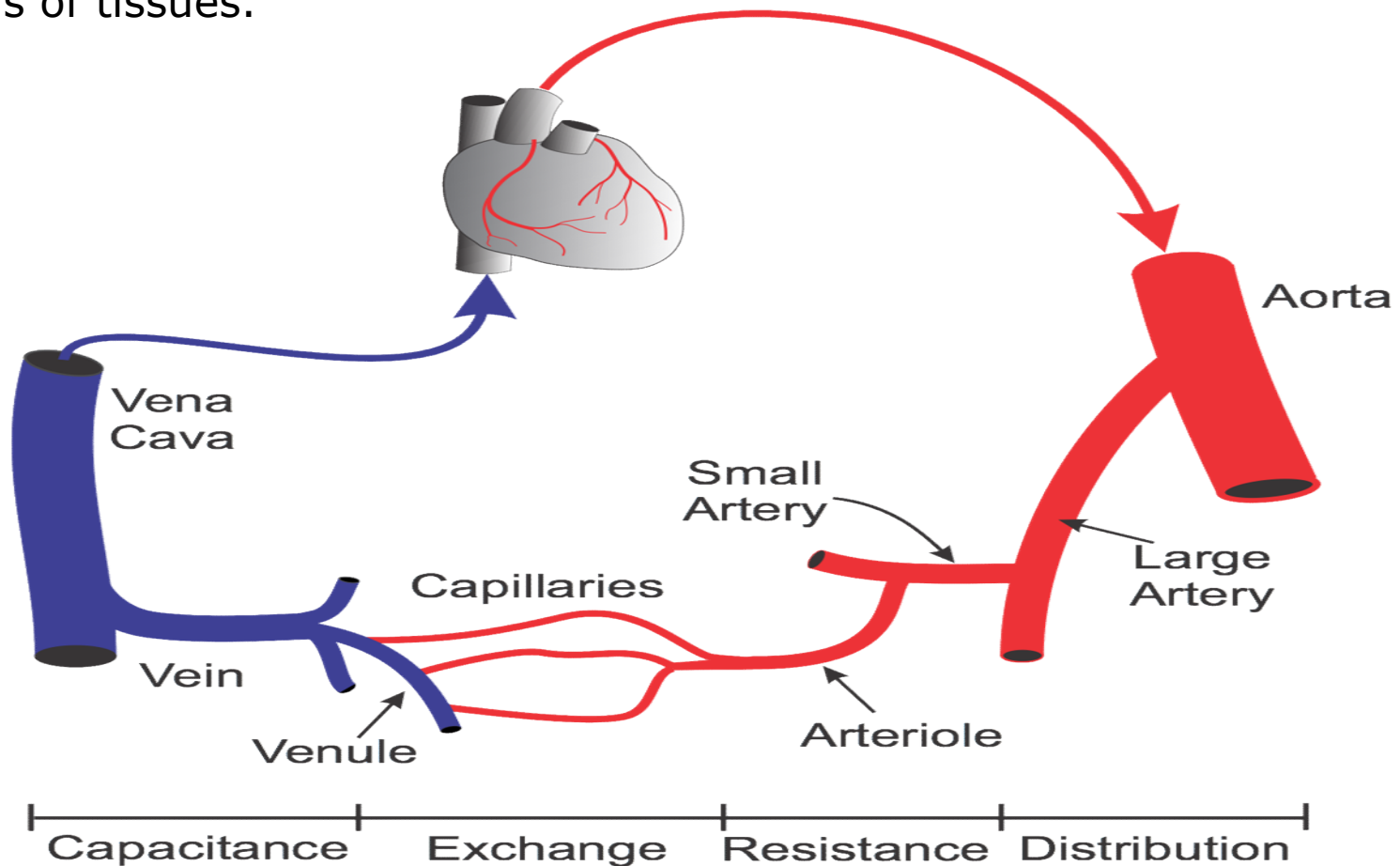


- There are 3 Major Types of **Blood Vessels**: **Arteries**, **Veins** and **Capillaries**.
- **Blood vessels** flow **blood** throughout the body.
- **Arteries** transport **blood** away from the heart.
- **Veins** return **blood** back toward the heart.
- **Capillaries** surround body cells and tissues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





- 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

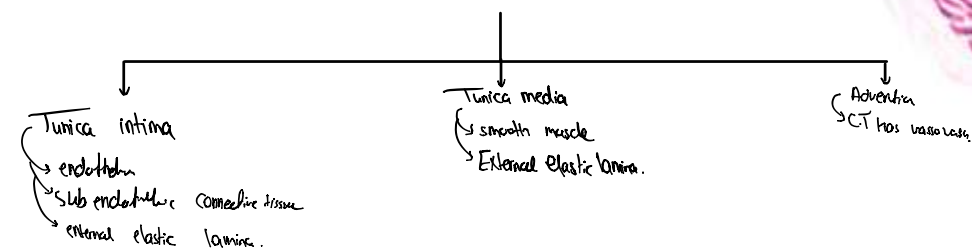
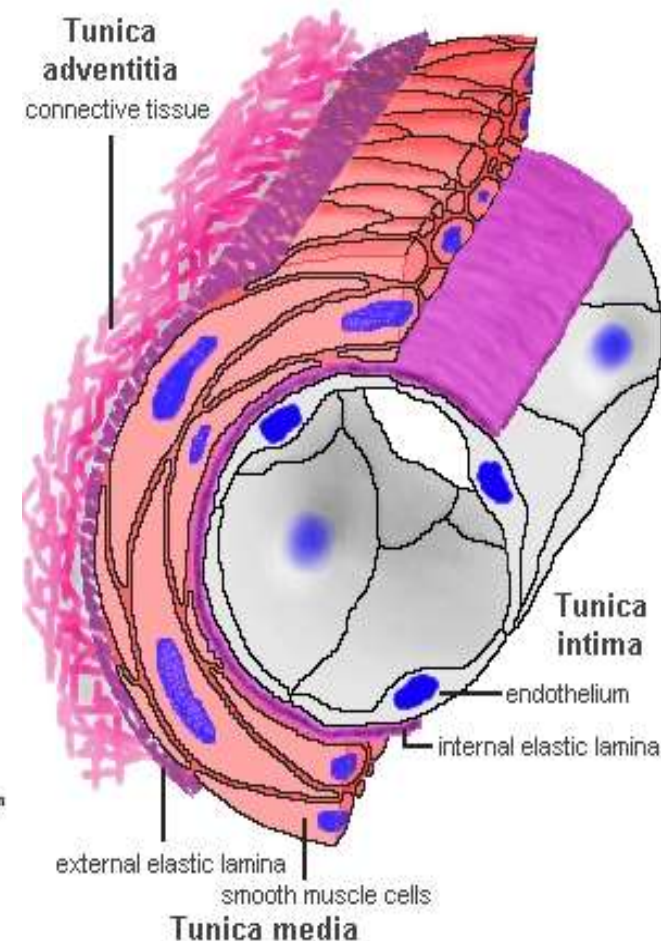
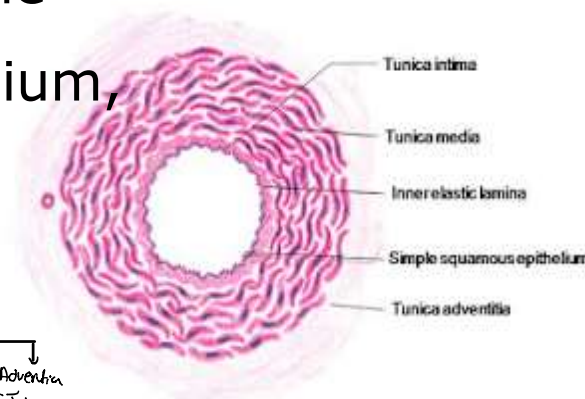
The wall of a blood vessel consists of **3 layers** from the lumen outward are:

1. Tunica intima

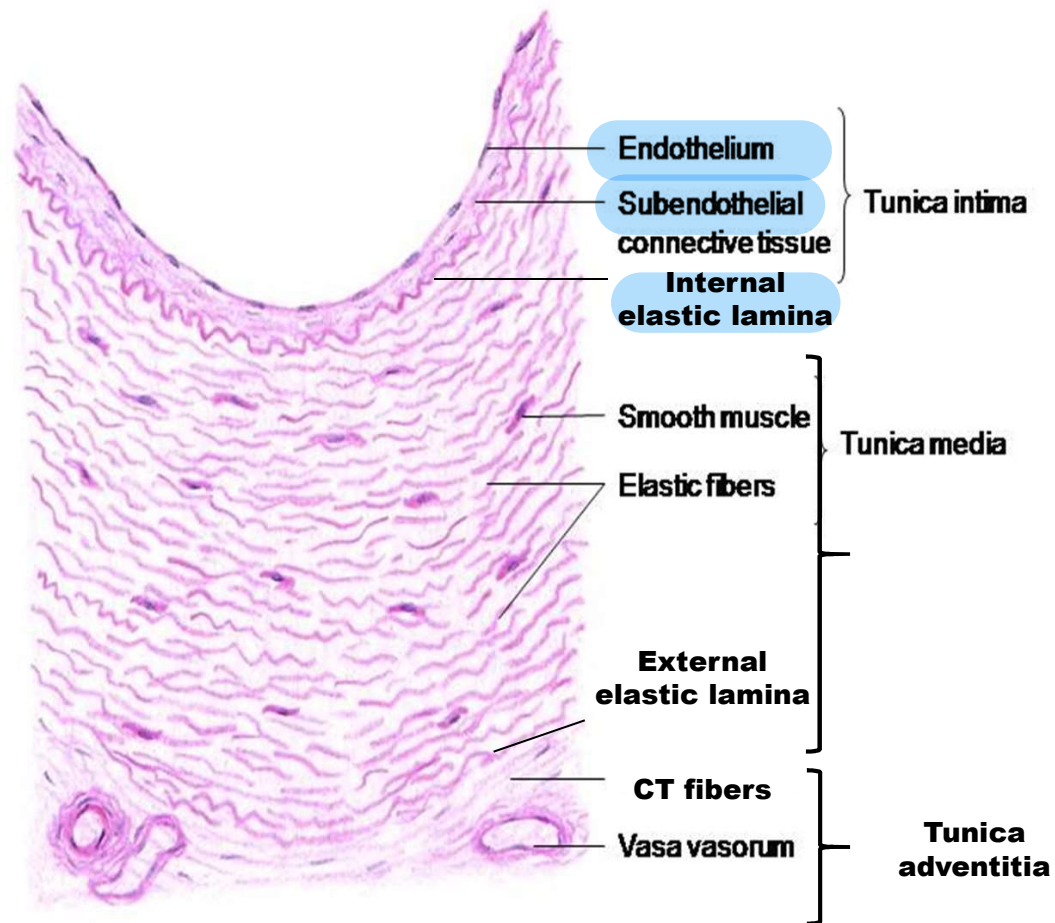
2. Tunica media

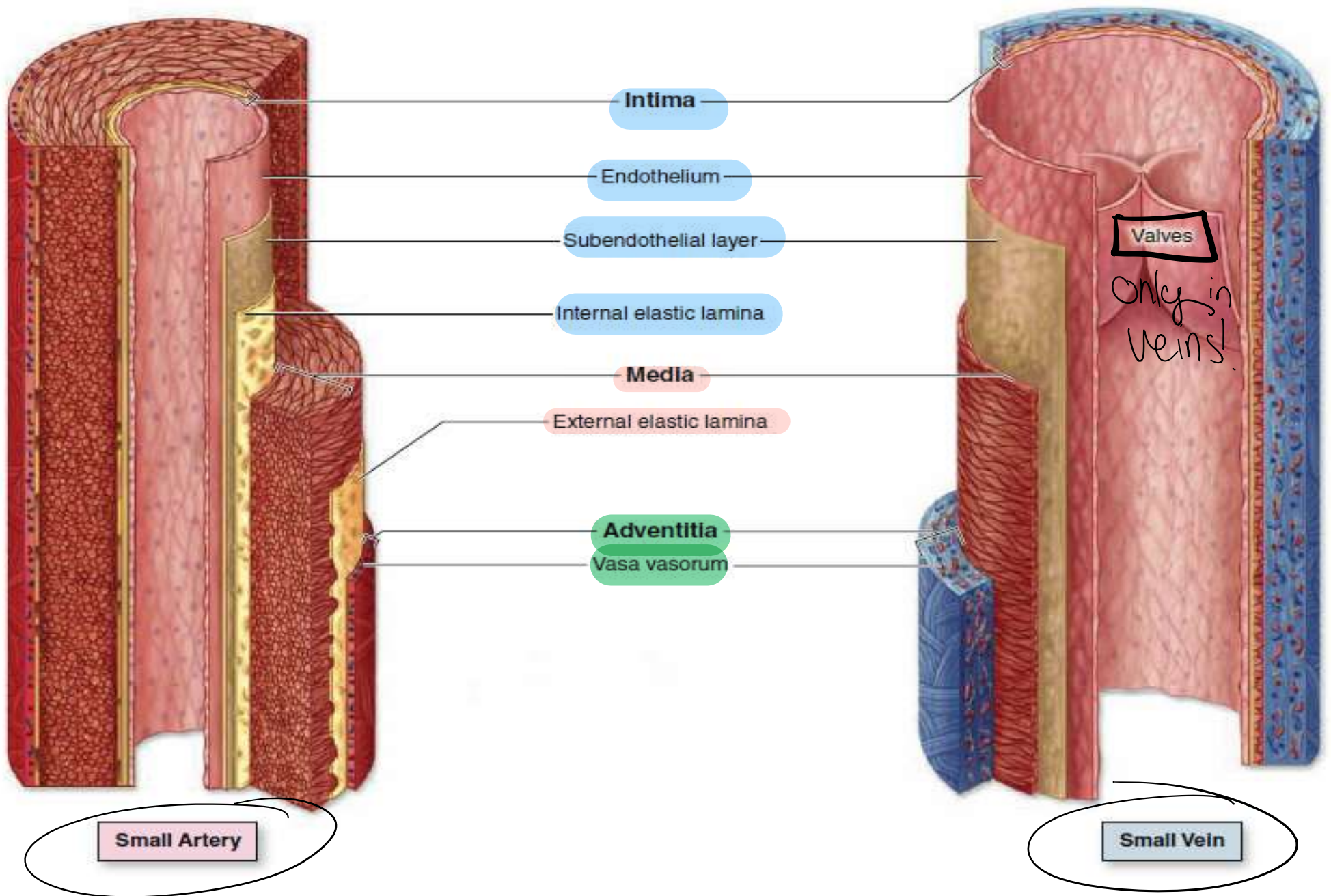
3. Tunica adventitia

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



Histological Structure of Blood Vessels





1-Tunica intima

The innermost coat & consists of:

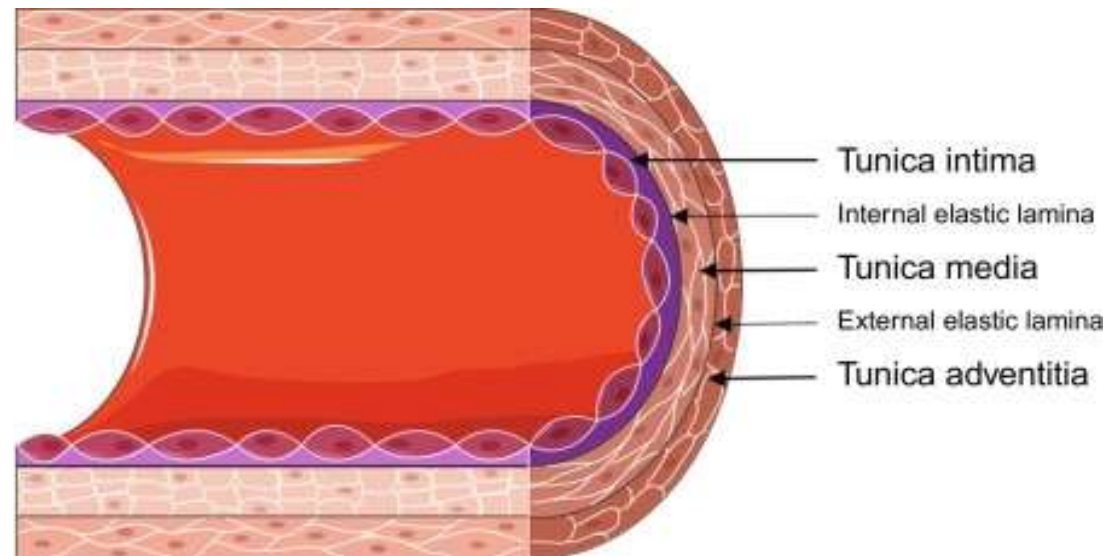
a- **Endothelium**: a simple squamous epithelium that provides a smooth surface for blood flow.

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

أحمة: barrier between blood and extracellular fluid.

Connective tissue

Simple squamous epithelium flat
Endothelium

Blood vessel

Blood vessel

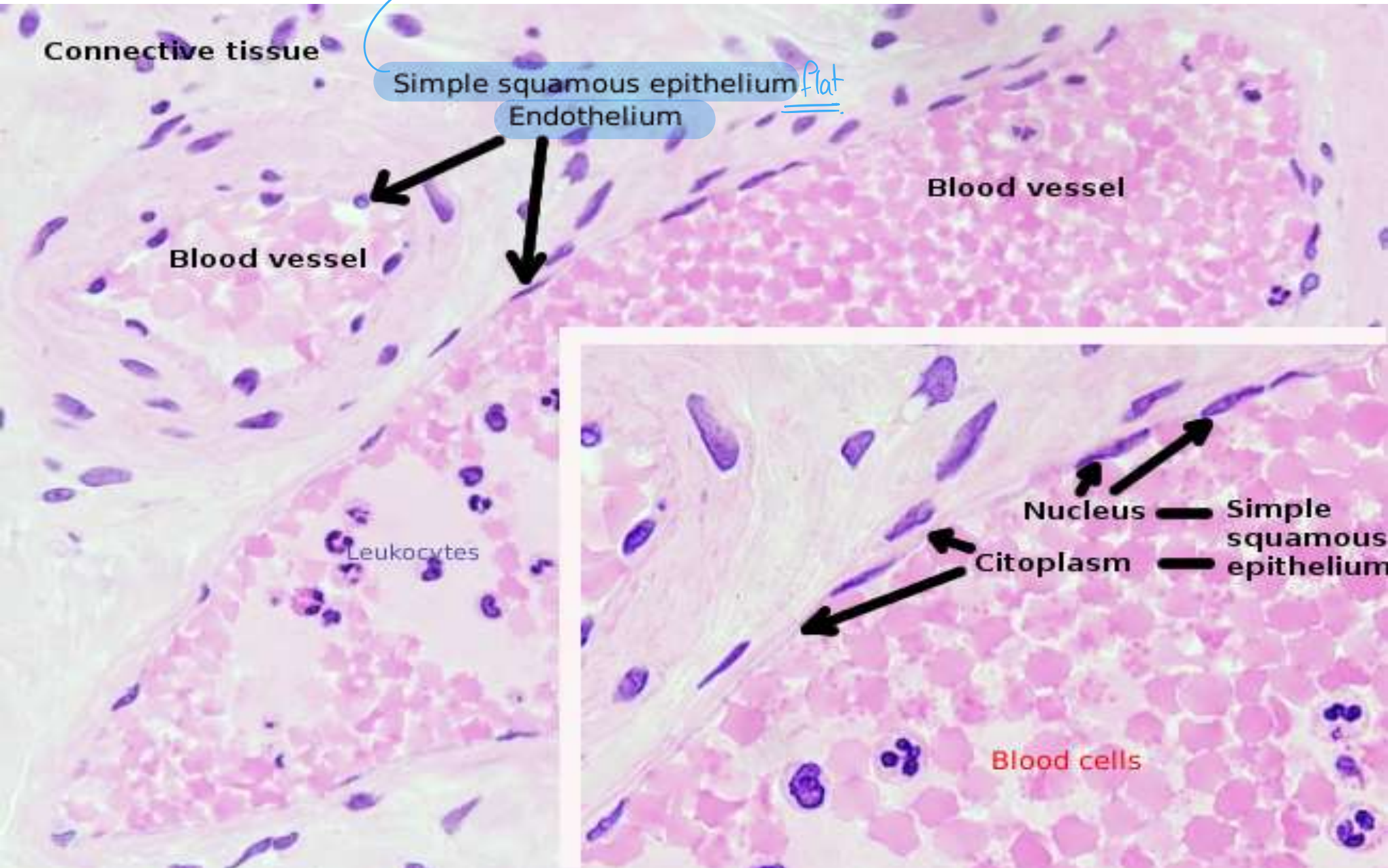
Leukocytes

Nucleus

Simple
squamous
epithelium

Cytoplasm

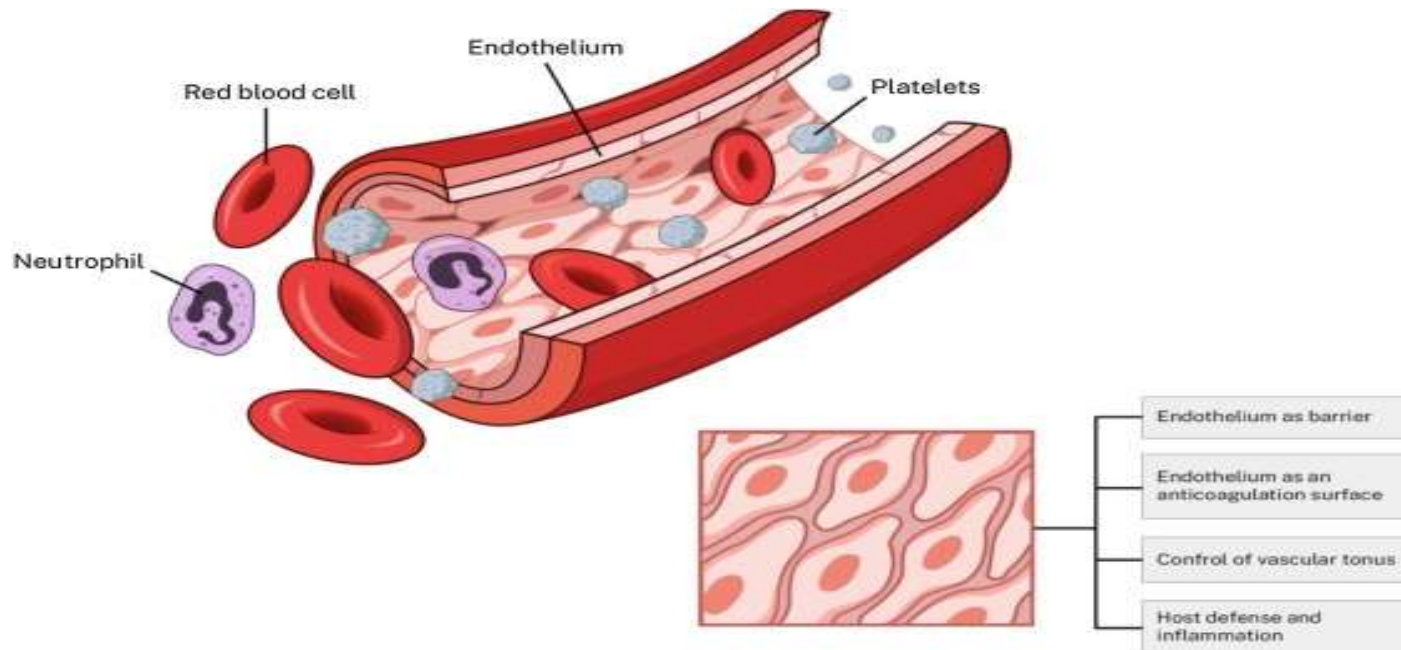
Blood cells



Functions of Endothelium

1. Maintain a selectively permeable, anti-thrombogenic (inhibitory to clot formation) barrier
2. Determine when and where white blood cells leave the circulation for the interstitial space of tissues
3. Secrete a variety of paracrine factors for vessel dilation, constriction, and growth of adjacent cells.
→ cell secrete factors that work on other cells.

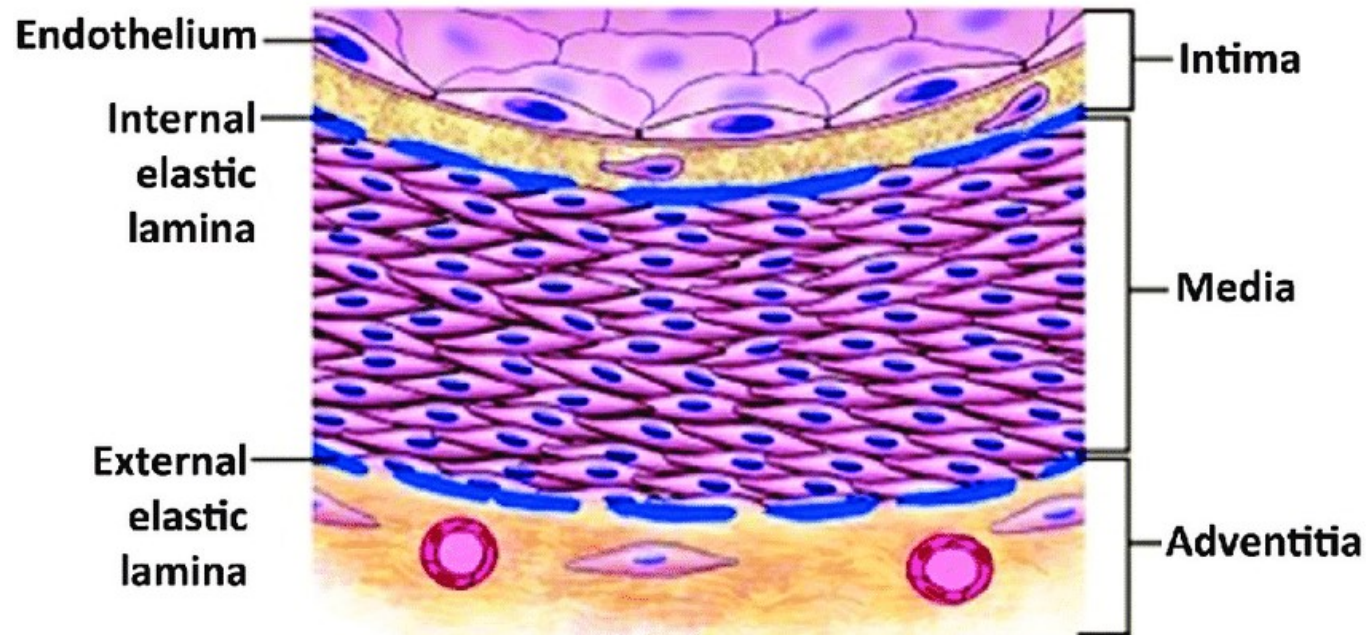
Paracrine factors are factors produced by one cell that act on a neighboring cell or cells



2-Tunica media

The middle coat & consists of:

- a- **Smooth muscle fibers**: circularly arranged.
- b- **Variable amounts of** ^{Elastic fibers} **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.

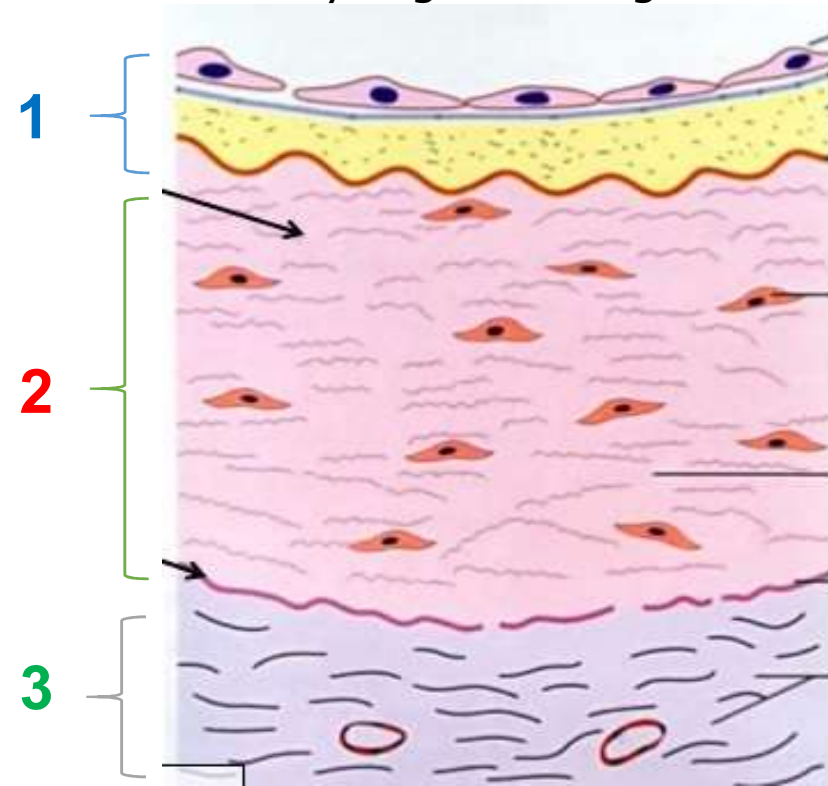


3-Tunica(adventitia)

Connective tissue surround blood vessels.

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.

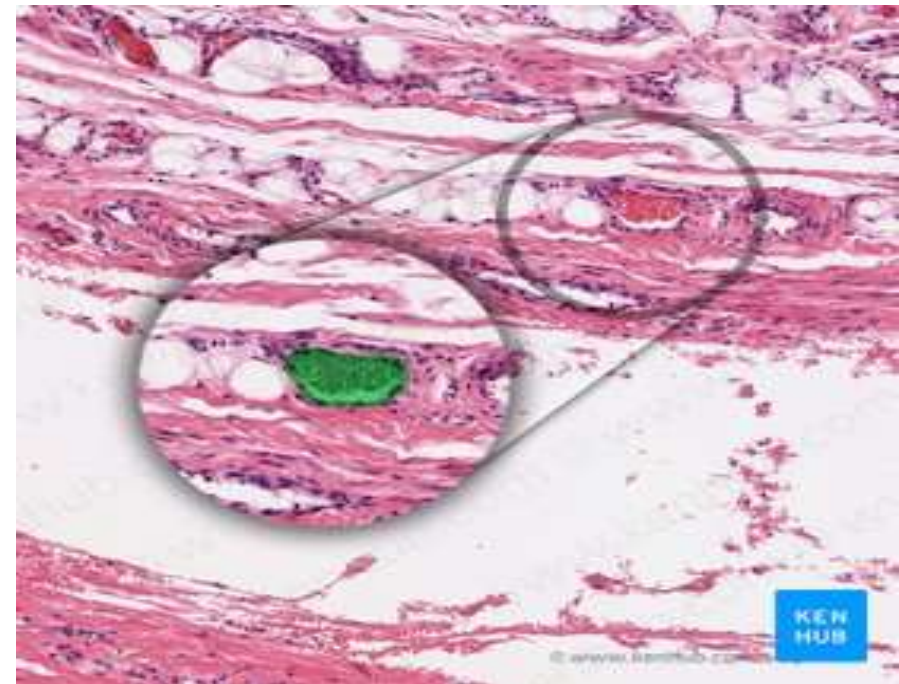
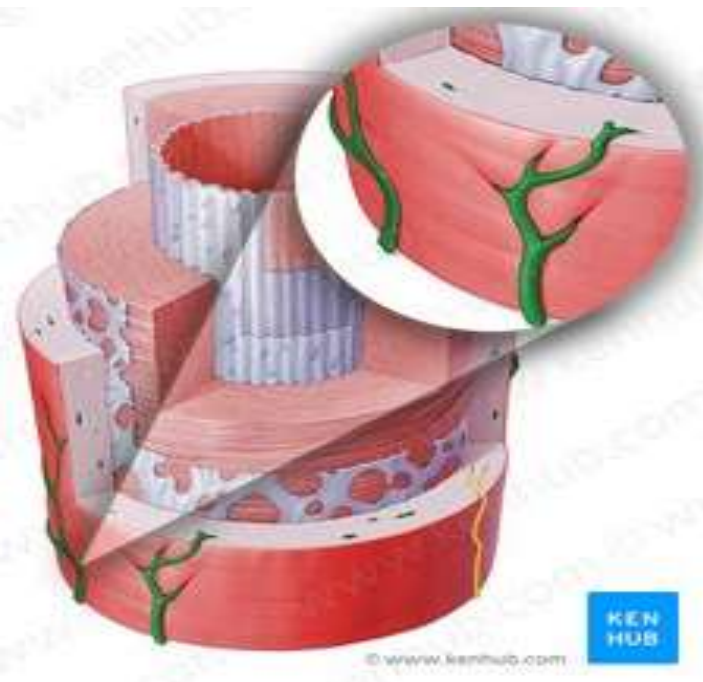


Vasa Vasorum

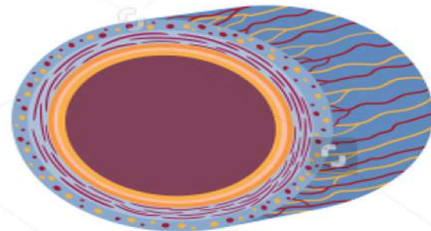
• Blood vessels
• Adventitia

* mainly found in large vessels
* Vein (need Blood supply) > Artery ; since they carry deoxygenated blood.

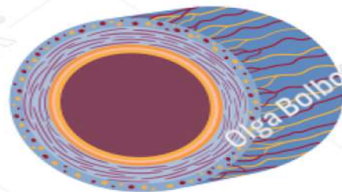
1. Large vessels usually have **vasa vasorum** ("vessels of the vessel")
2. The vasa vasorum are required to provide metabolites to cells in those larger vessels tunics , because the wall is too thick to be nourished solely by diffusion from the blood in the lumen.
3. Large veins have more vasa vasorum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



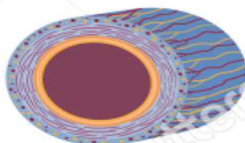
Blood vessels types



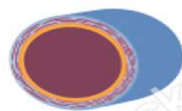
Vena cava



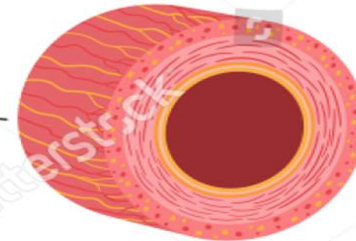
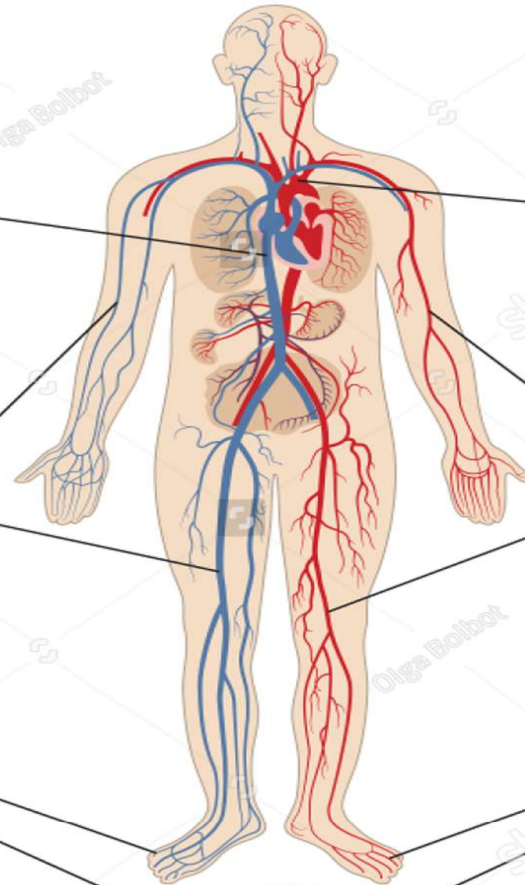
Veins



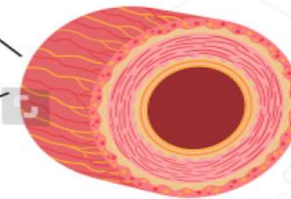
Small veins



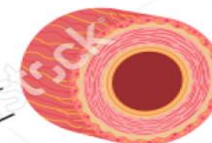
Venule



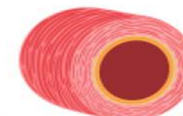
Elastic artery



Muscular artery



Small arteries



Arteriole



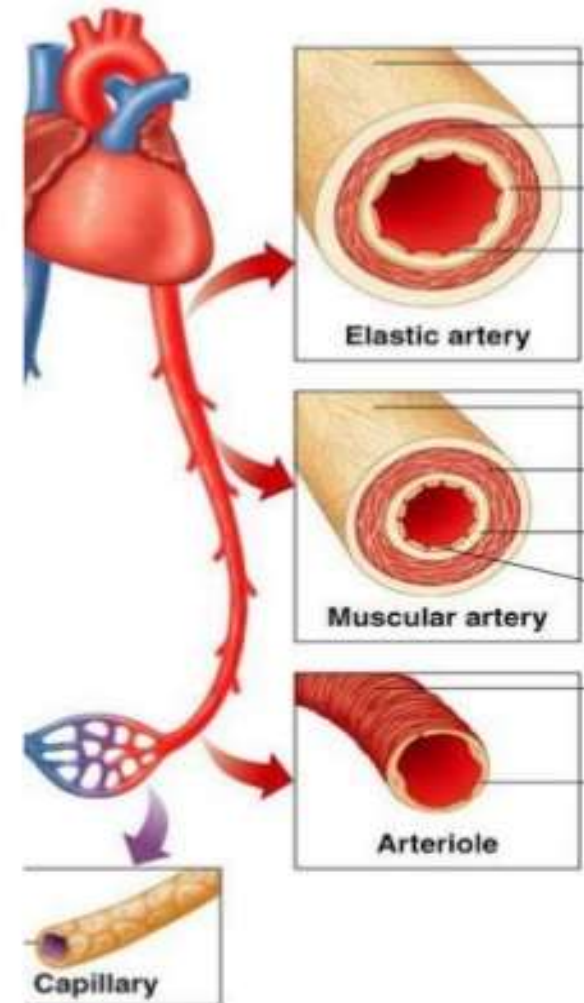
Capillary

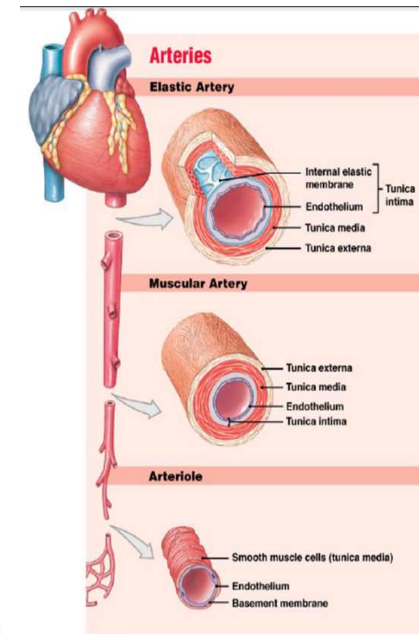
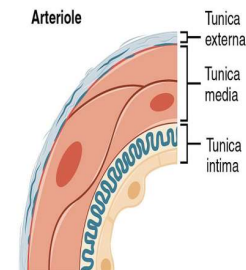
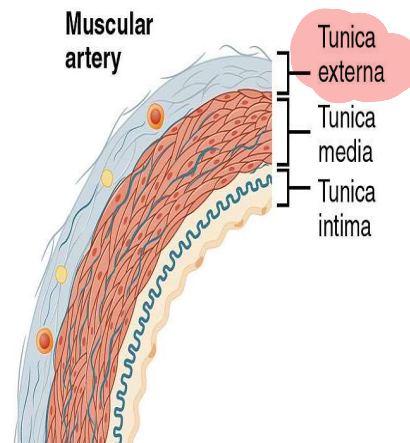
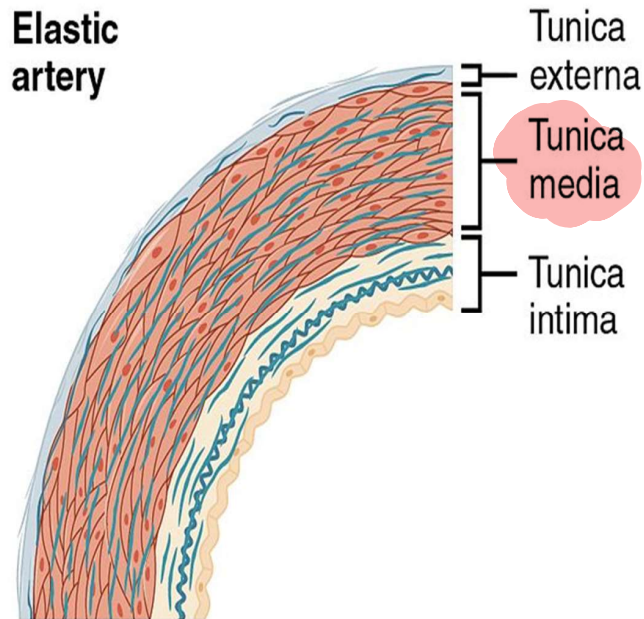
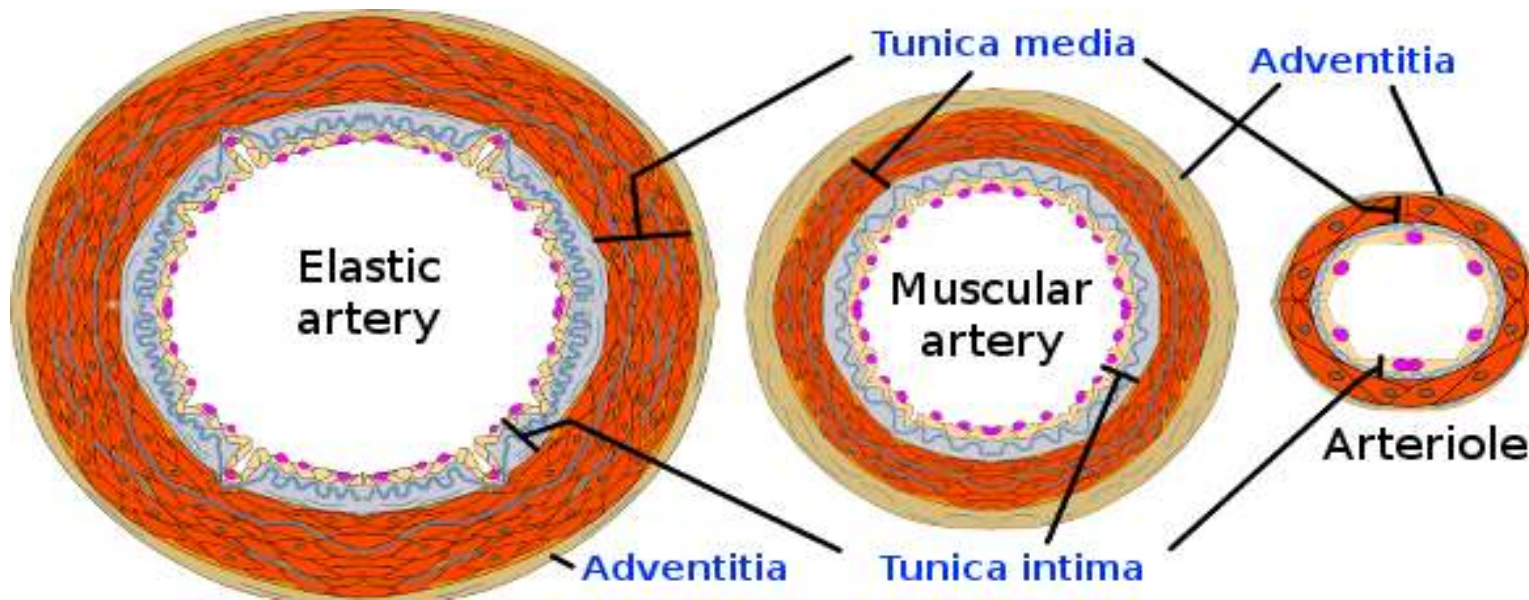
Arteries

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

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

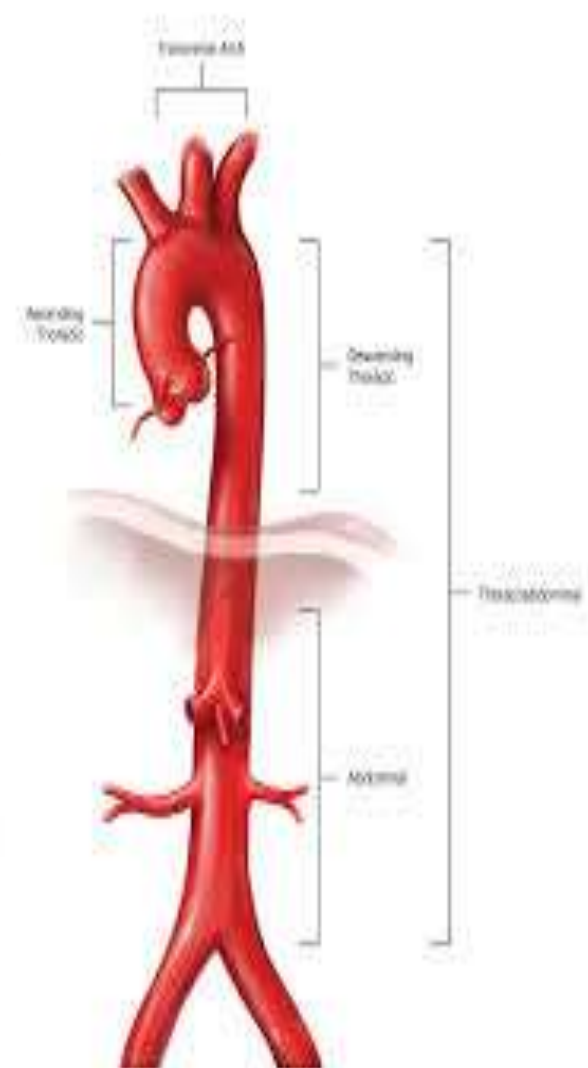
* الشرايين
elastic .f
Smooth muscles
بنزود و ينقر حسب المكان.





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**.
to accommodate this large amount
- 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
نَرَك
- Examples: **the aorta** & its largest main branches, **common carotid artery** and **common iliac artery**



Aorta

- **Tunica intima: thin**

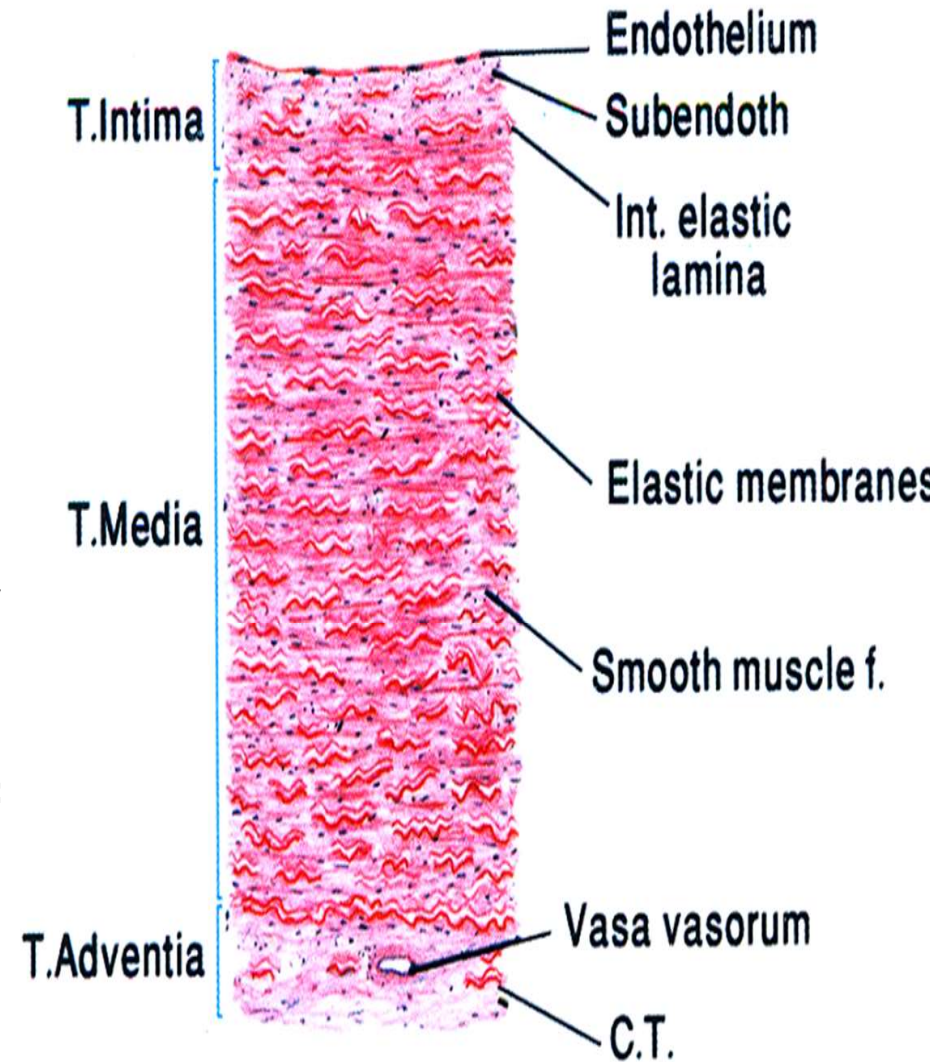
1. **Endothelium**
2. **Subendothelial layer** contains some smooth muscle, elastic fibers, collagen fibers
3. **Internal elastic lamina** : it is present but **indistinct** as it merges with the elastic membranes in tunica media

- **Tunica media : very thick** • external elastic lamina
• لا يوجد طبقة خارجية واضحة للليفات المرنة.

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**.

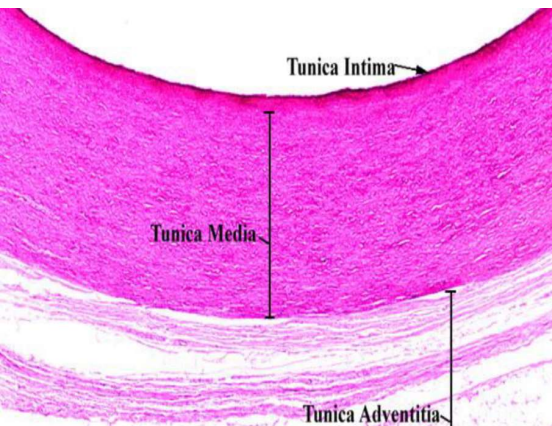
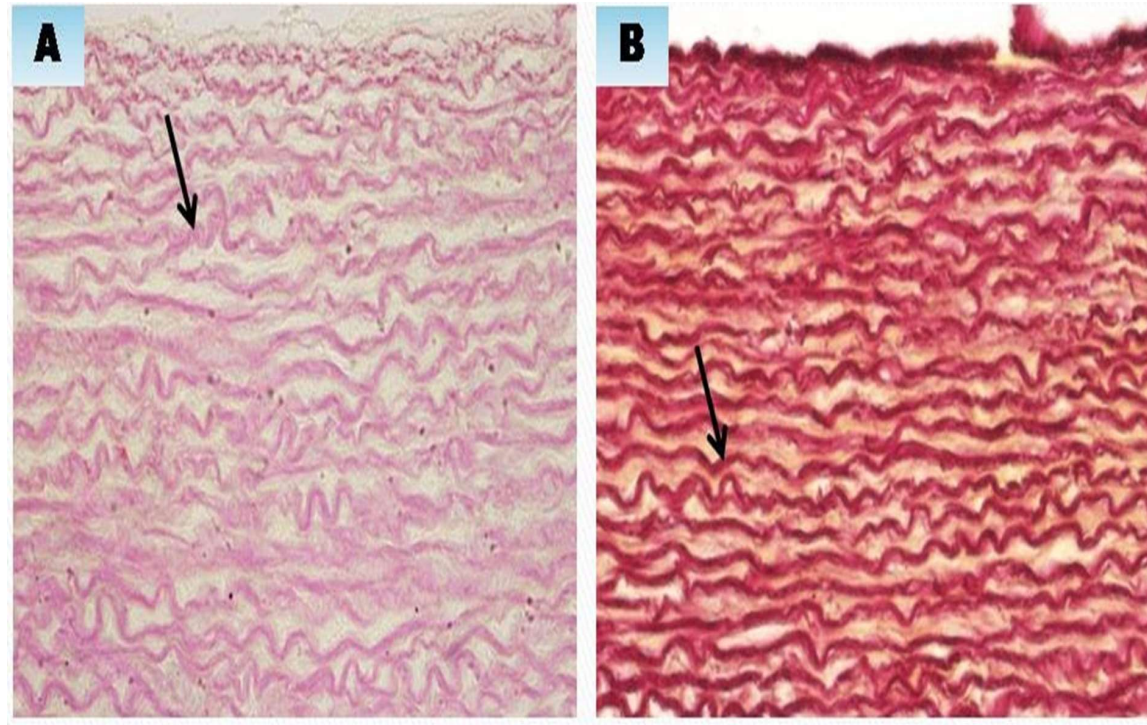
- **Tunica adventitia: thin**

1. consists mainly of **collagen fibers**, blood vessels (**vasa vasorum**), **nerves**; some **elastic fibers & fibroblasts**.



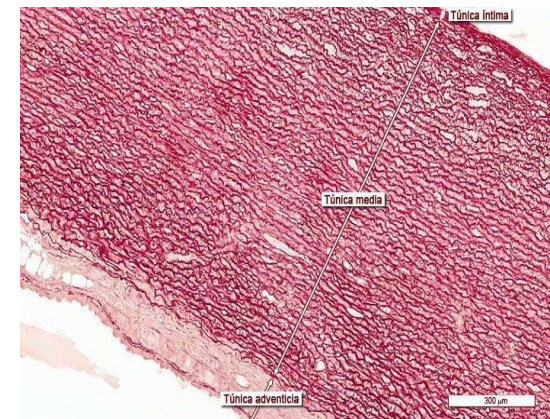
Aorta

Structure of the Aorta

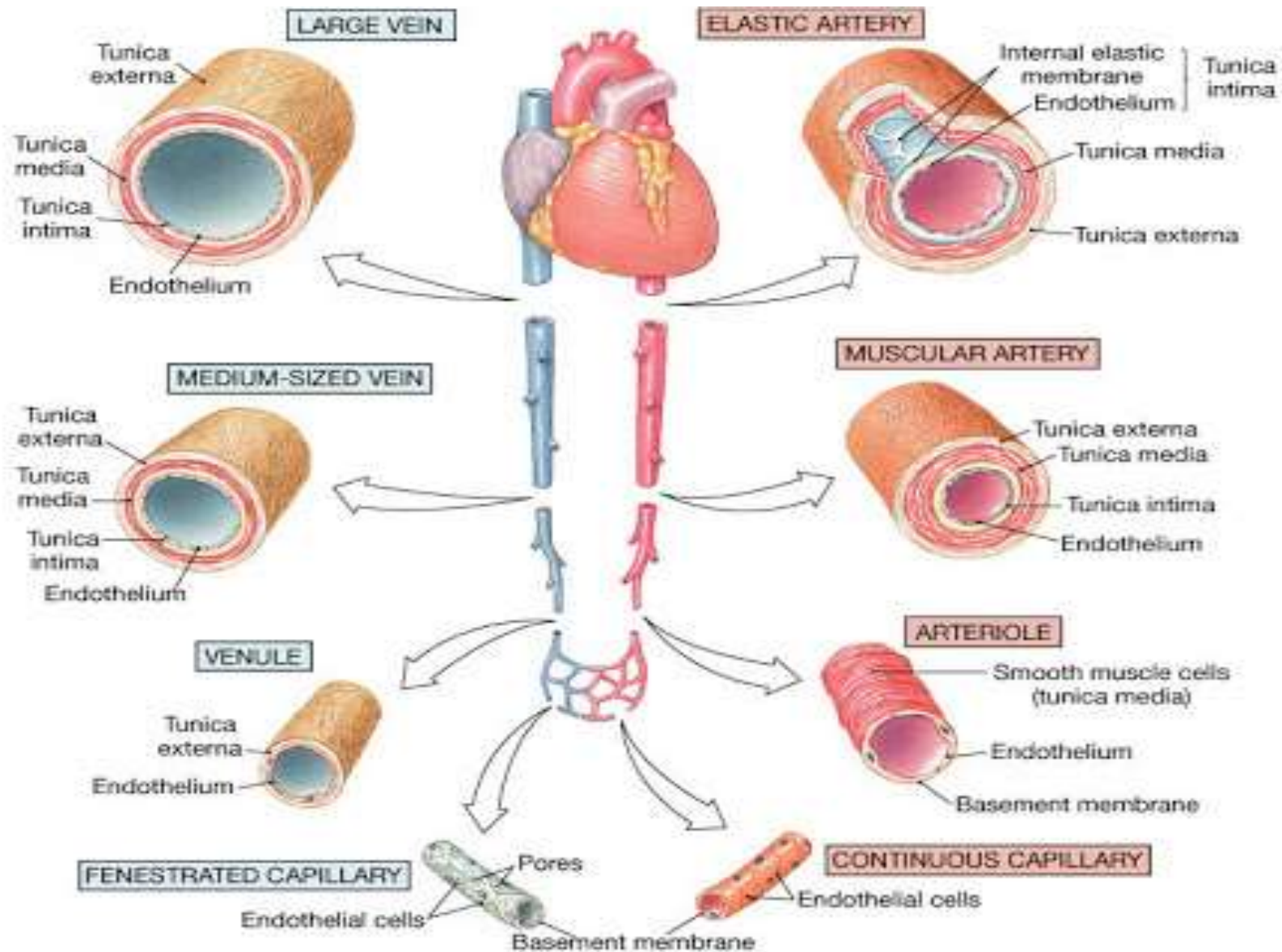


Hx & E

Orcein



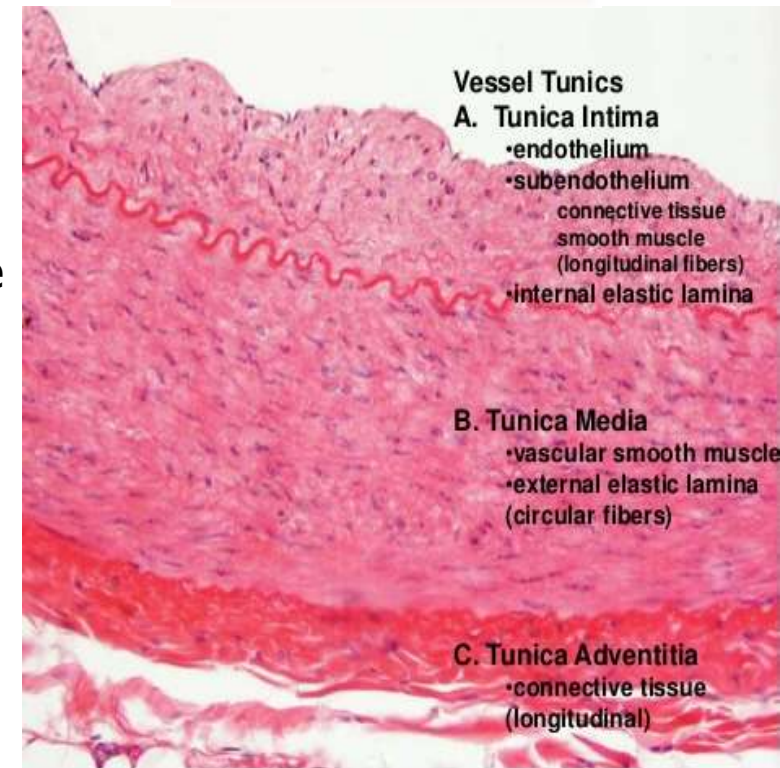
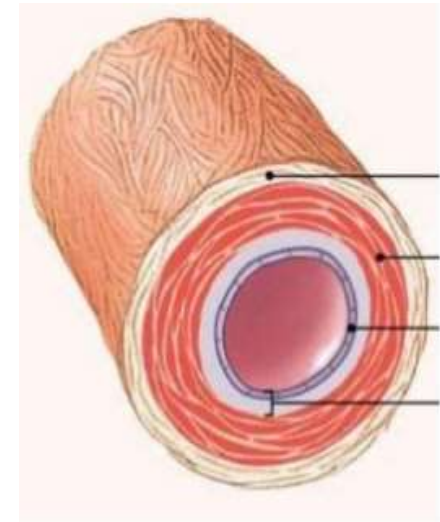
Medium sized A & V



Medium sized (Muscular) or distributing arteries

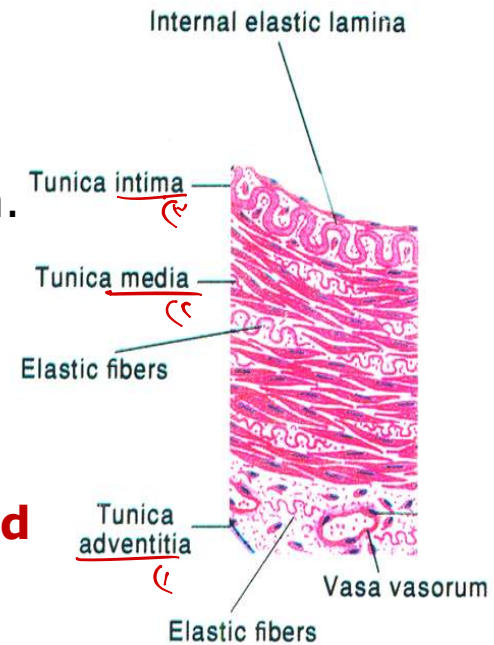
→ to keep blood motility.

- 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**.

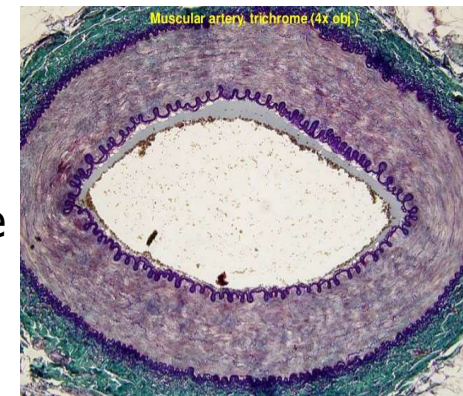


Structure of Medium Sized Artery

- **Tunica intima: thin**
 - Endothelium: simple squamous epithelium resting on a basal lamina.
 - Subendothelium layer
 - Internal elastic lamina: is **prominent**.
- **Tunica media : thick** *large size*
 - 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.

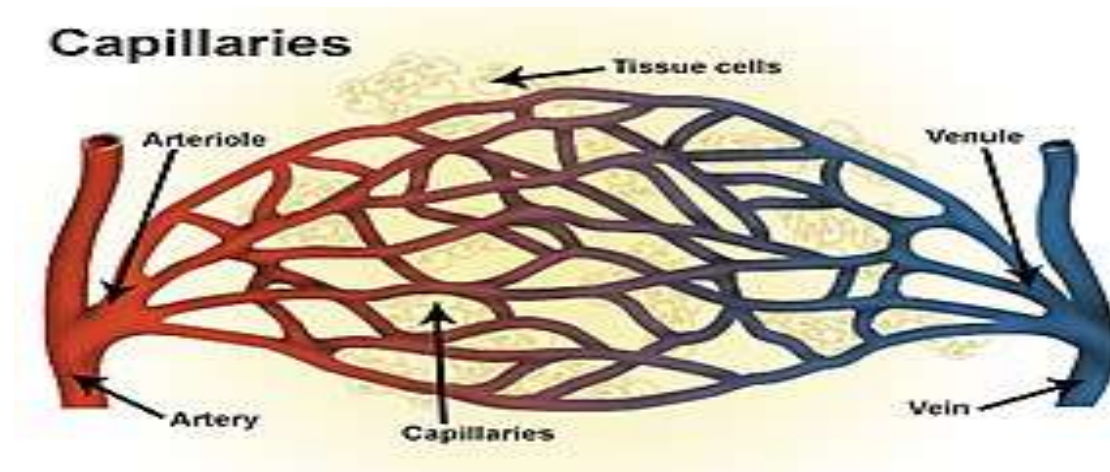


Medium sized
artery (T.S.) H&E&



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.** *"Pre capillary sphincter"*
- 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:

> Artery.

❖ 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**.

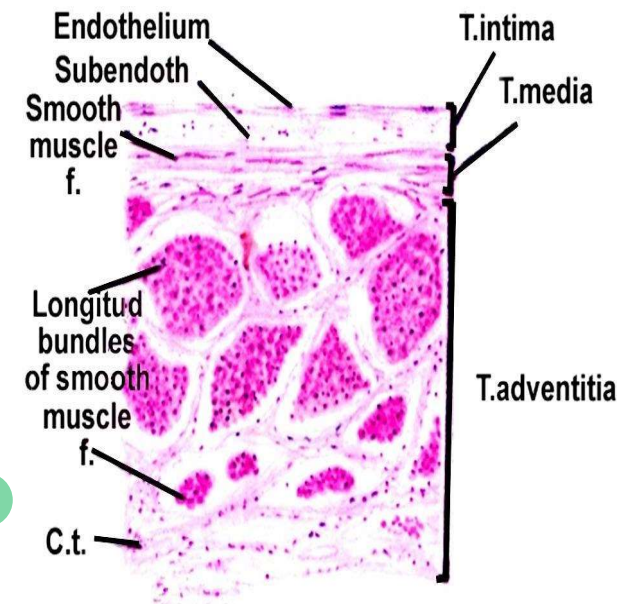
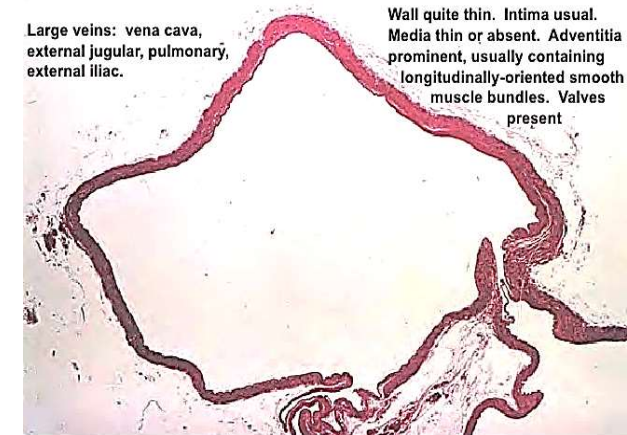
❖ Tunica media:

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

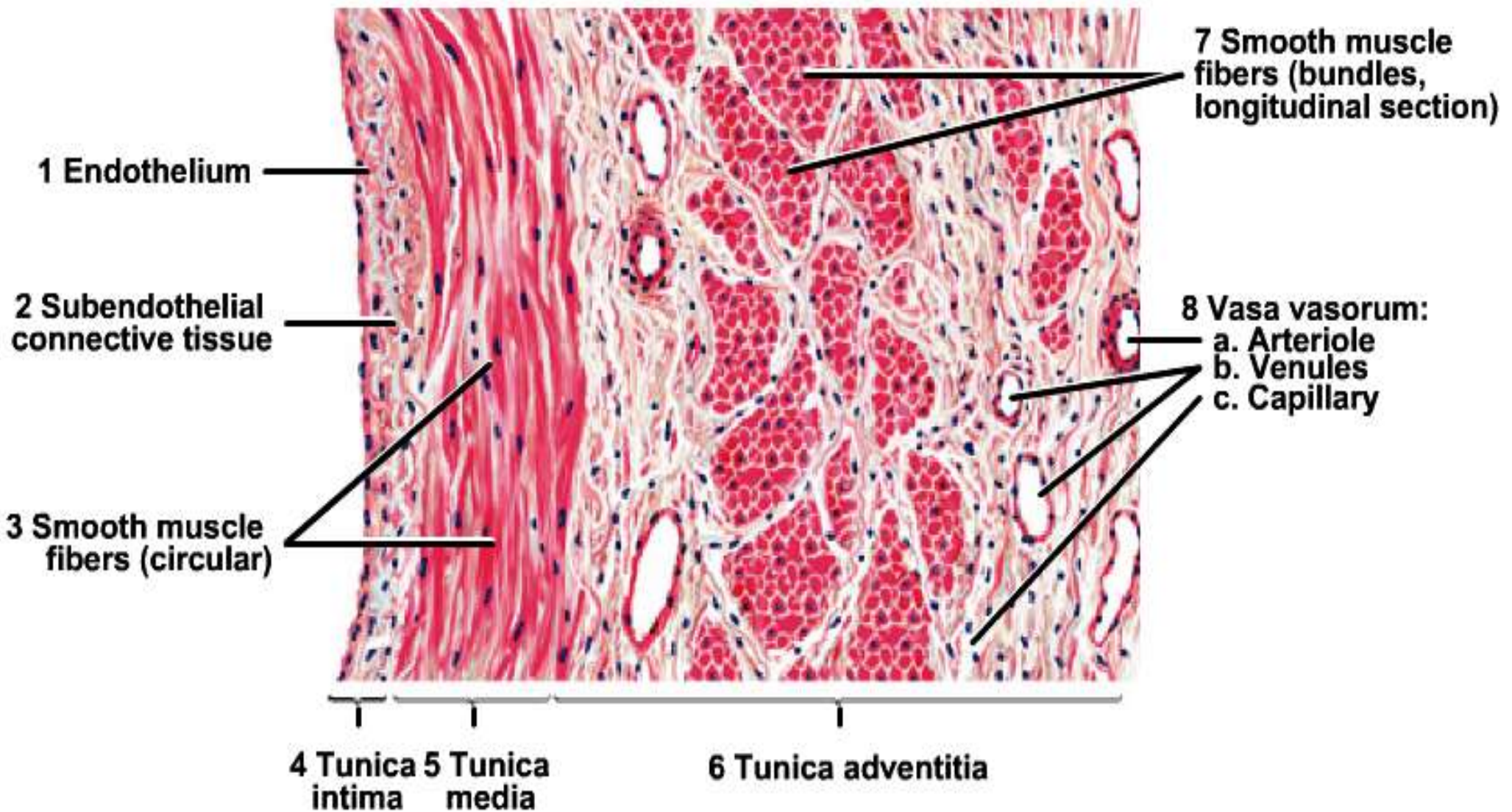
❖ Tunica adventitia: → the most thick.

- 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.

* Smooth muscle prevent overdistension of vein.



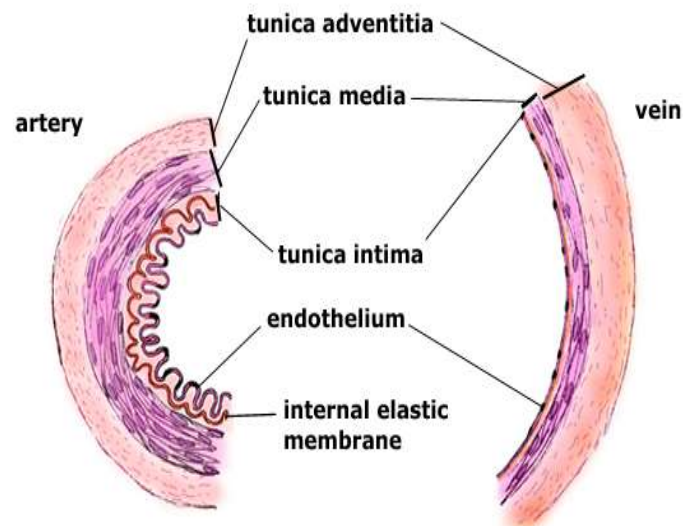
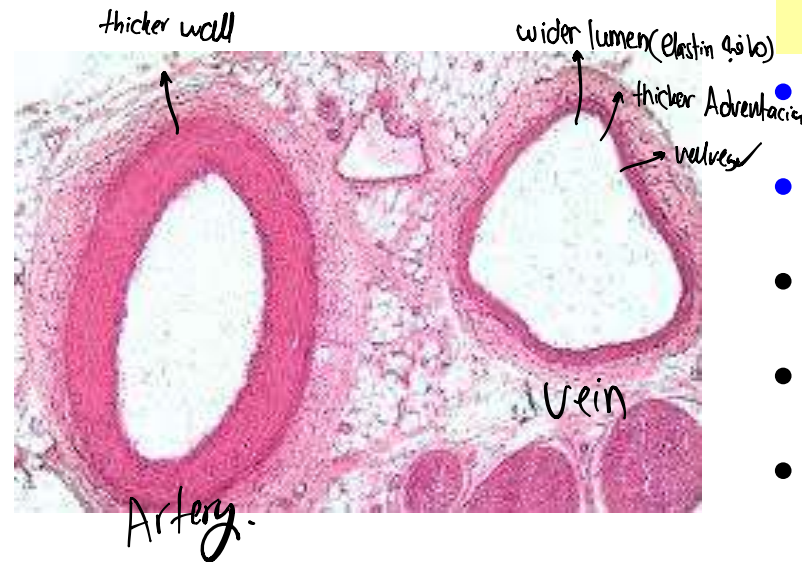
INFERIOR VENA CAVA (T.S.)



WALL OF LARGE VEIN (T.S)

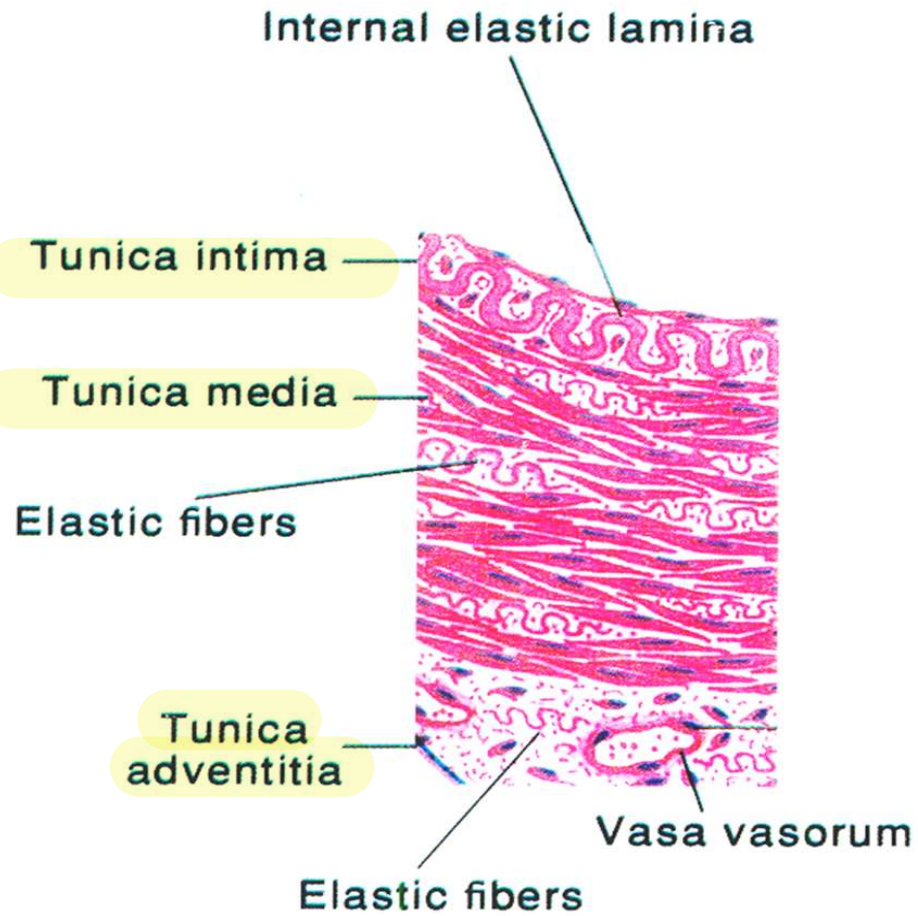
Medium sized A

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

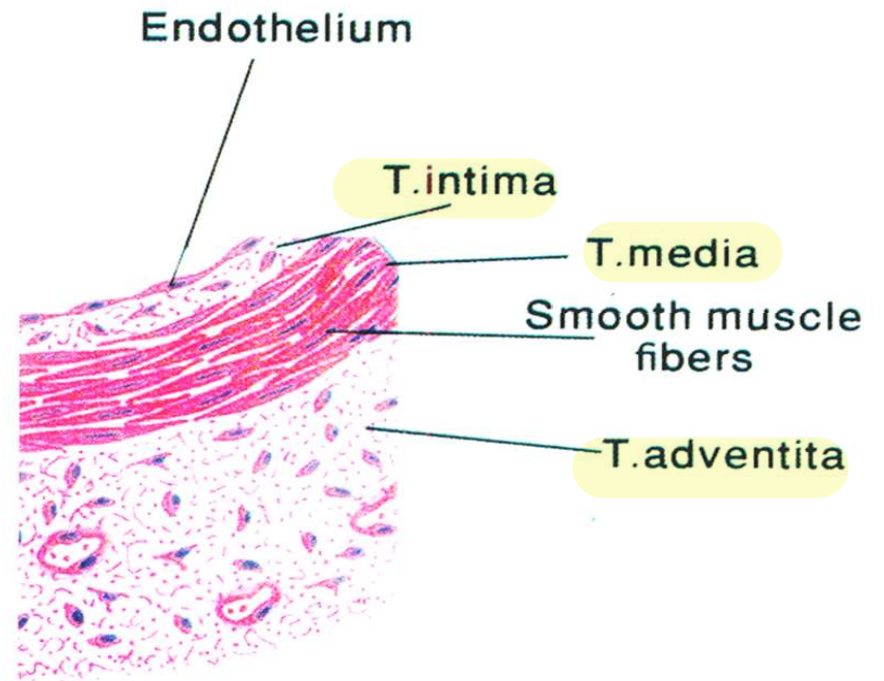


Medium sized V

- **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&

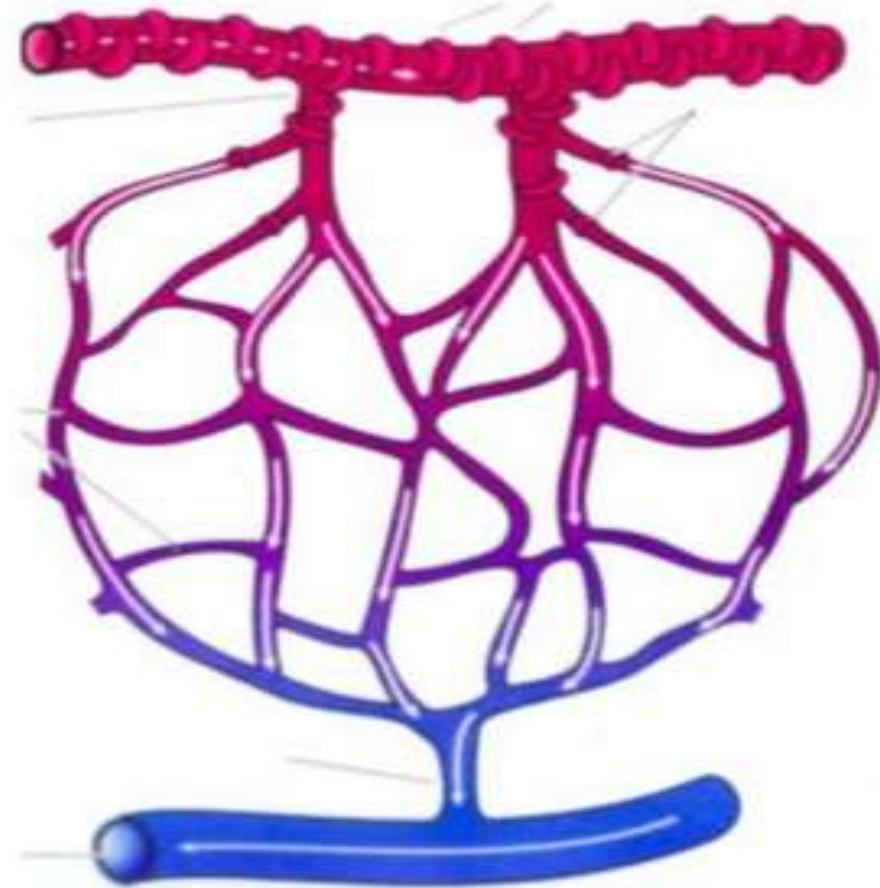


Medium sized
vein (T.S.) H&E

Q. 10

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



Basement membrane: طبقة غشائية tube layer of endothelium: طبقة

Pericyte: خلية

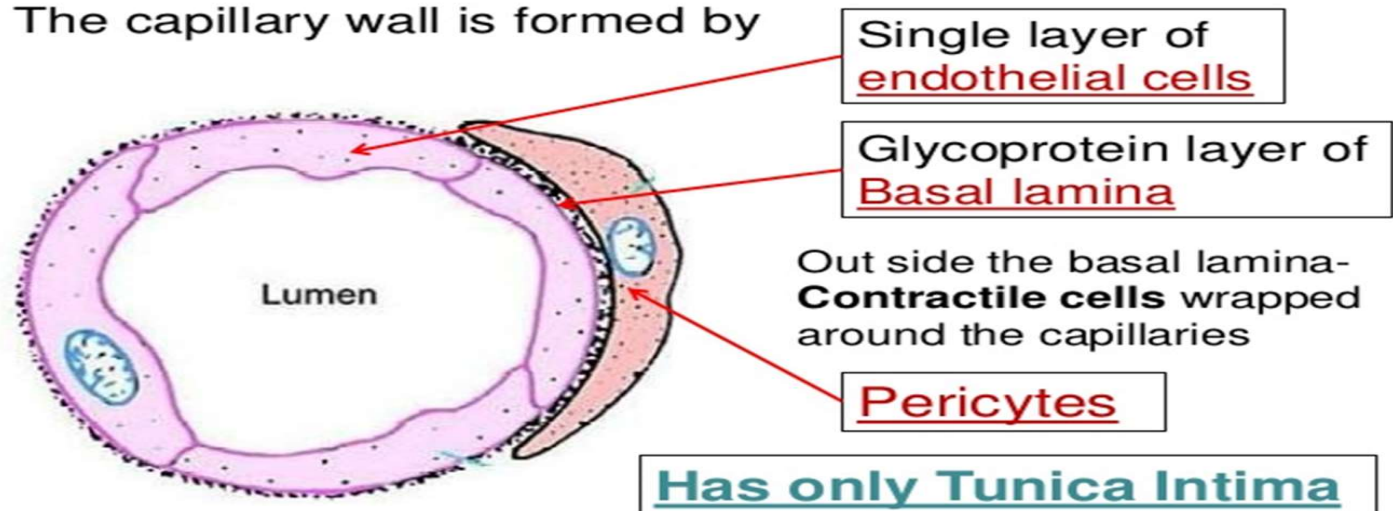
Contraction: انقباض

Capillaries

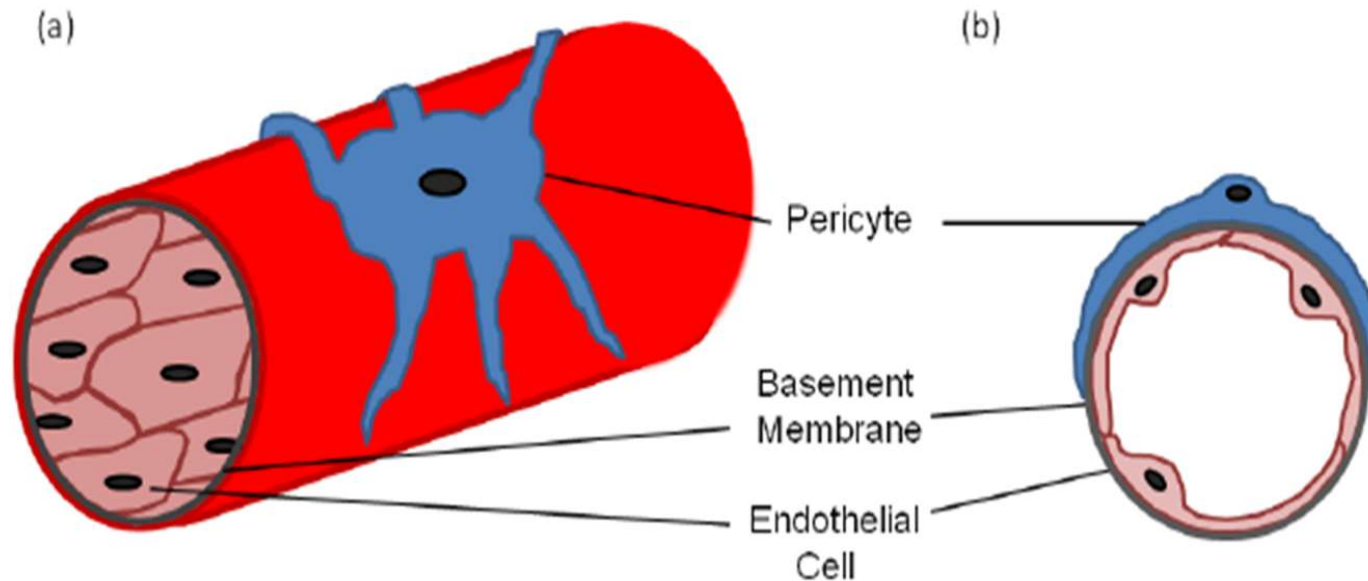
- Capillaries are composed of the simple layer of **endothelial cells** rolled up as a tube surrounded by basement membrane.
- The nuclei of endothelial cells are oval and **bulge** into the lumen of capillaries
- The average diameter of capillaries varies from 4 to 10 μm , which allows transit of blood 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



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**:

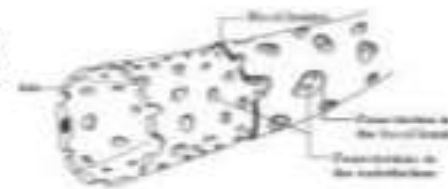
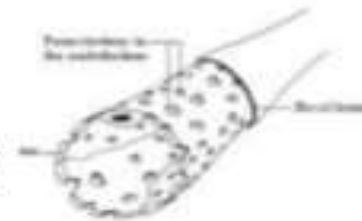
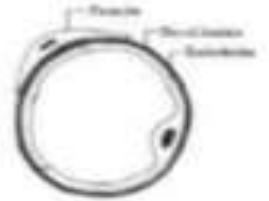
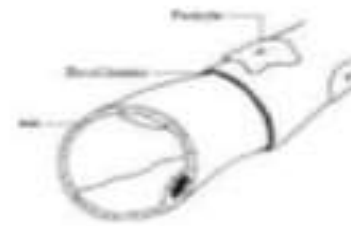
1. Continuous

2. Fenestrated

3. Sinusoidal

6-10 $\mu\text{m D}$

30-40 $\mu\text{m D}$



سبب
function

tight junction بحبي endothelial cell

continuous basement membrane

complete control

C.T / N.S

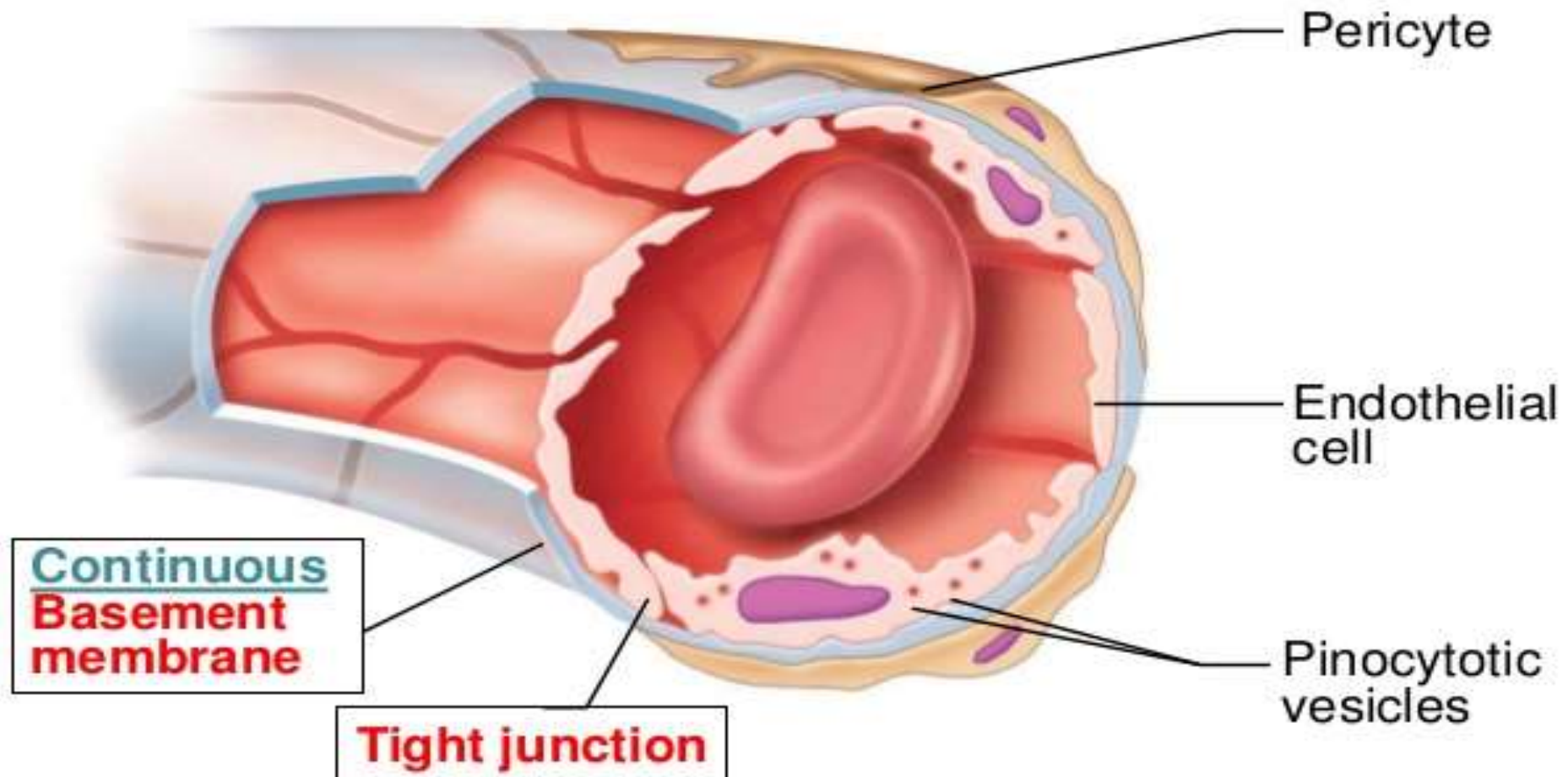
Continuous Capillaries

- **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.
- Ultra structural studies show numerous vesicles indicating transcytosis of macromolecules in both directions across the endothelial cell cytoplasm.

electrical microscope

cell transport

Continuous Capillaries



(a)

Least permeable, and most common
E.G., skin, muscle, nervous tissues, etc...

• Pores present in endothelium

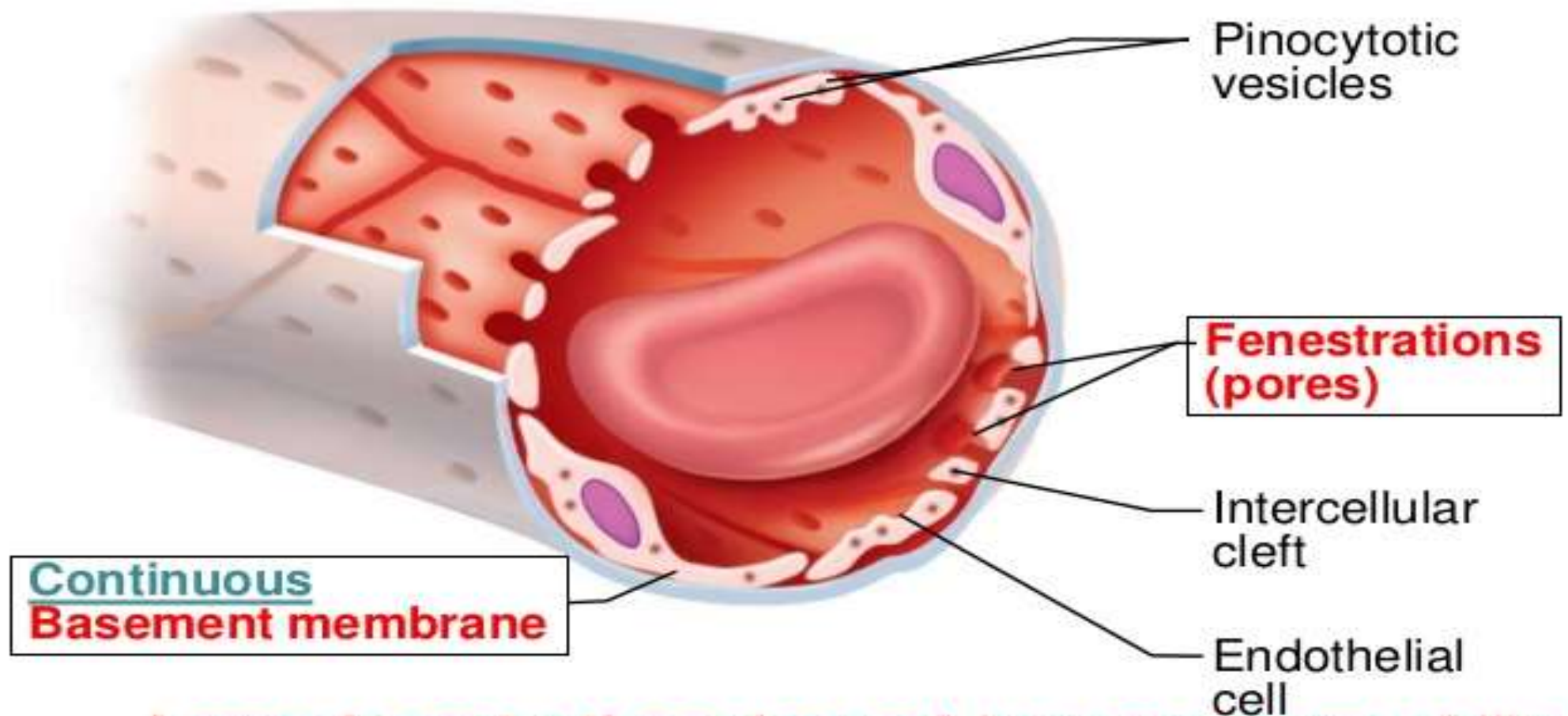
• diaphragm membrane به دیواره Pores بی های ال
surrounded by continuous basement membrane.

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



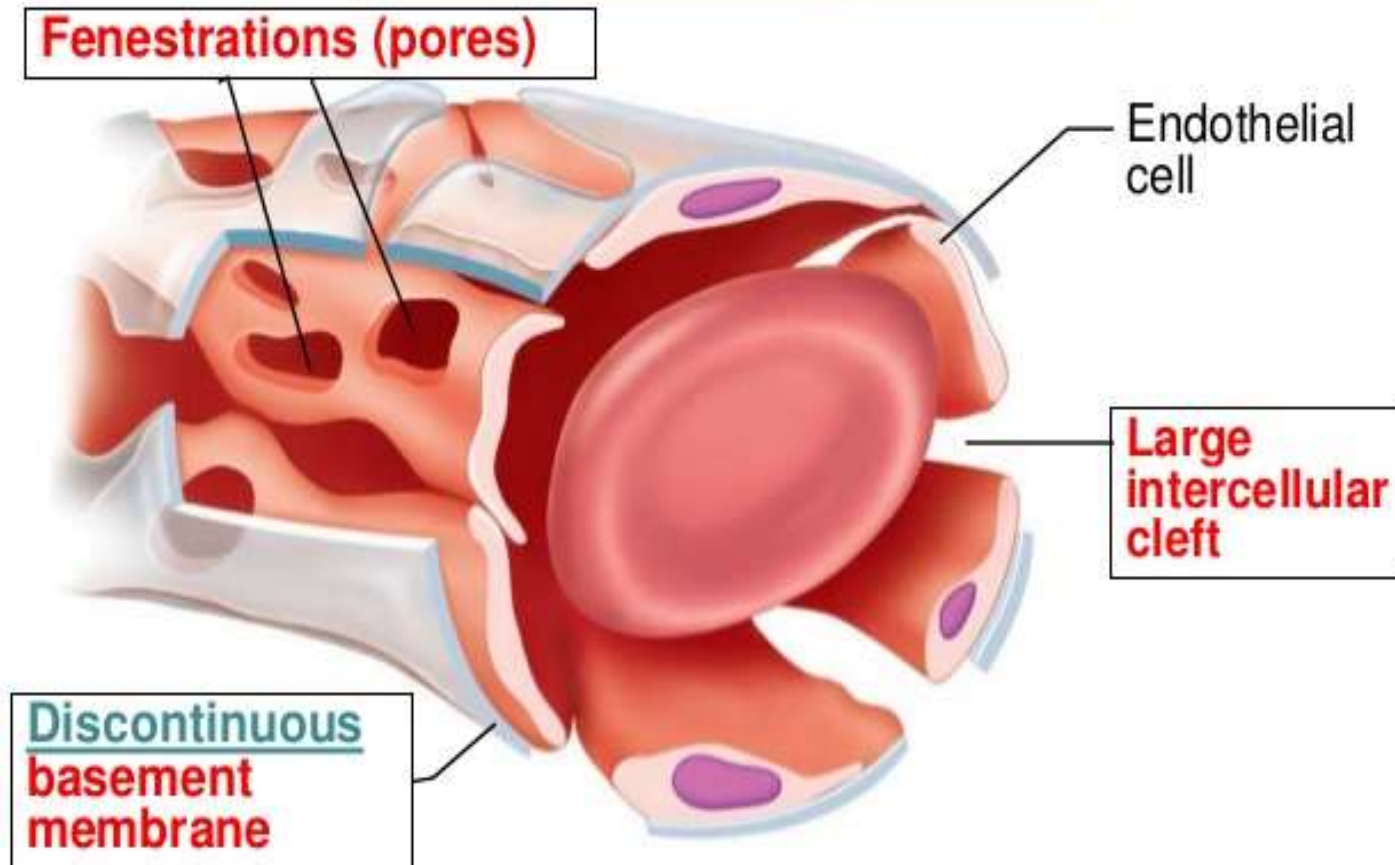
- Large fenestrations (pores) increase permeability**
- (b)** Occurs in areas of **active absorption or filtration**
E.G., kidney, small intestine, endocrine glands etc...

Discontinuous capillaries

cleft between endothelial
شقوب surrounded by
وسايع Porel basement membrane.
وسايع غشاء منقطعة

- **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



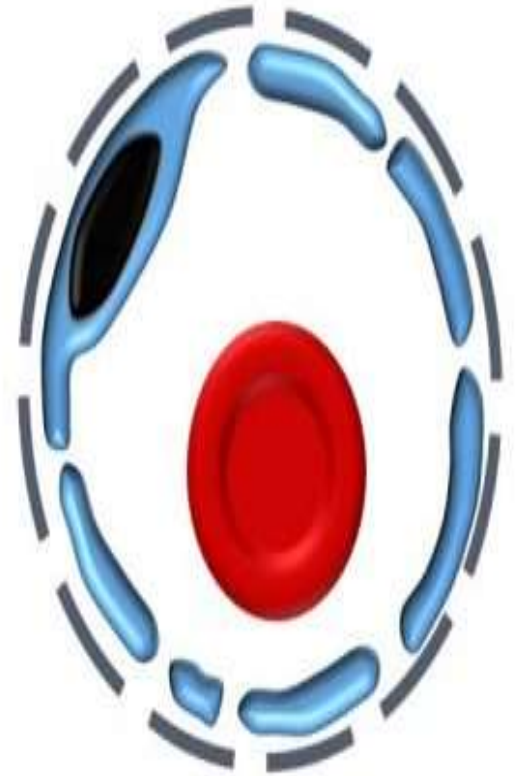
- (c) Most permeable. Occurs in special locations**
E.G., liver, bone marrow, spleen



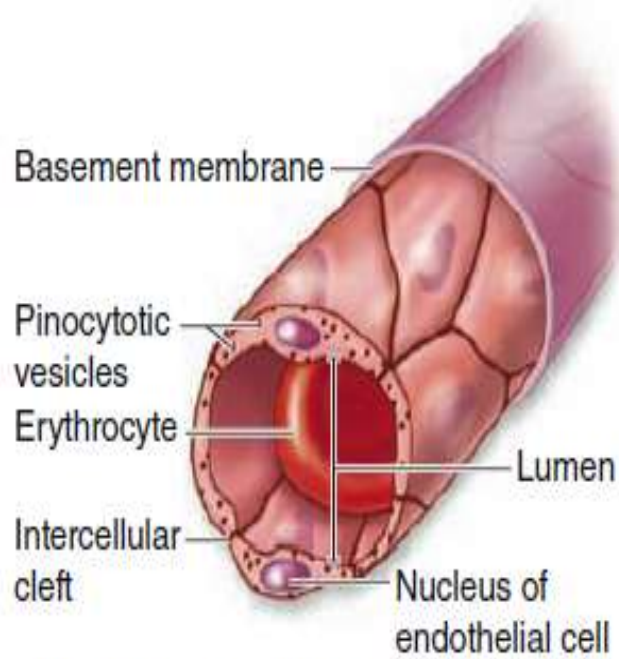
Continuous



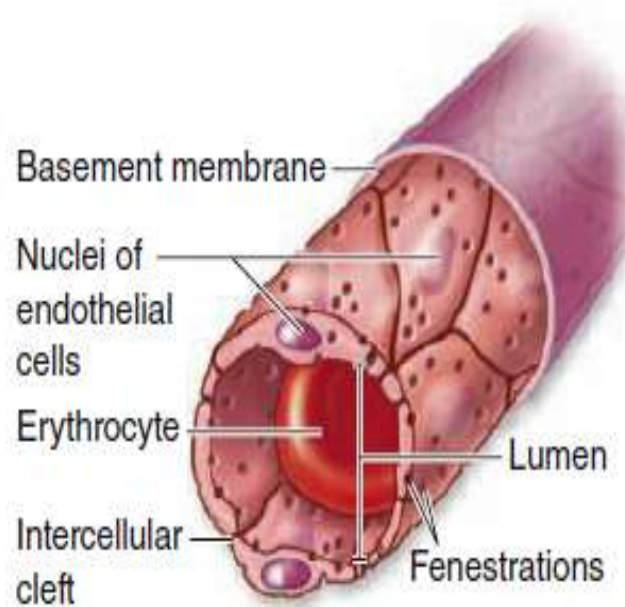
Fenestrated



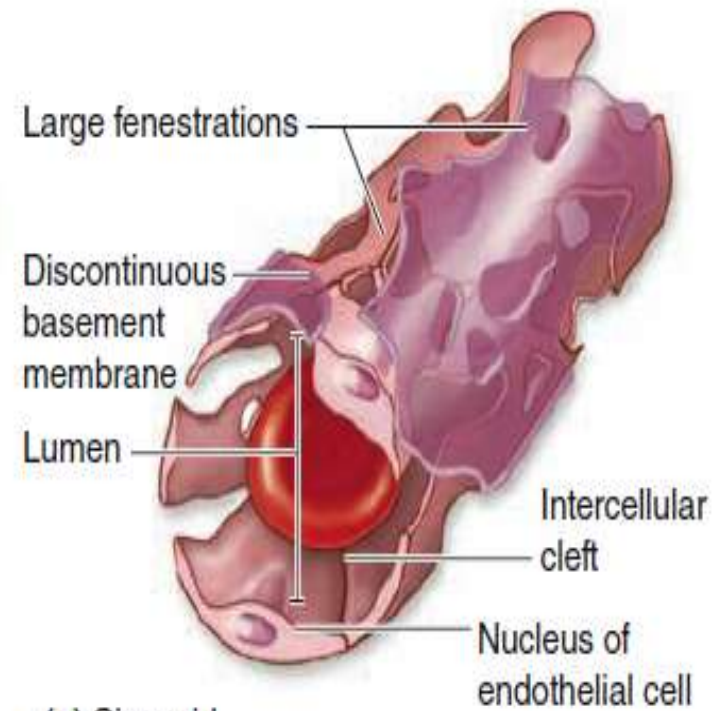
Sinusoidal
(Discontinuous)



(a) Continuous capillary



(b) Fenestrated capillary



(c) Sinusoid



THANK YOU