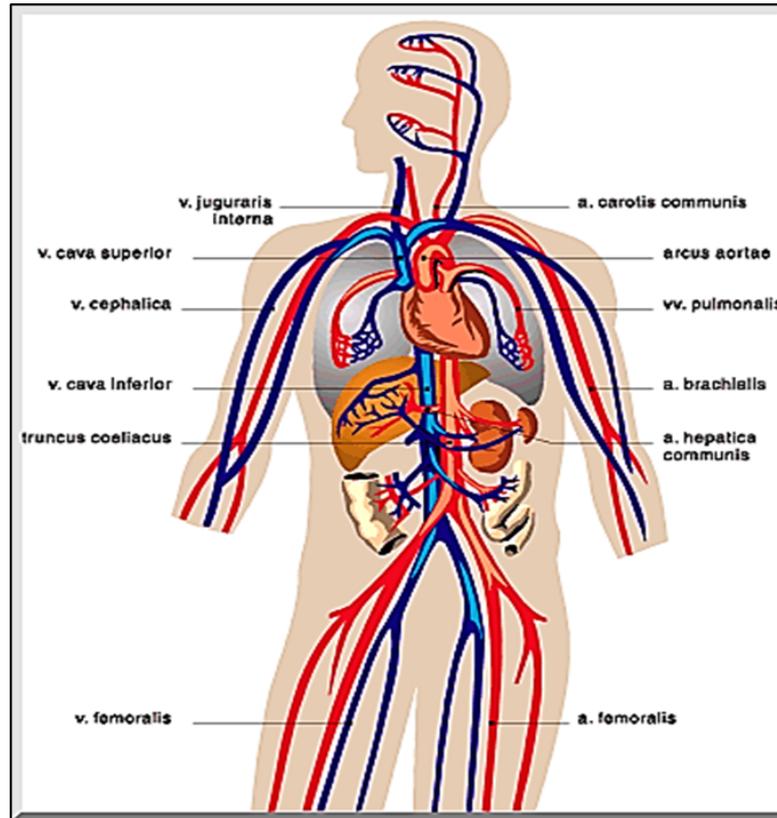


The vascular system Part II)

Medical Students / First Year

Professor Dr. Hala El-mazar 2024



Professor Dr. Hala El-mazar

microcirculation

Composed of :

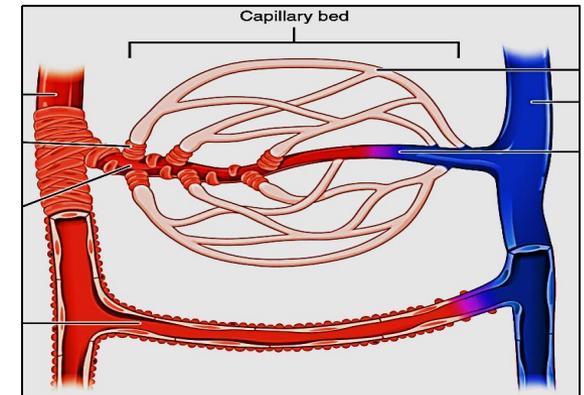
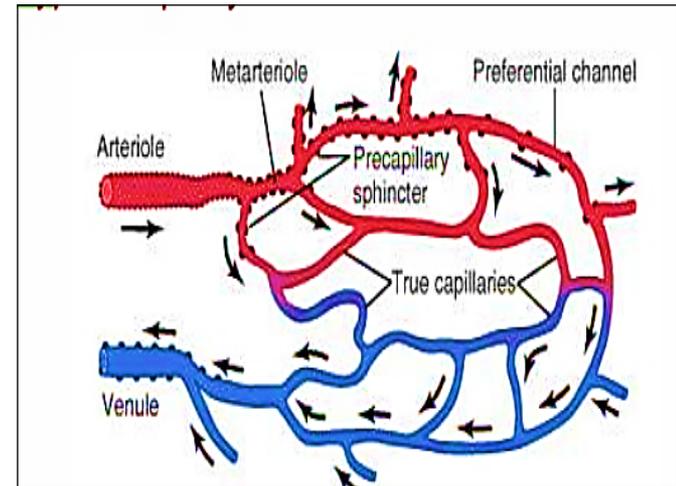
- Terminal arterioles → metarterioles → capillaries → Thoroughfare channel → post-capillary venules

- Capillaries are where exchange between blood & tissue fluids occur

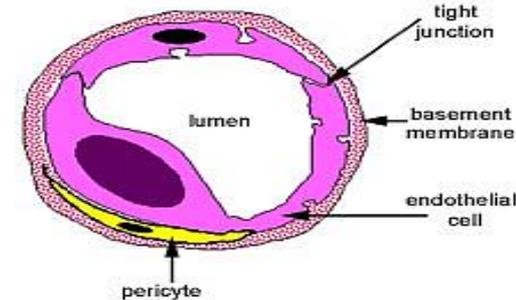
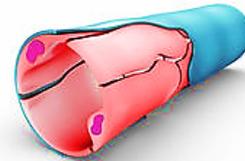
- **Capillaries:**

- * Continuous
- * Fenestrated
- * Sinusoidal

- **Arterio-venous anastomosis**



- Most of microcirculation are lined by **one or two endothelial cells** and many of them are surrounded by pericytes



Function of endothelial cells:

1. Permeability

- Allows exchange of water, CO₂ and metabolites between blood and tissue
- Allows migration of leucocytes from blood to tissue (diapedesis) during inflammation.
- Forms Blood Brain Barrier through the tight junctions between the endothelial cells

2. Metabolic function:

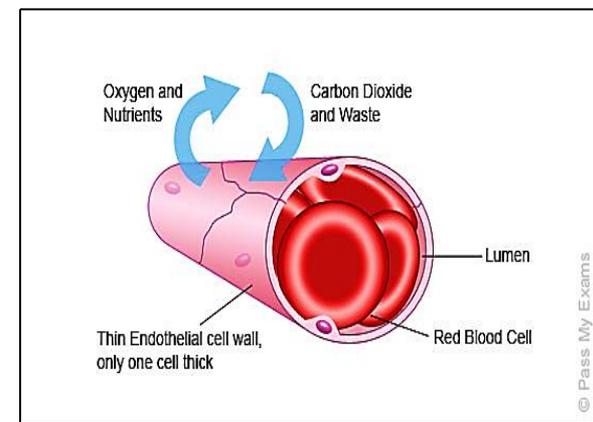
- Activates angiotensin I to Angiotensin II, because the endothelial cells of the lung capillaries have the converting enzyme (which plays major role in bl pressure)

3. Nonthrombogenic function

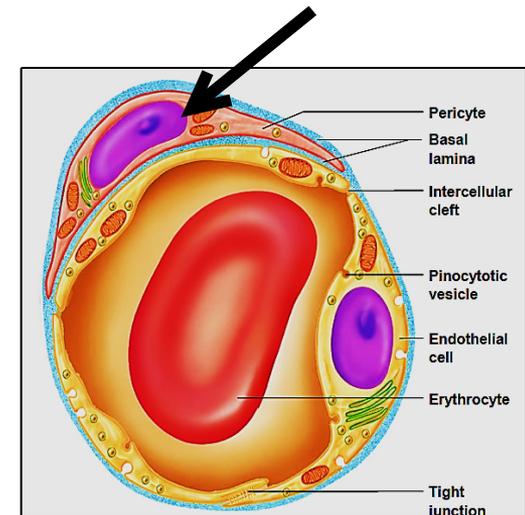
- Platelets normally do not adhere to an intact endothelium because Prostacyclin is released by endothelium which is a powerful inhibitor of platelet aggregation and thus prevents clot formation

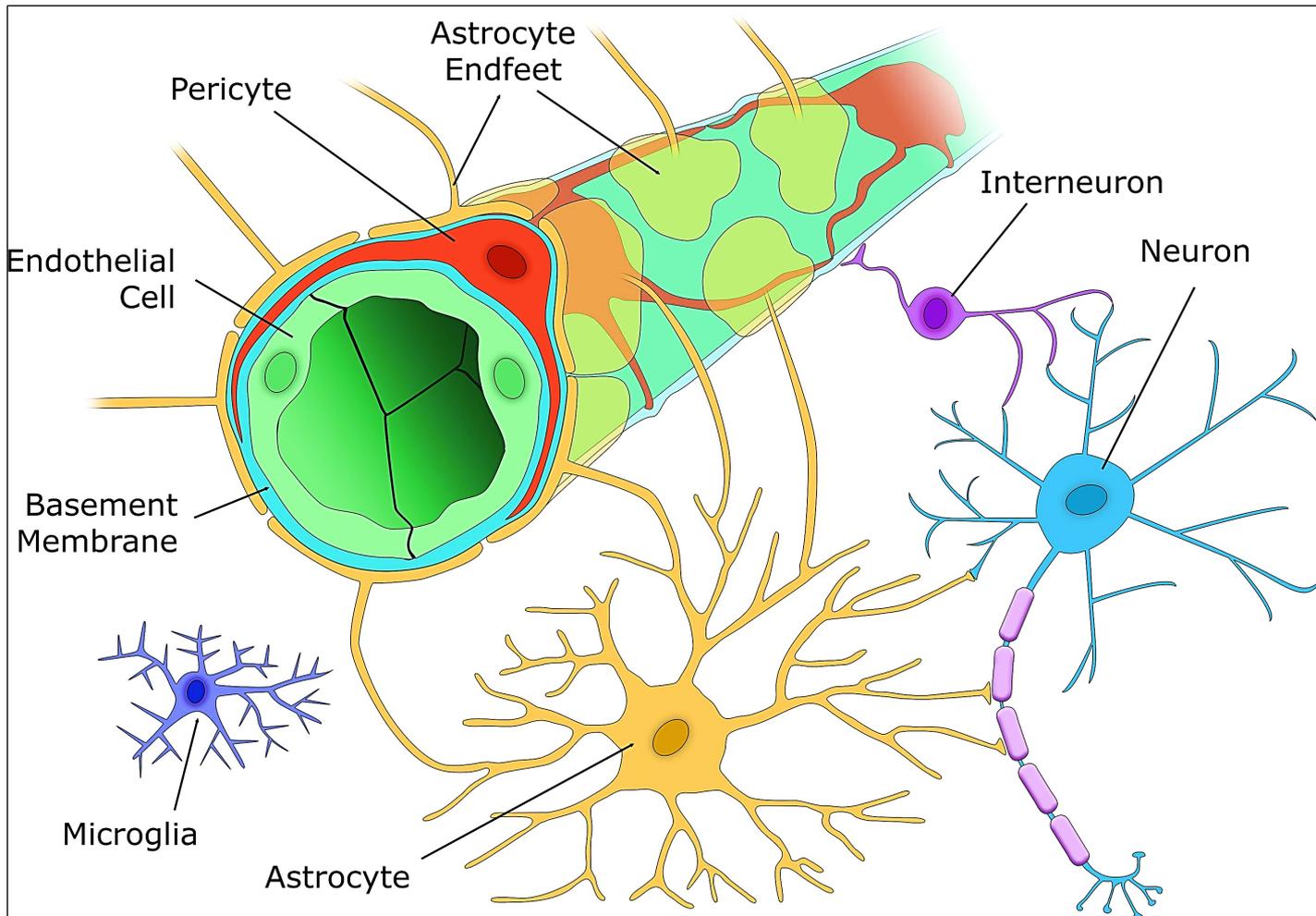
Capillaries

- 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**



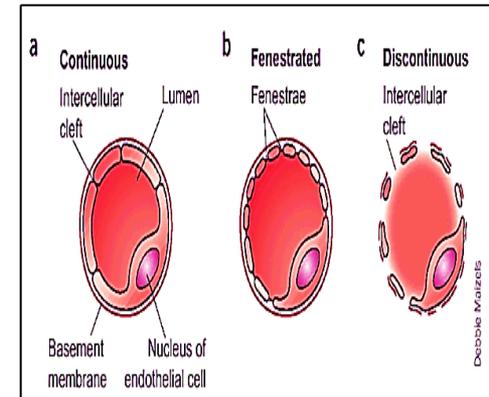
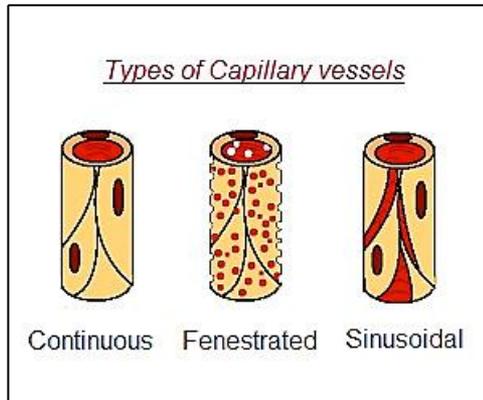
Pericytes: branched cells, stabilize capillary wall, control permeability (contract) , blood flow, play role in vessel repair





Pericytes in relation to endothelial cell in capillaries

Types of capillaries



**Continuous
(Somatic)**

**Fenestrated
(Visceral)**

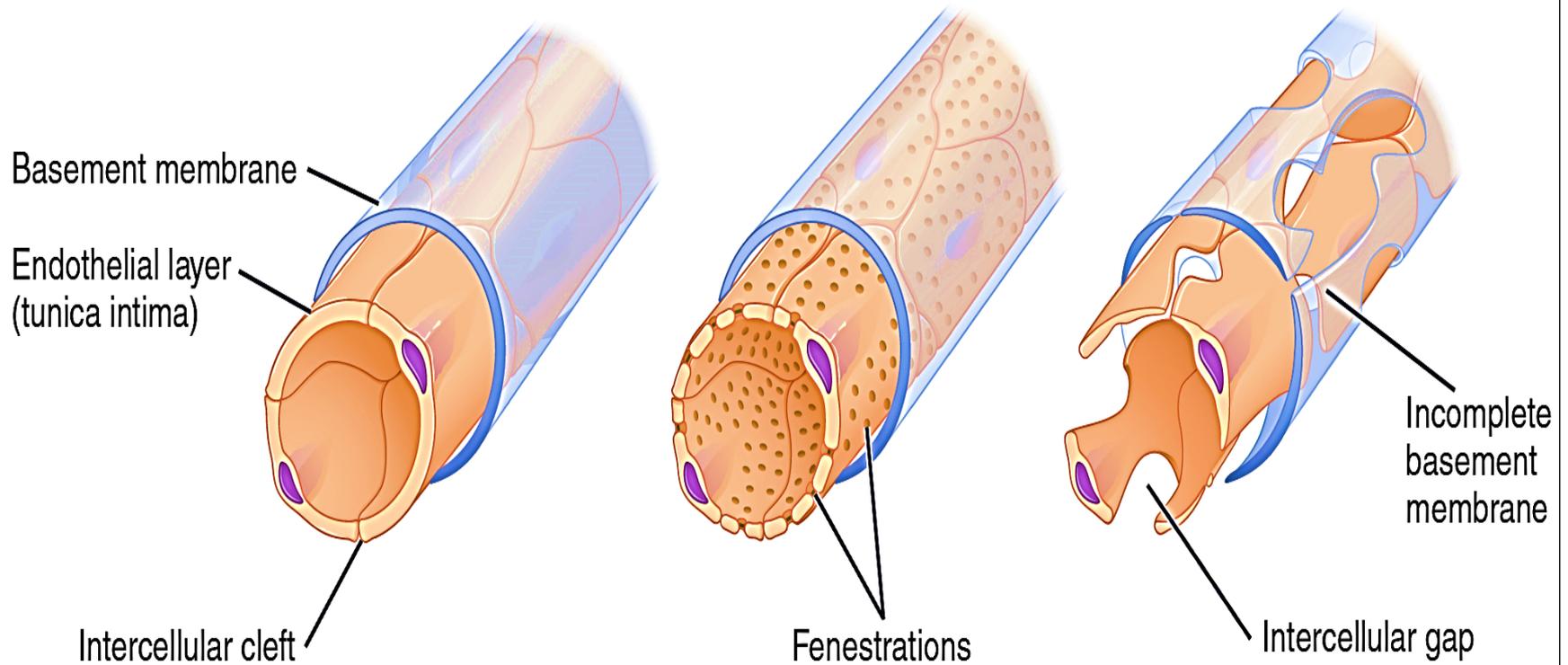
**Discontinues
(Sinusoidal)**

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

Continuous

Fenestrated

Sinusoid



Types of capillaries

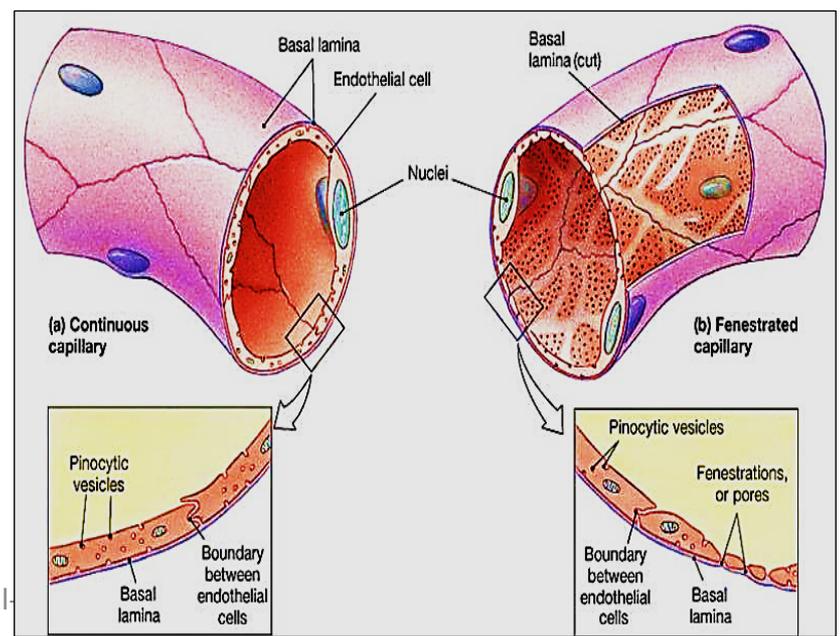
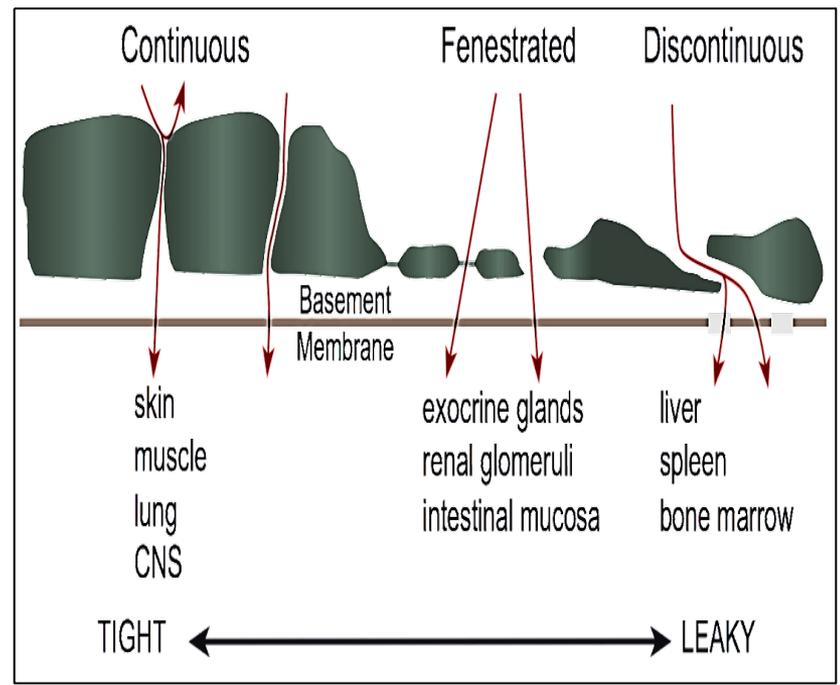
- **Continuous (somatic):** tight junctions between the endothelial cells
.Continuous basal lamina
- has the lowest permeability (water, ions, lipid & soluble molecules)
(diffusion , transcytosis)

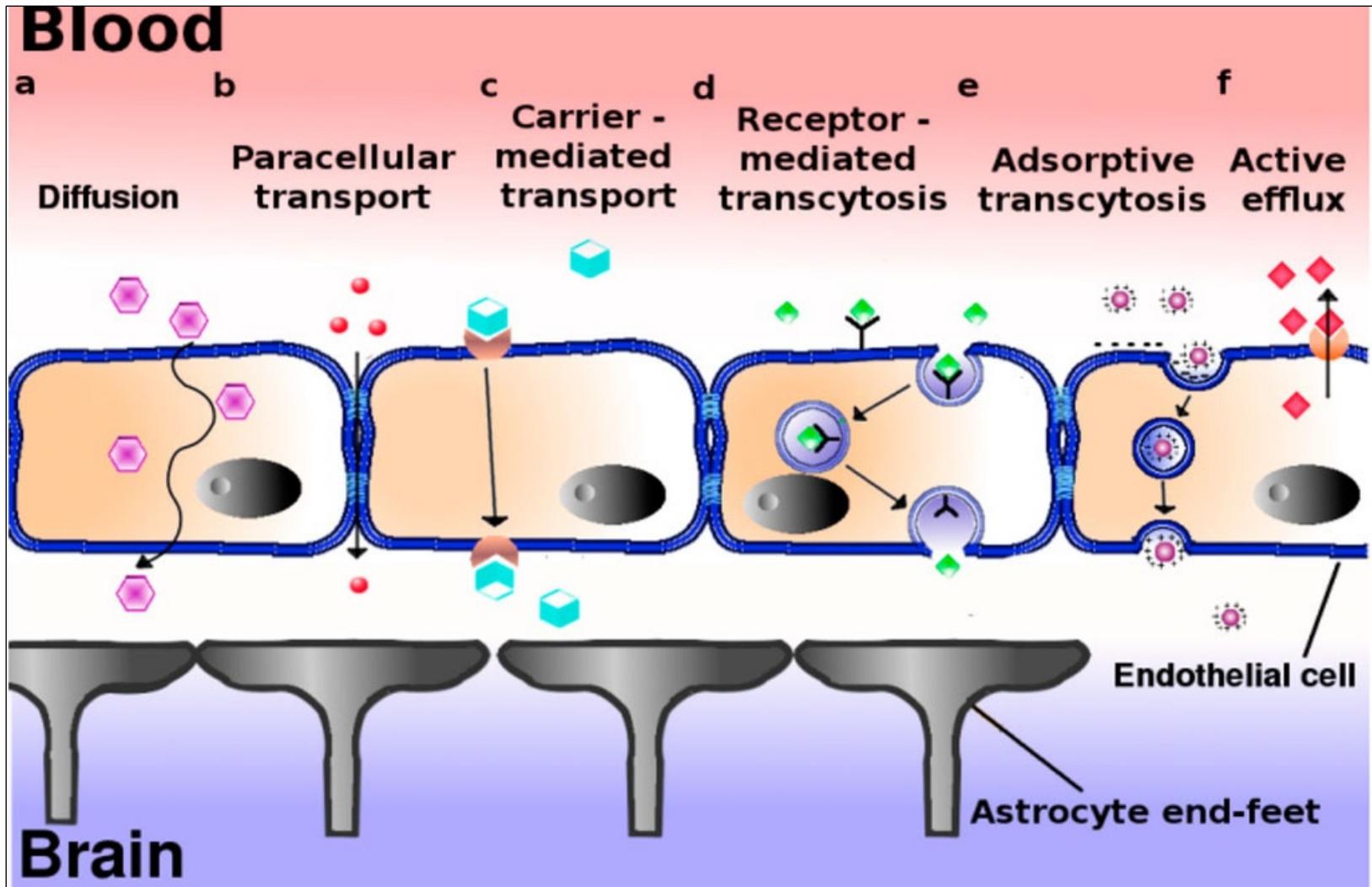
- **Fenestrated (visceral):** cells have pores which may be/ may be not covered by diaphragm, the basement membrane is continuous
- relatively high permeability

(active filtration, reabsorption, hormone secretion)

No diaphragm: renal glomeruli
Has diaphragm: intestine & endocrine gland , pancreas

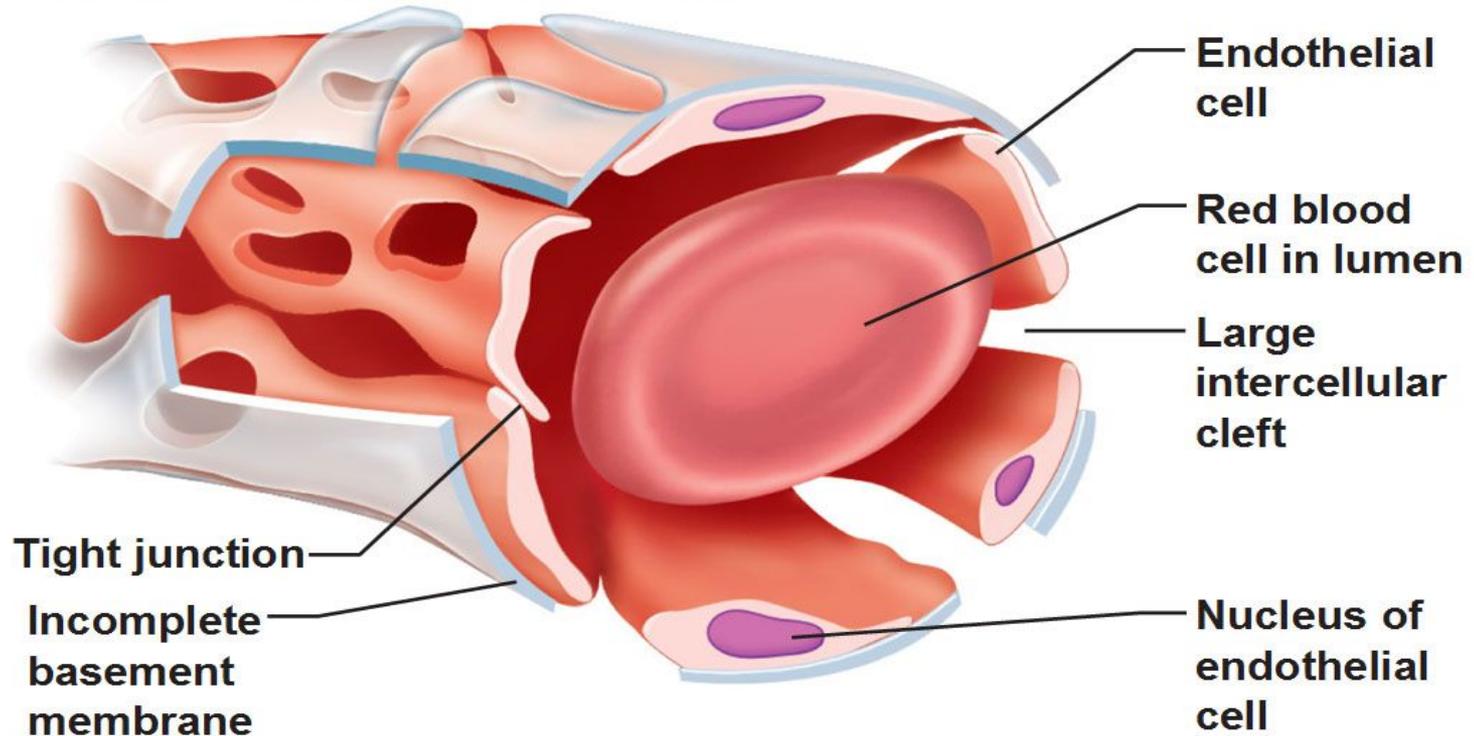
- **Sinusoidal:**
Extremely highly permeable
(permit cross of cells & serum proteins)
Liver, spleen , bone marrow





Mode of transport across the endothelial cells

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

Blood capillary

Blood sinusoid

1- Narrow regular lumen
(5-8 μm)

1-Wide irregular lumen
(30-40 μm)

2- Uniform diameter

2- Variable diameters & tortuous

3-Continuous or fenestrated
endothelium

3- Always fenestrated

4- Complete basal lamina

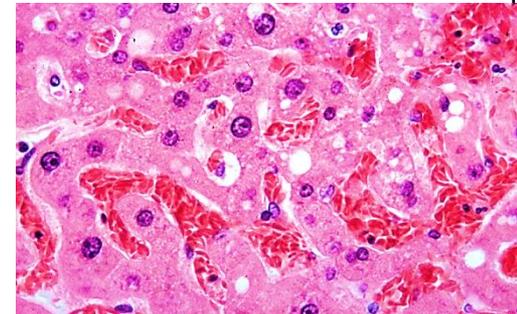
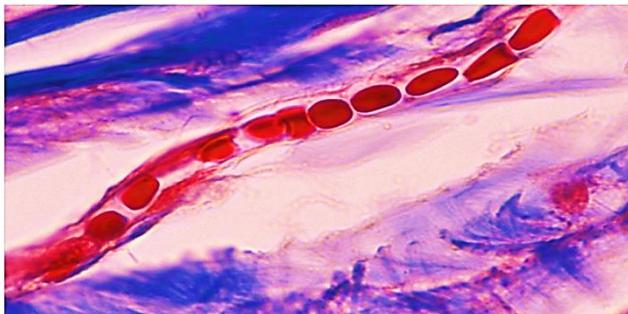
4- Incomplete basal lamina

5-Surrounded with
Pericytes

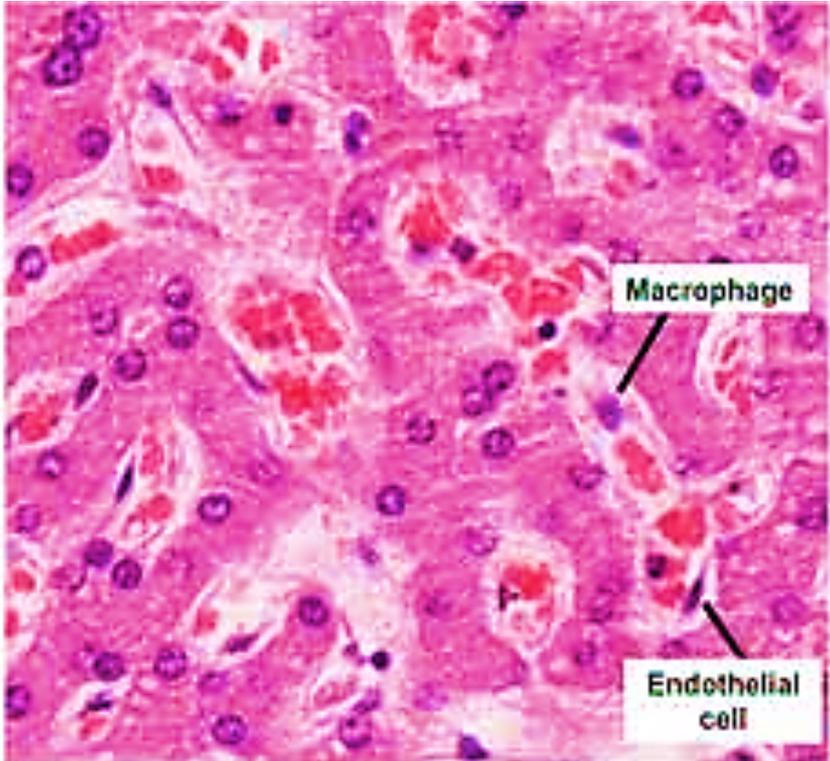
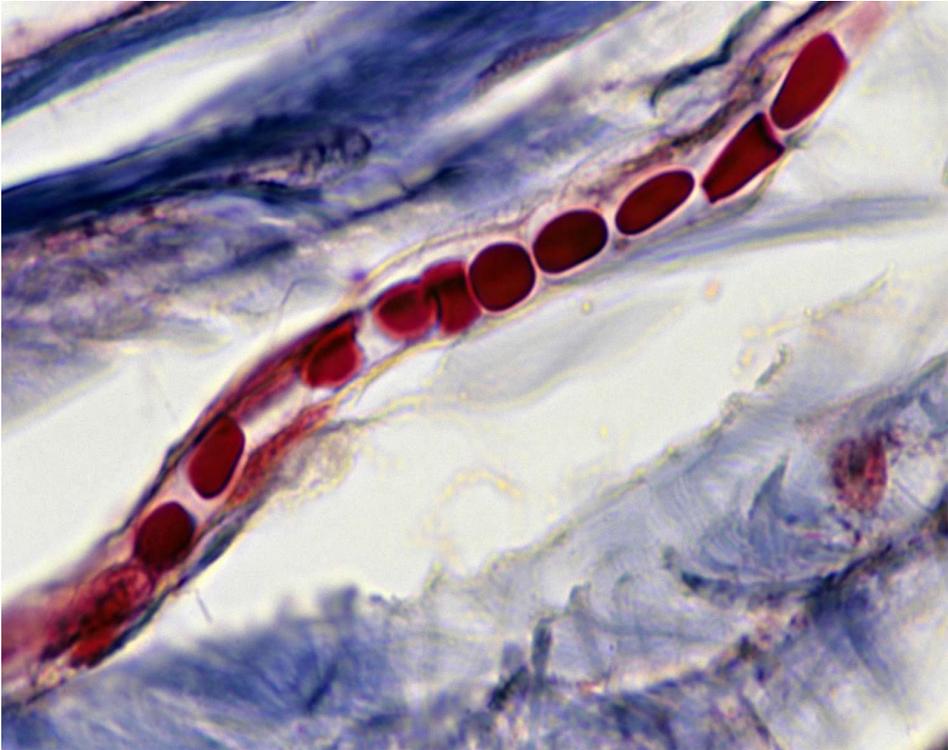
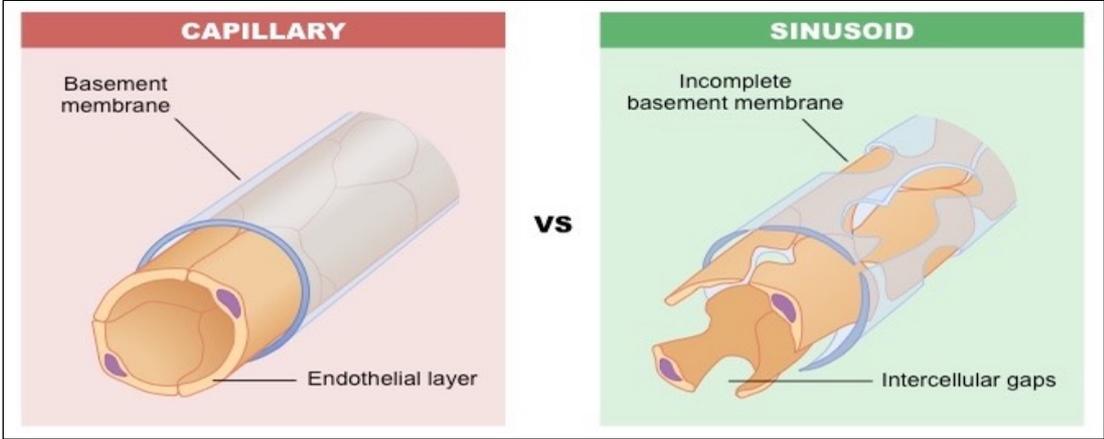
5- Contain macrophages e.g. **Littoral cells (spleen), Kupffer cells (liver)**

6-Present in all tissues

6- present in certain sites as :bone marrow, spleen, liver & Endocrine glands.



Capillary vs Sinusoid



Professor Dr. Hala E

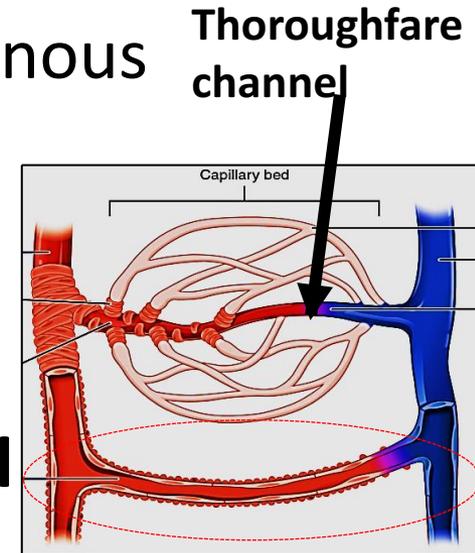
Hepatocytes and sinusoids

Arterio- venous anastomoses (AVA)/ Shunt

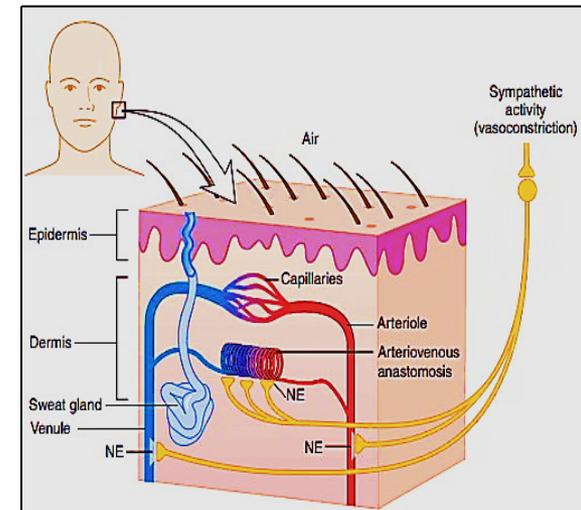
Direct connection between arterioles & venules without passing through capillary bed → ↑ venous return to the heart

Conditions:

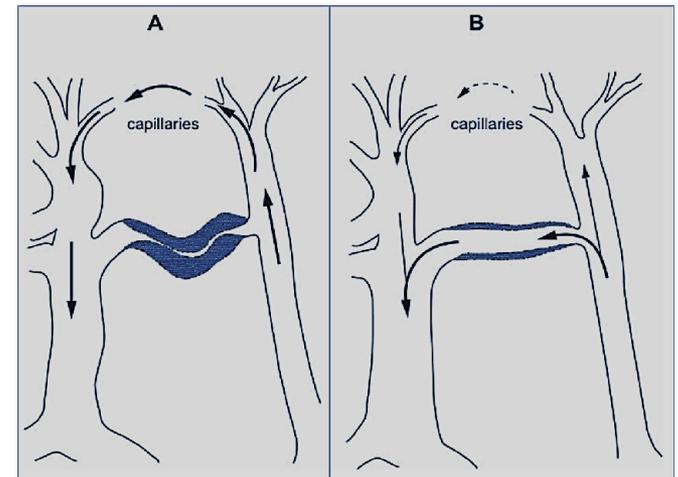
A- contraction of pre- capillary sphincters → Blood will pass through **thoroughfare channel**

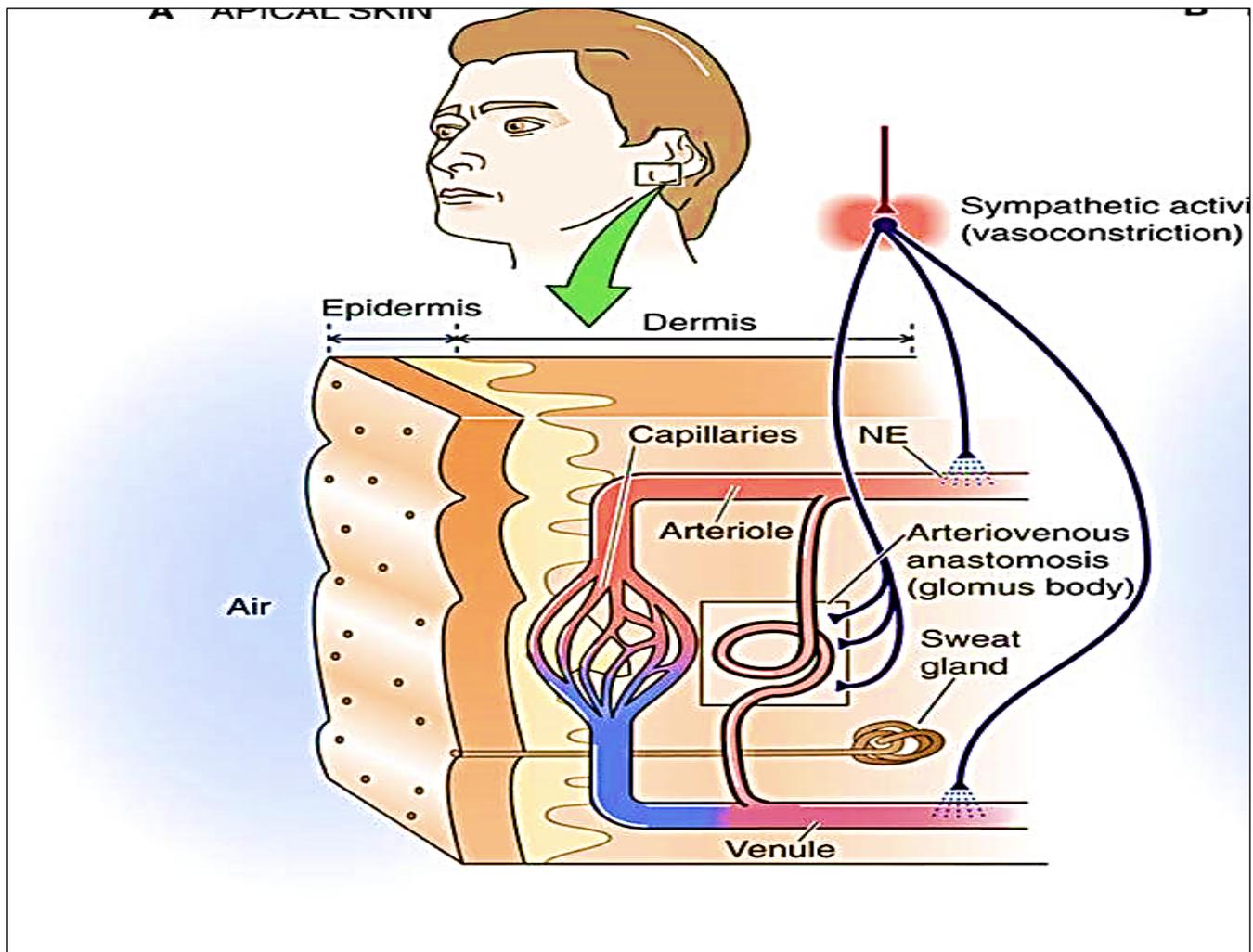


B- AV anastomosis: small vessels connect directly arterioles to venules



- 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





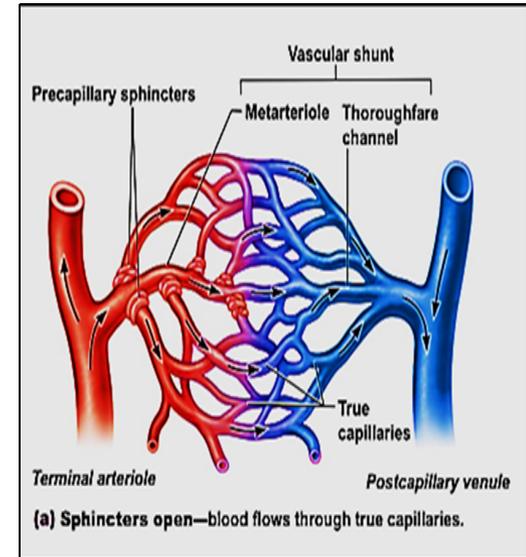
The glomus body

is an arteriovenous shunt that regulates temperature and blood flow throughout the body but most commonly in the fingertips and nail beds

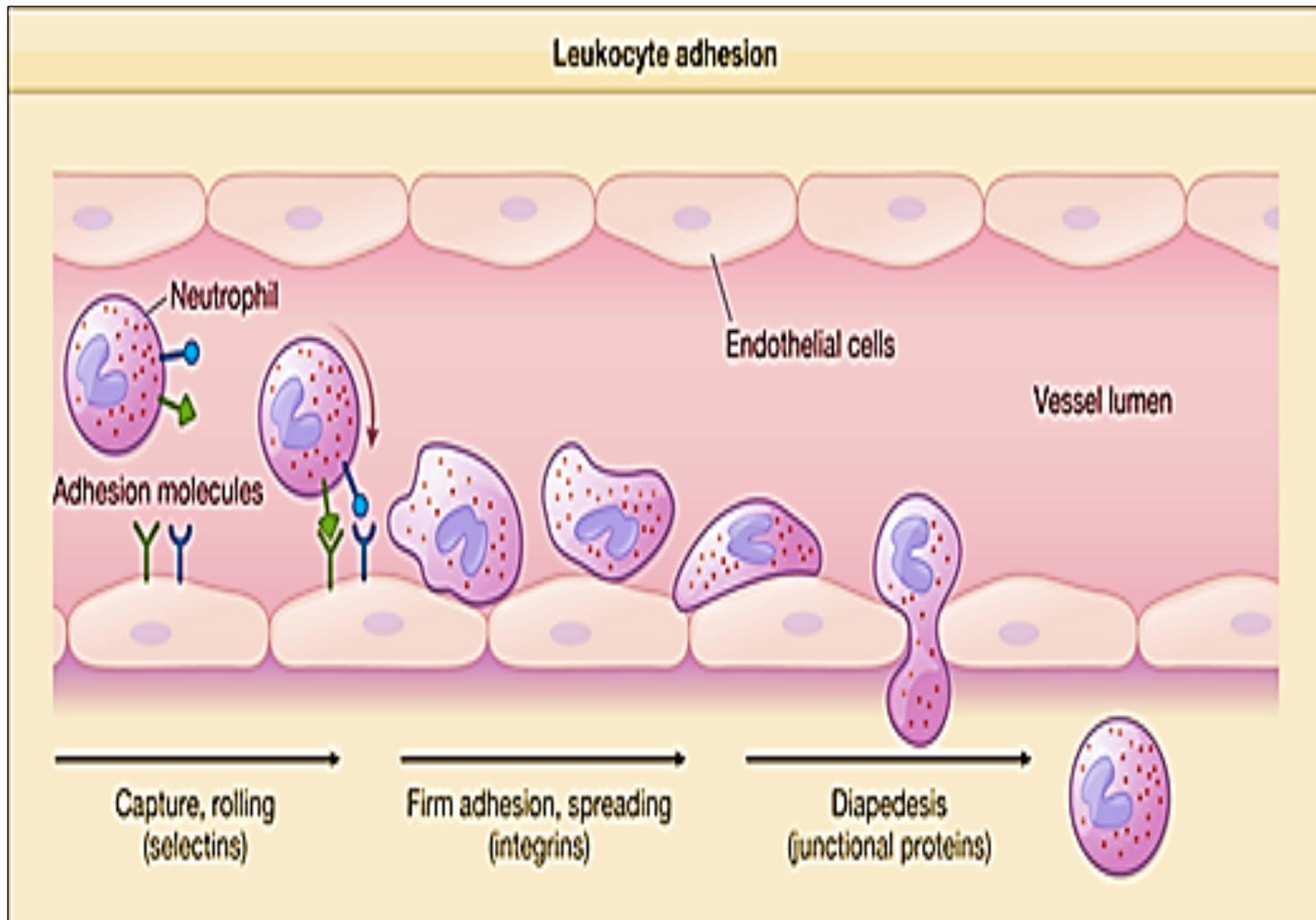
Post -capillary venules

- 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)

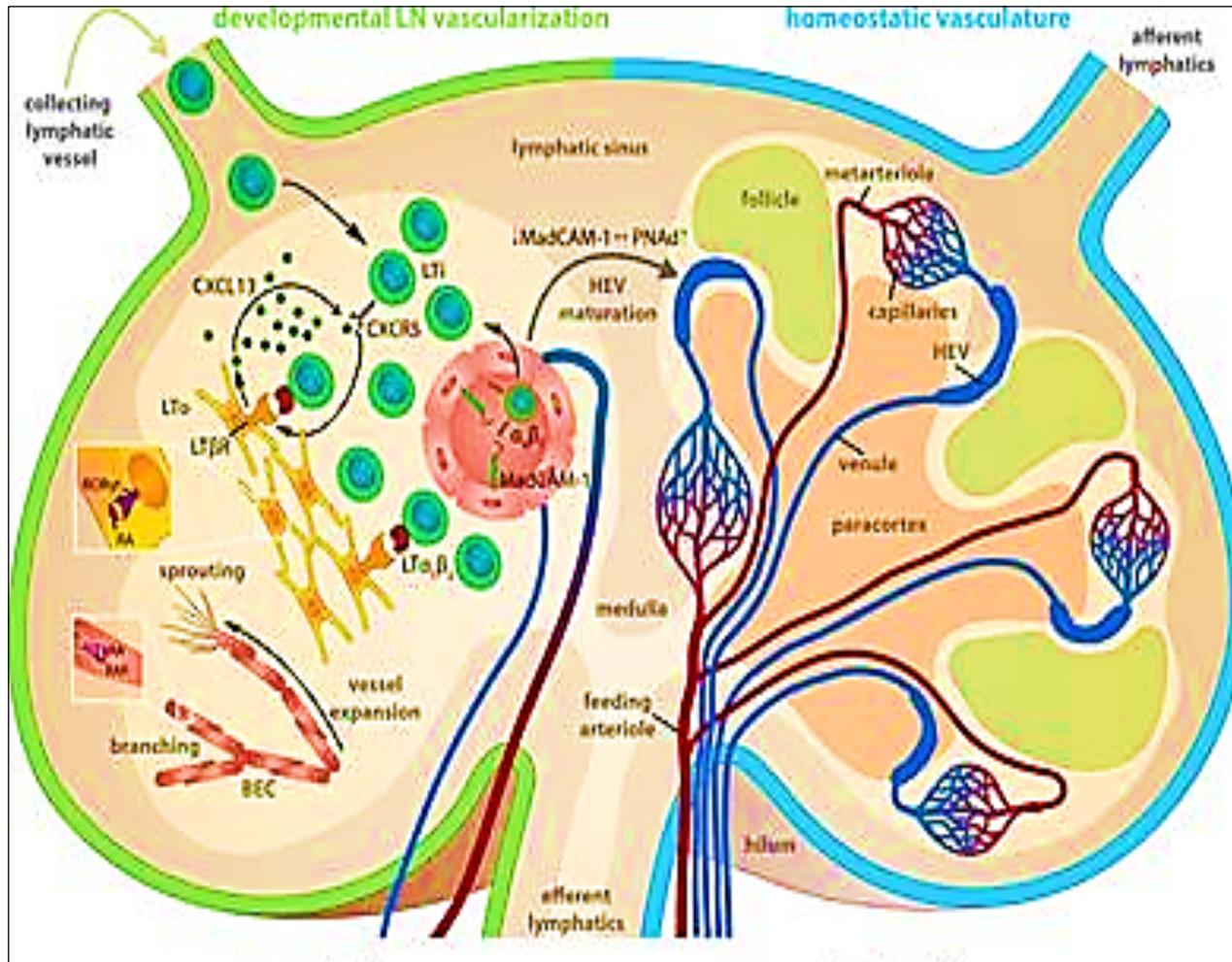


- They are the play imp. role in inflammation
- contain intercellular endothelial junctions that can open to allow plasma proteins and circulating cells (leukocytes) to escape from the bloodstream to site of inflammation called **leukocyte extravasation**



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)
- Respond to vasoactive agents e.g. histamine H., also site of exchange of materials between tissue fluid & blood
- The venules converge to form collecting venules → muscular veins



High endothelial venule in Paracortex of lymph node

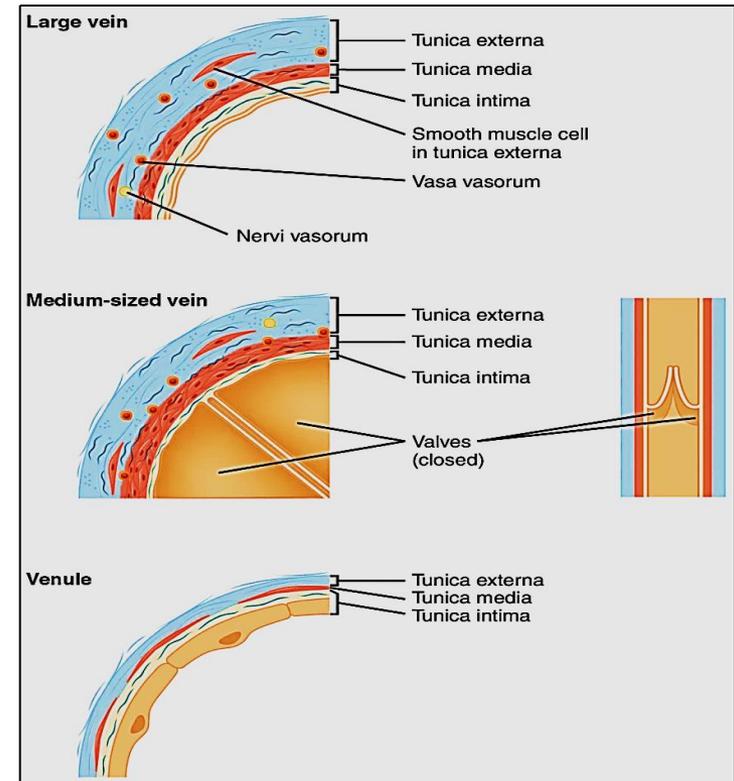
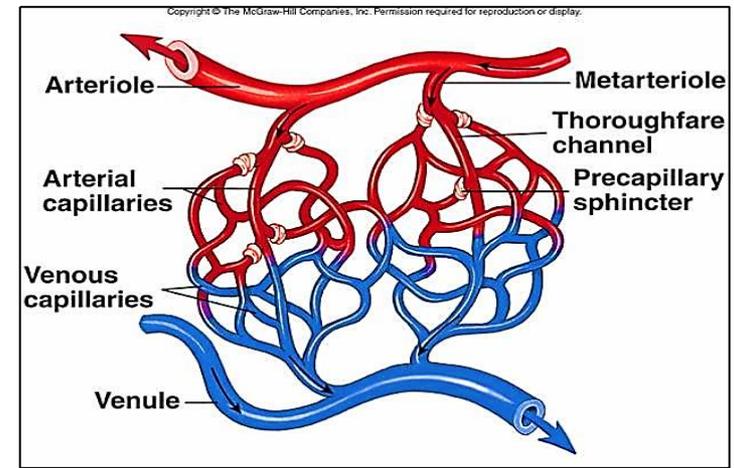
venules

- The smallest veins (20- 30 μm)

Intima: endothelium

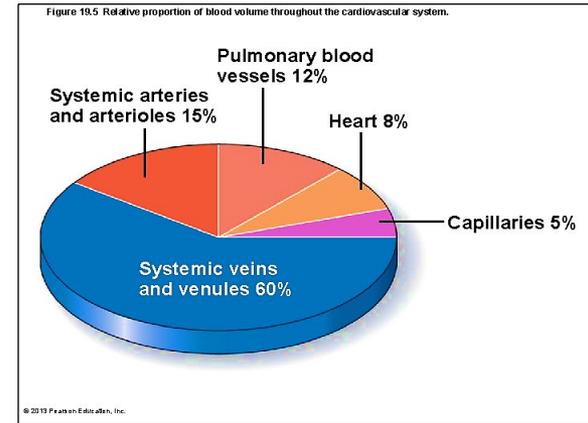
Media: 1 or 2 layers of smooth ms. cells, The thickness \uparrow as the vessel diameter increased

Adventitia: relatively thick



Medium size veins

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

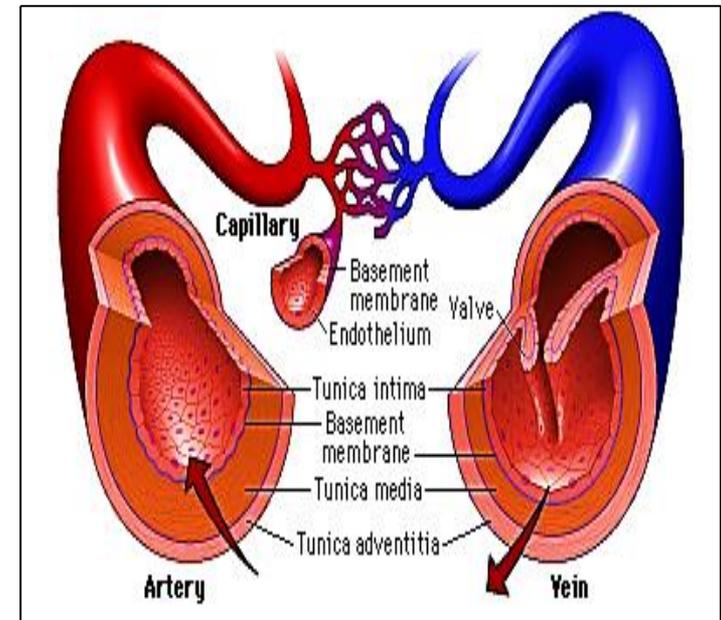


- Veins have 3 tunics, but thinner walls with wider lumen comparing with corresponding arteries... cuz they can hold most of the blood, called capacitance vessels

- Tunica media is thin , adventitia is thick

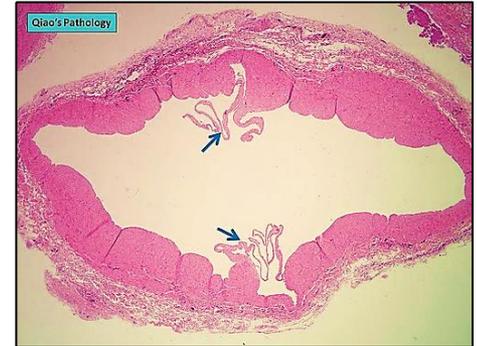
- **Valves are** special adaptation in the veins helps return of blood to heart & prevents its back flow

- **Valves are absent in small & large veins**

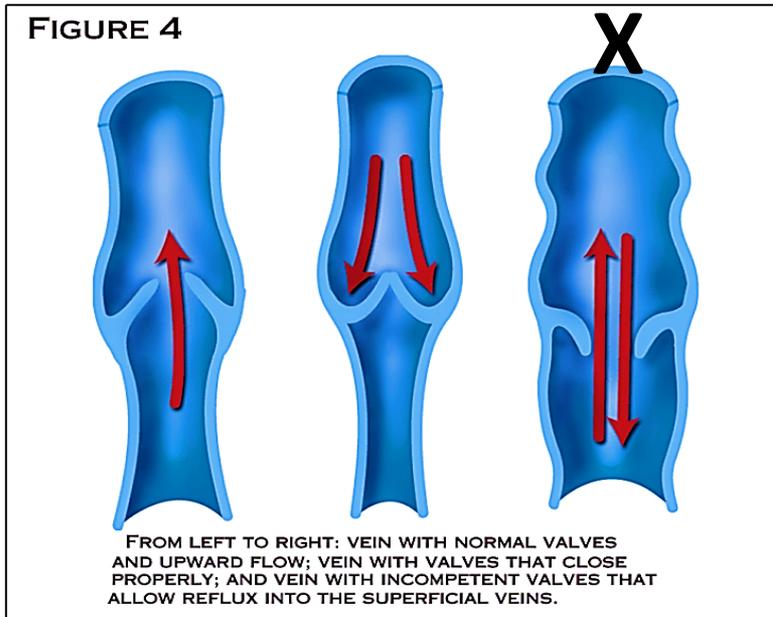


Valves:

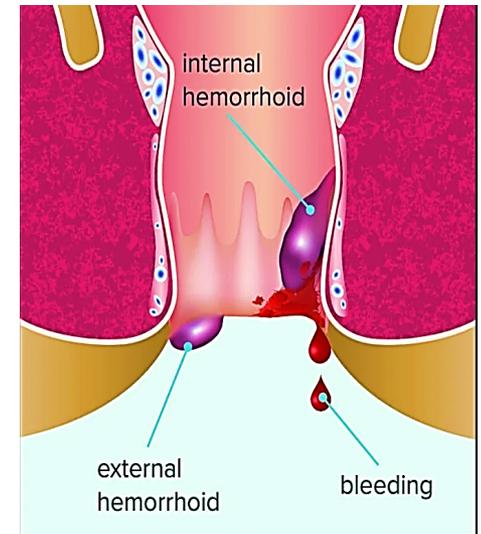
- are folds project from intima into lumen of the vein
- Lined on both sides by endothelium,
- their core formed of elastic tissue
- Valves Are most abundant in veins of limbs



Valves



Varicose veins



Hemorrhoids

Vena cava (inferior & superior)

Tunica intima: thin

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

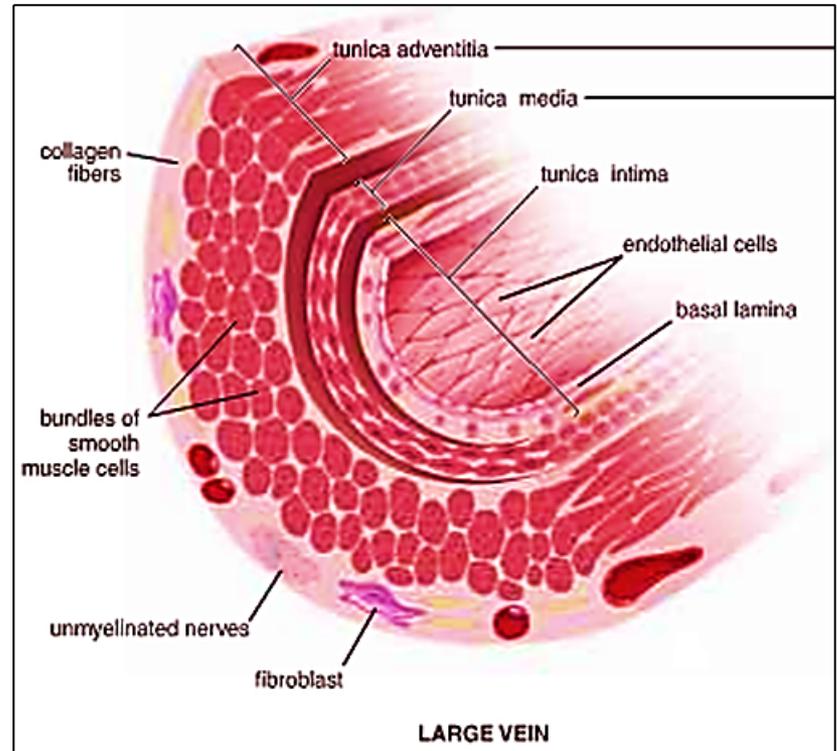
Tunica media:

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.



Medium sized

artery

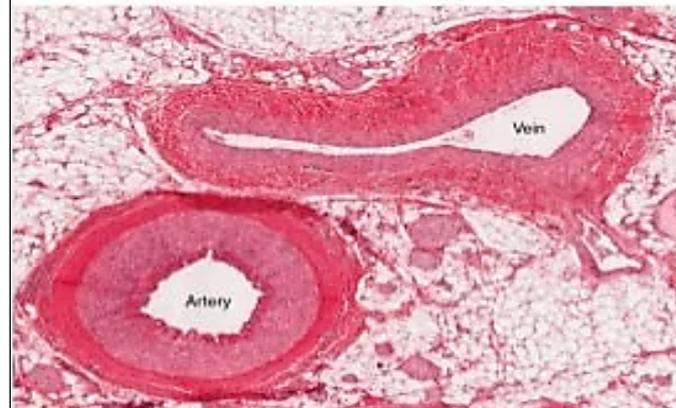
and

vein

- **Narrow lumen**
- **Thick wall**
- **No valves**
- **Intima (thick, IEL)**
- **Media (thickest)**
- **Adventitia equal to media**
- **Rapid flow of blood**

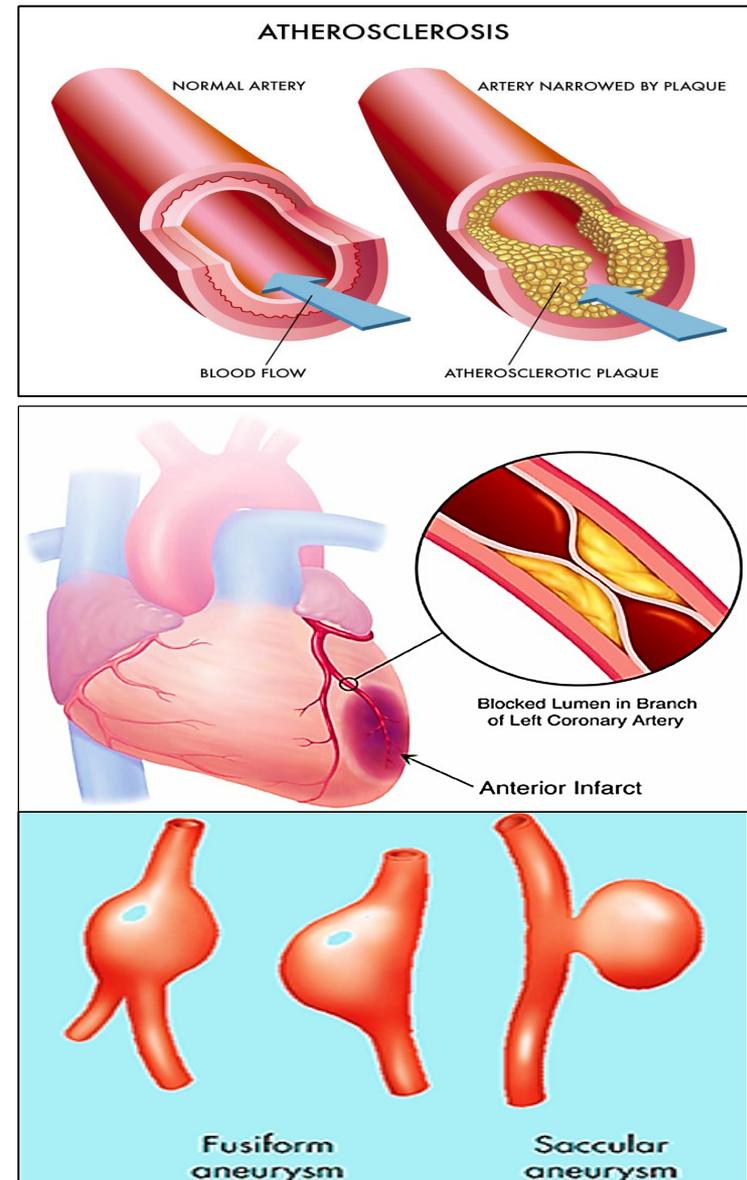
- **Wide lumen**
- **Thin wall**
- **Valves**
- **Thin, no IEL**
- **Media (thin)**
- **Thick compare to media**
- **Slow flow of blood**

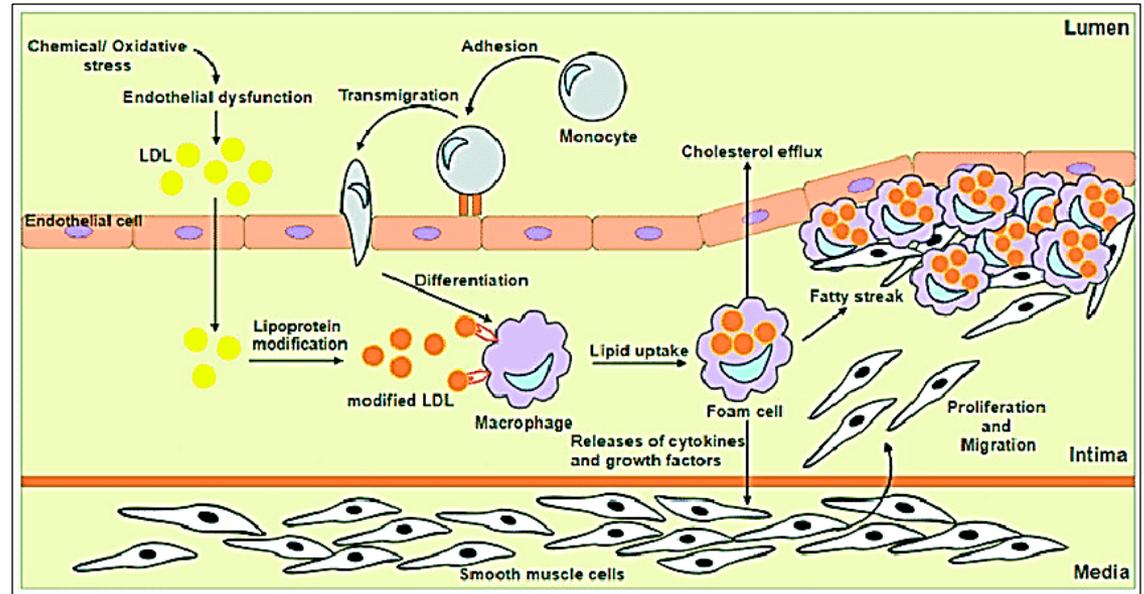
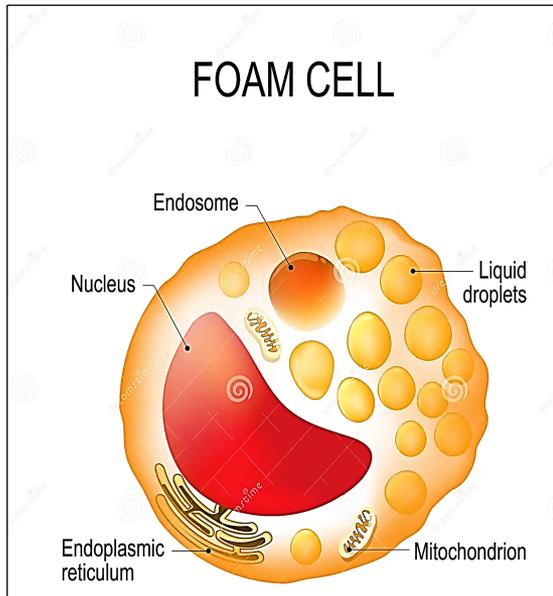
Vessels: Histology



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.





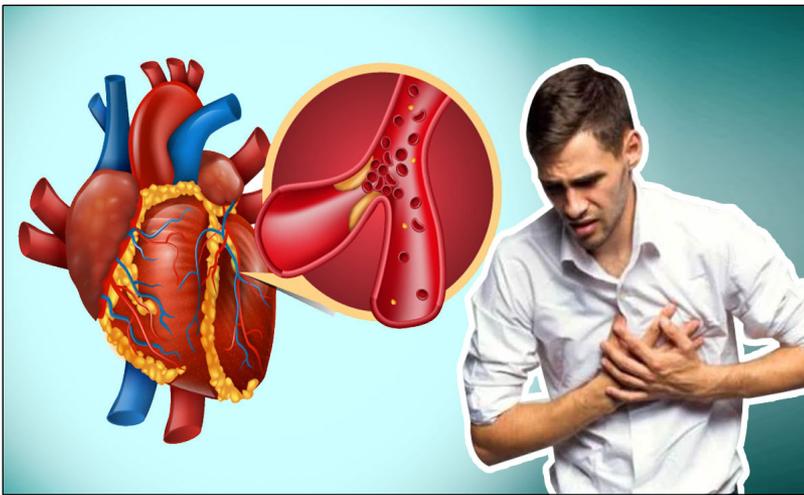
Foam cells

Atherosclerosis: when the endothelial cells damage → ↑ permeability of arterial wall → LDL enter to tunica intima → damaged endothelial cell will attract WBCs , WBCs will squeeze itself and enter by diapedesis to reach intima layer. WBCs will release free radicals that will oxidize LDL molecules.

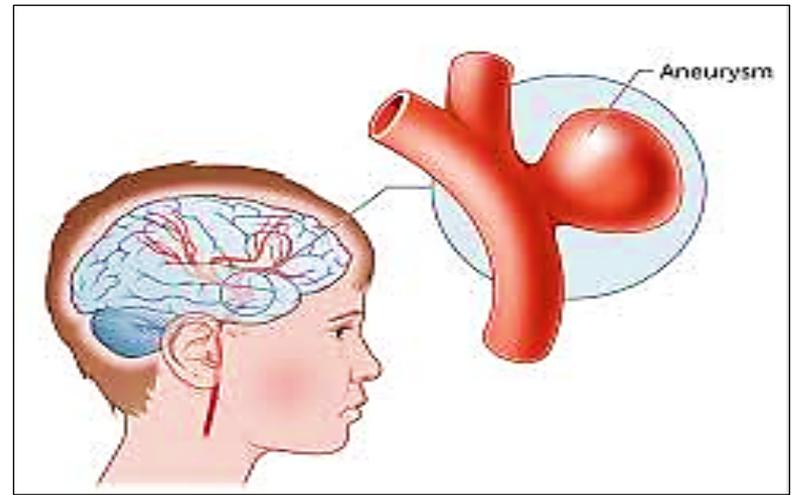
Macrophages will start to engulf the LDL particles → foamy appearance

Accumulating lipid & dead cells & migration of muscle cells from media layer will form plaque, the plaque will deposit Ca^{+} → hardening of the wall as atherosclerosis .

If endothelial over the plaque is compromised blood clots can form (thrombus) which may break → emboli

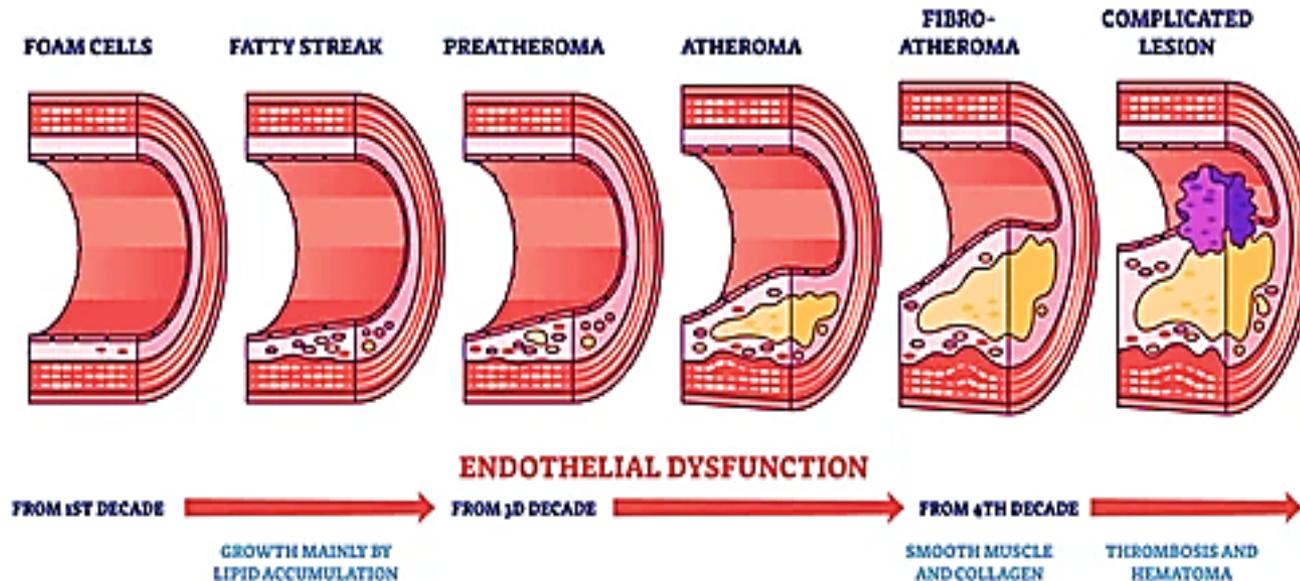


Myocardial infarction



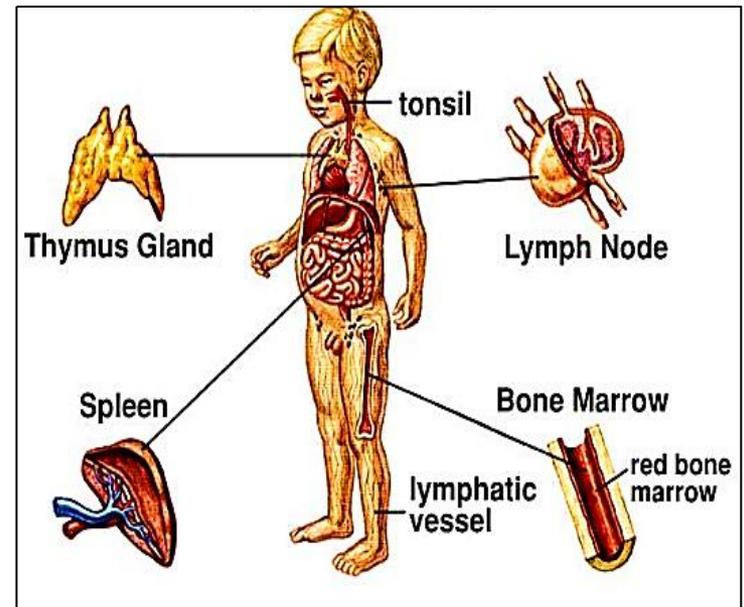
Rupture aneurysm

PROGRESSION OF ATHEROSCLEROSIS



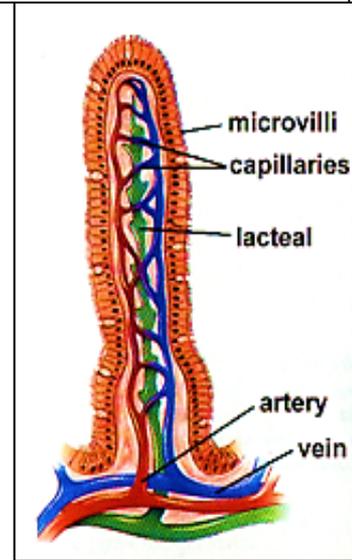
Lymphatic system consists of:

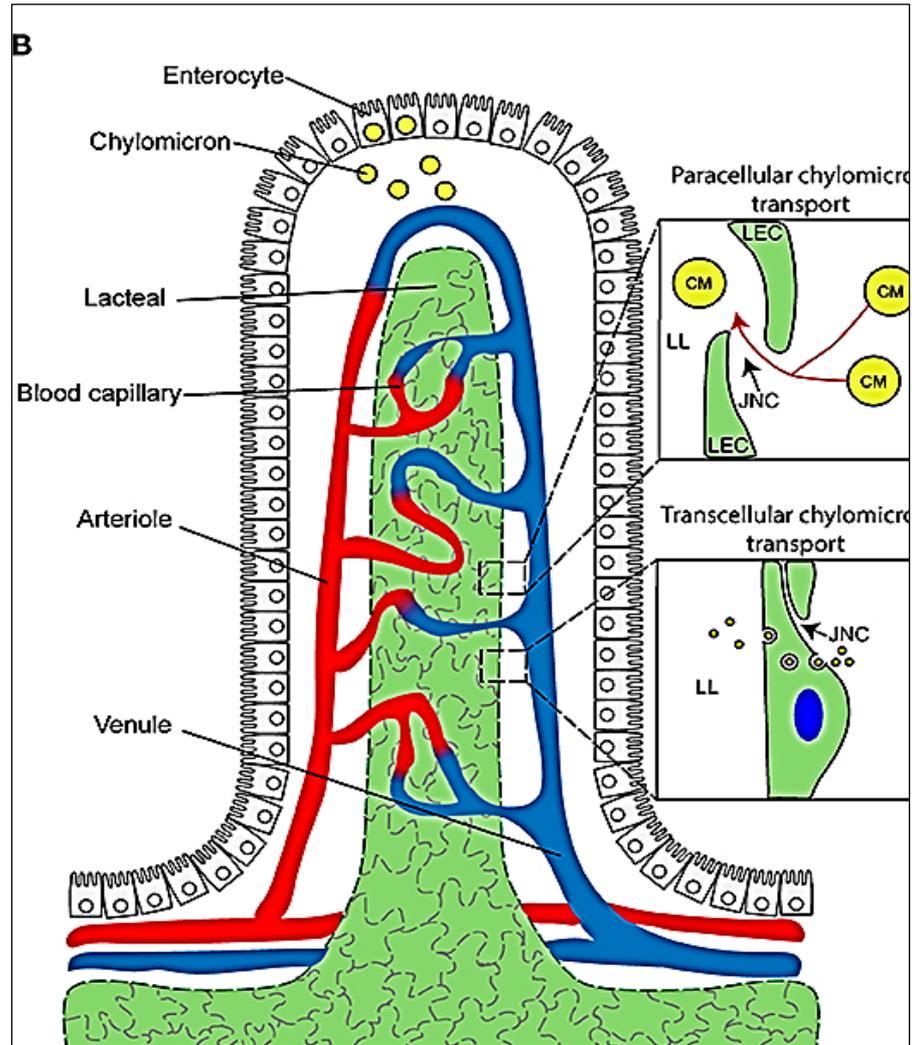
- Lymph fluid
- Lymphatic vessels
- Lymphoid tissues & organs



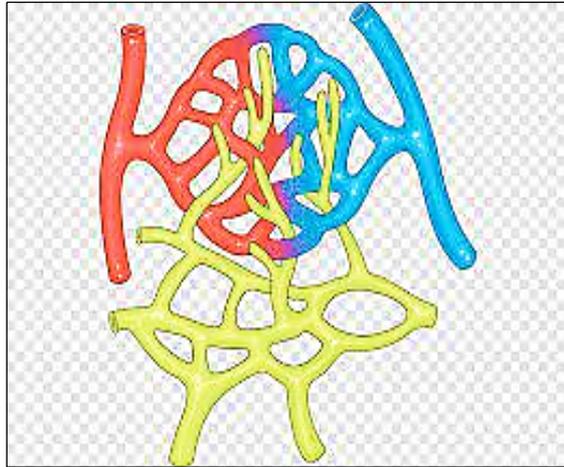
Function of lymphatic system :

- 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





Lacteal = lymphatic capillary



Lymphatic vessels

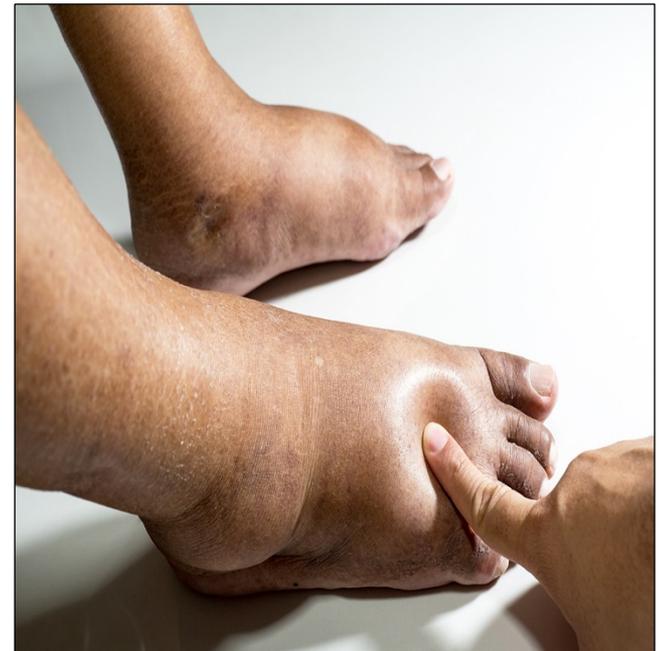
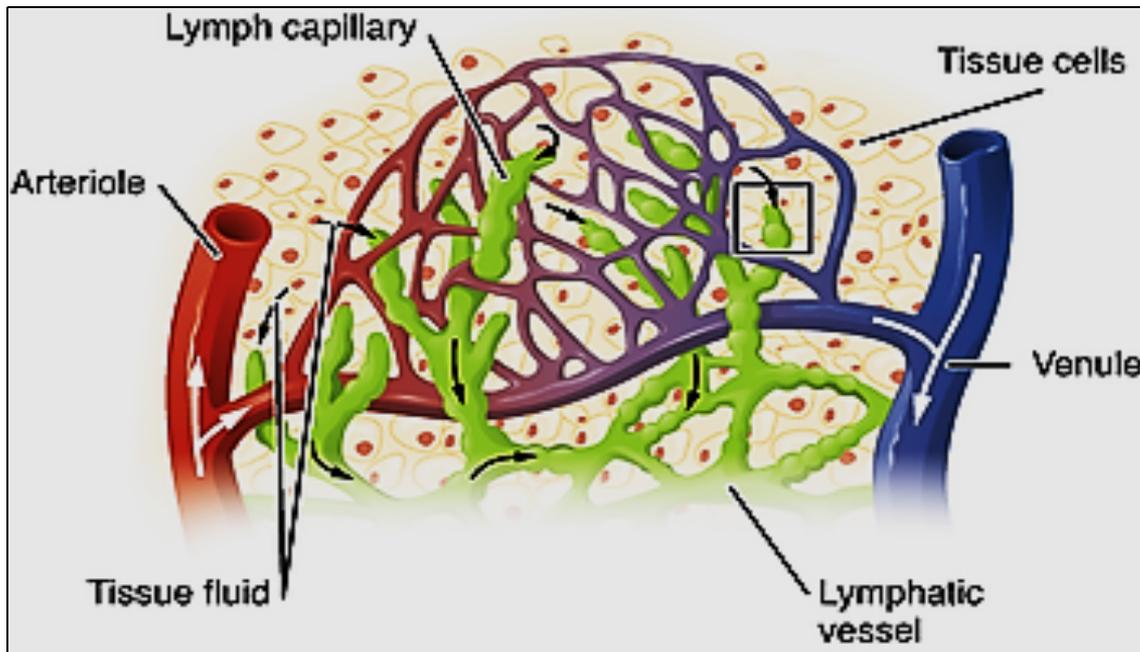
L. Capillaries
(Blind ended)

**Medium
size L.
vessels**
(Valves)

L. Ducts
(like veins)

Lymph

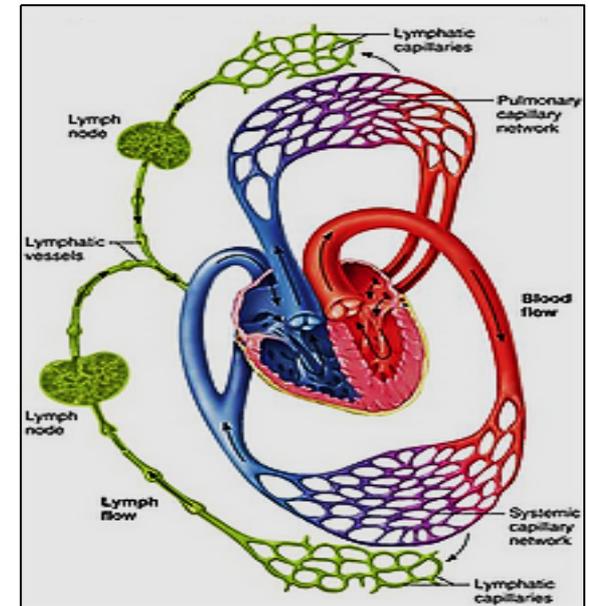
- **Lymph** is a colorless fluid that circulates through the lymphatic system
- The lymph is formed when the interstitial fluid is collected through lymph capillaries



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

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

- Lymph returns proteins and excess interstitial fluid back to the blood stream. Venous blood



- 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



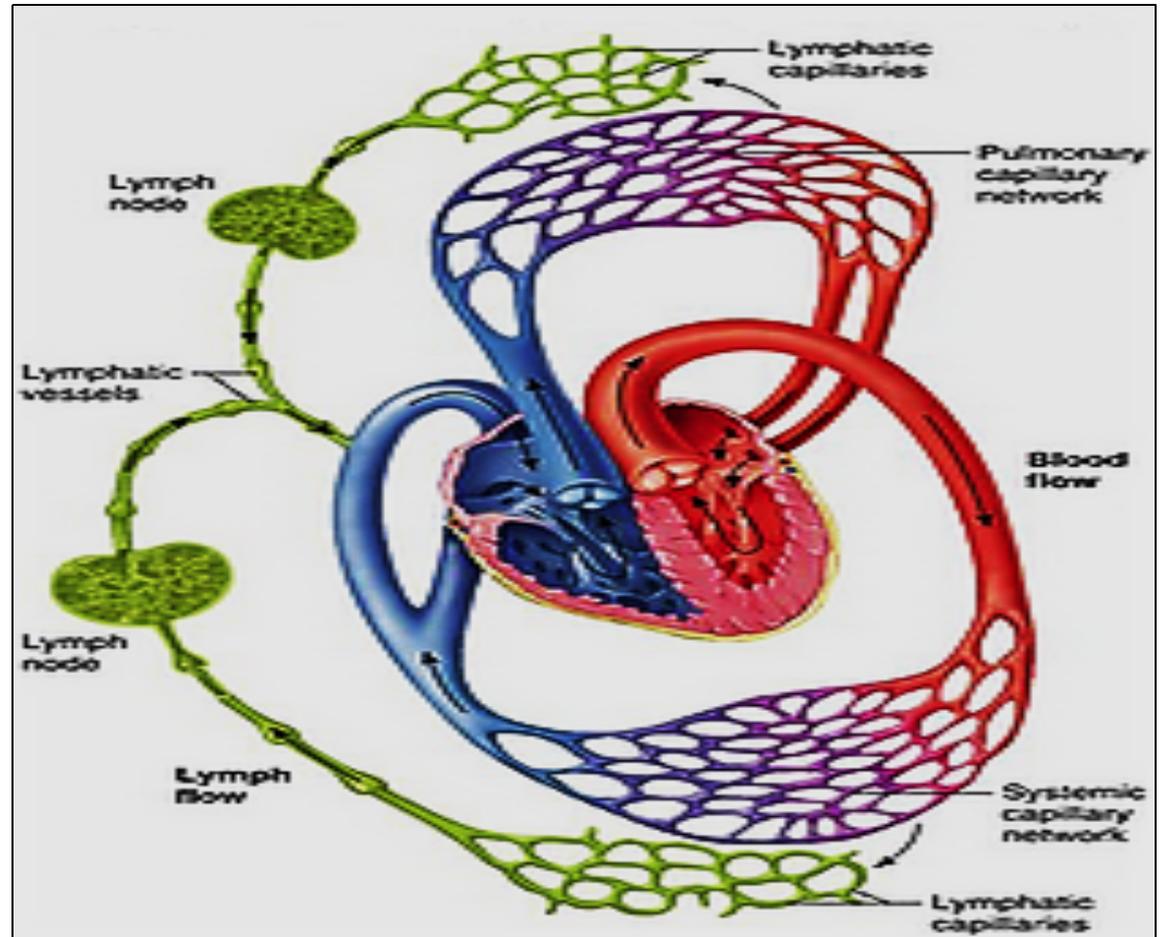
Lymphatic vessels



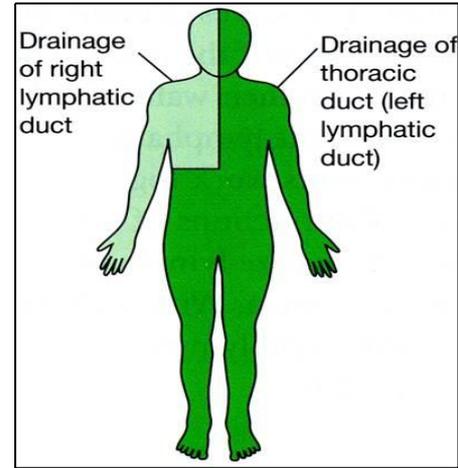
Lymphatic duct



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



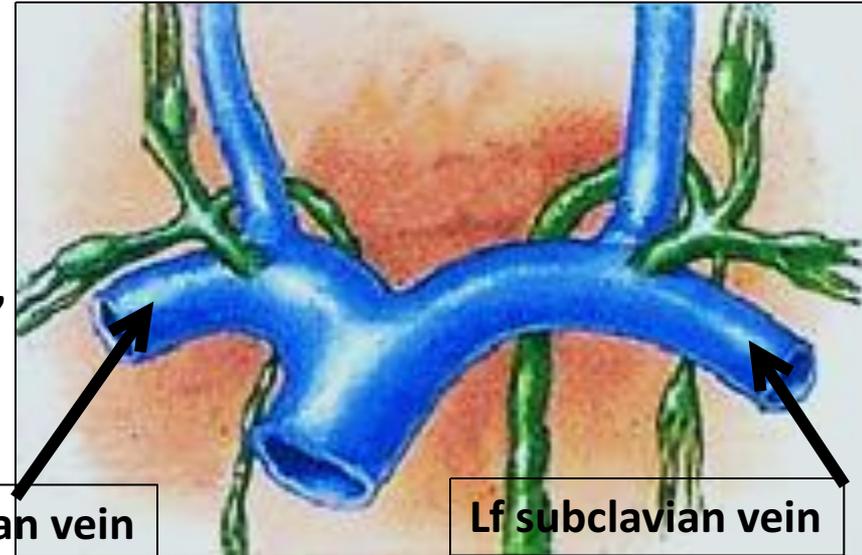
- lymph vessels similar to veins in structure
One direction & contain valves
- they pass through the lymph nodes where filtration of the lymph from bacteria occurs



- Lymphatic vessels ultimately drain lymph into 2 main ducts:

➤ Right lymphatic duct

Drains right side of head & neck, right arm, right thorax → into the right subclavian vein

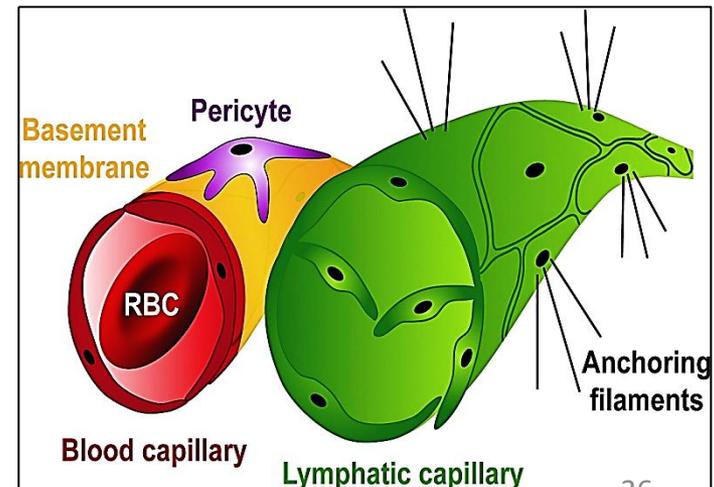
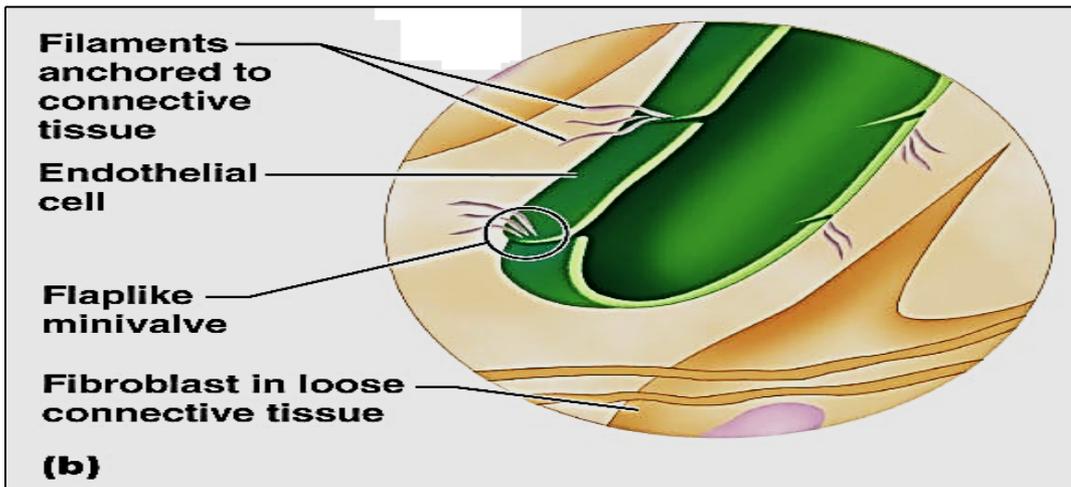
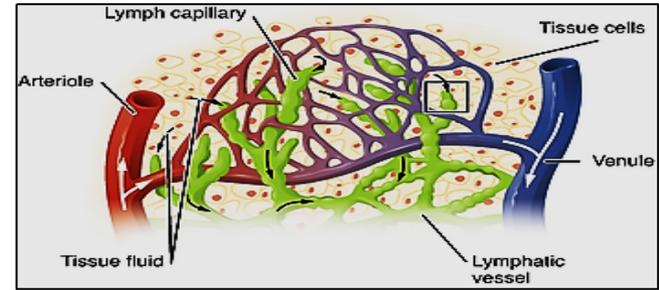


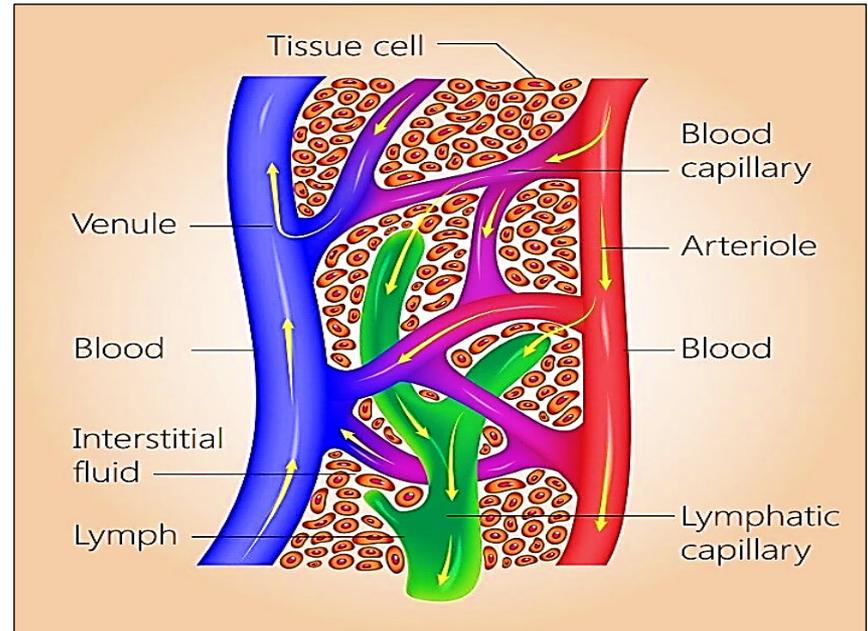
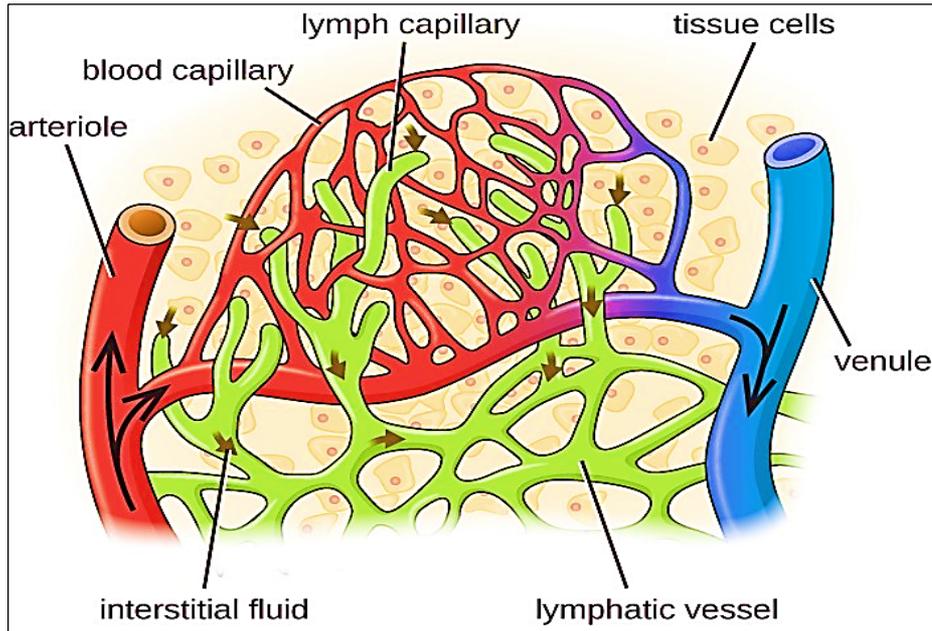
➤ Thoracic duct

Drains the rest of the body → into the left subclavian vein

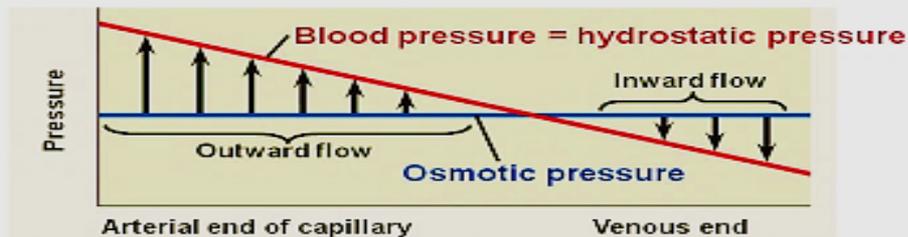
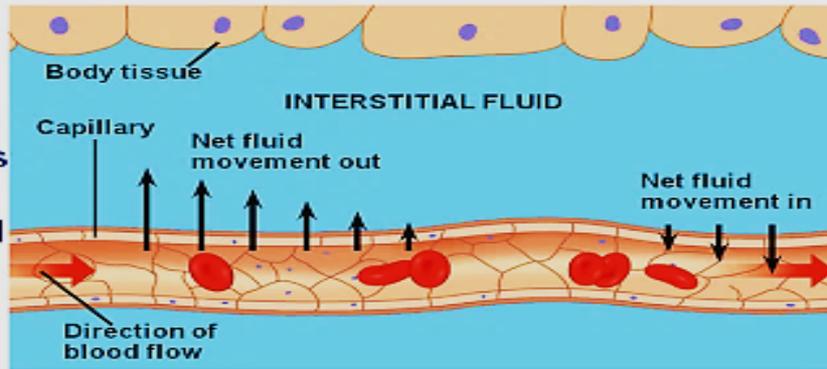
Structure of Lymphatic capillaries

- 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)

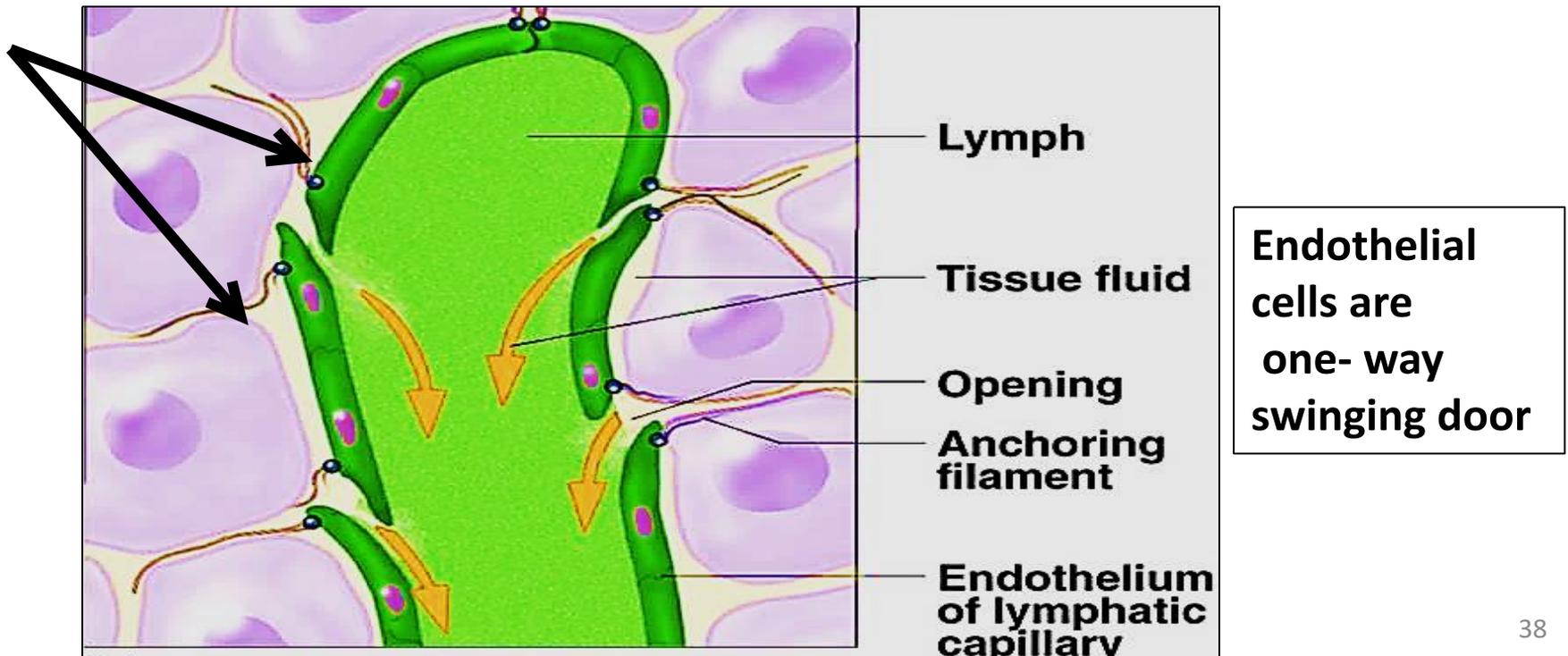


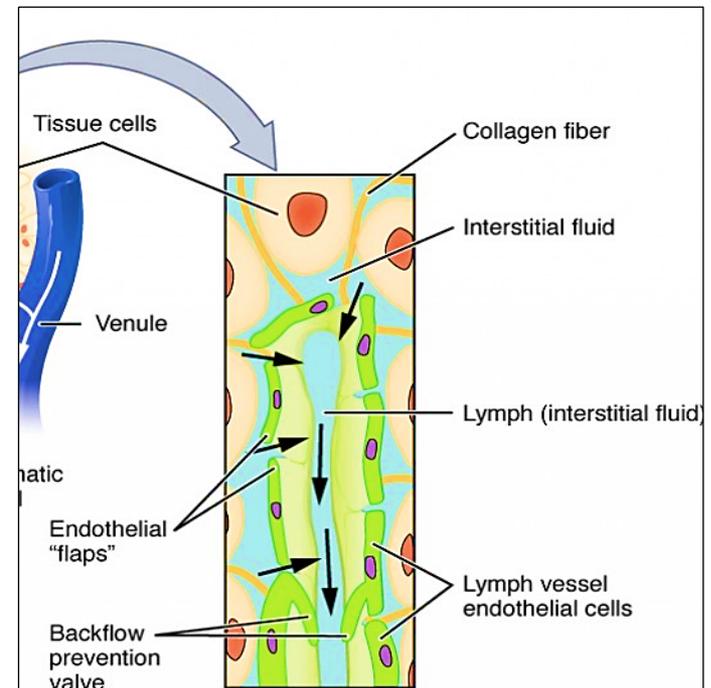
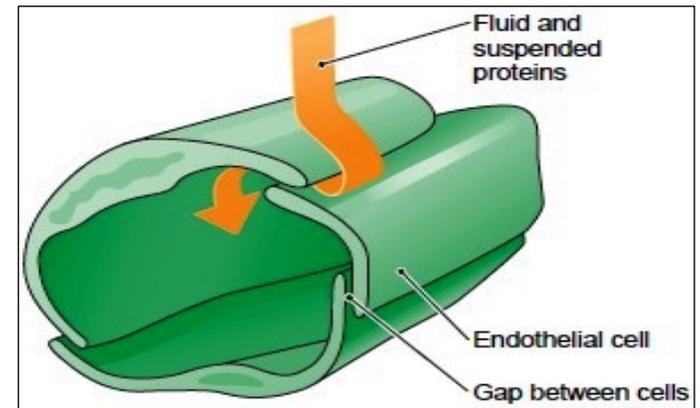
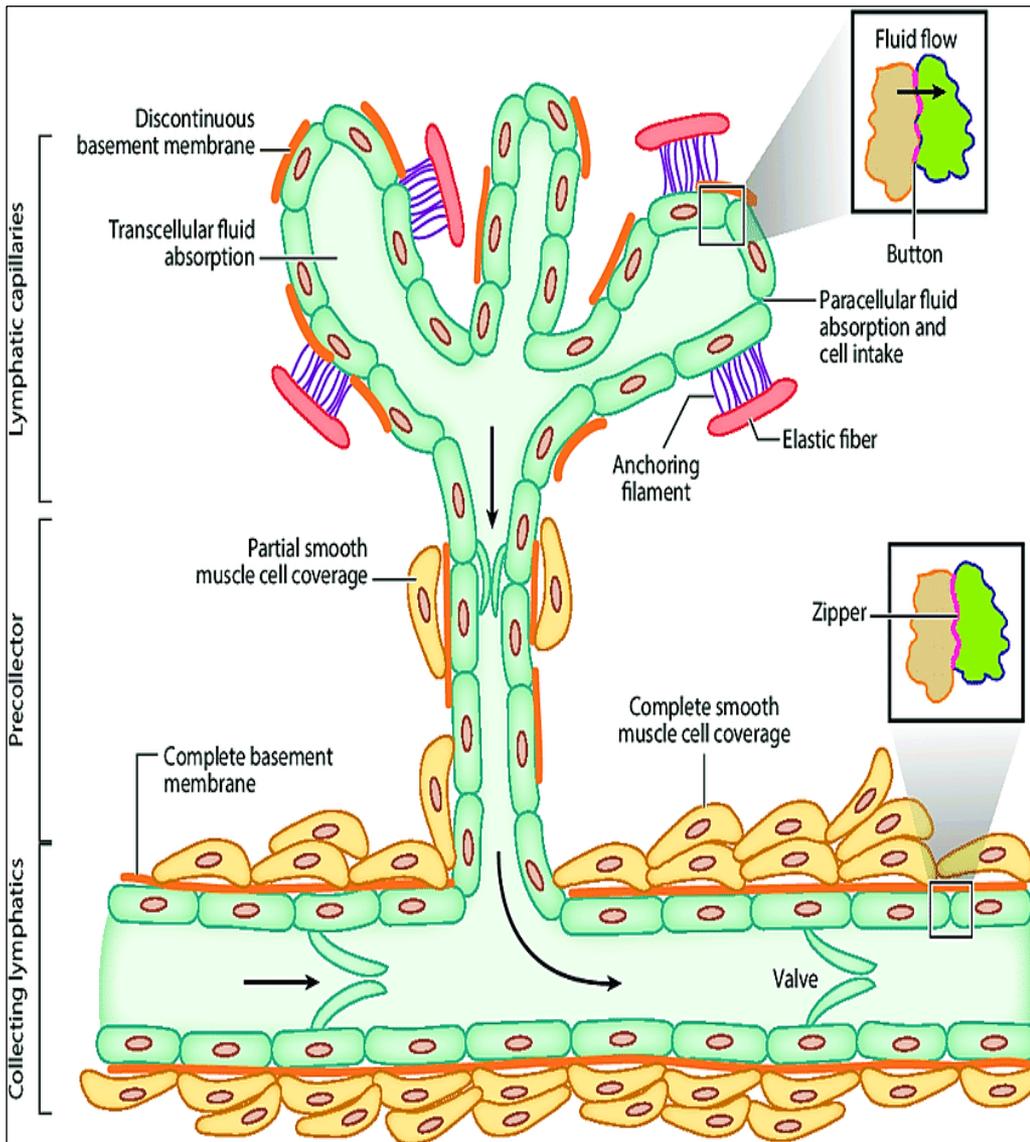


Fluid exchange between capillaries and the interstitial fluid



- Lymphatic endothelial cells attaches to anchoring filaments made of elastic fibers which:
 - 1- attach endothelial cells to surrounding tissue.
 - 2- pull on → widen gap between endothelial cells → draw more fluid into lymphatic capillary

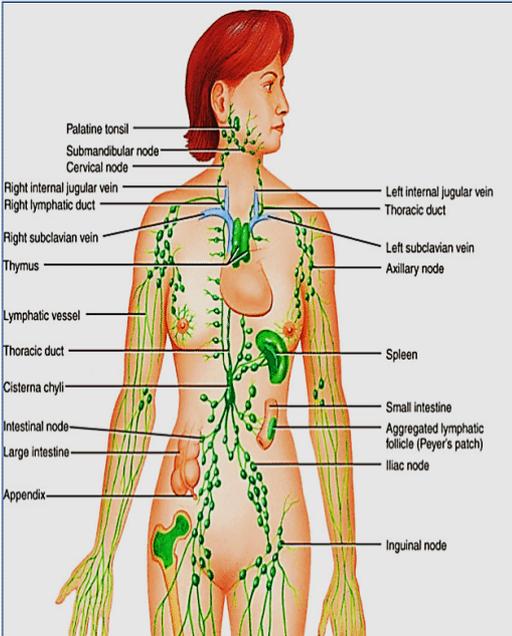




Lymphatic capillaries in relation to lymphatic vessels

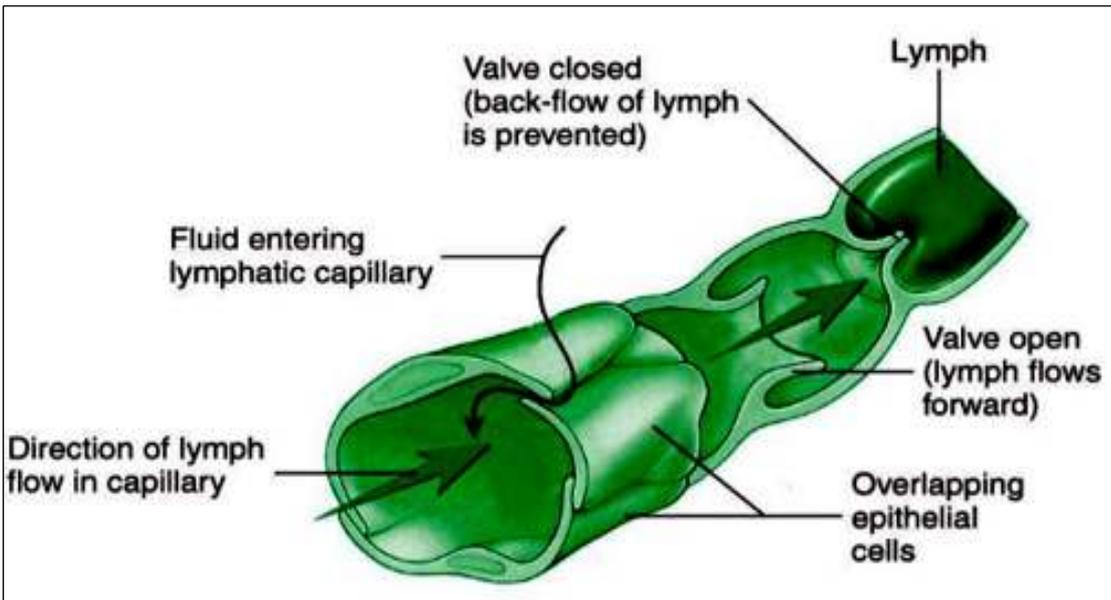
Structure of Lymphatic vessels:

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



Structure:

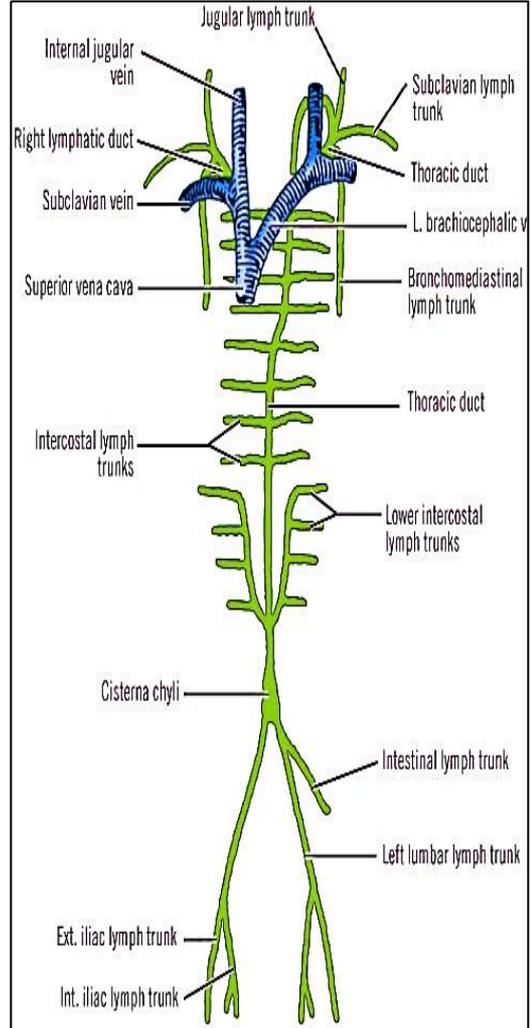
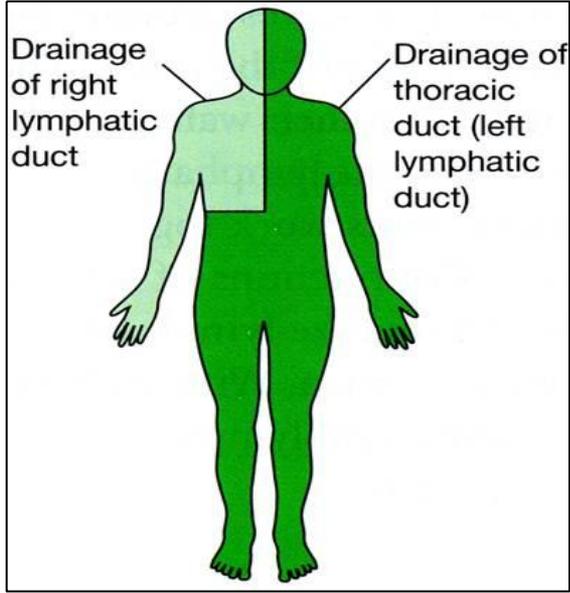
Endothelium / valves , media (few smooth muscle cells) - adventitia



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

