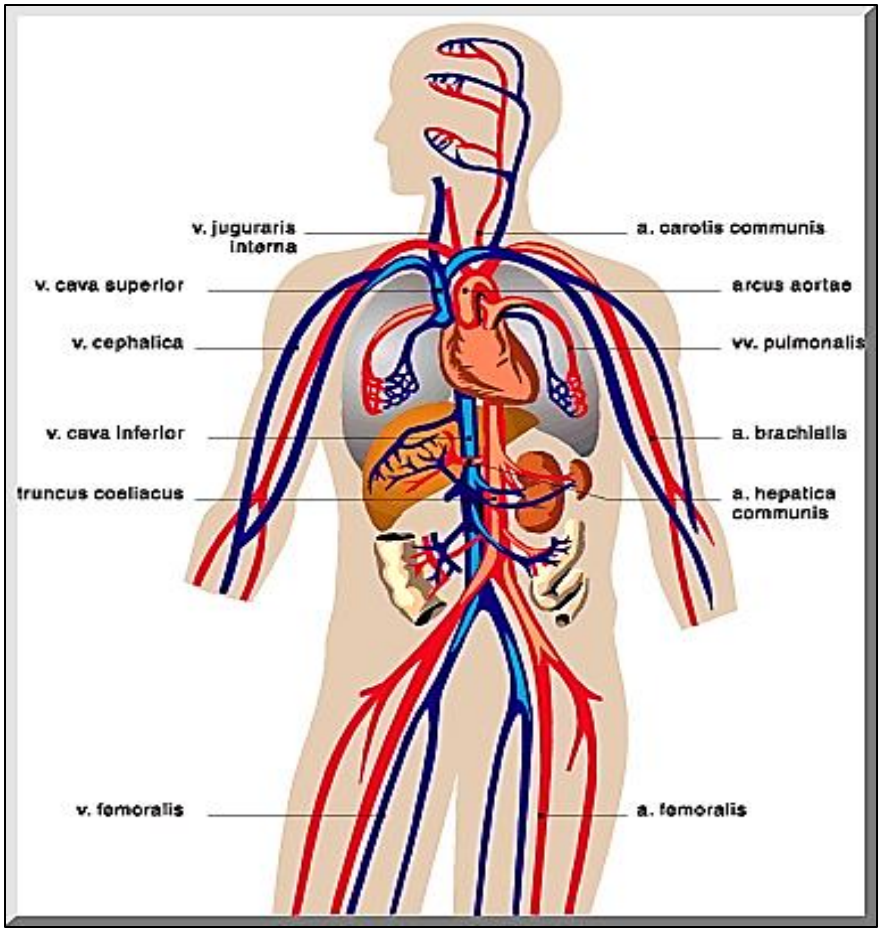
Cardio-vascular System Module

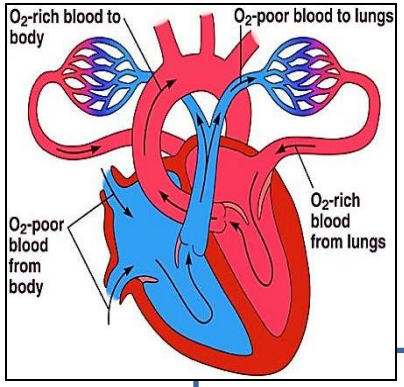
1- The vascular system

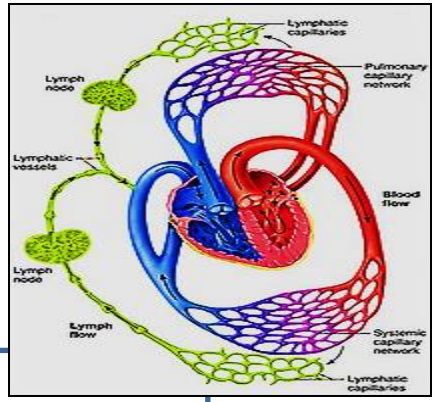
Medical students /3rd Year

Professor Dr. Hala El-mazar



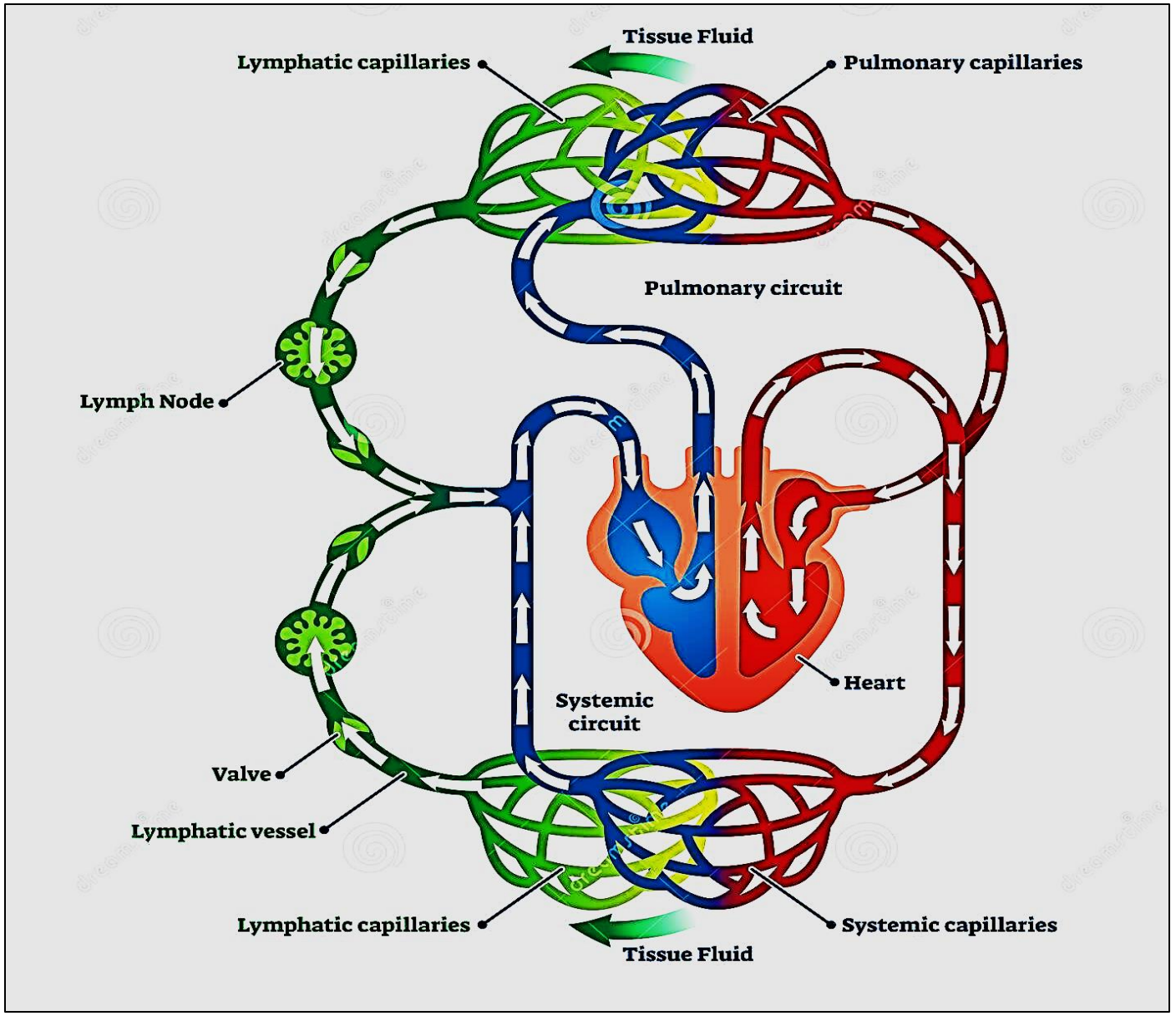
Circulatory system





I. Blood - vascular

II. Lymphatic vascular

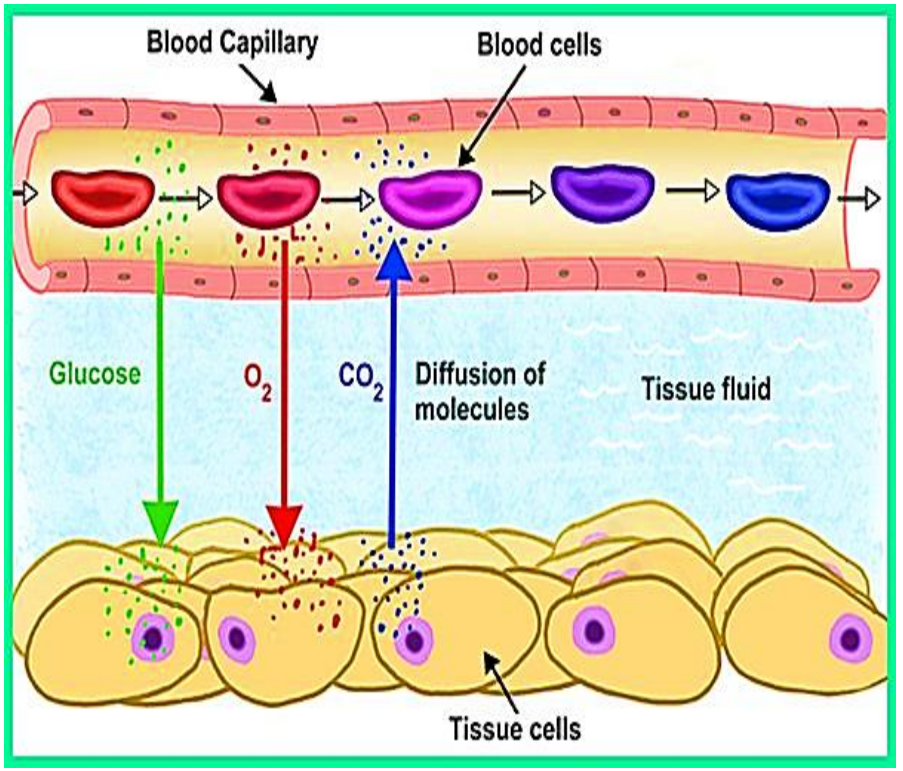

Tissue Fluid
Lymphatic capillaries
Pulmonary capillaries
Pulmonary circuit
Lymph Node
Heart
Systemic
circuit
Valve
Lymphatic vessel
Lymphatic capillaries
Systemic capillaries
Tissue Fluid

Cardio-vascular system

- Includes: The heart + blood vessels + blood
- Humans have a closed circulatory system i.e ***blood circulates within vessels & is different from interstitial fluid***

The heart pumps the blood into **large vessels** which branch into **smaller ones** that end in body organs in the form of **capillaries**

Substances are exchanged between the blood and the interstitial fluid around the cells through a process called **diffusion**



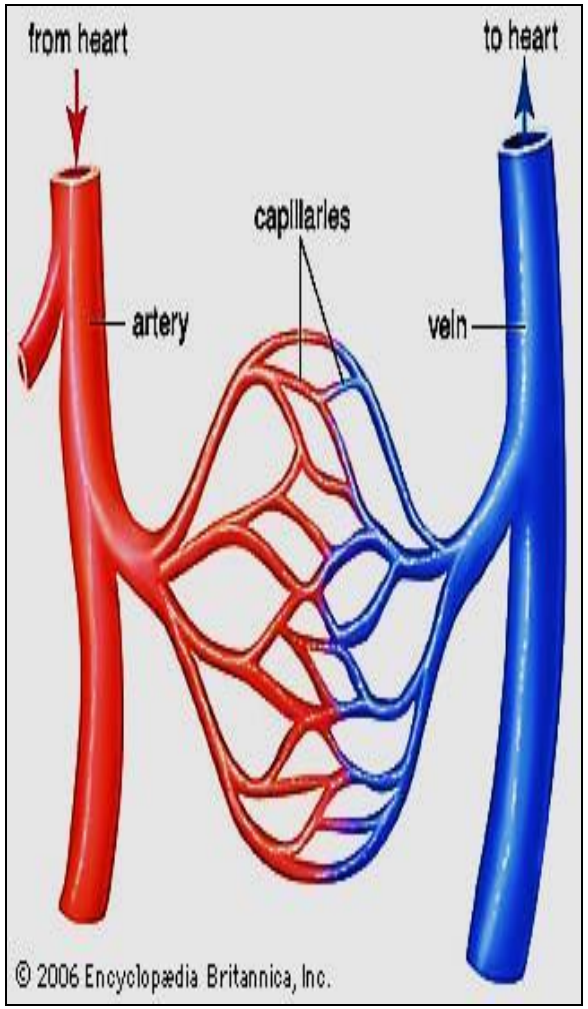
The blood vessels

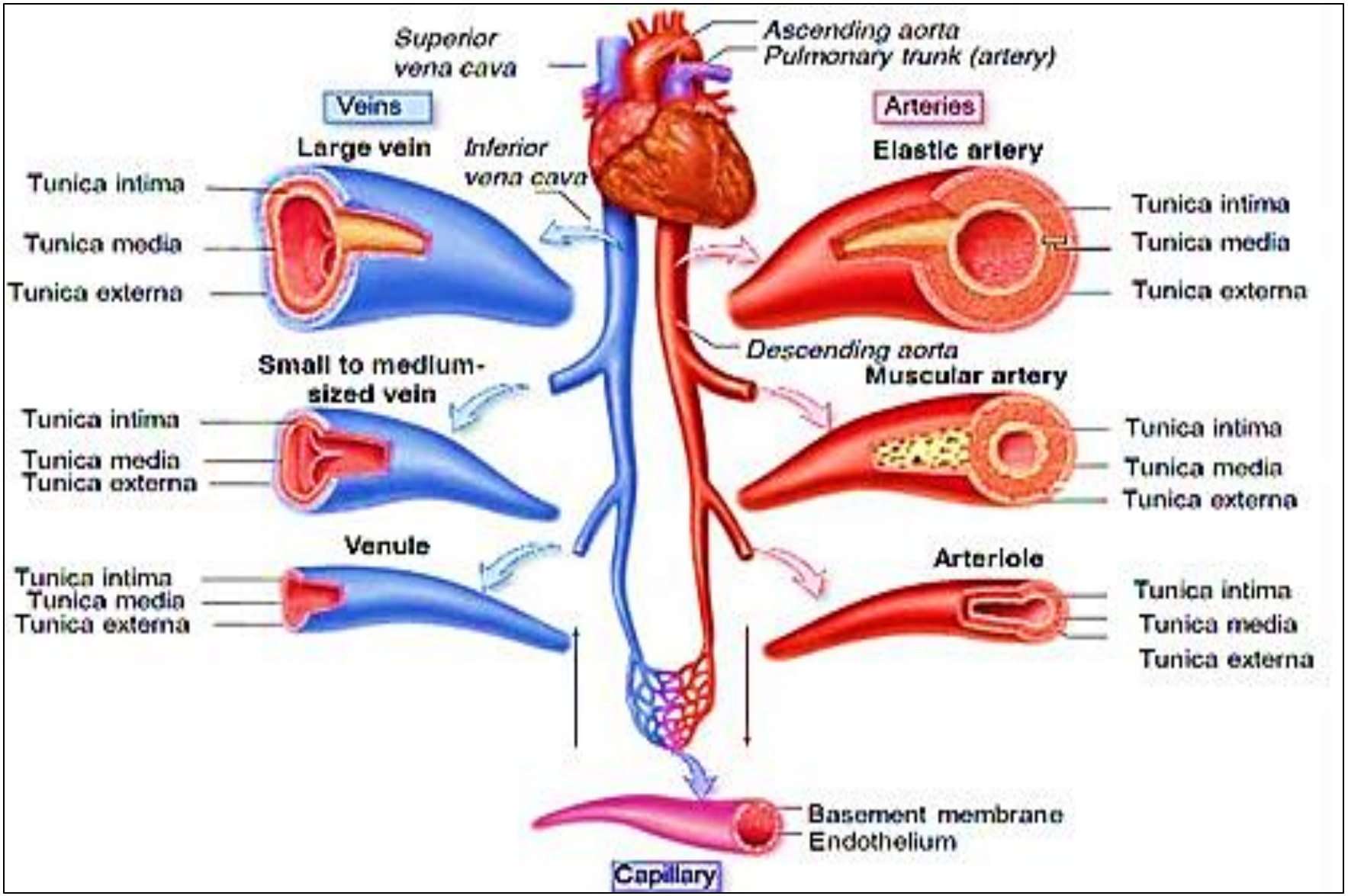
Include:

- Arteries: Large (**elastic)** arteries
  Medium (**muscular**) arteries
  Arterioles

- Veins: Large veins
  Medium sized veins
  Venules

- Microcirulation:
  Capillaries
  Arterio –venous anastomosis





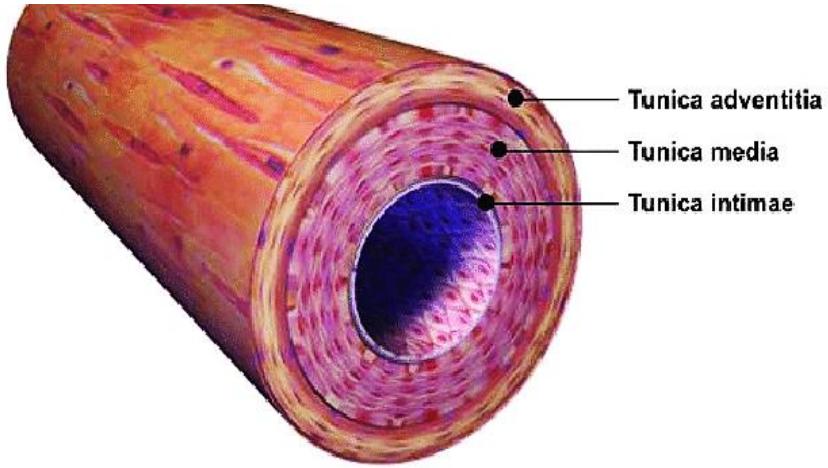
The vascular system

The transition from one type of vessels to another is gradual

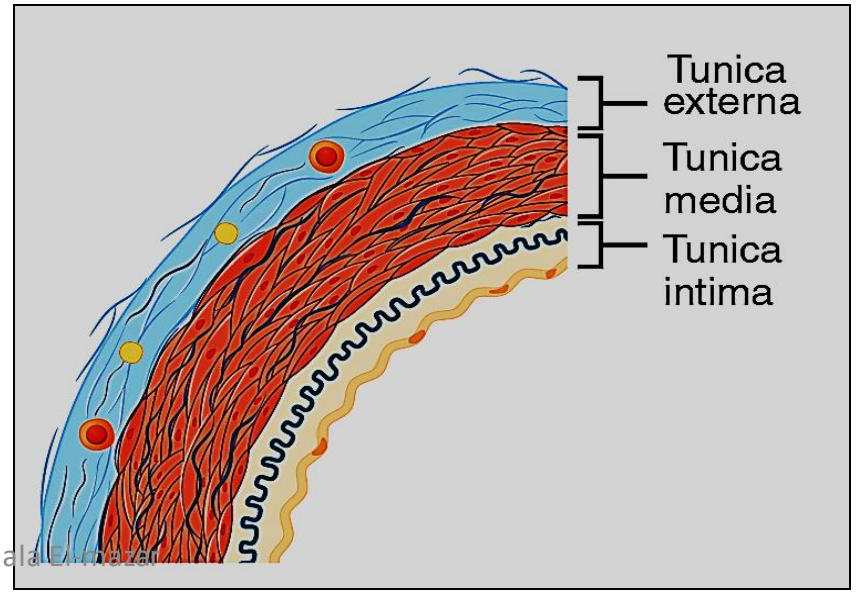
General structure of the wall of a blood vessel

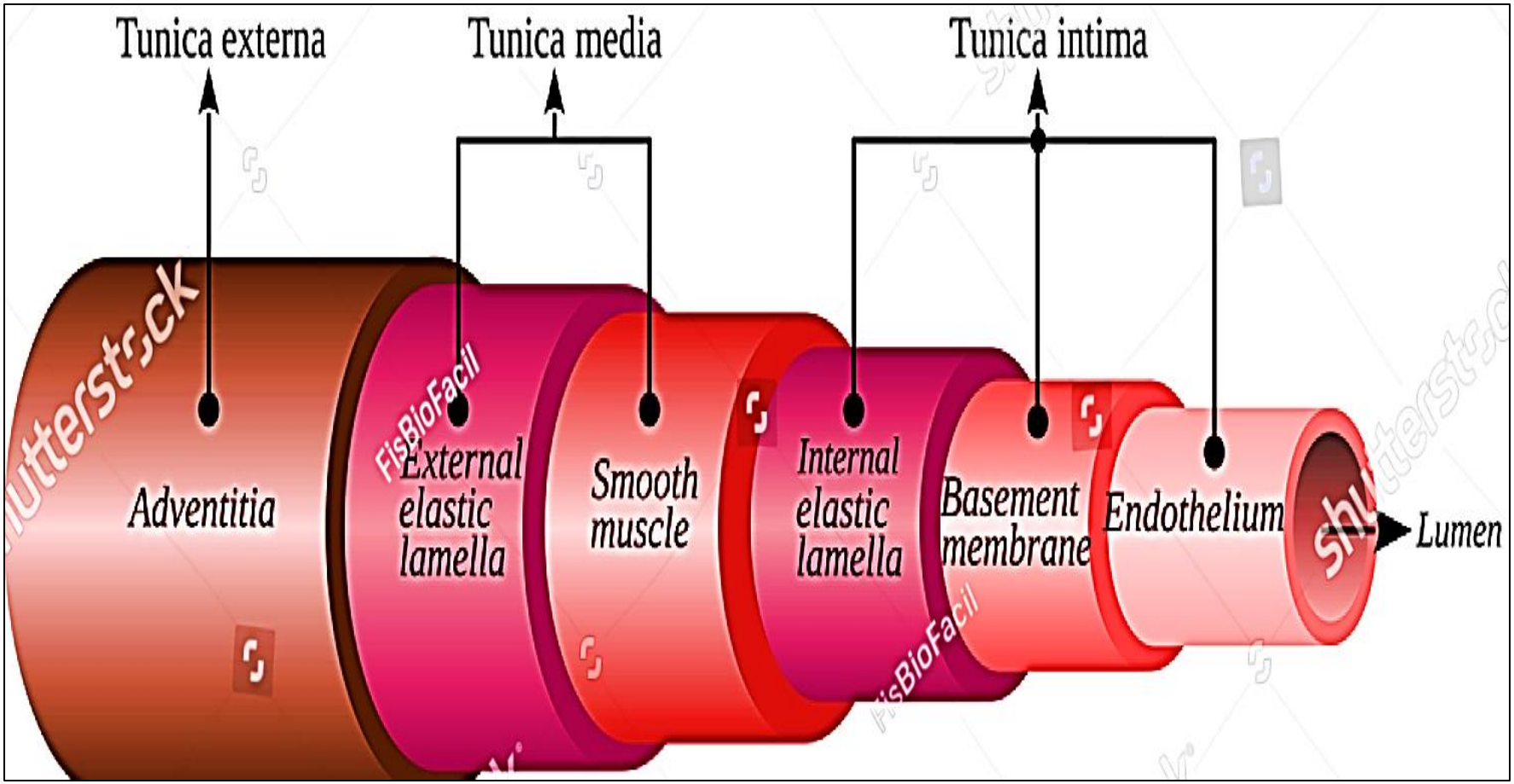
Formed of 3 layers or tunics (Except for capillaries)

(inside → outside)



- Tunica intima
- Tunica media
- Tunica adventitia (C.T.)





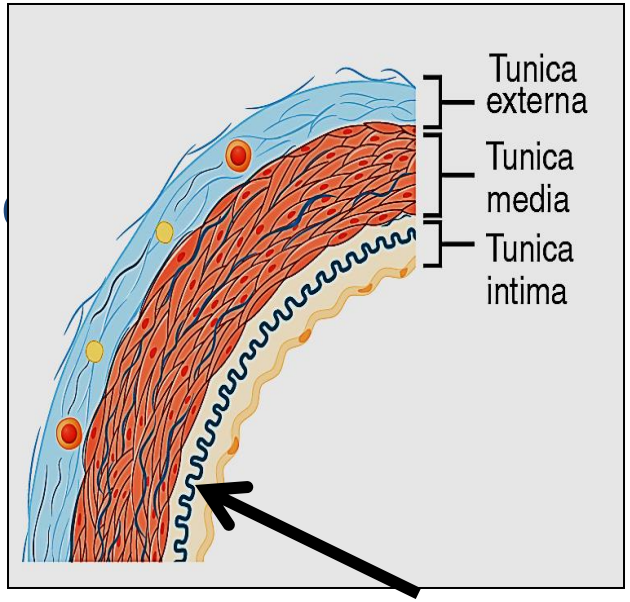
General Structure of the wall of the blood vessel

Tunica intima

1- Endothelium:

simple squamous epith. + basal lamina

smooth surface, easy diffusion /exchang



2- Sub-endothelium:

3- Internal elastic lamina (IEL):

Layer of elastic fibers separates intima from media

Present ONLY in arteries , very clear in muscular arteries,

absent in veins & small arterioles

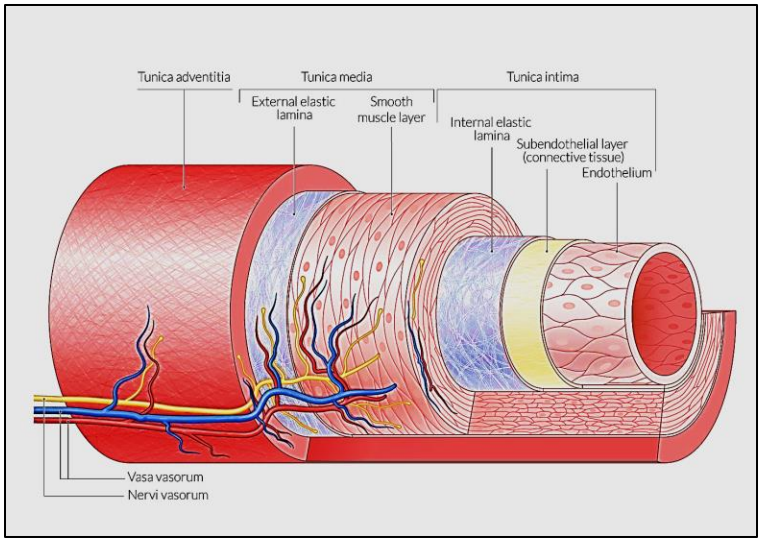
(for elasticity & prevent complete occlusion of arteries)

The IEL composed of elastin , has holes that allow the diffusion of substances to nourish cells deep in the vessel wall

Tunica media

1- Smooth muscle cells, circularly arranged . Form middle layer

contains collagen & elastic fibers



2- External elastic lamina (EEL)

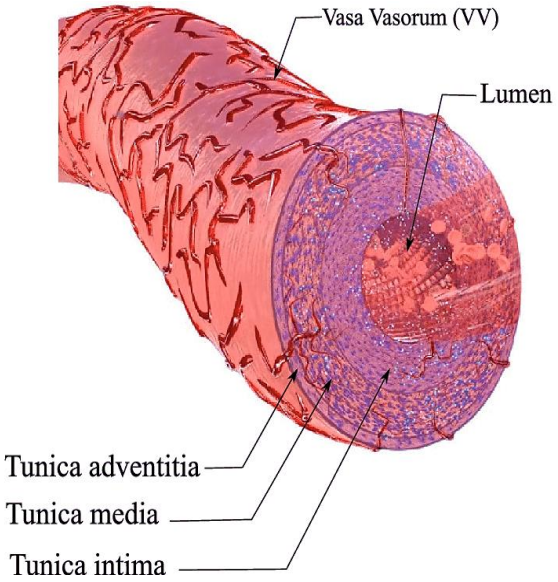
separates The tunica media from adventitia

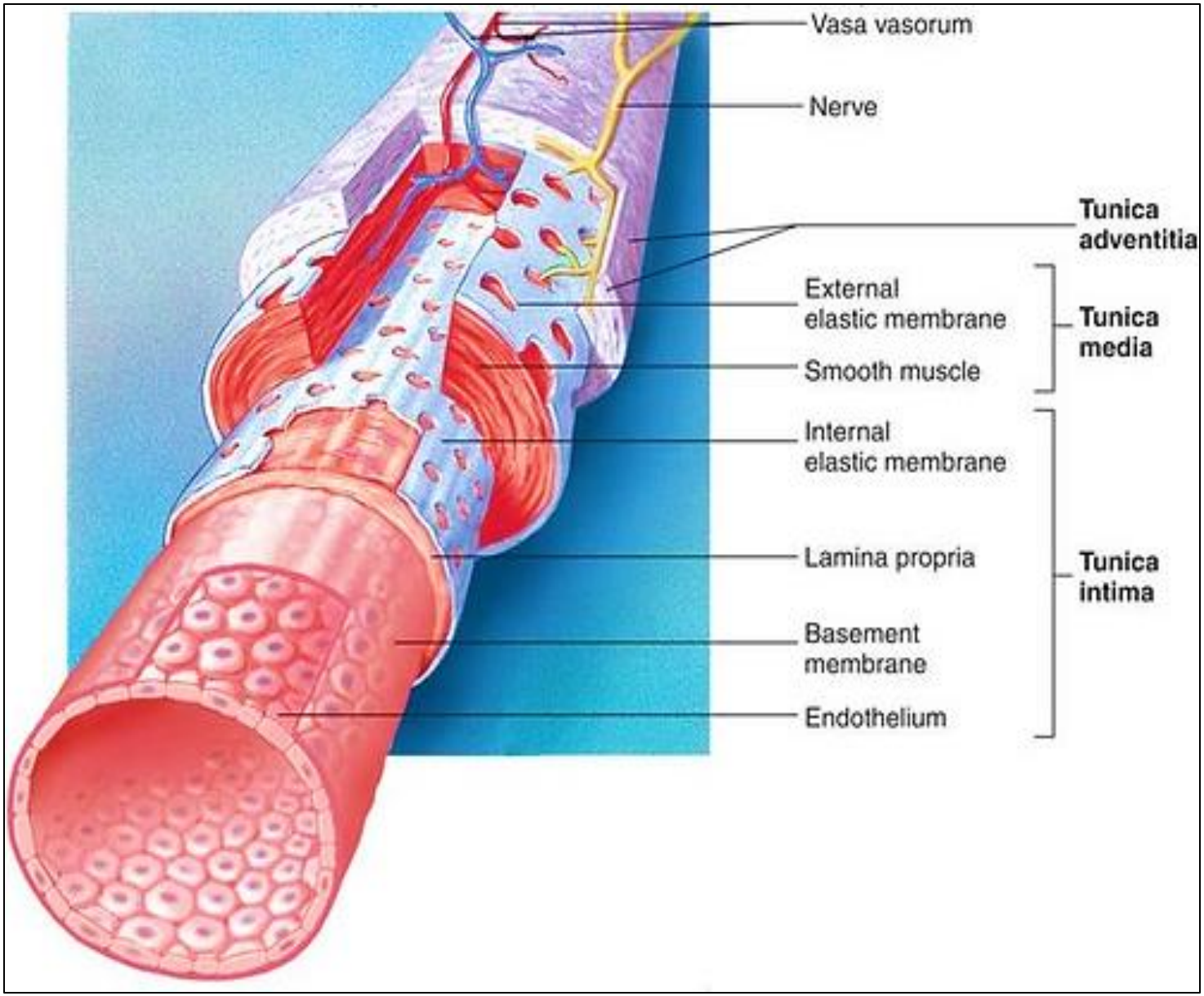
- Elastic fibers help expansion in systole & its recoil helps maintain blood flow in diastole

- The activity of smooth ms. Fibers is regulated by vasomotor autonomic supply

Tunica adventitia

- Outermost C.T. layer, contains collagen fibers more than elastic fibers
- Contains nerves, lymphatics & vasa vasorum (VV) are common *in large vessels since their wall is too thick to be nourished only by diffusion from blood in lumen*
- It prevents over distension of vessel
- Anchor the blood vessel to the surroundings organs and tissues
- Tunica adventitia prevents shortening if vessel is cut
- Since veins carry deoxygenated blood they have vasa vasorum More than arteries




Vasa vasorum
Nerve
Tunica adventitia
External elastic membrane
Tunica media
Smooth muscle
Internal elastic membrane
Lamina propria
Tunica intima
Basement membrane
Endothelium

Large (Elastic) arteries/ Aorta

- Large branches e.g. pulmonary, subclavian, innominate a.
- Wide lumen + very thick wall (mainly elastic fibers)
- Tunica intima:

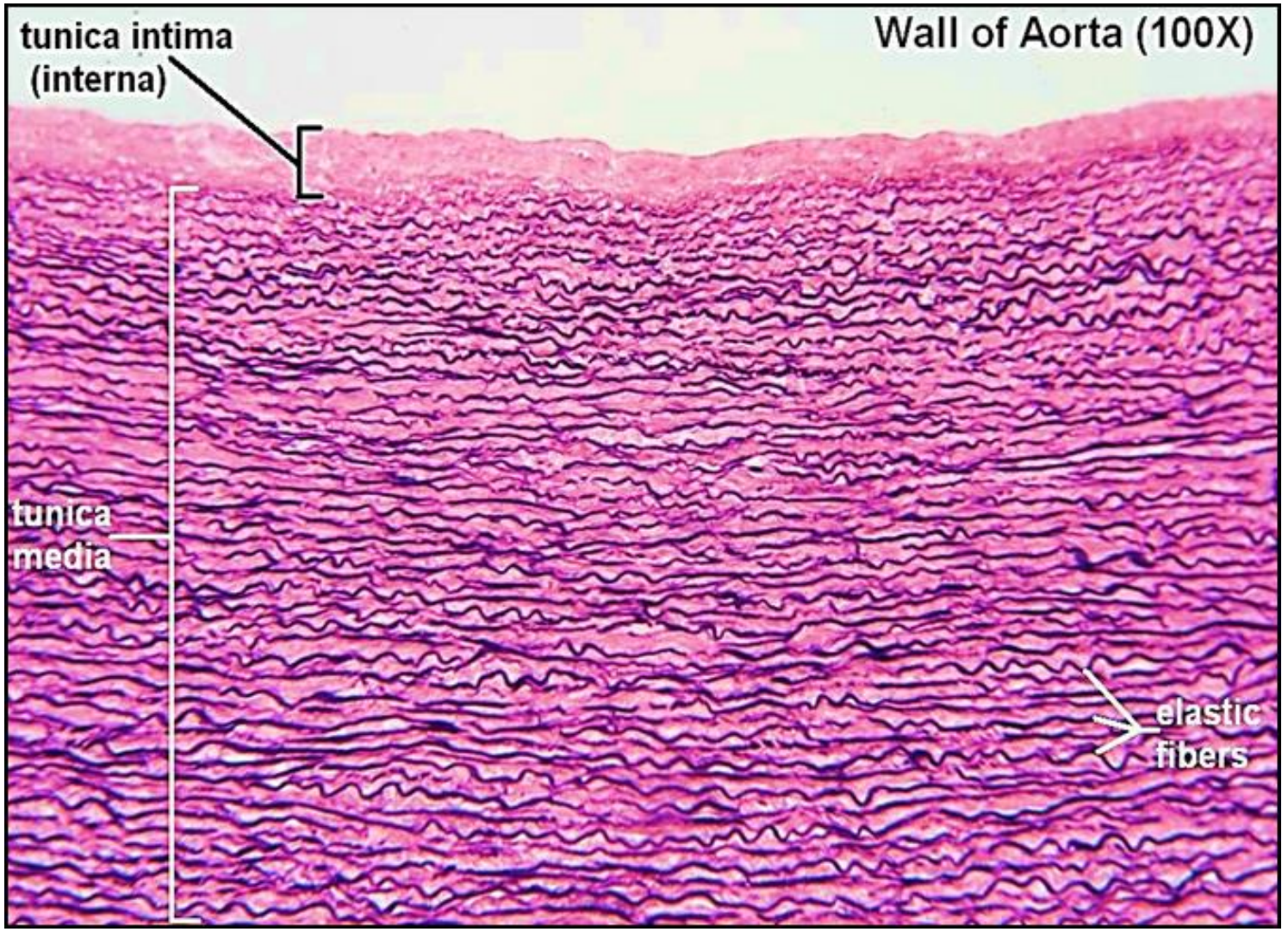
  Thick, sub-endothelium rich in elastic fibers, **IEL present but not clear**

- Tunica media (70%):

- **very thick** mostly fenestrated elastic membranes (elasticity) + smooth muscle cells ,
- **EEL present but not clear**

- Tunica adventitia:

CT contains collagen + elastic fibers + **vasa vasorum**



Section in the wall of aorta

Medium sized (Muscular) arteries

- They deliver blood to muscles & organs (**renal , coronary**)
- Their wall is formed mainly of **smooth muscles**
- The transition from elastic to muscular arteries **is gradual**

(Gradual ↓in elastic fibers & ↑in smooth ms cells)

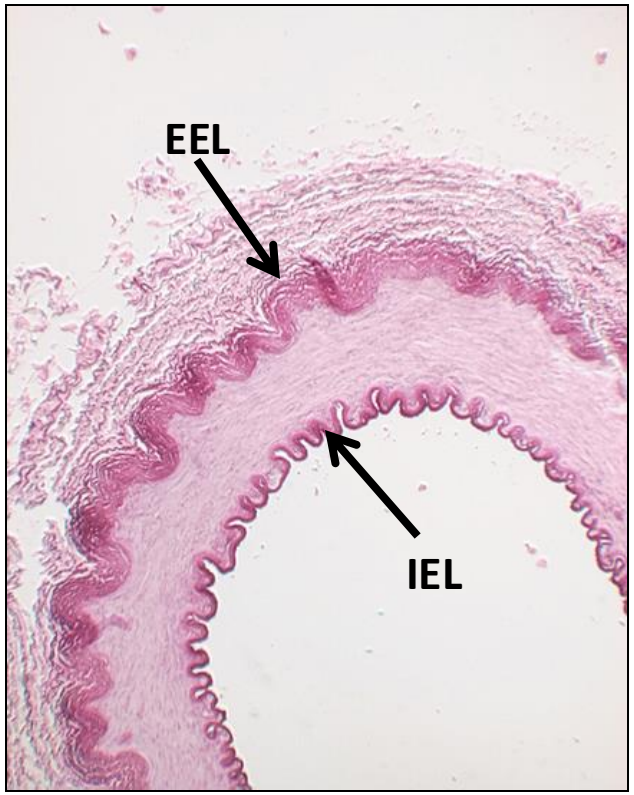
Tunica Intima: thinner, No subendothelial layer + **clear IEL**

Tunica media: mainly smooth muscles (40 layers) + **EEL is clear**

Tunica adventitia:

Thick CT layer contains collagen & elastic fibers + V.V.

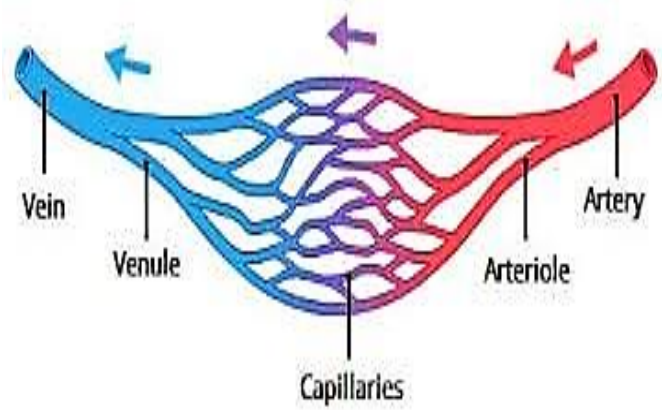
(Adventitia = Media 50/50 in thickness)



Arterioles (10- 100 µm)

Responsible for **peripheral resistance** of blood vessels

Control blood flow into capillaries



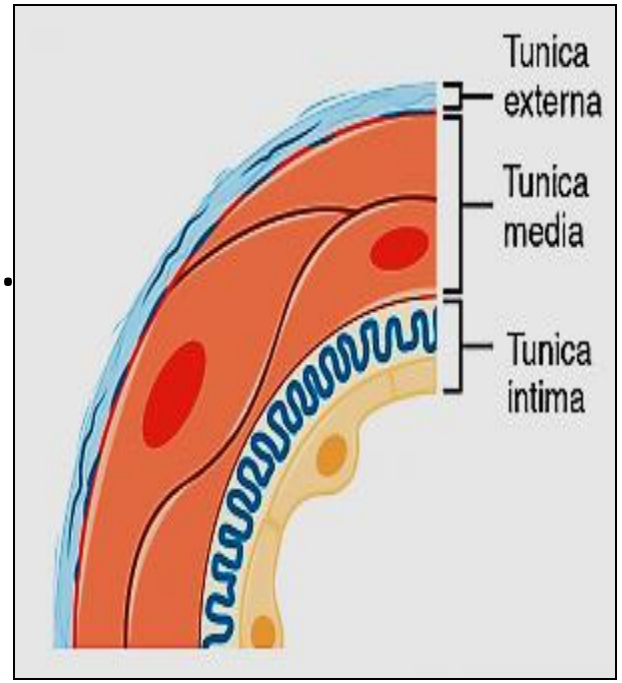
Tunica intima: thin with thin IEL

(IEL gradually disappear in small arterioles)

Tunica media: 1 or 2 layers of smooth m.

(gradually disappear & replaced by pericytes in capillaries

Tunica adventitia : very thin

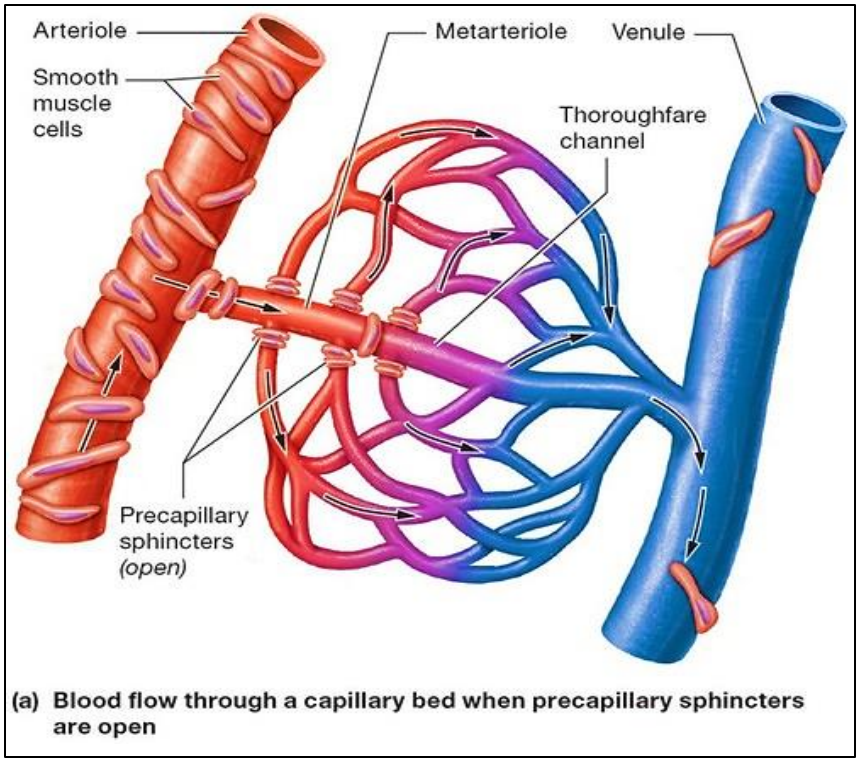


Metarterioles (arterial capillaries)

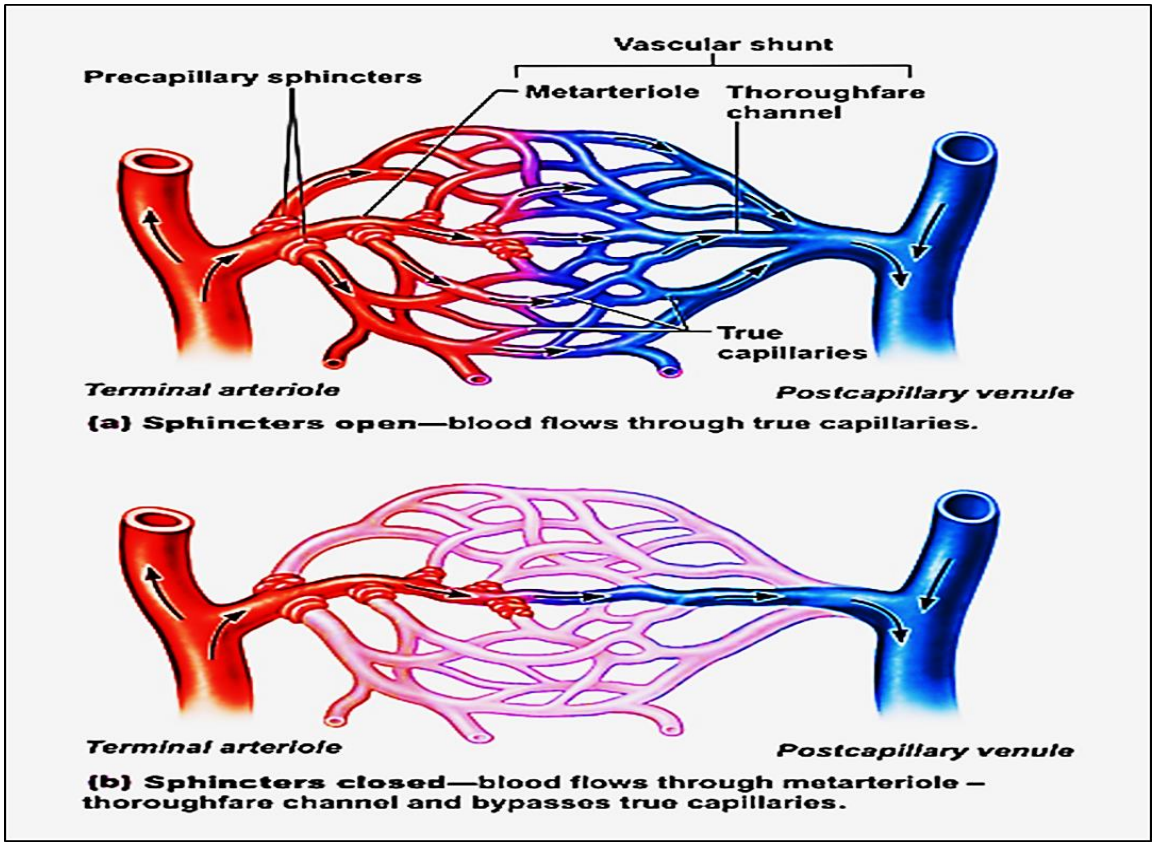
- short micro vessels (8- 10 µm) that links terminal arterioles to capillaries

- Tunica media they have individual muscle cells placed short distance apart.

- There are rings of smooth ms at the entrance to capillaries called **pre-capillary sphincters** act as a valve to regulate blood flow into the capillaries

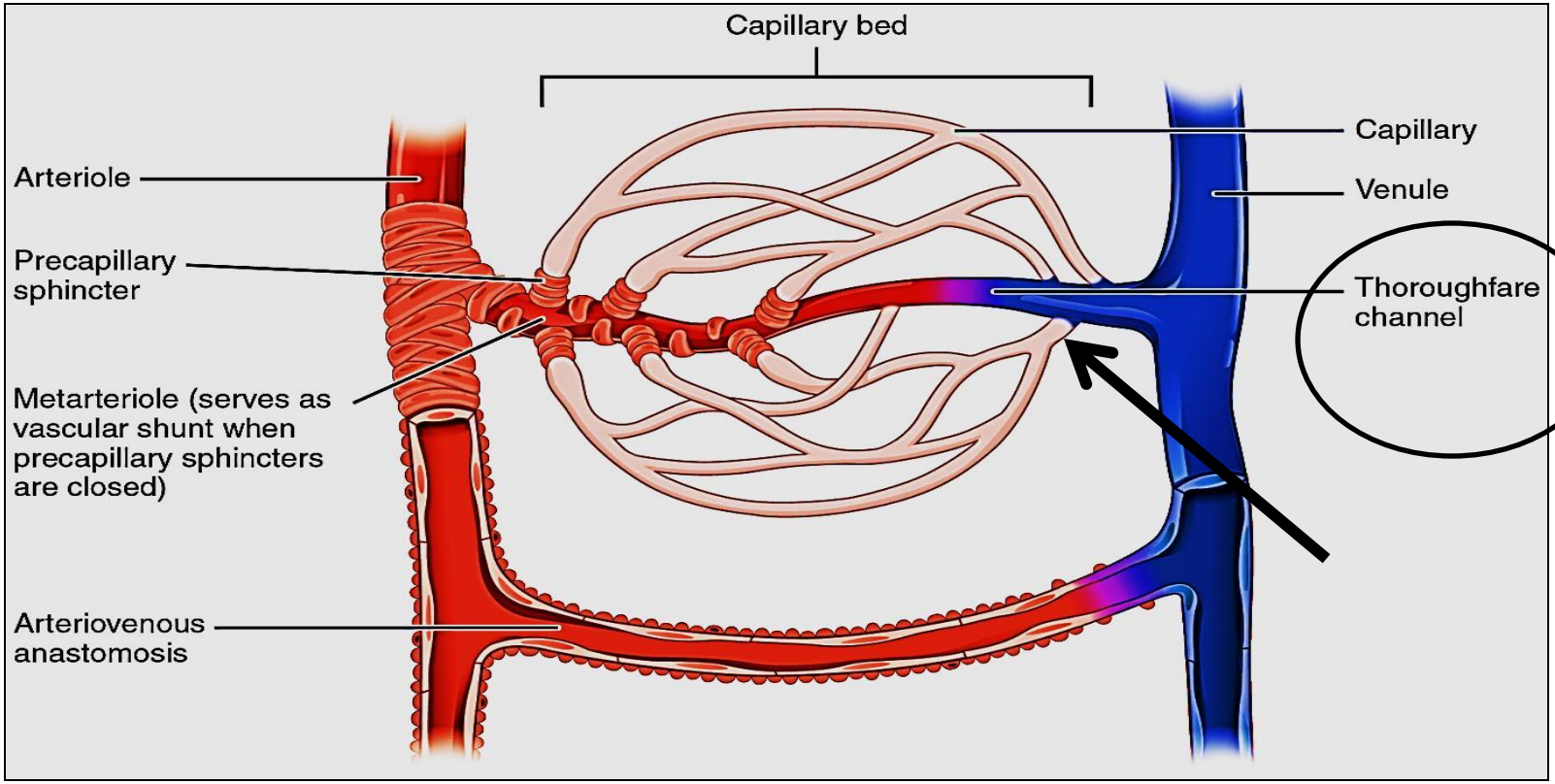


(a) Blood flow through a capillary bed when precapillary sphincters are open



- When pre- capillary sphincter **relaxed** →blood flow through true capillaries → exchange with tissue

- When pre- capillary sphincter **contracted** blood flows through thoroughfare shunt and bypasses tissue cells



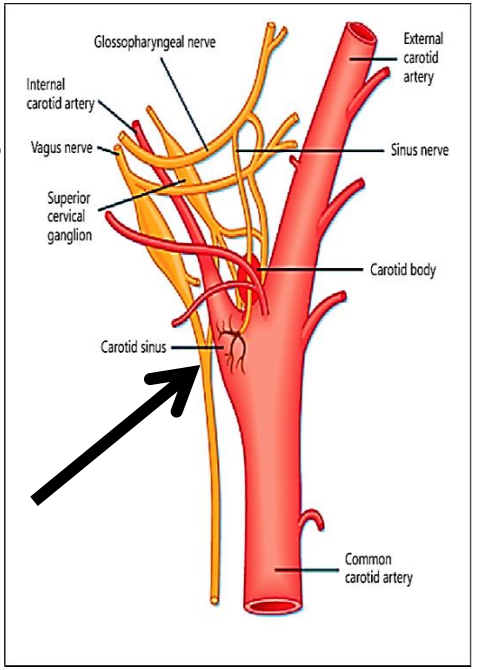
The smooth muscle of metarterioles and the precapillary sphincters contract and relax causing intermittent flow of blood in capillaries this is known as vasomotion.

Thoroughfare channel = the distal half of the metarteriole is called thoroughfare Channel which has no sphincters (No smooth muscles) and receives blood from the capillary bed , becoming more like a venule

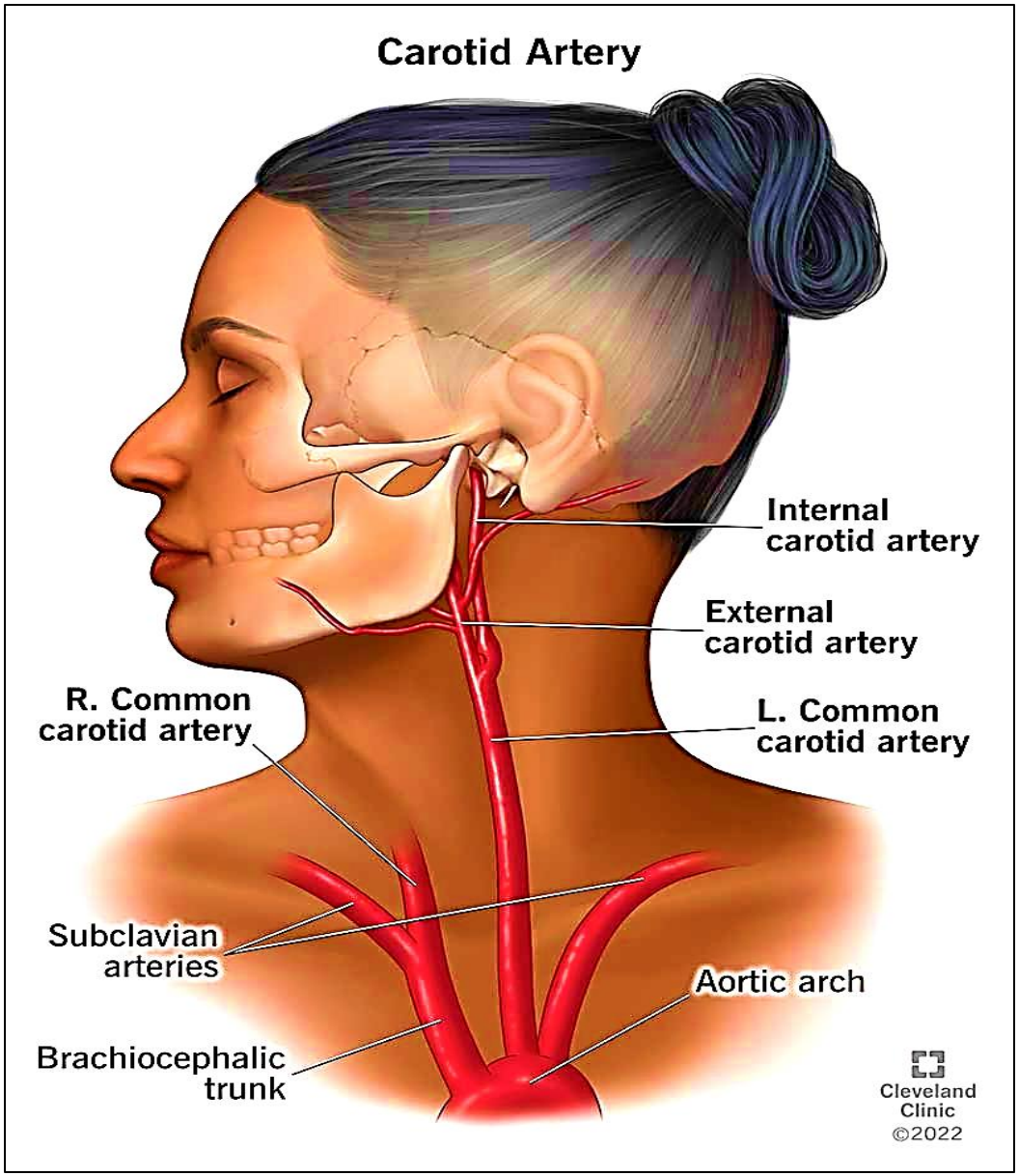
Arterial sensory structures

1- Carotid sinuses:

- Dilatation in the wall internal carotid arteries and in Aortic arch
- Contains baroreceptors which monitor Changes in blood pressure.
- The tunica media of each carotid sinus is thinner allowing greater distension when bl. pressure rises

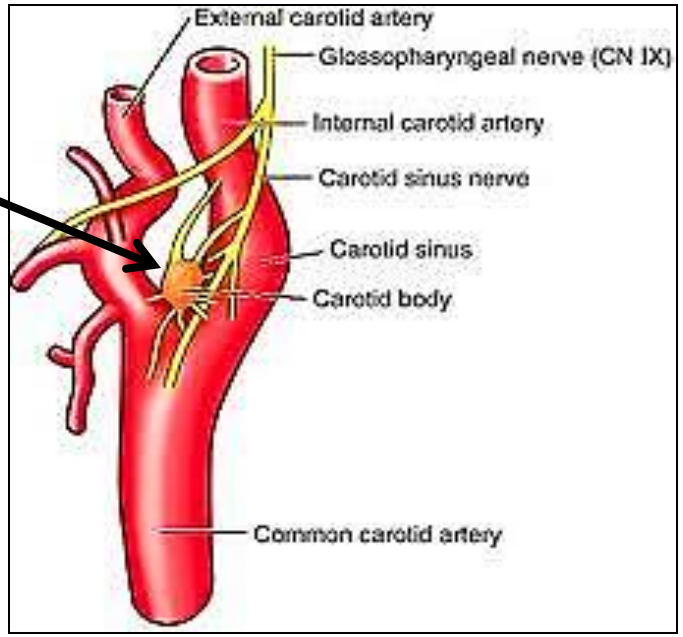


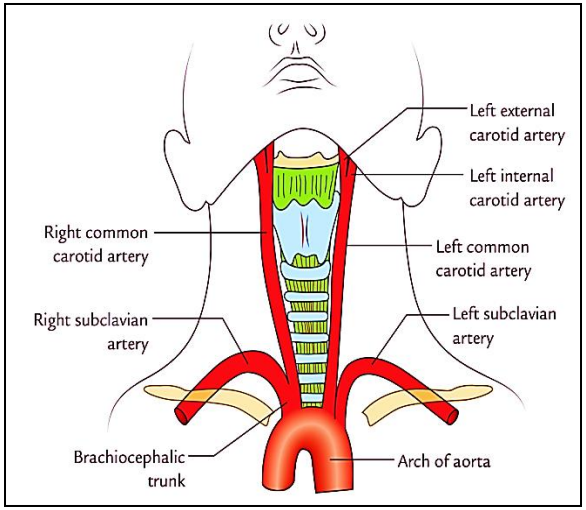
- Sensory nerve endings from cranial n. IX glossopharyngeal nerve are embedded in the wall of the artery
- Afferent n impulse → brain → trigger adjustment in vasoconstriction → blood pressure return to normal


Carotid Artery
Internal carotid artery
External carotid artery
R. Common carotid artery
L. Common carotid artery
Subclavian arteries
Aortic arch
Brachiocephalic trunk
Cleveland Clinic ©2022

2- Carotid bodies:

- Small , ganglion like structures
- Found in the adventitia near the bifurcation of common Carotid arteries

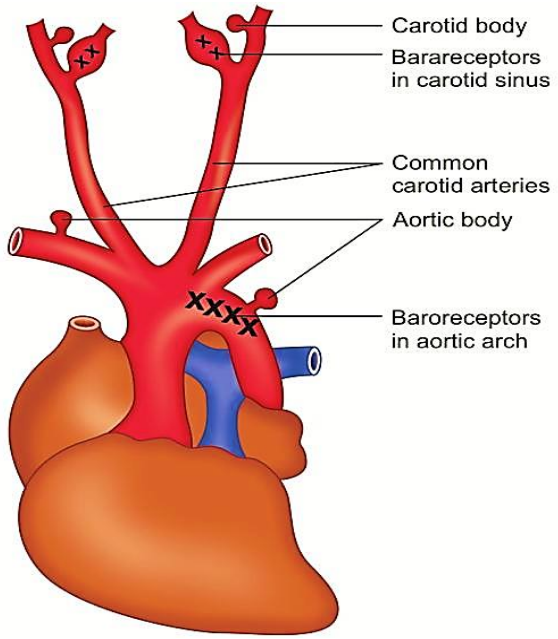


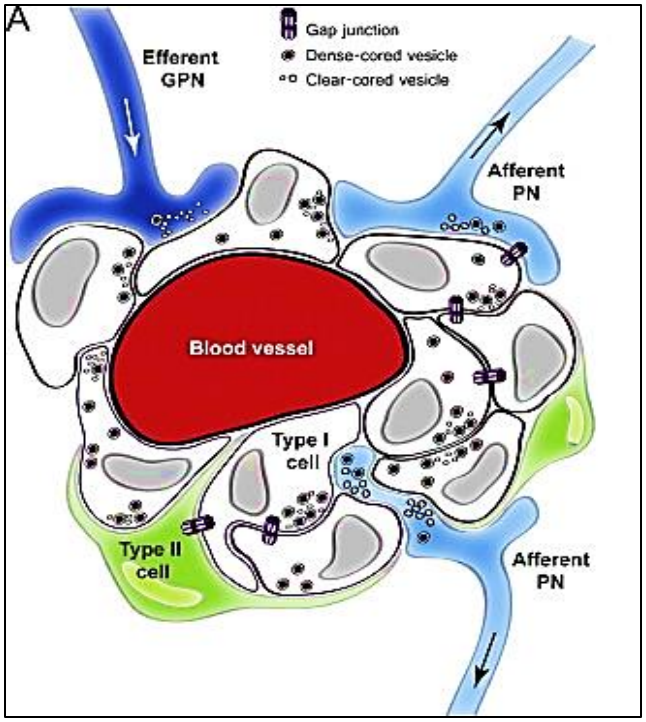


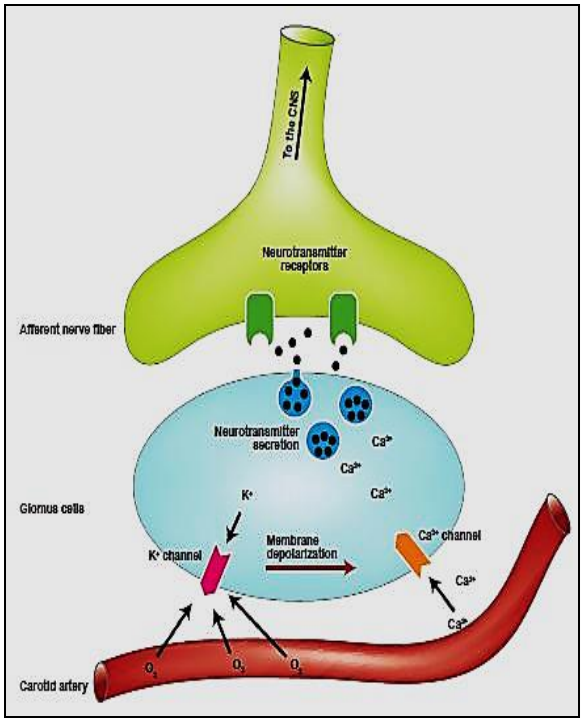
- Contain **chemoreceptors** sensitive to blood Co_2 & O_2 & H^+ concentrations
- These structures contains **sinusoidal capillaries** that - intermingled with clusters of cells called **Glomus cells**

- Glomus cells cytoplasm contain neurotransmitters e.g. dopamine, serotonin , adrenaline,

- Glomus cells form synaptic connection with afferent fibers of glossopharyngeal nerve. the sensory nerve is activated by neurotransmitters released from glomus cells in response to changes in the composition of the sinusoidal blood

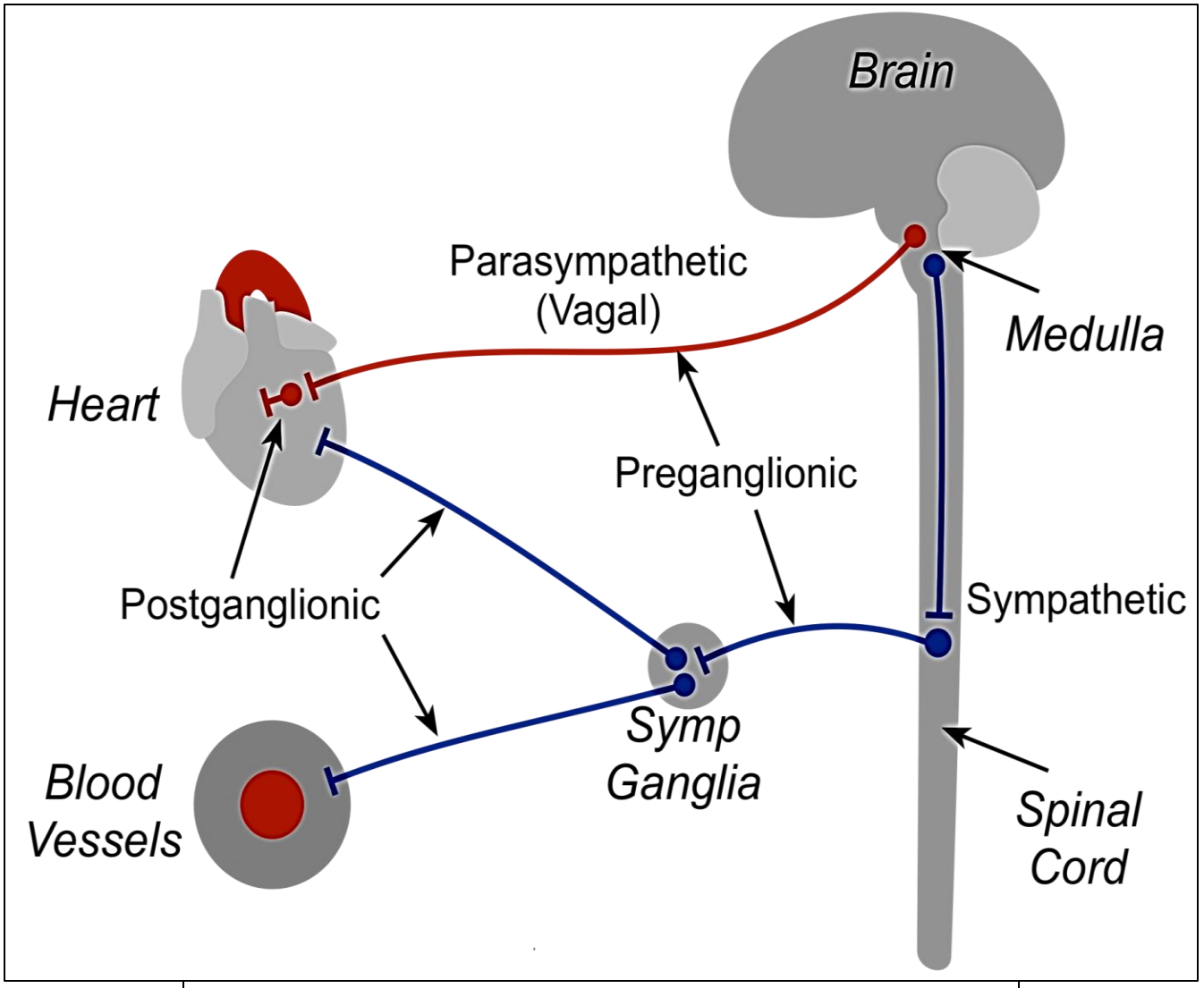






3- Aortic bodies

Located on the arch of aorta similar to carotid bodies

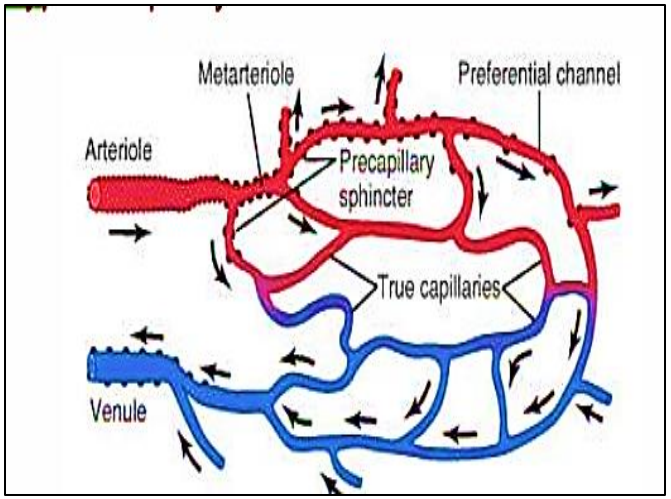


Innervation of blood vessels

microcirculation

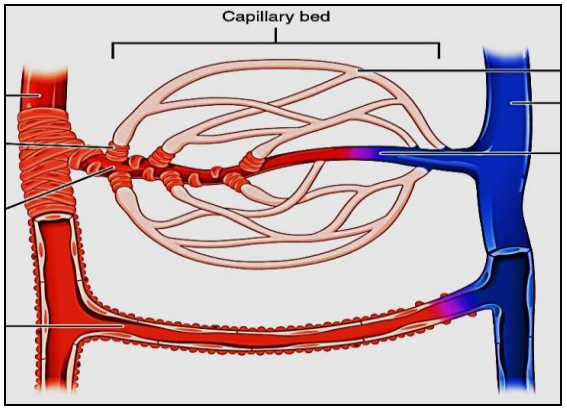
Composed of :

- Terminal arterioles → metarterioles → capillaries → Thoroughfare channel → post-capillary venules

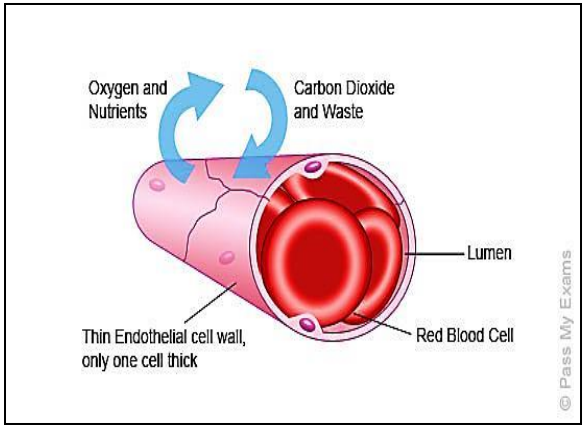


- Capillaries are where exchange between blood & tissue fluids occur

- Capillaries:
  - * Continuous
  - * Fenestrated
  - * Sinusoidal
- Arterio-venous anastomosis



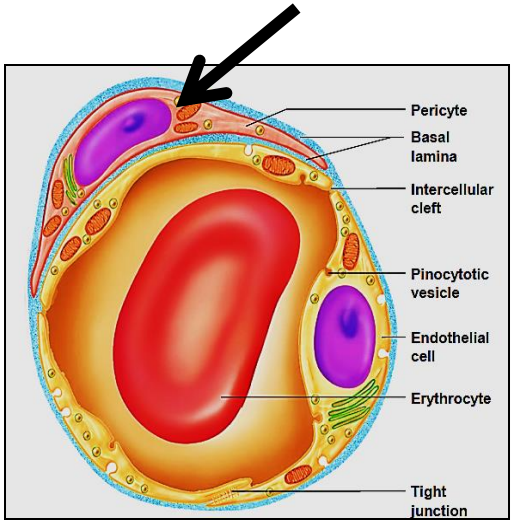
Capillaries

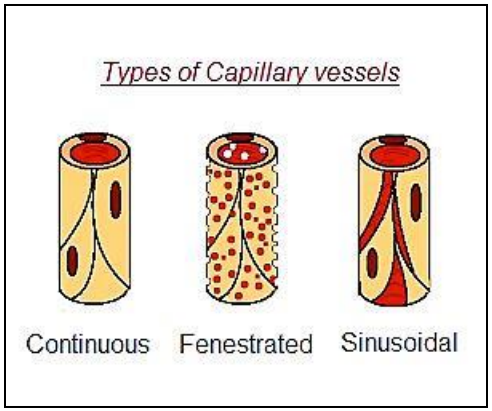


- the smallest blood vessels 5- 8 µm

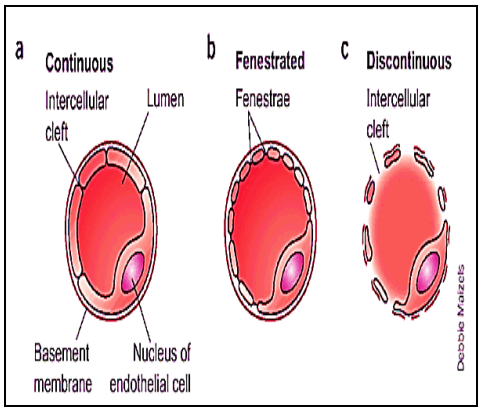
- Is where exchange of water and nutrients occur between blood and tissues hence called **(Exchange vessels)**
- Wall is formed by a single layer of endothelial cells + Pericytes + basal lamina , **NO** smooth ms cells

Pericytes: branched cells, stabilize capillary wall, control permeability (contract) , blood flow, play role in vessel repair





Types of capillaries

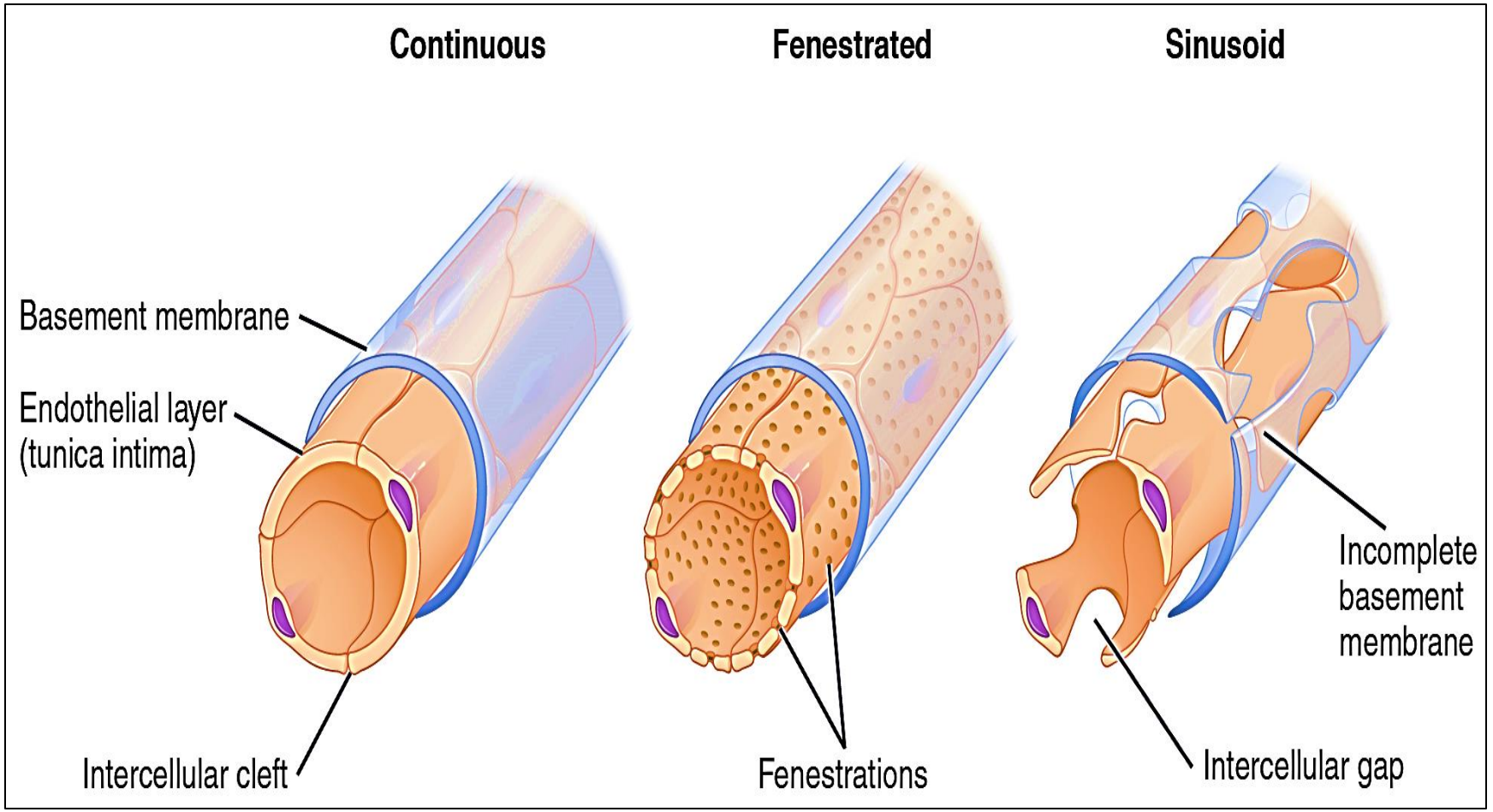


Continuous (Somatic)

Fenestrated (Visceral)

Discontinues (Sinusoidal)

Depends on the continuity of endothelial cells (pores & intercellular clefts) & the basal lamina



Types of capillaries

- **Continuous (somatic):** tight junctions between the endothelial cells .Continuous basal lamina
- has the lowest permeability (water, ions, lipid & soluble molecules)

  (diffusion , transcytosis)

- **Fenestrated (visceral):** cells have pores which may be/ may be not covered by diaphragm, the basement membrane is continues

  relatively high permeability

  (active filtration, reabsorption, hormone secretion)

  No diaphragm: renal glomeruli

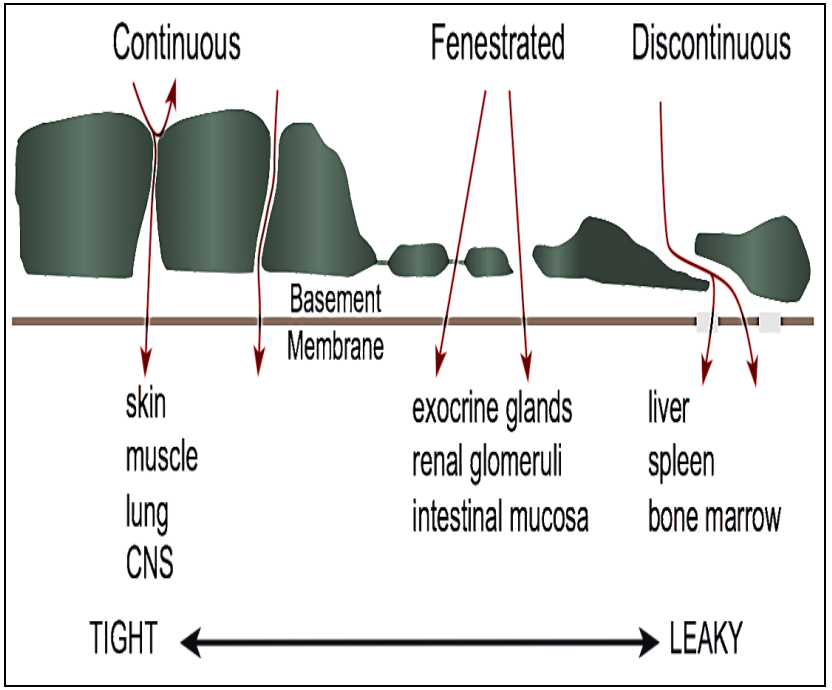
  Has diaphragm: intestine & endocrine gland , pancreas

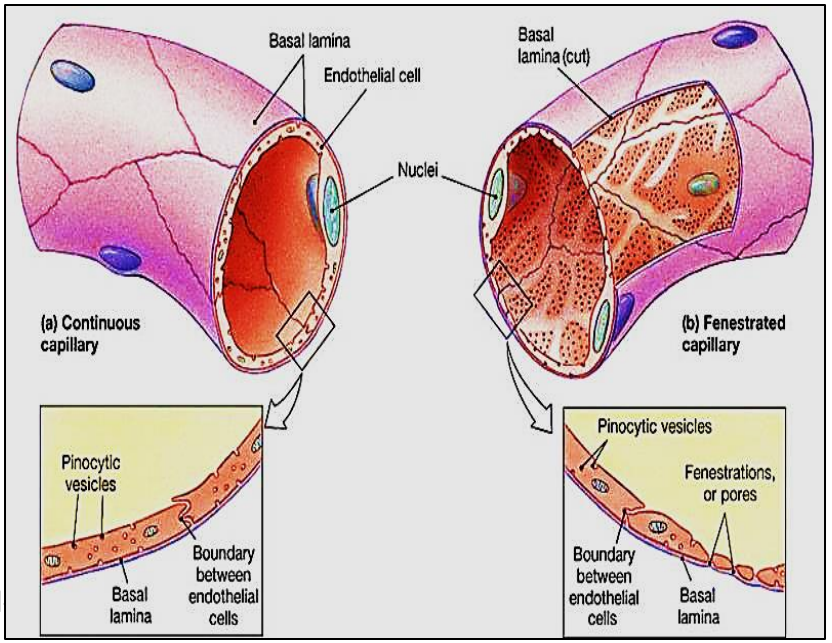
- **Sinusoidal**:

  Extremely highly permeable

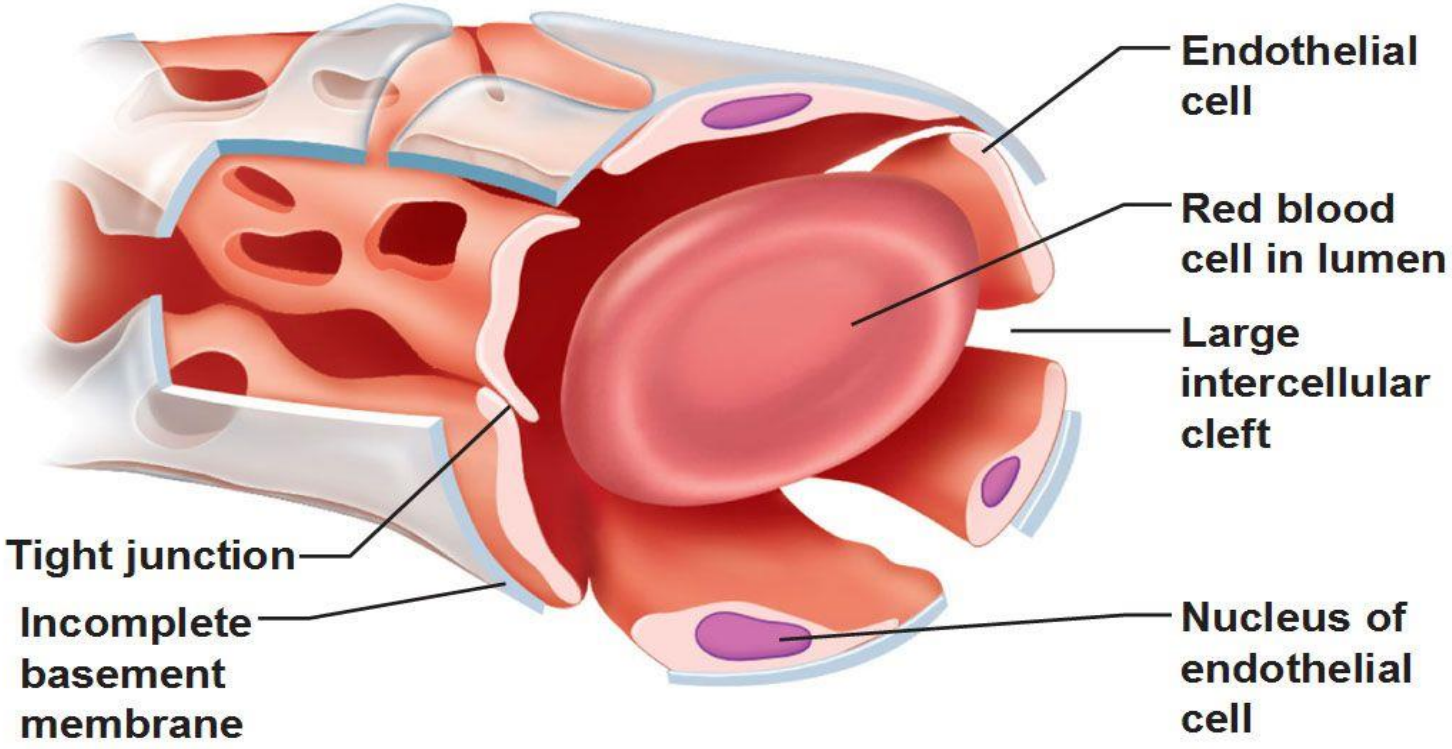
  (permit cross of cells & serum proteins)

  Liver, spleen , bone marrow





Structure of Capillaries: Sinusoids have big fenestrations, few tight junctions, and wide intercellular clefts, as well as incomplete basement membranes, allowing for *exchange of large molecules (whole cells)*

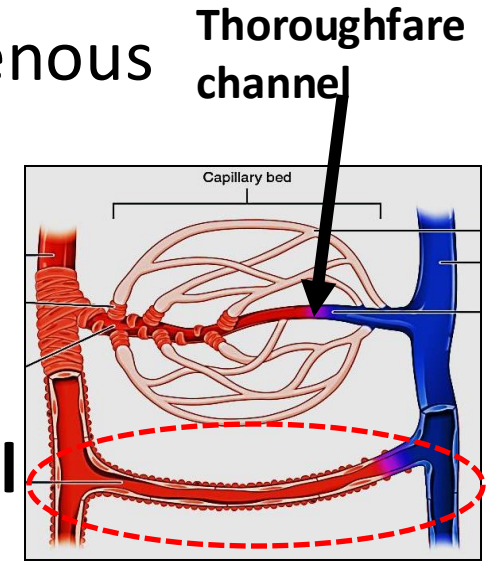


(c) Sinusoidal capillary. Most permeable. Occurs in special locations (e.g., liver, bone marrow, spleen).

Sinusoidal capillaries

Arterio- venous anastomoses (AVA)/ Shunt

Direct connection between arterioles & venules without passing through capillary bed →↑ venous return to the heart

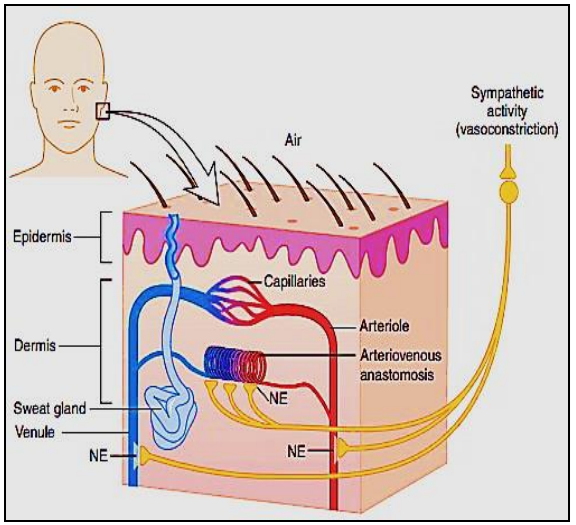


Conditions:

A- contraction of pre- capillary sphincters →

Blood will pass through **thoroughfare channel**

B- AV anastomosis: small vessels connect arterioles to venules **directly**



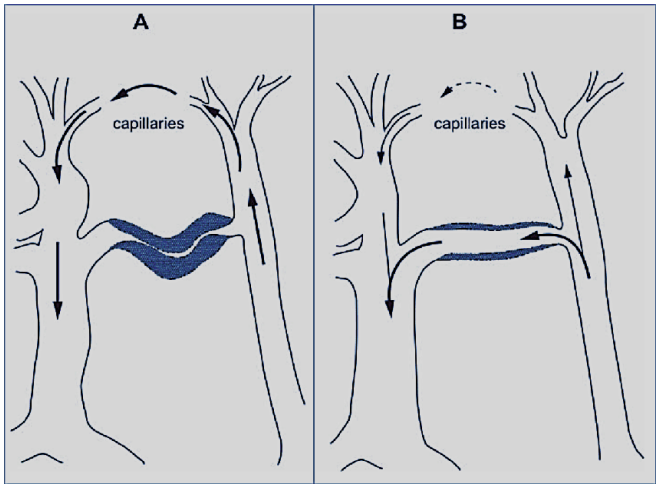
- The AVAs are short vessel with a large inner diameter 10 - 150 µm & a **thick muscular wall** , with no capillary bed between them (smooth ms in its wall)

- They are densely innervated by adrenergic fibers When they open they provide a low resistance connection between arteries and veins

- AVAs play important role in temperature regulation

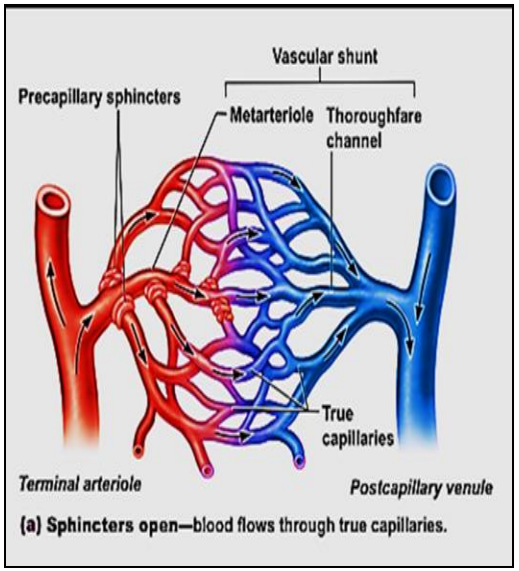
  e.g. skin (hands & feet)

  Blood flow in genital organs



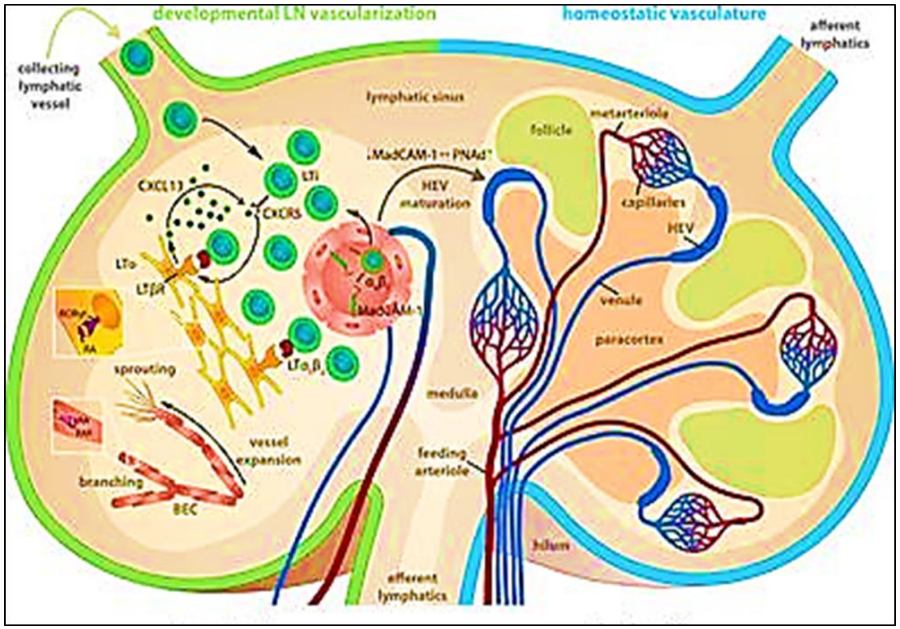
Post -capillary venules

- Post- capillary venules diameter (10-30 µm) form when capillaries re-unit ,they drain the capillary bed



- Its structure is similar to capillaries
- Porous , allow passage fluids & WBCs into tissues (as capillaries do)
- They are the play imp. role in inflammation
- contain intercellular endothelial junctions that can open to allow plasma proteins and circulating cells (leukocytes) to escape from the bloodstream to site of inflammation called **leukocyte extravasation**

- The post capillary venules in paracortex of **lymph node** are lined by tall cuboidal endothelial cells are called high endothelial venules (HEV) (entrance of T lymphocytes to LN)



High endothelial venule in Paracortex of lymph node

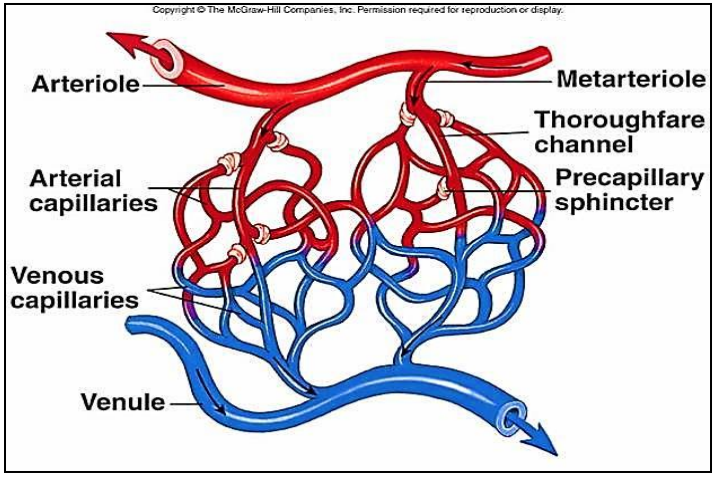
venules

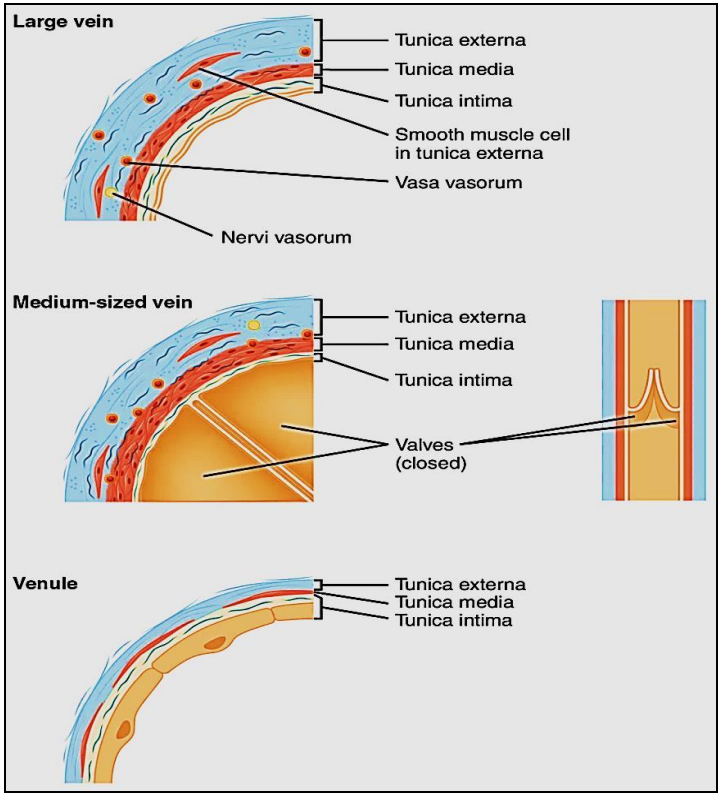
- The smallest veins (20- 30 µm)

Intima: endothelium

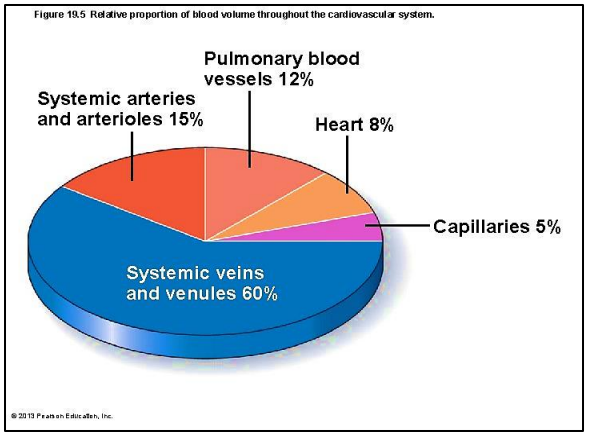
Media: 1 or 2 layers of smooth ms. cells, The thickness ↑ as the vessel diameter increased

Adventitia: relatively thick





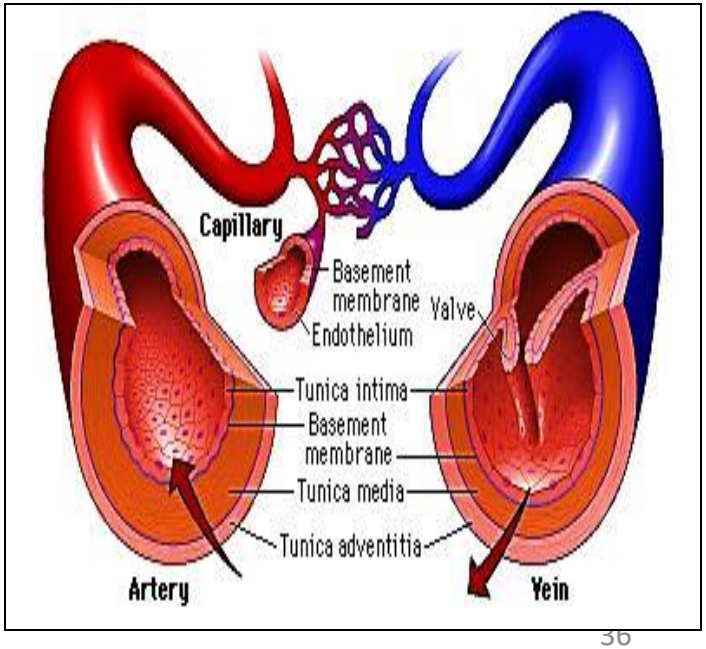
Medium size veins



- Carry blood toward → heart.
- The blood pressure in veins is much lower than arteries

- Veins have 3 tunics, but **thinner walls** with **wider lumen** comparing with corresponding arteries… cuz they can hold most of the blood, called **capacitance vessels**

- Tunica media is **thin** , adventitia is **thick**

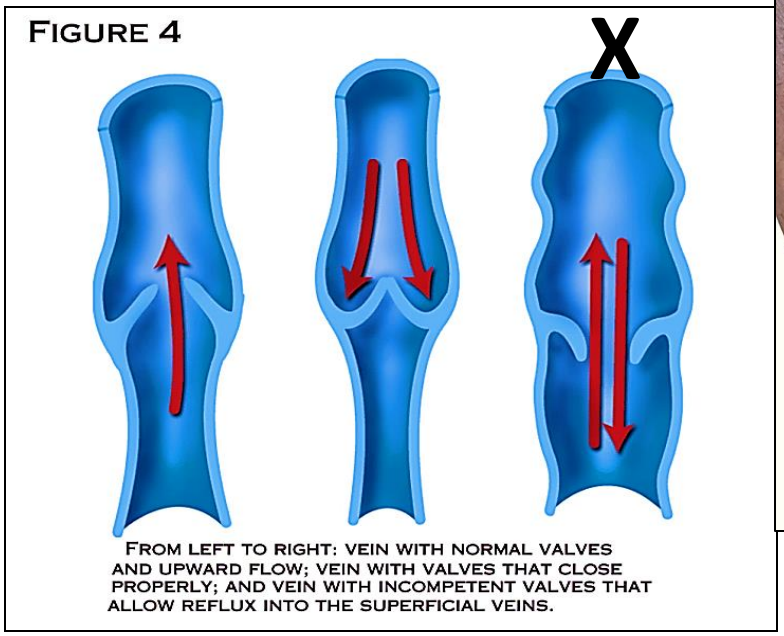


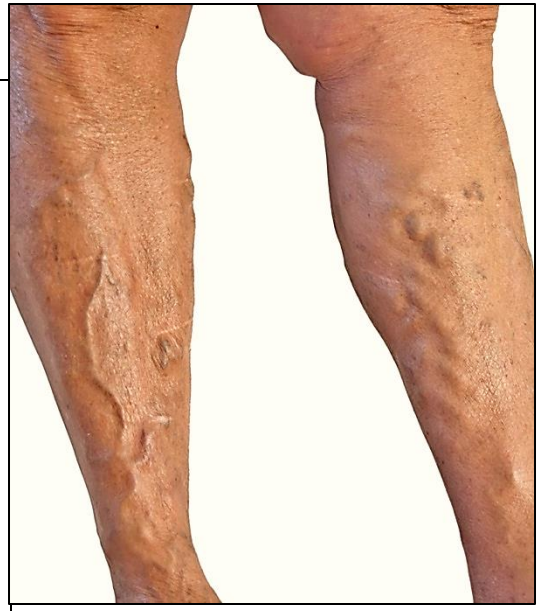
- **Valves are s**pecial adaptation in the veins helps return of blood to heart & prevents its back flow
- Valves are absent in small & large veins

Valves:

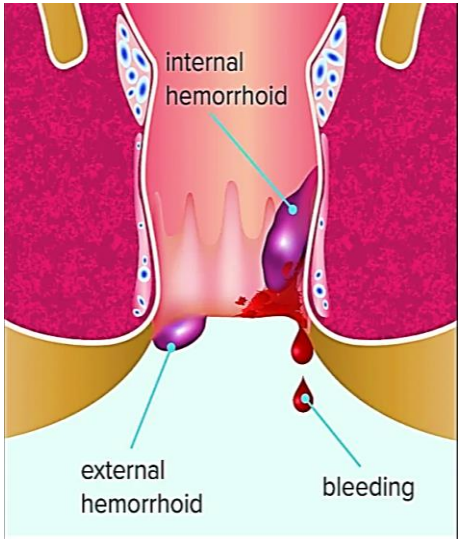
- are folds project from **intima** into lumen of the vein
- Lined on both sides by endothelium,
- their core formed of elastic tissue
- Valves Are most abundant in veins of limbs

Valves





Varicose veins

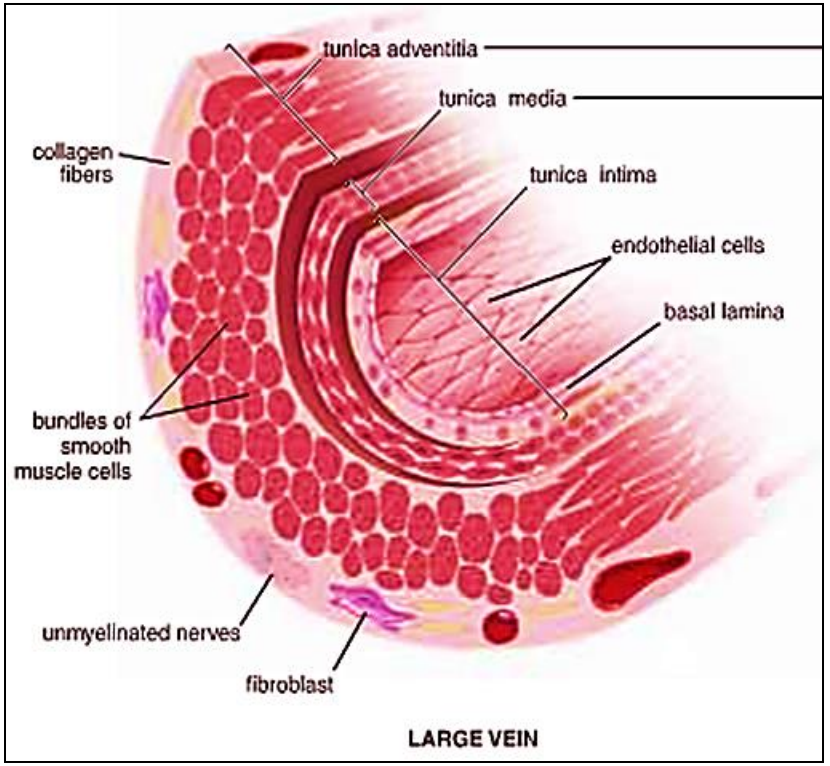


Hemorrhoids

Vena cava (inferior & superior)

Tunica intima: thin

Endothelium – sub-endothelial CT– **No IEL - No valves**



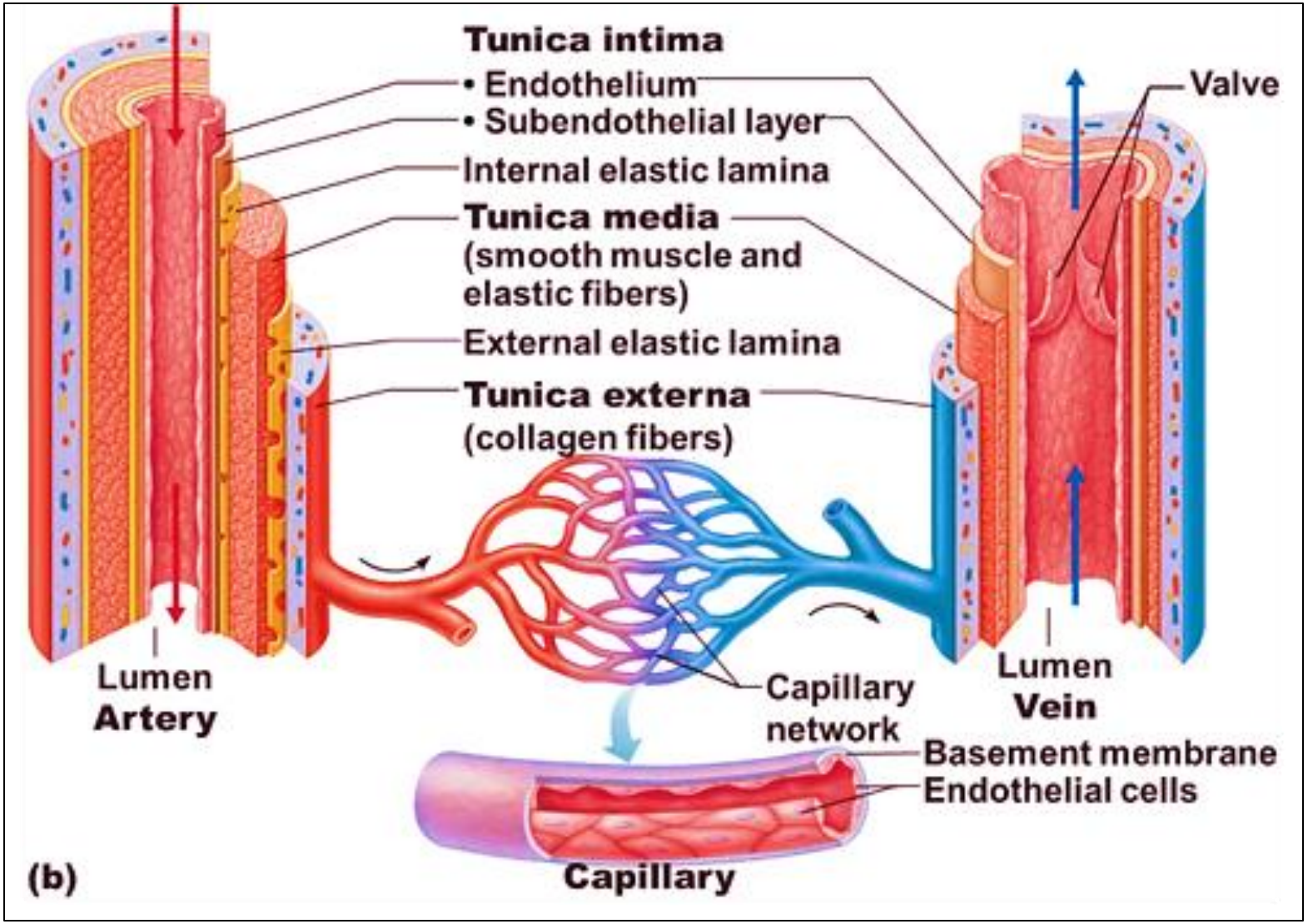
Tunica media:

thin layer, smooth ms, elastic, collagen fibers

Tunica adventitia:

Thick, contains **longitudinal bundles of smooth ms fibers**

facilitate shortening & elongation of the vena cava with respiration.



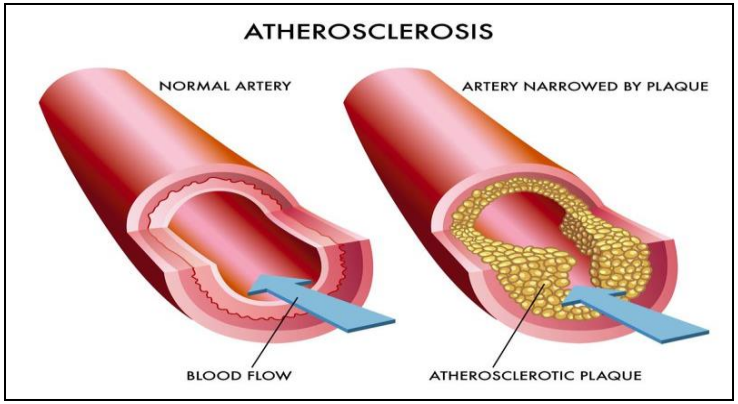
L.S showing the wall, of the Blood Vessel

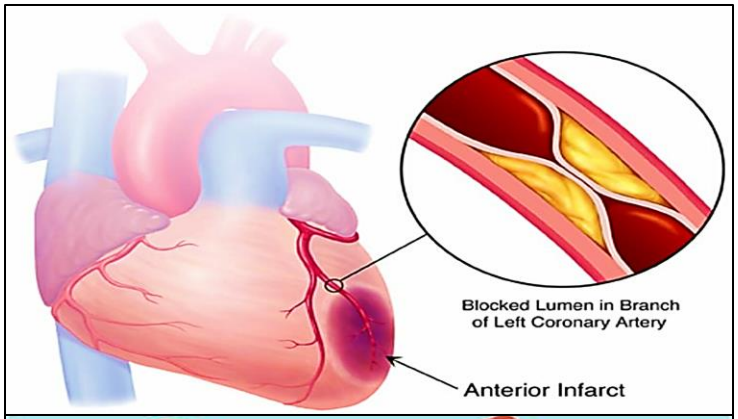
Medical applications

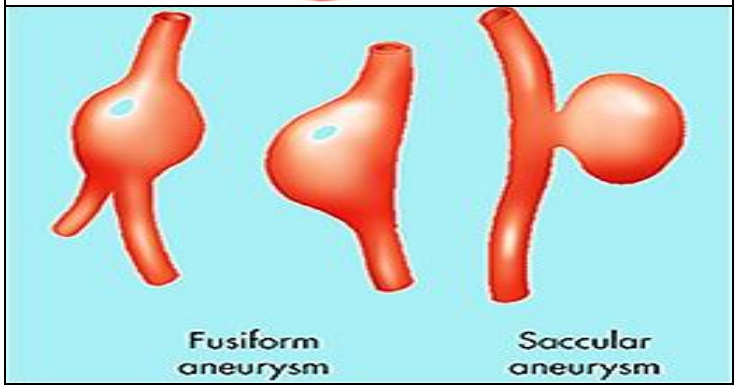
- **Atherosclerosis:** focal thickening of the intima of arteries due to deposition of cholesterol (lipid plaques) (Foam cells)

- **Infarction:** death of tissue due to lack of blood supply

- **Aneurysm:** marked dilation of BV due to weakening of tunica media →rupture & hemorrhage.

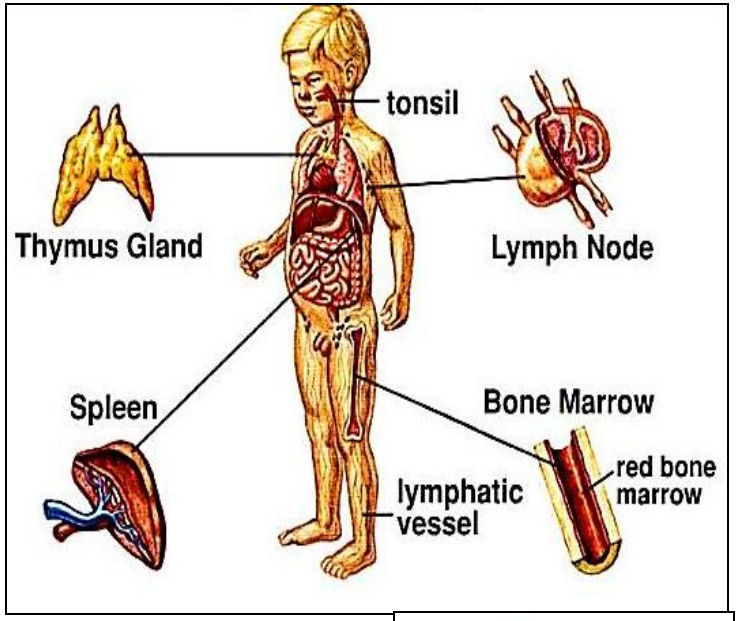






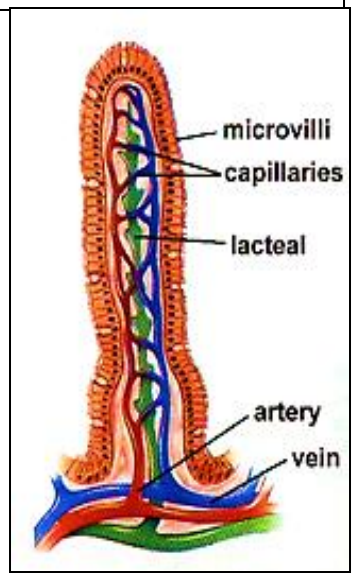
Lymphatic system consists of:

- Lymph fluid
- Lymphatic vessels
- Lymphoid tissues & organs

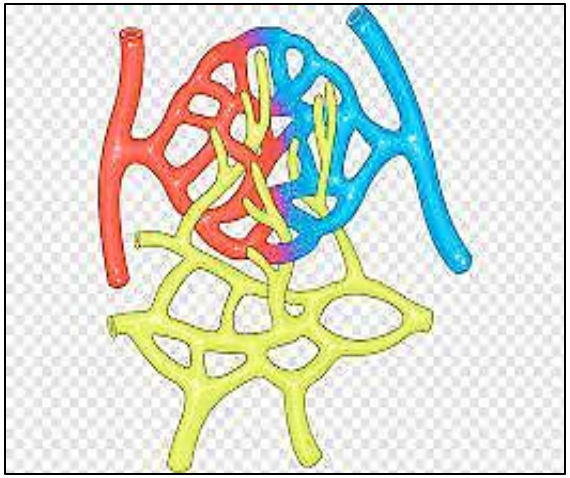


Function of lymphatic system :

- Fluid balance: carry excess tissue fluid back to circulation



- Fat absorption: transport fat from GIT to blood
- Immunological & defense function : Produces, maintains & distributes lymphocytes and filtrate lymph & blood



Lymphatic vessels

L. Capillaries

(Blind ended)

Medium size L. vessels

(Valves)

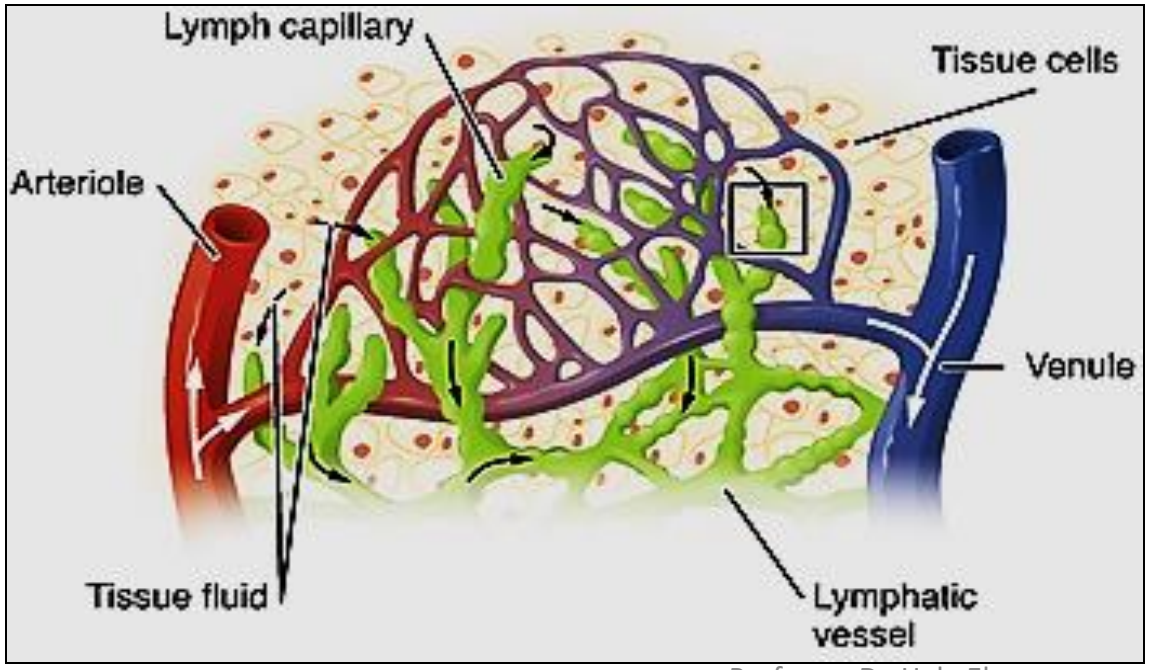
L. Ducts

(like veins)

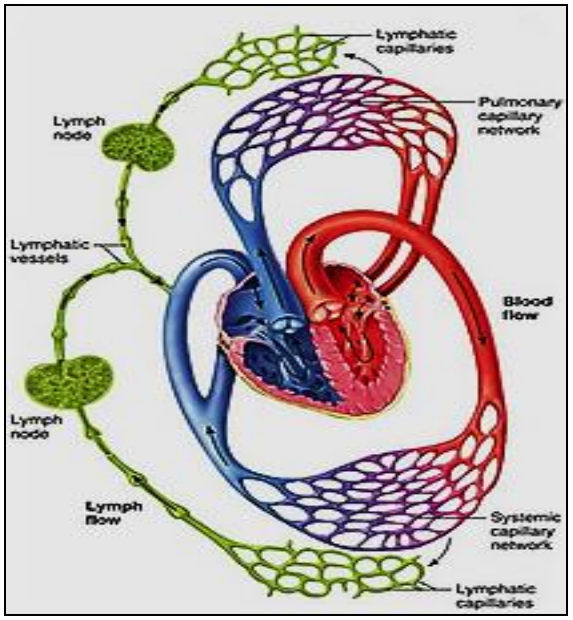
Lymph

- **Lymph** is a colorless fluid that circulates through the lymphatic system

- The lymph is formed when the **interstitial fluid** is collected through lymph capillaries



- lymph composition changes as the blood and the surrounding cells continually exchange substances with the interstitial fluid



- Generally similar to <u>blood plasma</u> + water + immune cells WBCs (lymphocytes & macrophages)

- Lymph returns proteins and excess interstitial fluid back to the blood stream. **<u>Venous blood</u>**

- Lymph may pick up bacteria & pathogens and large particles (fat) and bring them to lymph nodes where they are destroyed by immune cells→ before reach the blood stream

lymph circulation: interstitial fluid will drain into

lymph capillaries

↓

lymph vessels

↓

lymph nodes

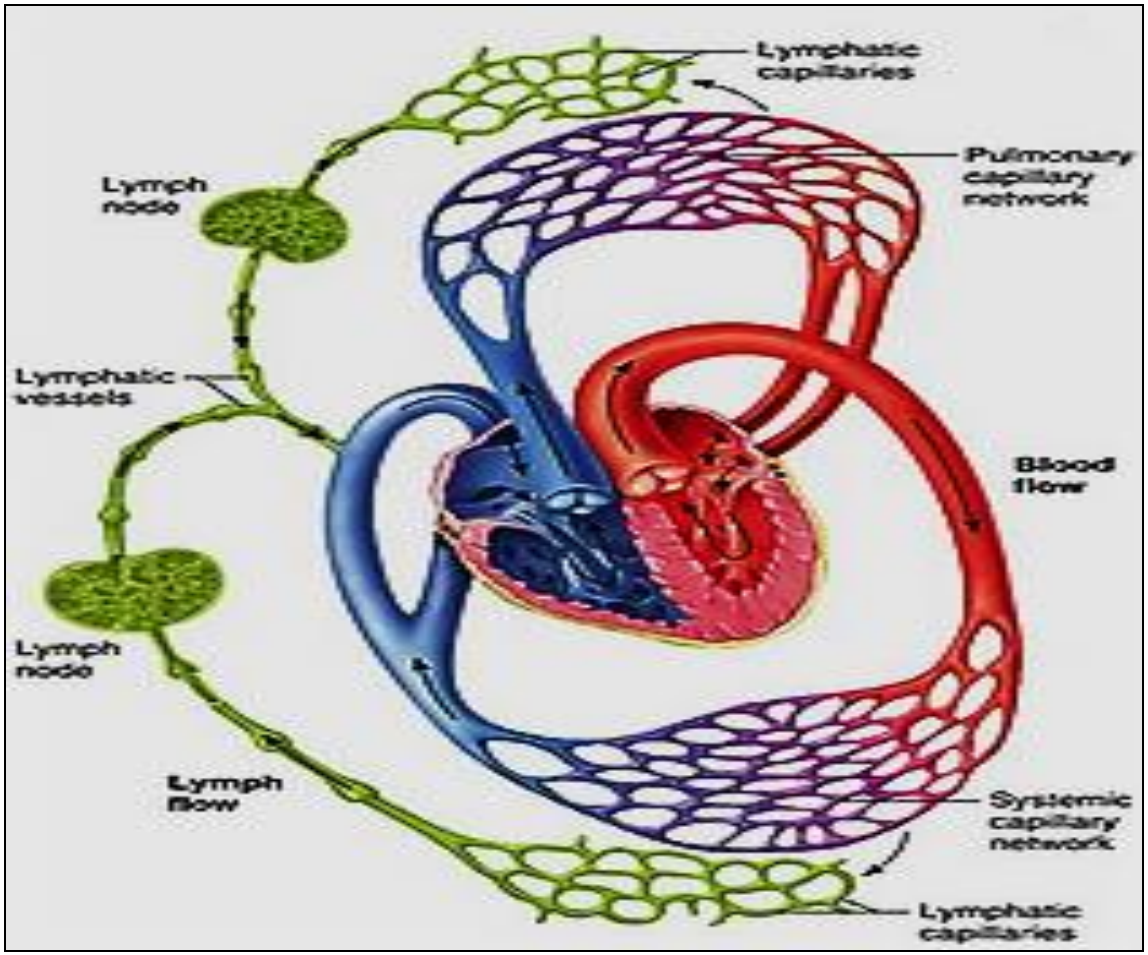
↓

Lymphatic vessels

↓

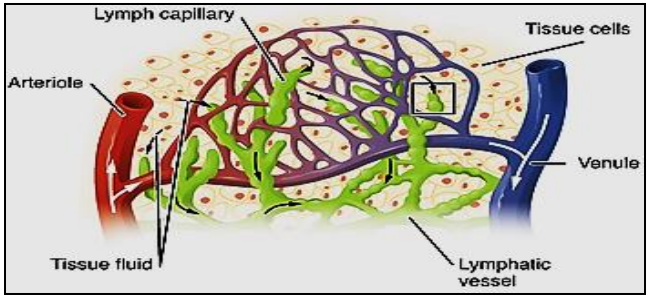
Lymphatic duct

↓

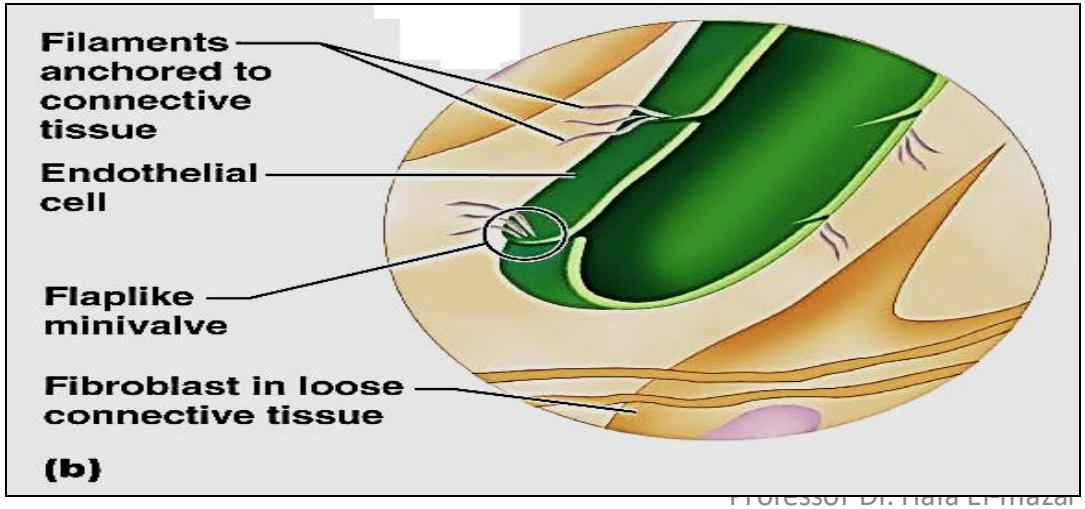


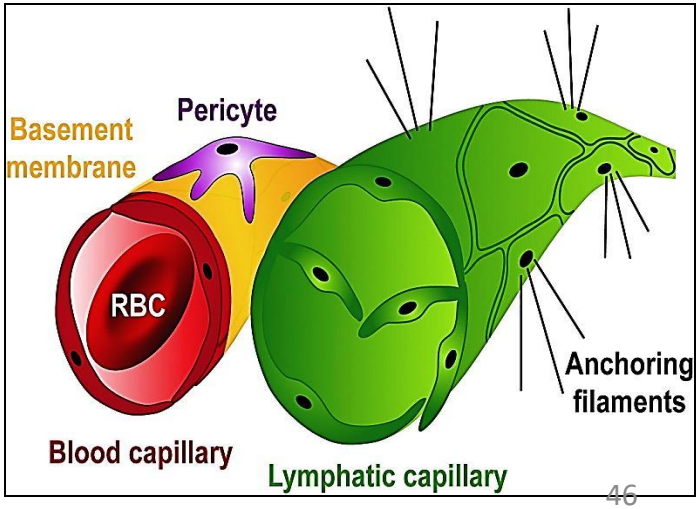
ultimately emptying into the **right** or the **left subclavian vein,** where it mixes back with blood.

Structure of Lymphatic capillaries



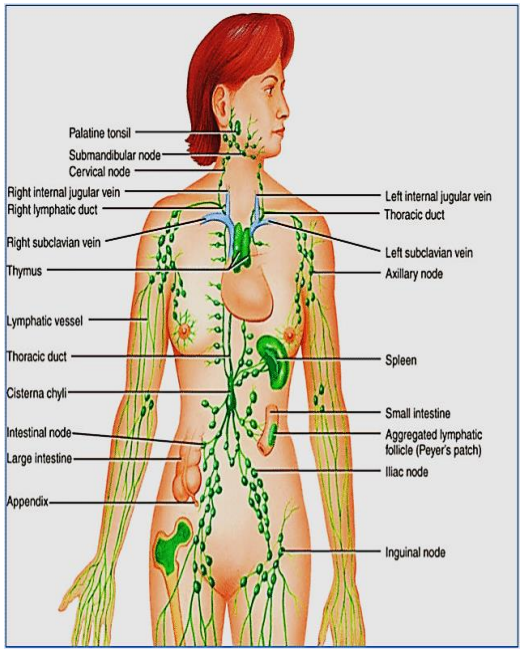
- Begin with a blind end
- Have similar structure to blood capillaries but larger & more permeable ,considered as **microcirculation**
- Made of single layer of overlapping endothelium with interrupted basal lamina
- its endoth. Has **NO** (fenestrae, tight junction, pericytes)





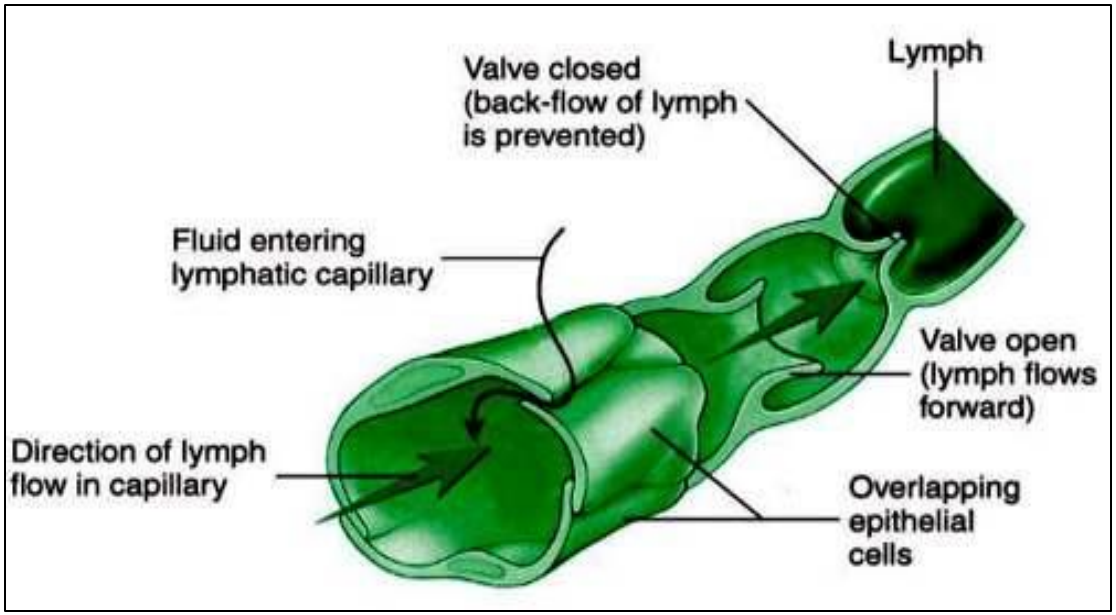
Structure of Lymphatic vessels:

- Thinner wall + large lumen+ **valves**
- Drain lymph from lymph capillaries
- Lymph nodes are found along their course



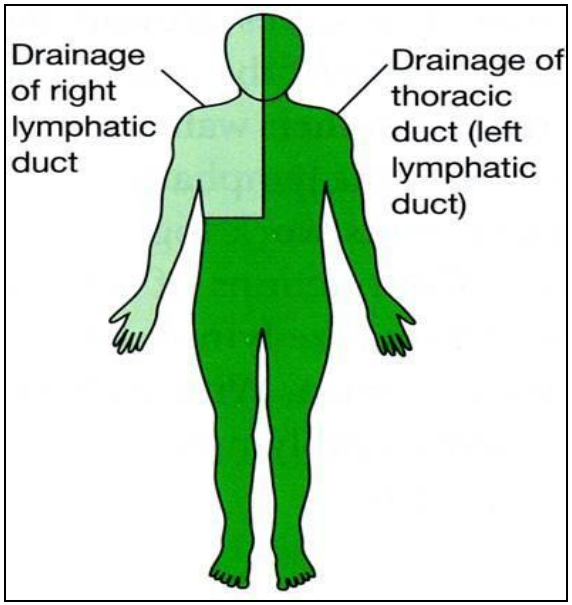
Structure:

Endothelium / **valves** , media (few smooth muscle cells) - adventitia

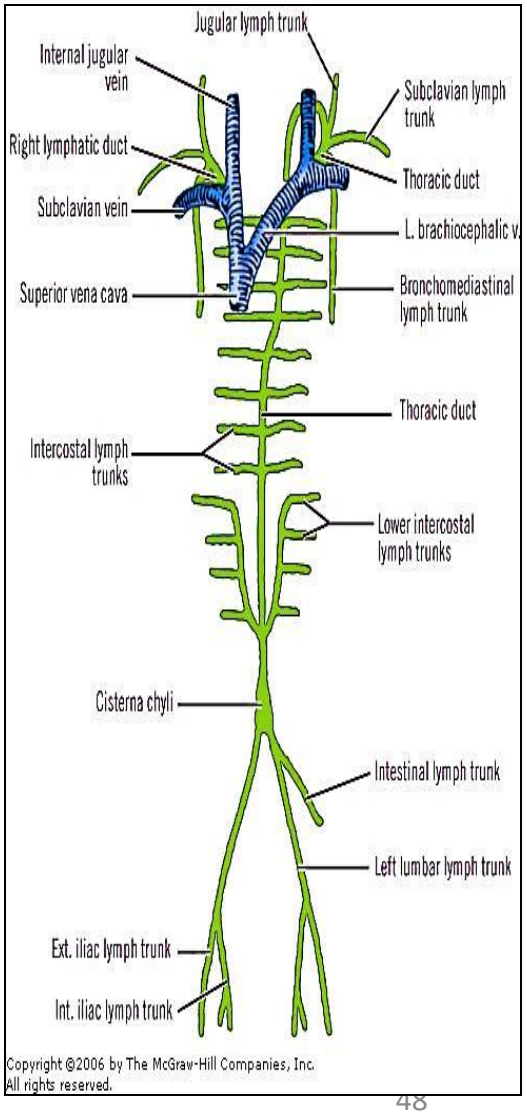


Structure of Lymphatic duct:

- Large vessel that drain lymph into one of the subclavian veins



- 2 lymph ducts:
  - **Right lymphatic duct**
  - **Thoracic duct**



Similar in structure to large veins

- Tunica intima: endothelium + CT
- Tunica media: smooth ms. + elastic fibers
- Tunica adventitia: CT + smooth ms.

Thank you