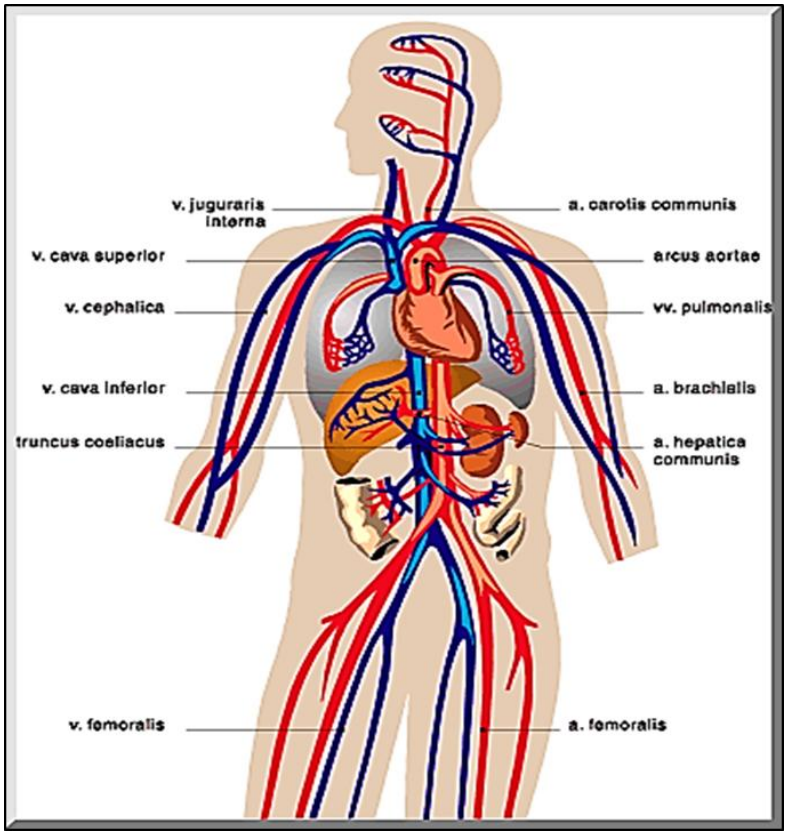
The vascular system Part II

Medical Students / First Year

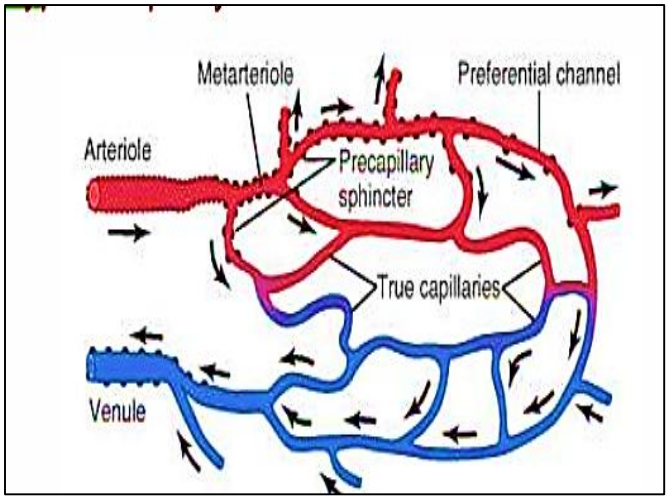
Professor Dr. Hala El-mazar



microcirculation

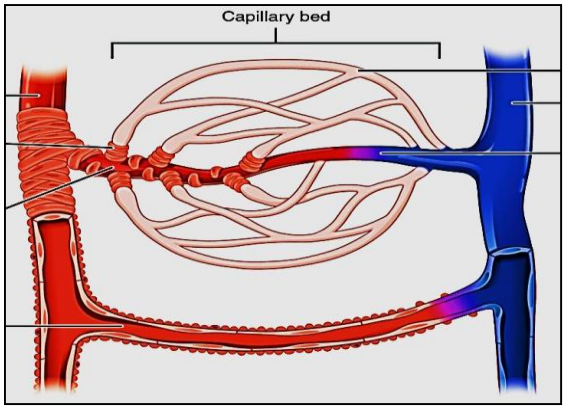
Composed of :

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

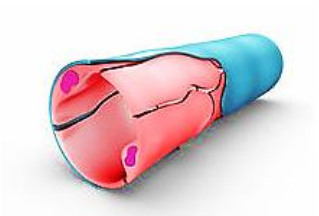


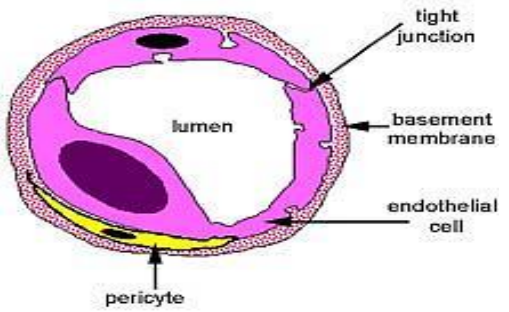
- Capillaries are where exchange between blood & tissue fluids occur

- 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 Barriers through the tight junctions between the endothelial cells

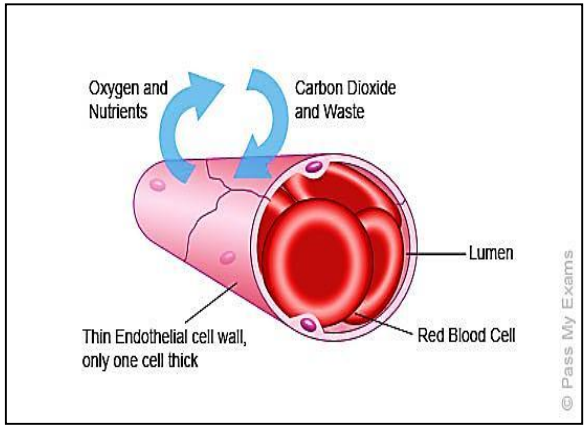
2. Metabolic function:

- 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. Non-thrombogenic 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

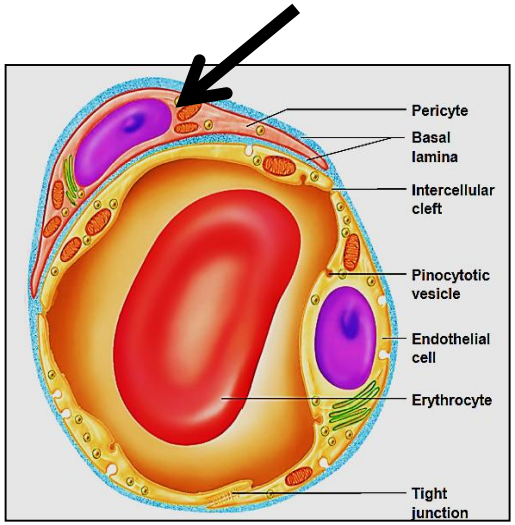
Capillaries

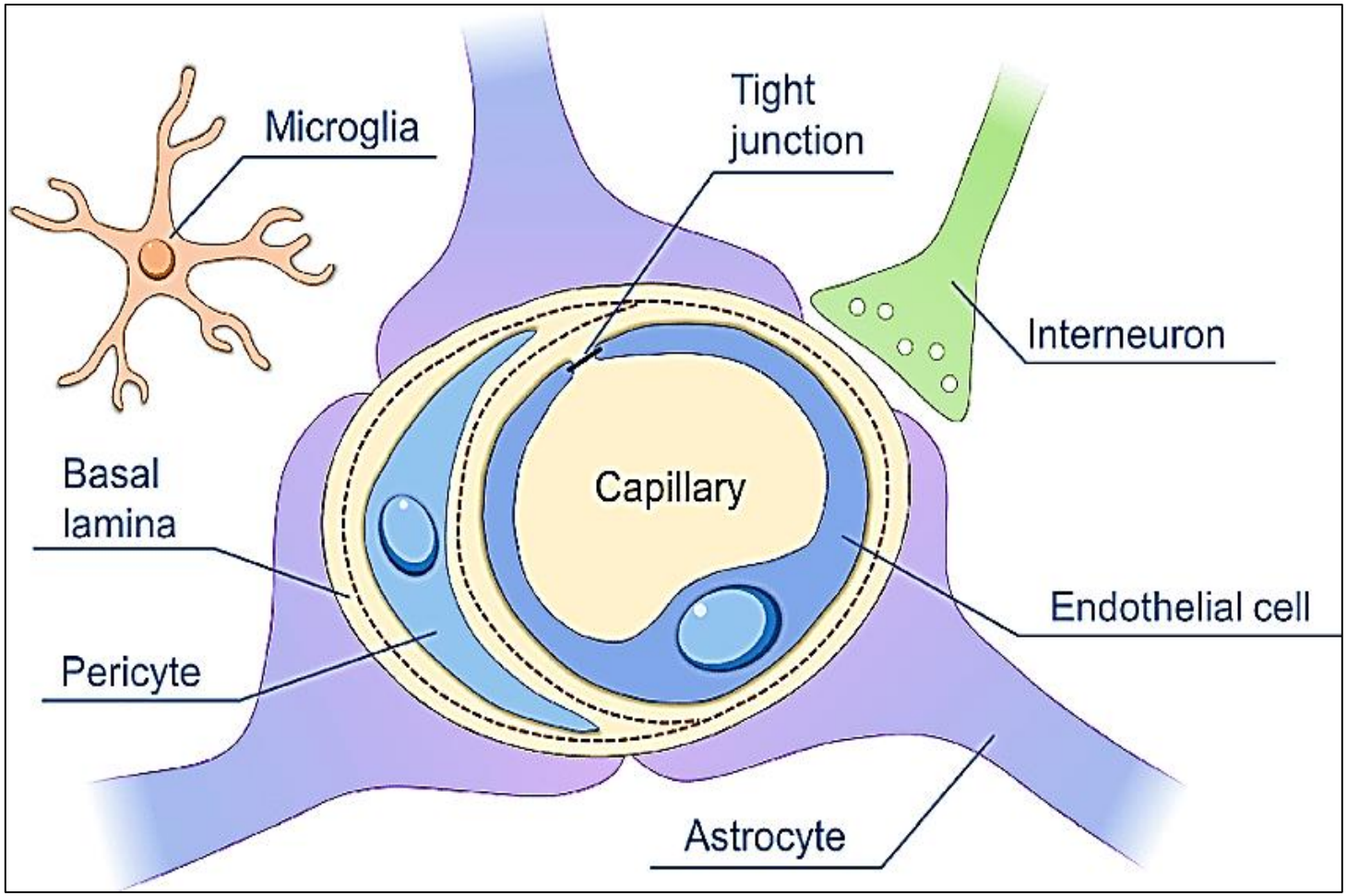


- the smallest blood vessels 5- 8 µm

- 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

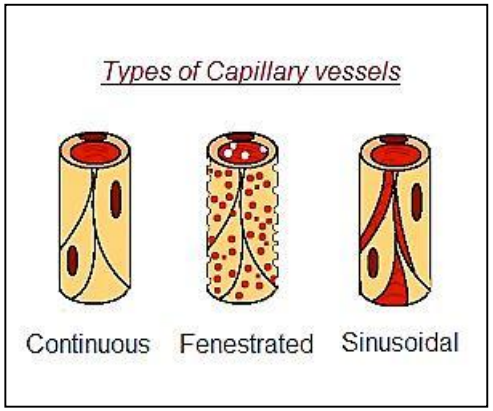
Pericytes: branched cells, stabilize capillary wall, control permeability (contract) , blood flow, play role in vessel repair

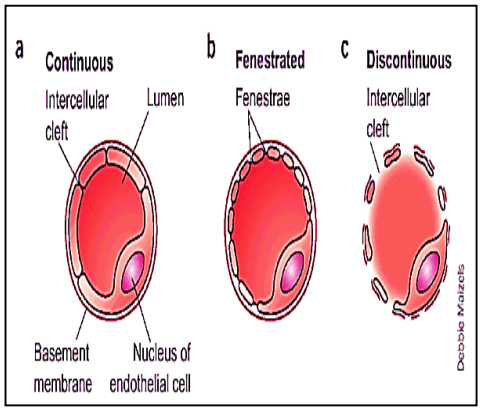




Pericytes in relation to endothelial cell in capillaries

Types of capillaries



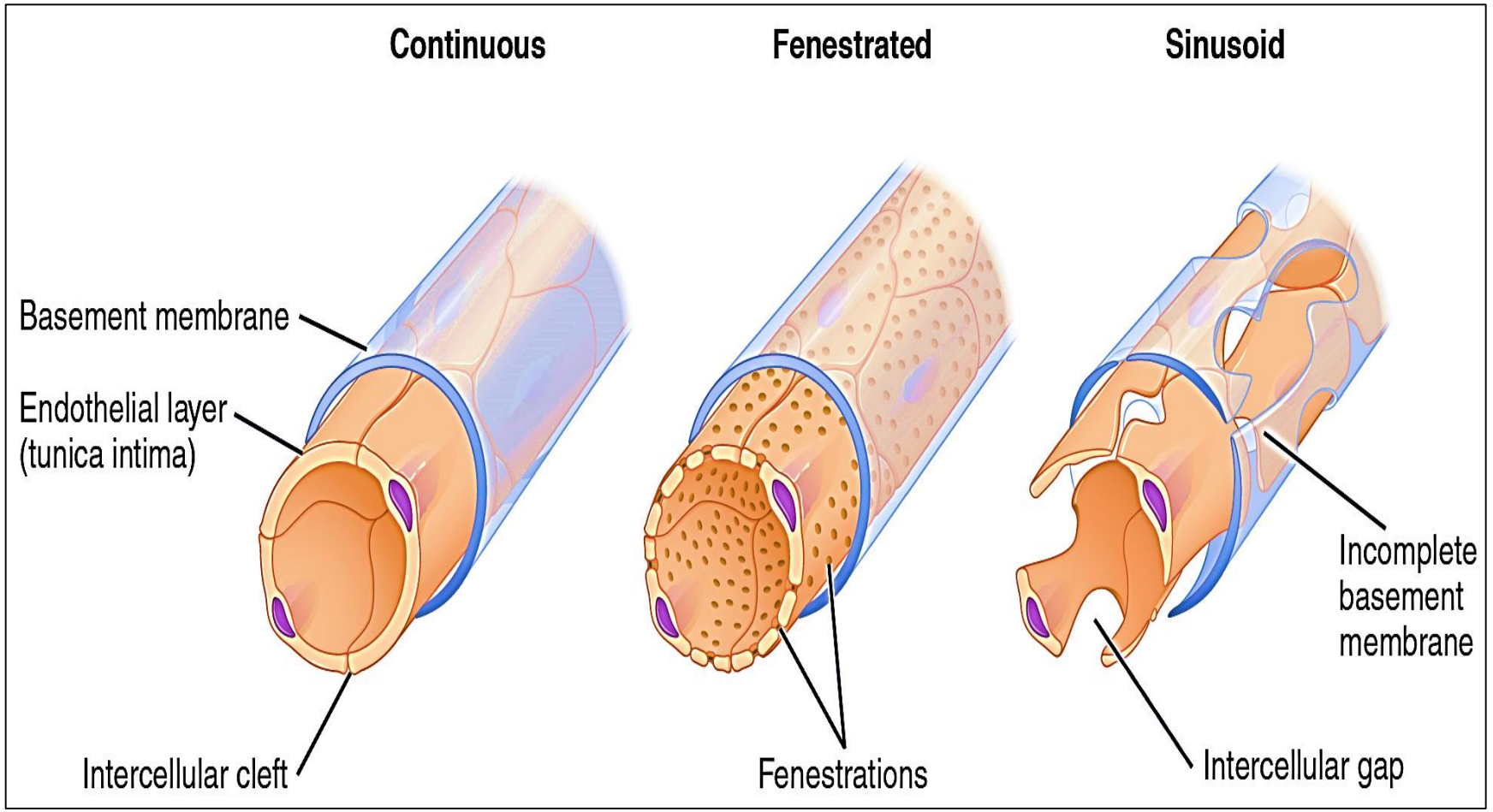


Continuous (Somatic)

Fenestrated (Visceral)

Discontinues (Sinusoidal)

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



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: Kidney glomeruli,

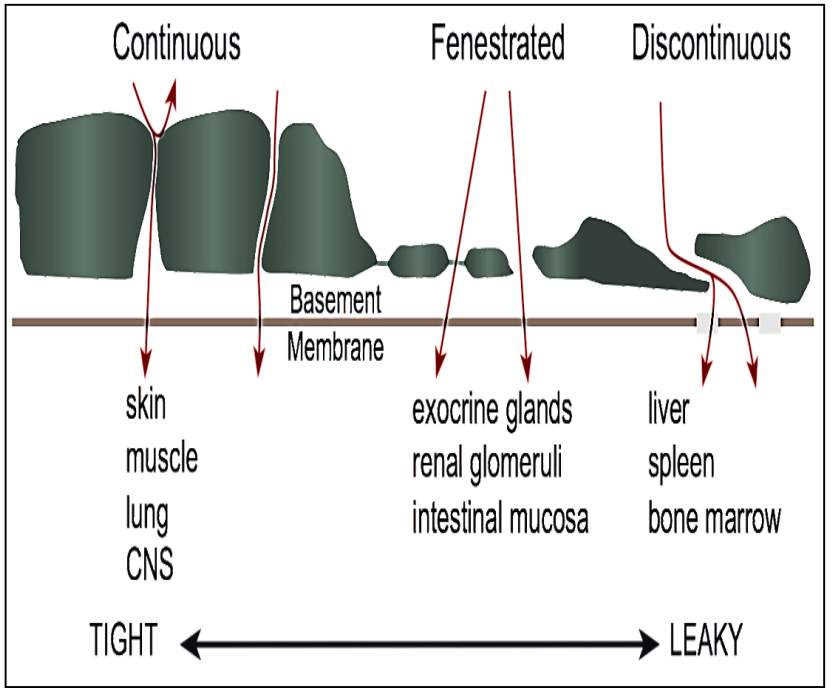
Diaphragm: intestine & endocrine G

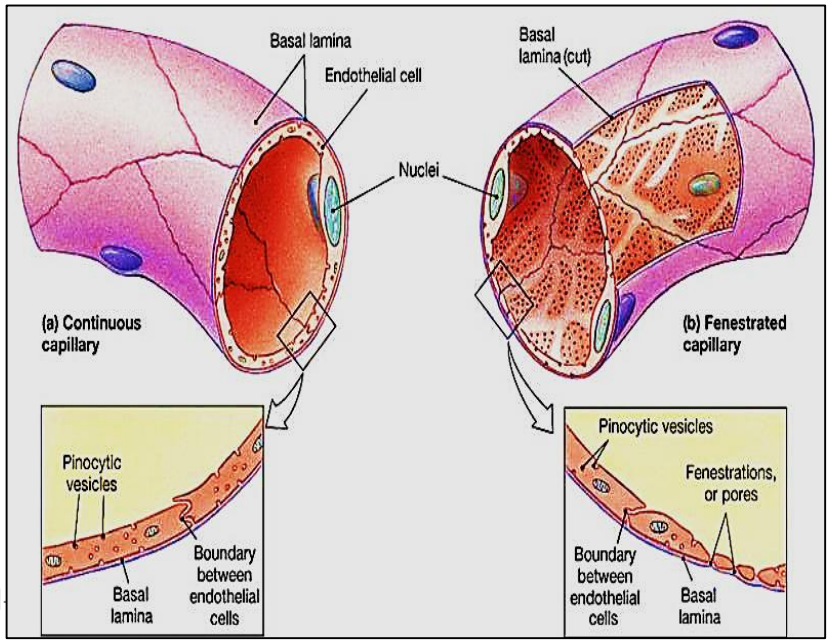
- **Sinusoidal**:

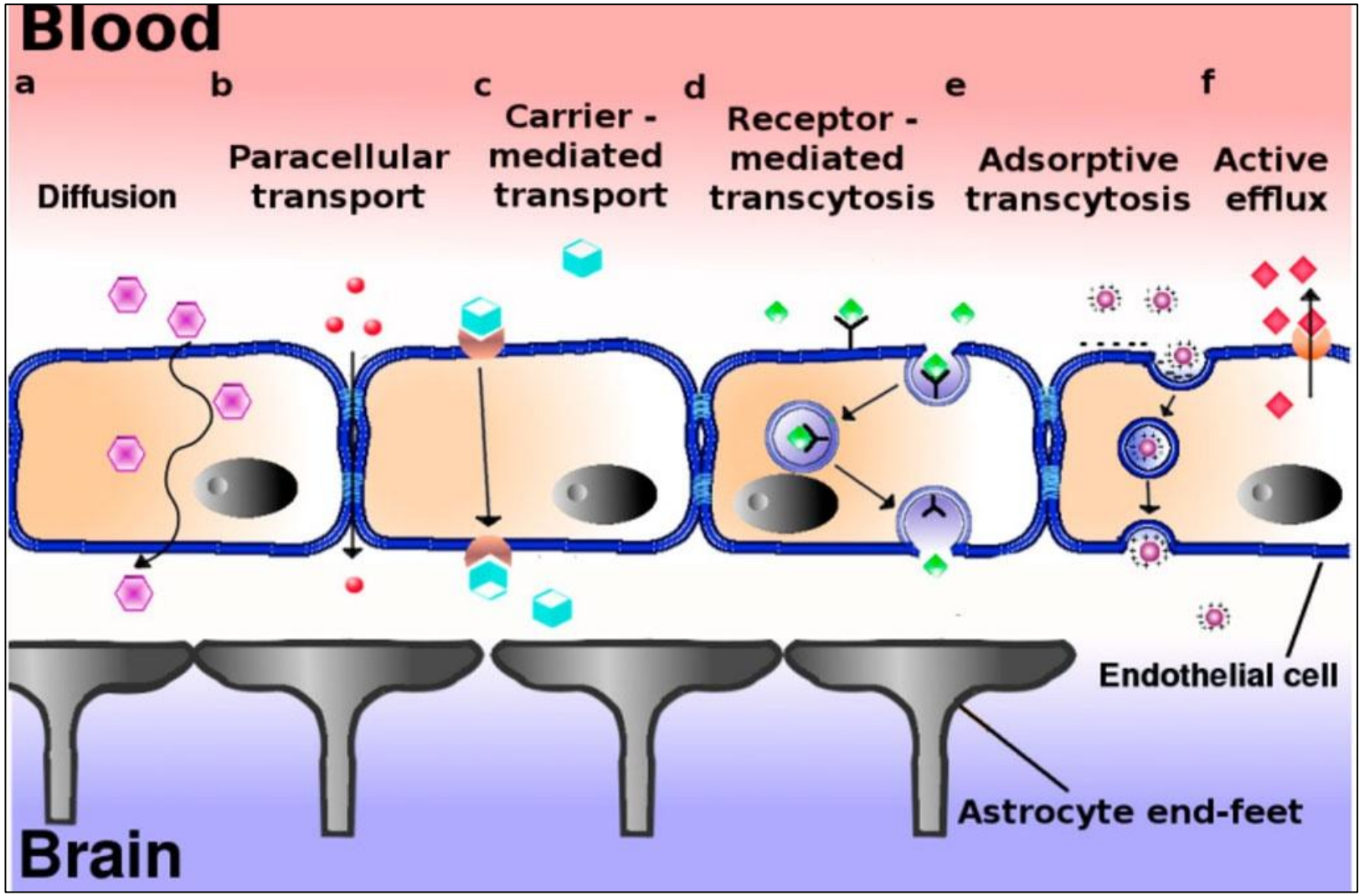
  Extremely highly permeable

(permit cross of cells & serum proteins)

Liver, spleen , bone marrow

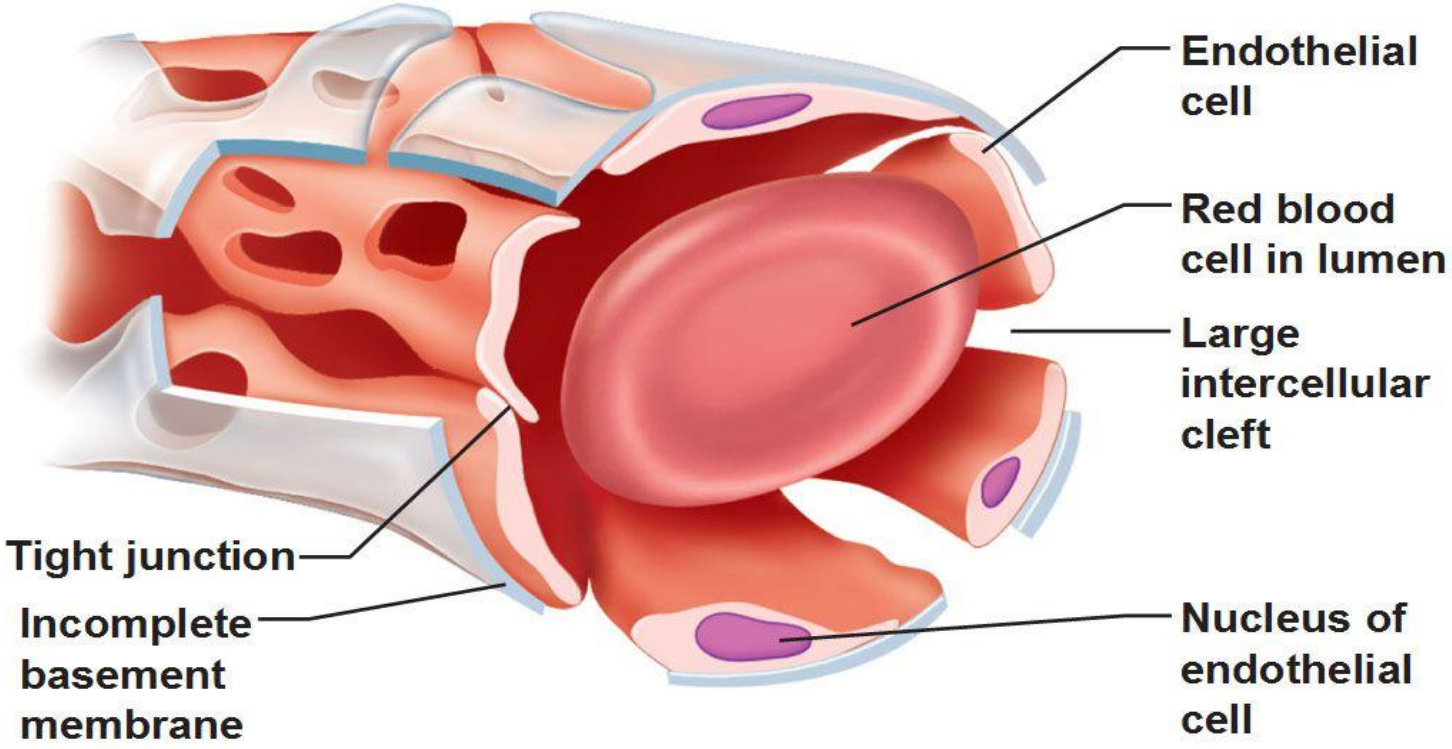






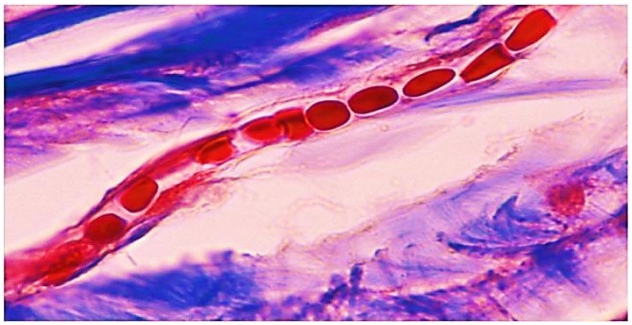
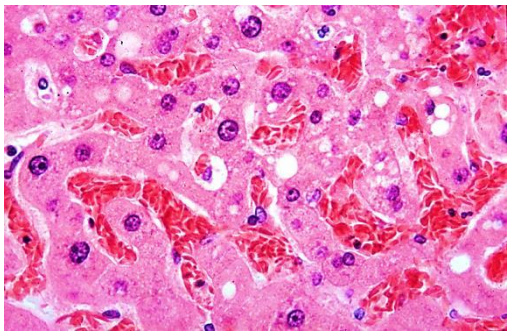
Mode of transport across the endothelial cells

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)*

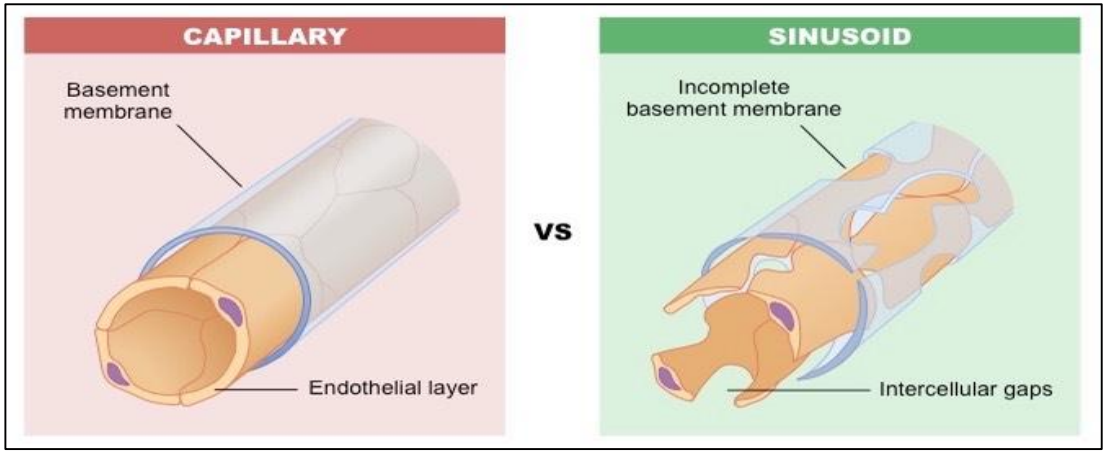


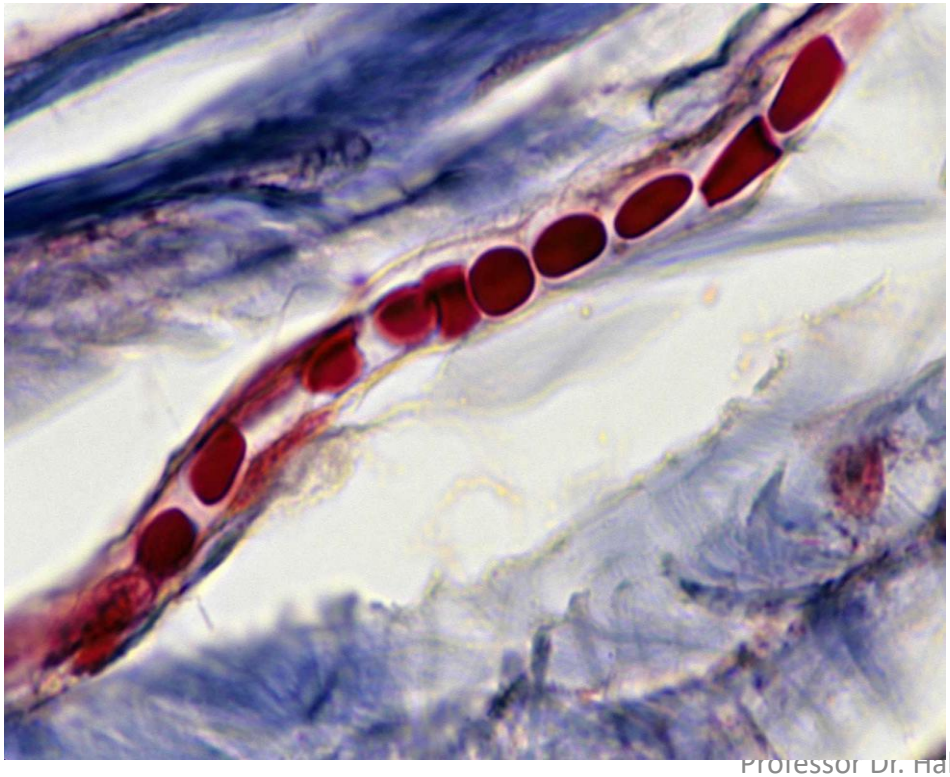
(c) Sinusoidal capillary. Most permeable. Occurs in special locations (e.g., liver, bone marrow, spleen).

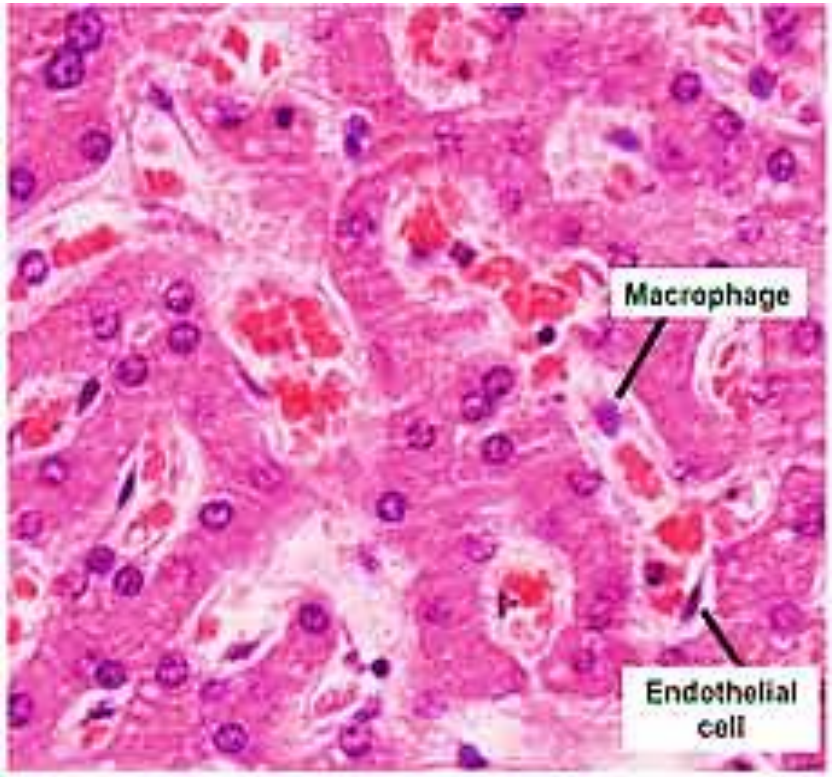
Sinusoidal capillaries

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), Kupffur cells (liver)**
6-Present in all tissues 	6- present in certain sites as :bone marrow, spleen, liver& 

Capillary vs Sinusoid



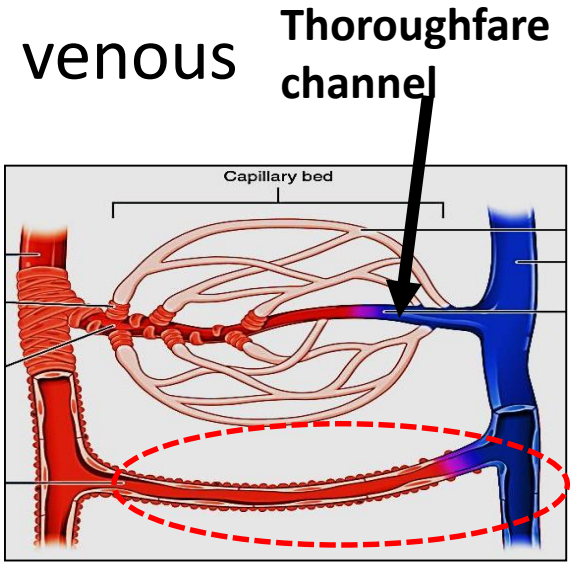




Hepatocytes and sinusoids

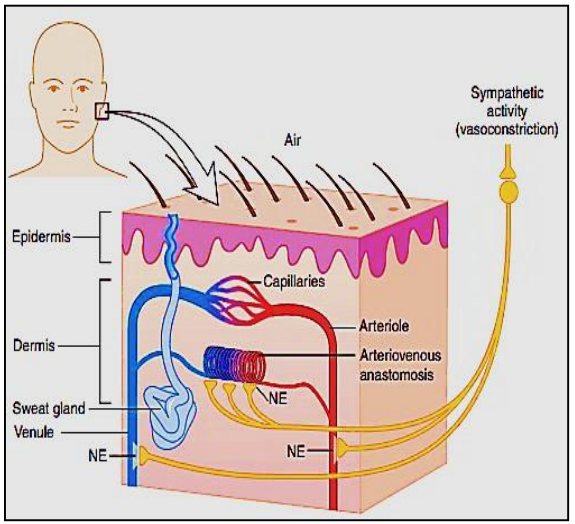
Arterio- venous anastomoses (AVA)/ Shunt

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



A- **thoroughfare channel** contraction of pre- capillary sphincters → Blood will flow Through the thoroughfare channel

B- **AV anastomosis**: direct connection Between an artery & vein or arteriole & venule



Feature	AV Shunt (Arteriovenous Shunt)	Thoroughfare Channel
Definition	A direct connection between an artery & a vein bypassing capillaries	A vessel that connect a terminal arteriole to a venule via capillaries
Capillary bypass	Completely outside the capillary bed	Short cut within the capillary bed
structure	No capillaries involved	Part of a true capillary with preferential flow
function	Rapid blood flow or thermoregulation	Allows efficient blood flow when capillary demand low
Clinical relevance	Used in hemodialysis & temperature control	Important in resting tissue perfusion

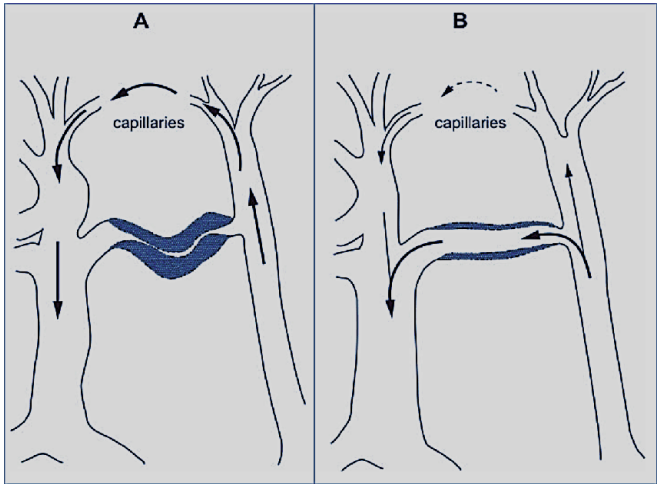
- The AVAs are short vessel with a large inner diameter 10 - 150 µm & a **thick muscular wall** , with no capillary bed between them (smooth ms in its wall)

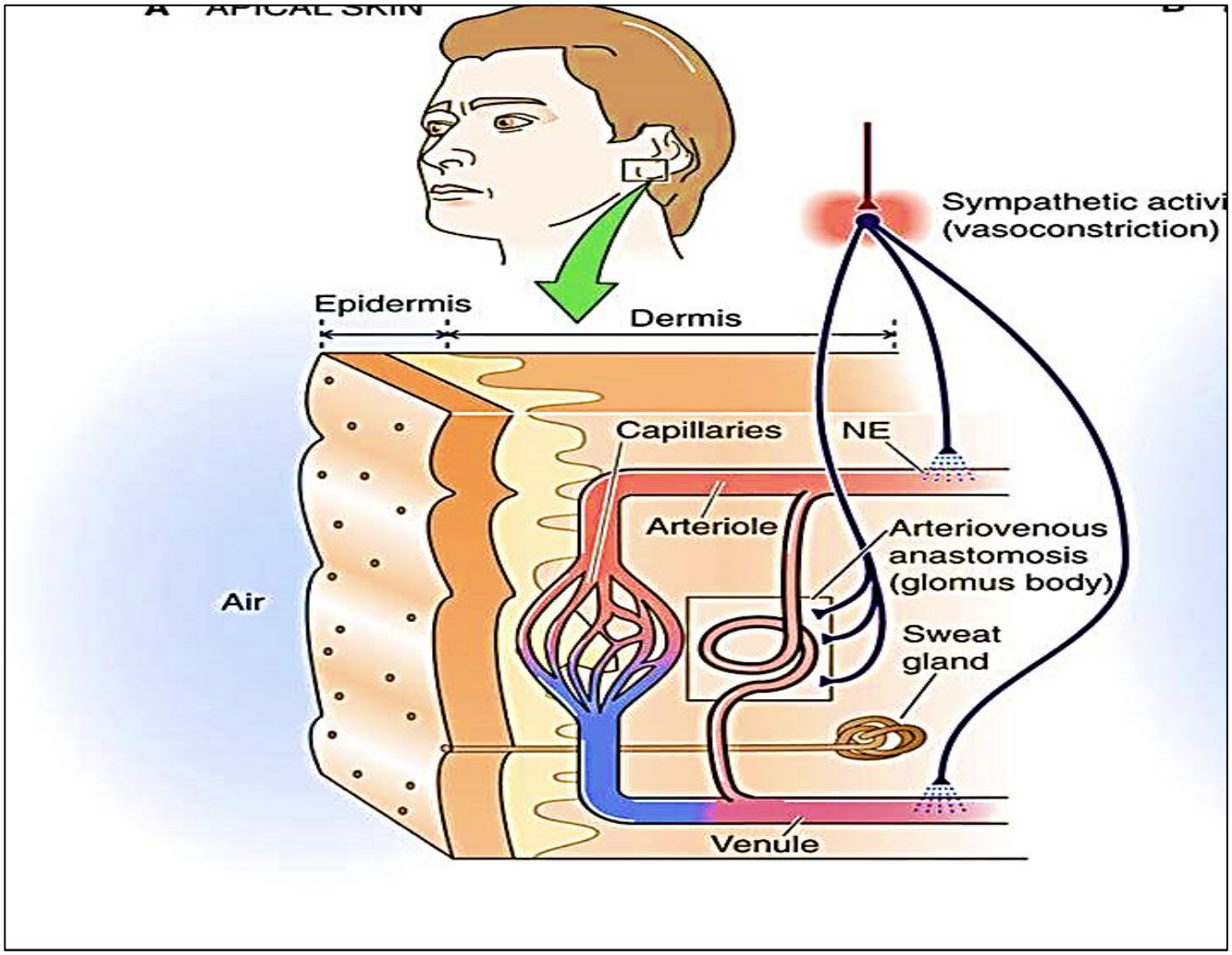
- They are densely innervated by adrenergic fibers When they open they provide a low resistance connection between arteries and veins

- AVAs play important role in temperature regulation

  e.g. skin (hands & feet)

  Blood flow in genital organs

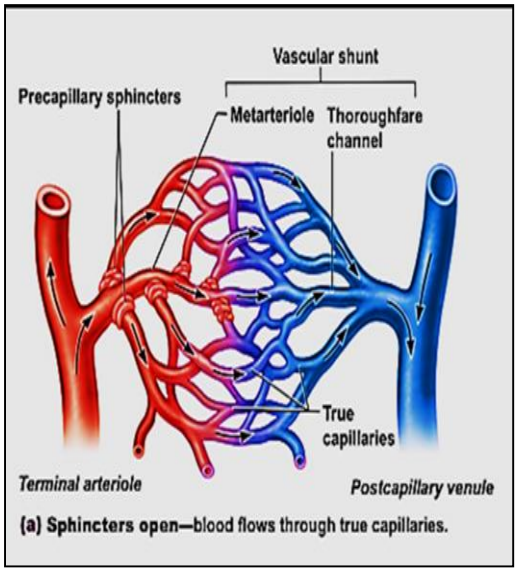




Arteriovenous shunt that regulates temperature and blood flow throughout the body most common in the fingertips and nose tips

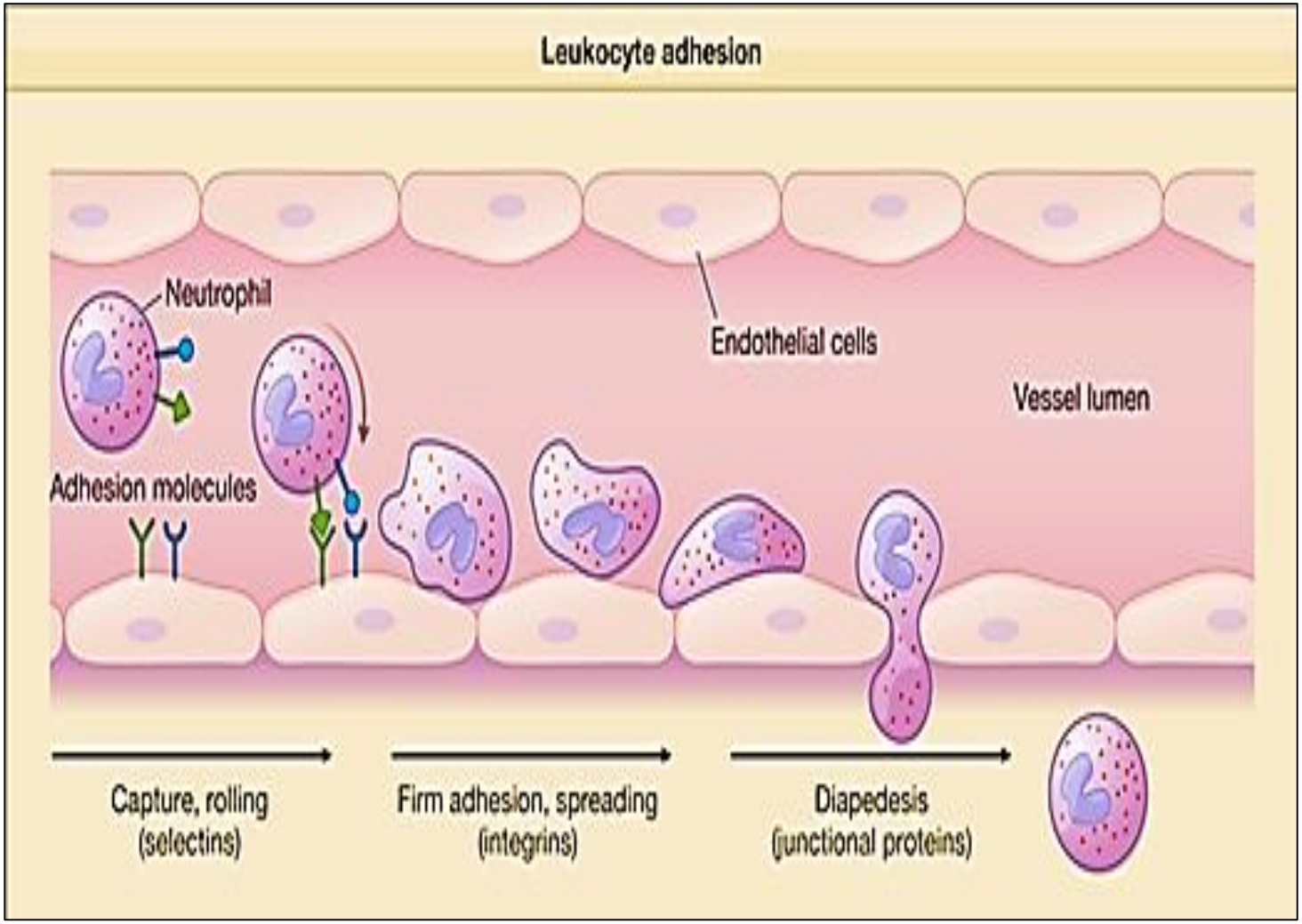
Post -capillary venules

- 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

- **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**

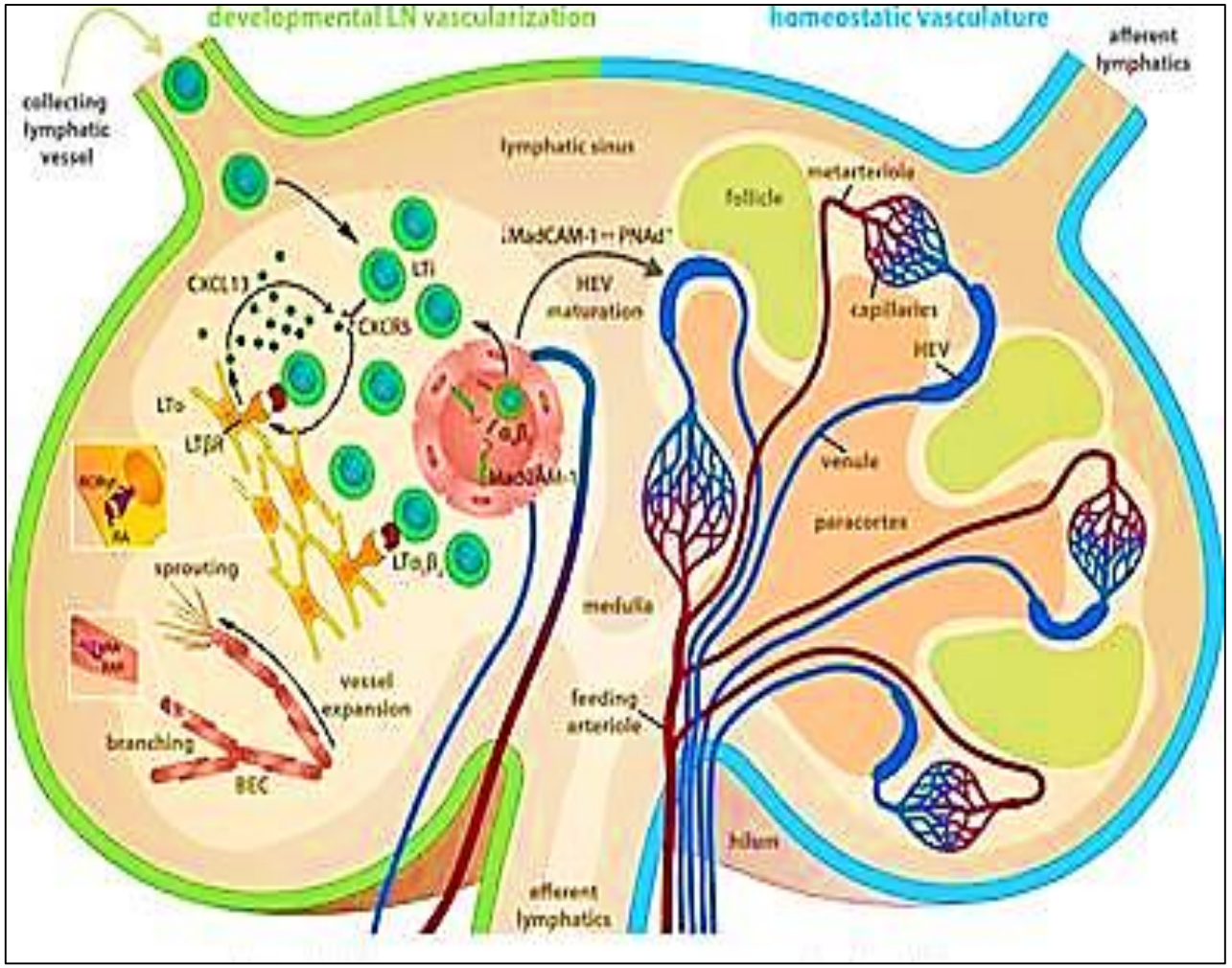


Leukocyte extravasation

- 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

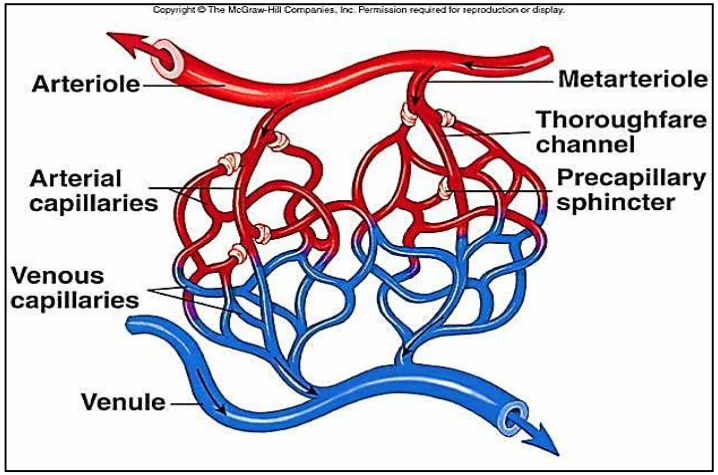
venules

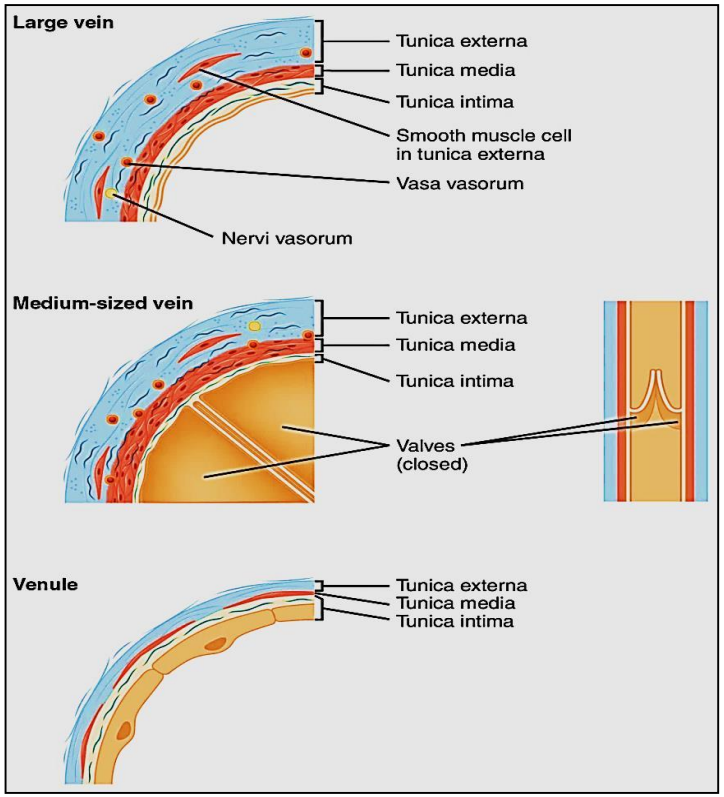
- The smallest veins (20- 30 µm)

Intima: endothelium

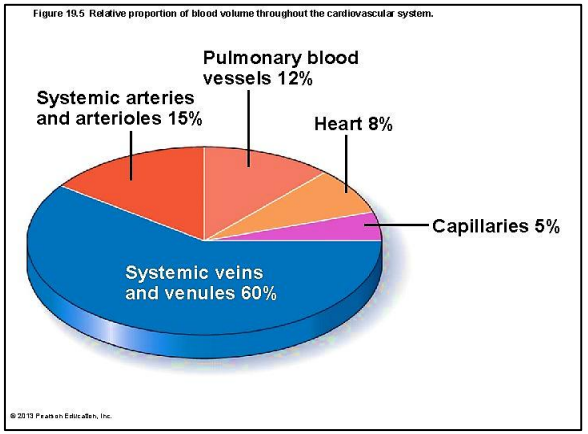
Media: 1 or 2 layers of smooth ms. cells, The thickness ↑ as the vessel diameter increased

Adventitia: relatively thick





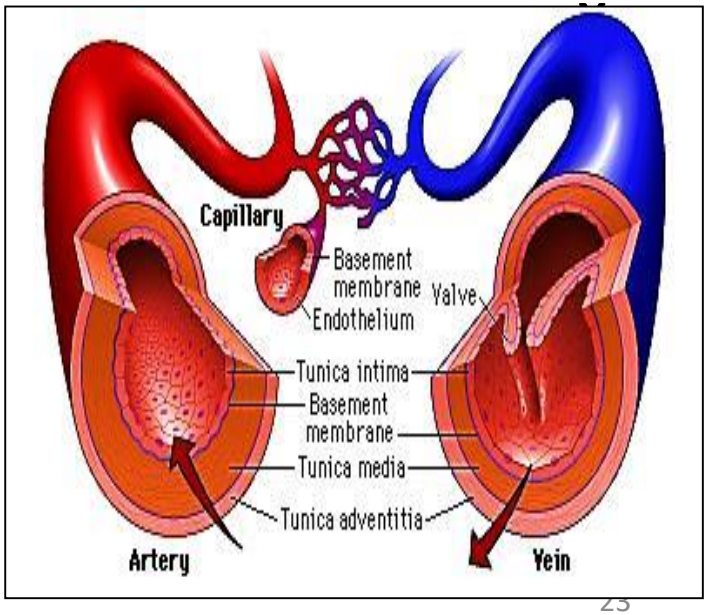
Medium size veins



- 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 (reservoir) vessels**

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

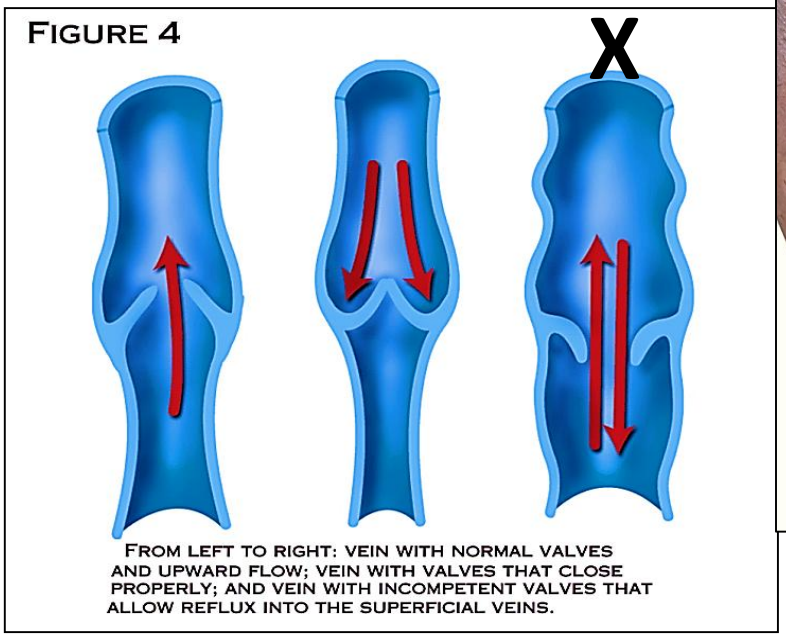


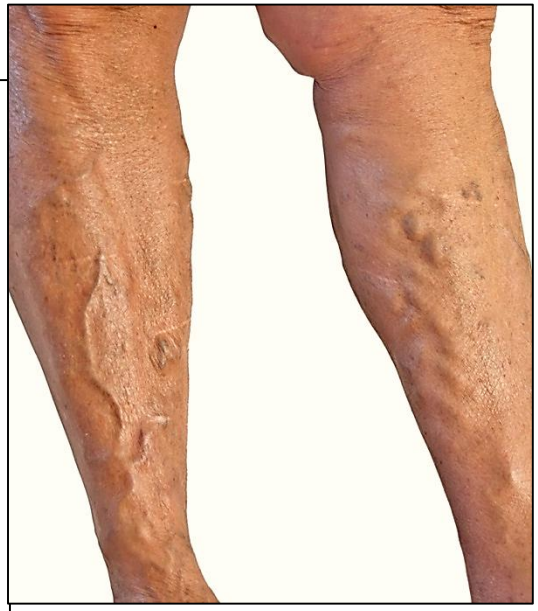
- **Valves are s**pecial adaptation in the veins helps return of blood to heart & prevents its back flow
- Valves are absent in small & large veins

Valves:

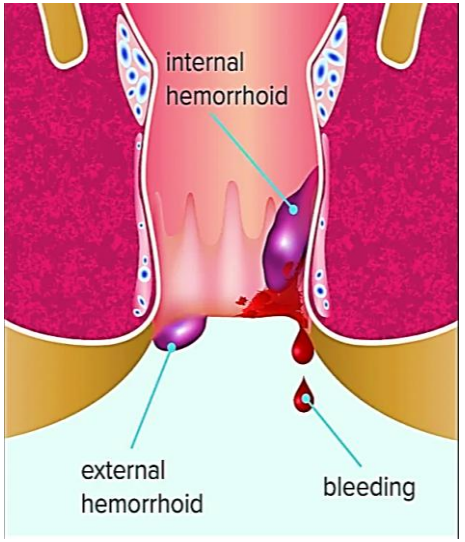
- are folds project from **intima** into lumen of the vein
- Lined on both sides by endothelium,
- their core formed of elastic tissue
- Valves Are most abundant in veins of limbs

Valves





Varicose veins

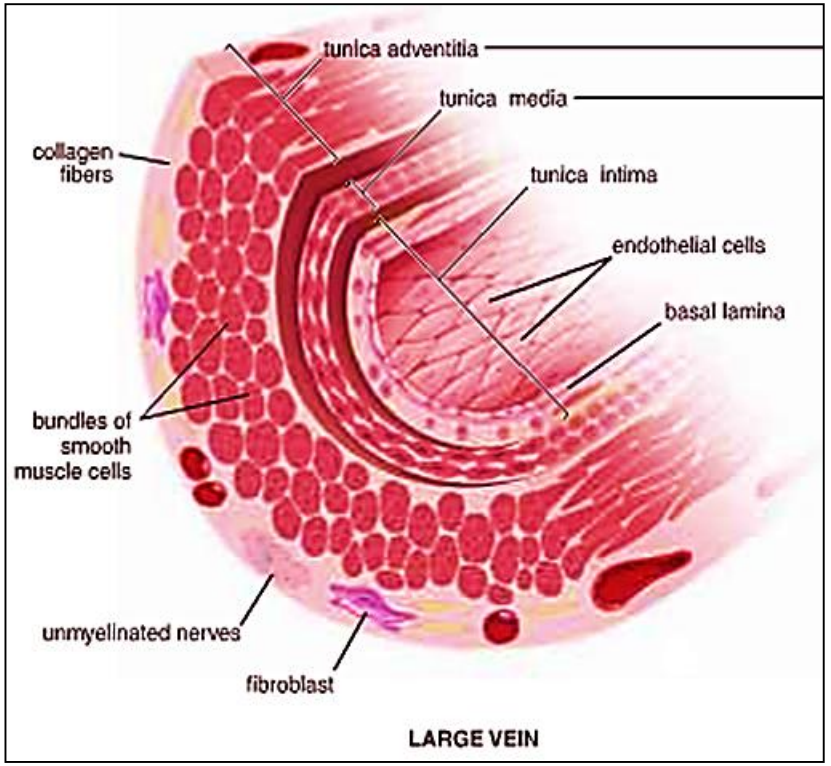


Hemorrhoids

Vena cava (inferior & superior)

Tunica intima: thin

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



Tunica media:

thin layer, smooth ms, elastic, collagen fibers

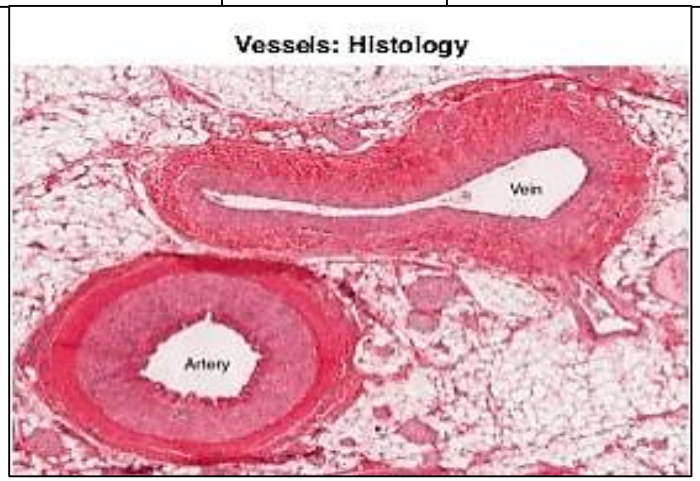
Tunica adventitia:

Thick, contains **longitudinal bundles of smooth ms fibers** facilitate shortening & elongation of the vena cava with respiration.

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

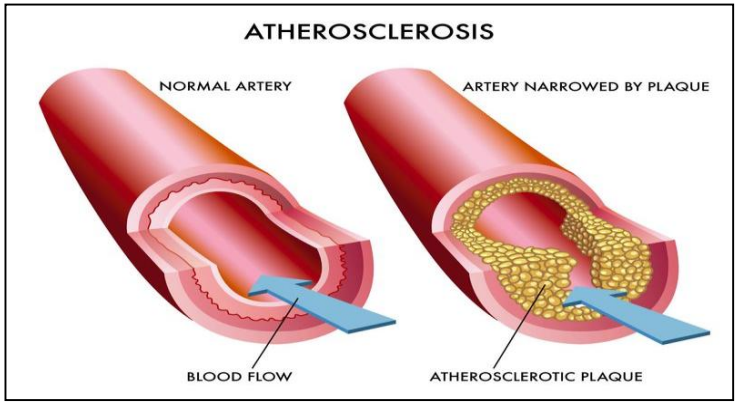


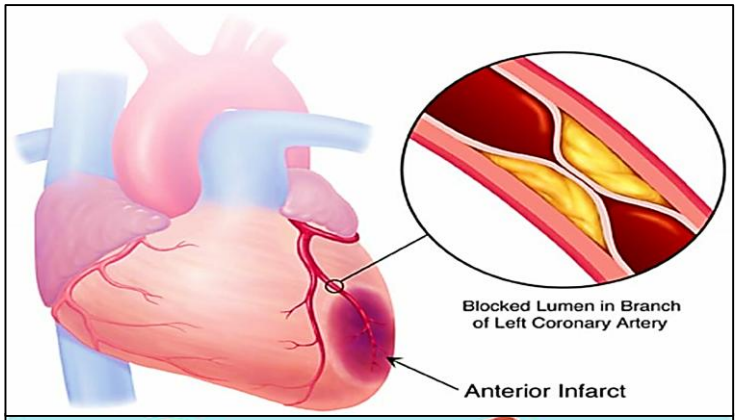
Medical applications

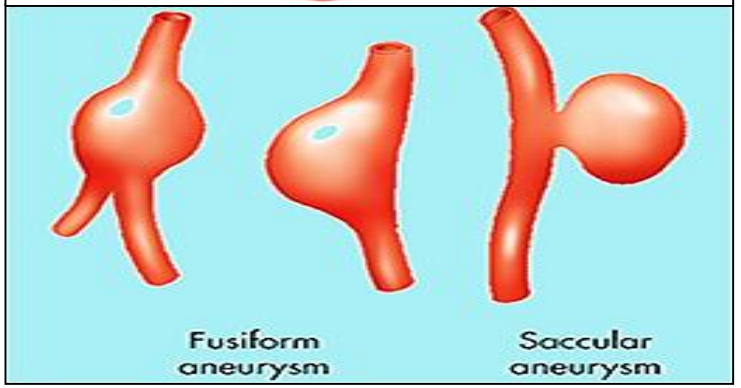
- **Atherosclerosis:** focal thickening of the intima of arteries due to deposition of cholesterol (lipid plaques) (Foam cells)

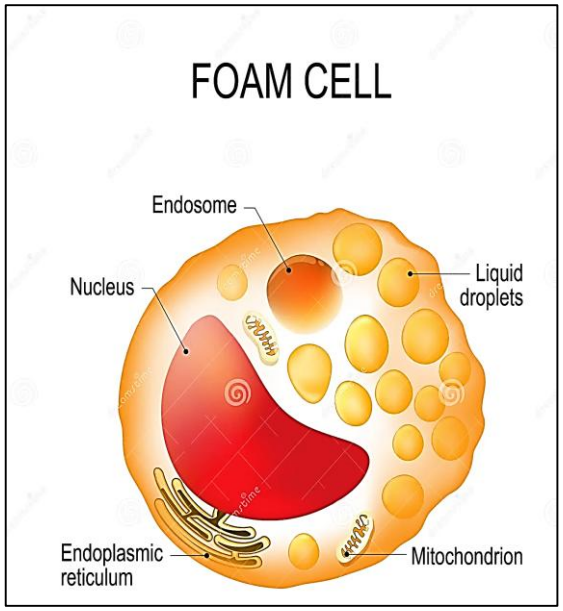
- **Infarction:** death of tissue due to lack of blood supply

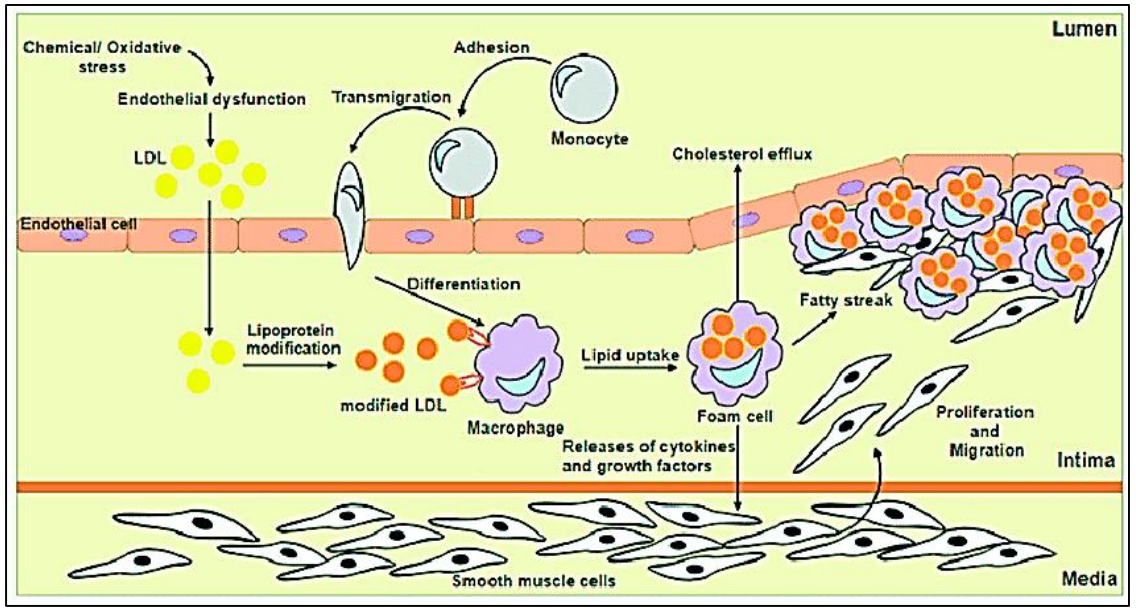
- **Aneurysm:** marked dilation of BV due to weakening of tunica media →rupture & hemorrhage.





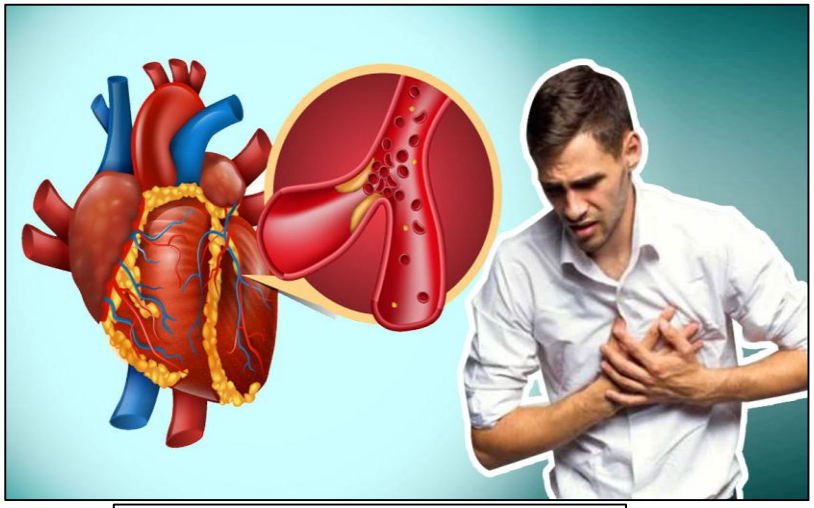




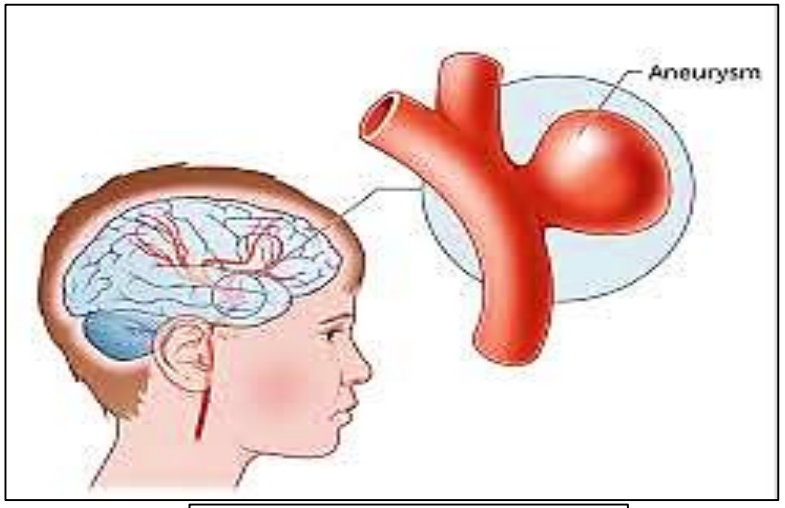


Foam cells

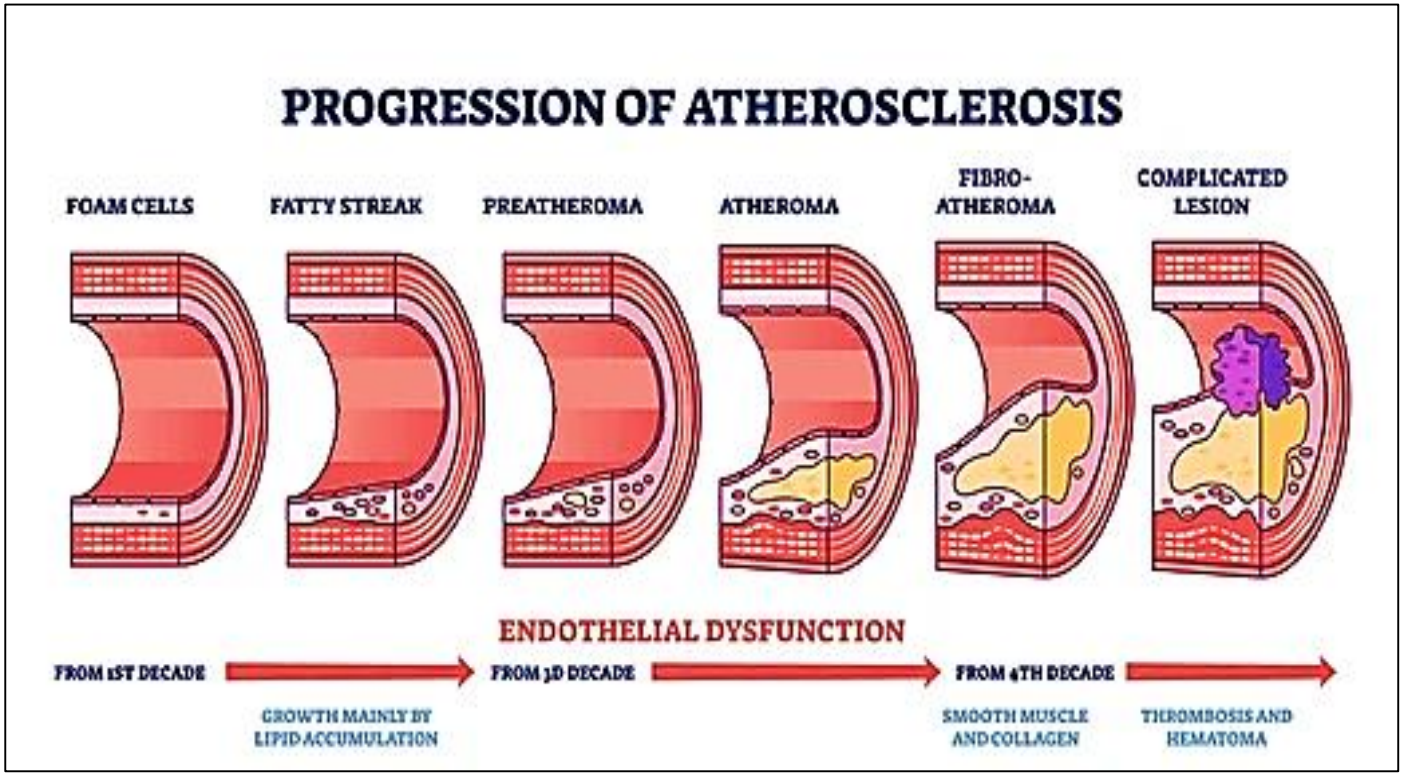
Atherosclerosis: when the endothelial cells damage→ ↑ permeability of arterial wall → LDL enter to tunica intima →damaged endothelial cell will attract WBCs , WBCs will squeeze itself and enter by diapedesis to reach intima layer. WBCs will release free radicals that will oxidize LDL molecules.
Macrophages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

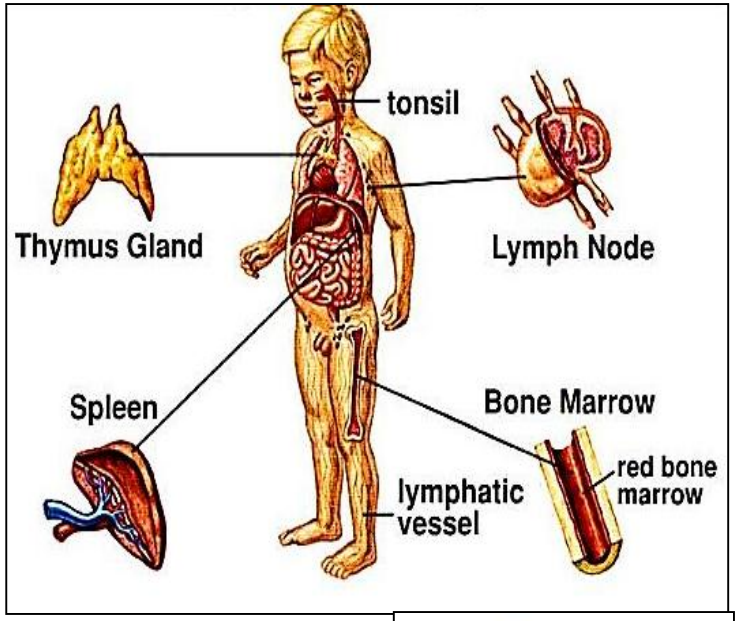


Rupture aneurysm



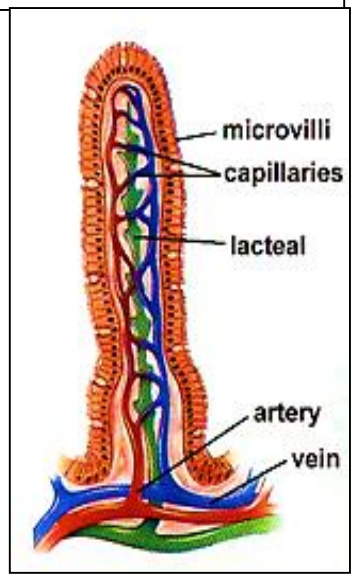
Lymphatic system consists of:

- Lymph fluid
- Lymphatic vessels
- Lymphoid tissues & organs

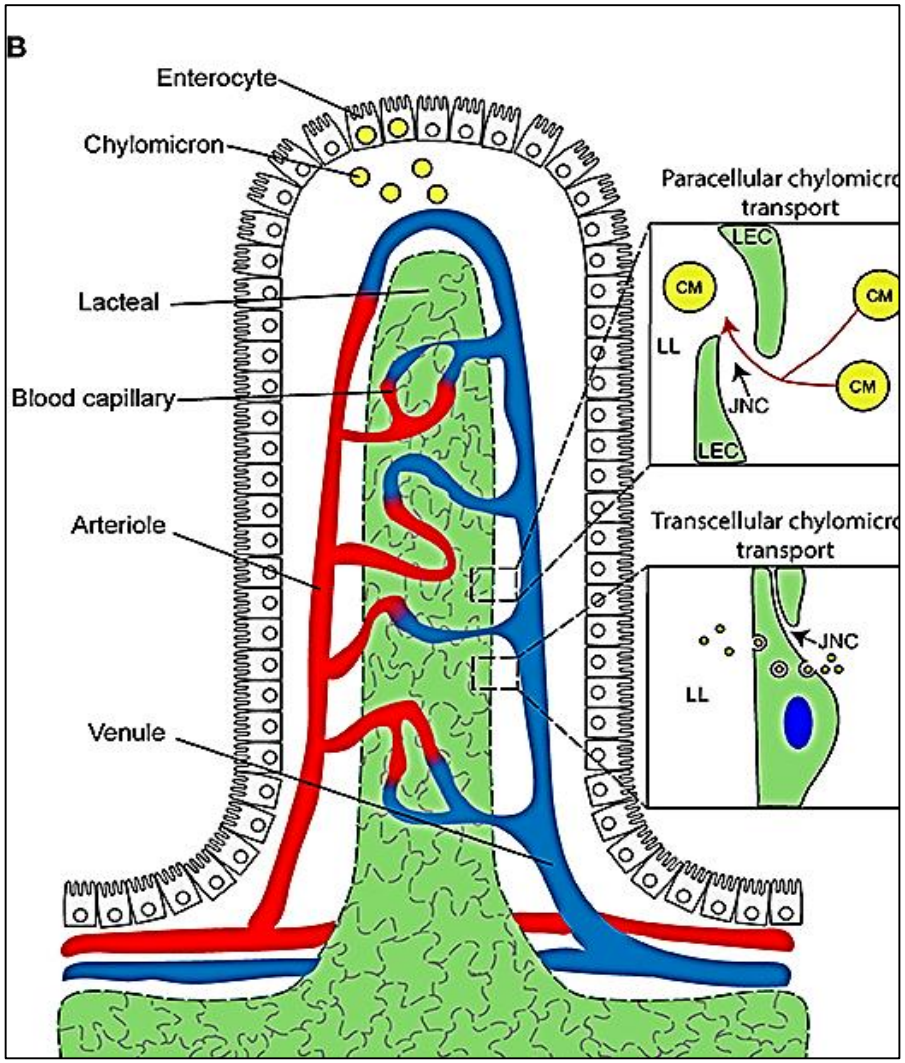


Function of lymphatic system :

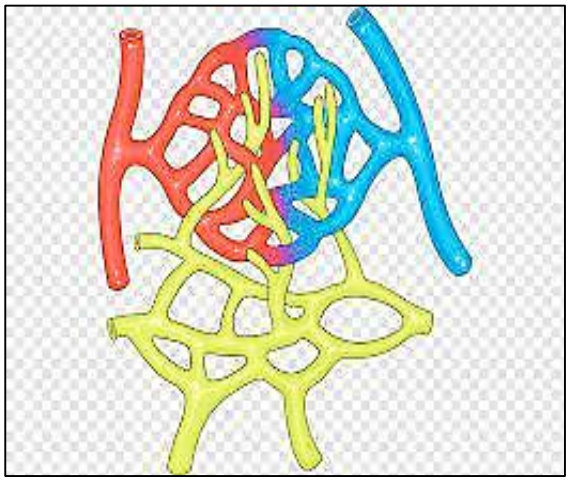
- Fluid balance: carry excess tissue fluid back to circulation



- 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)

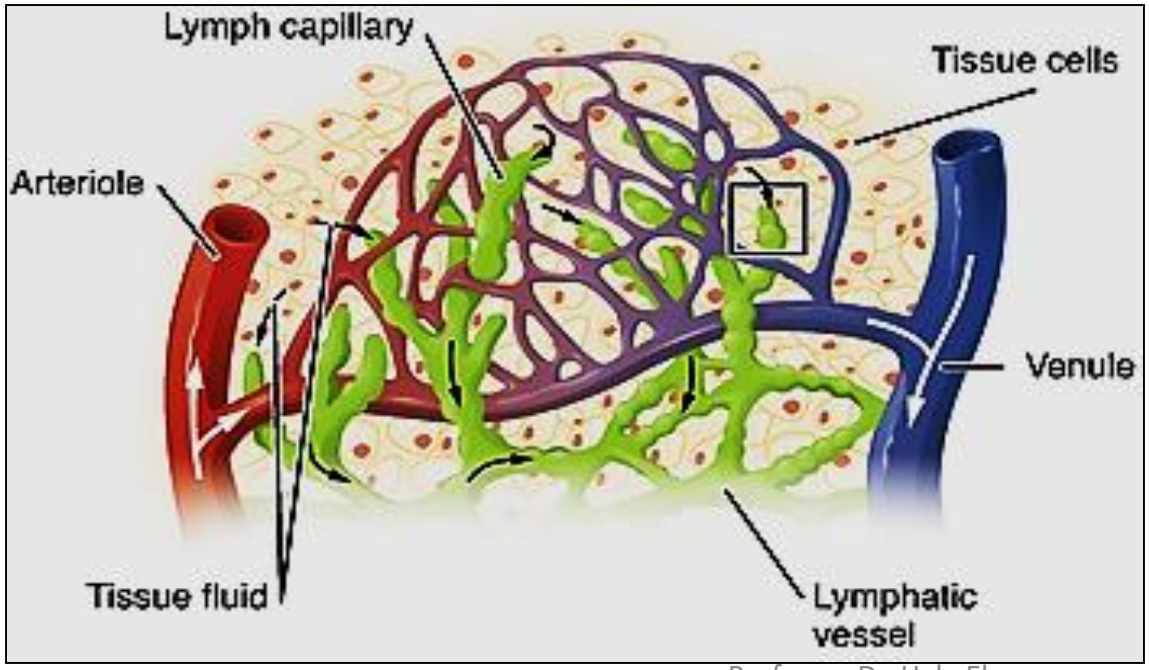
L. Ducts

(like veins)

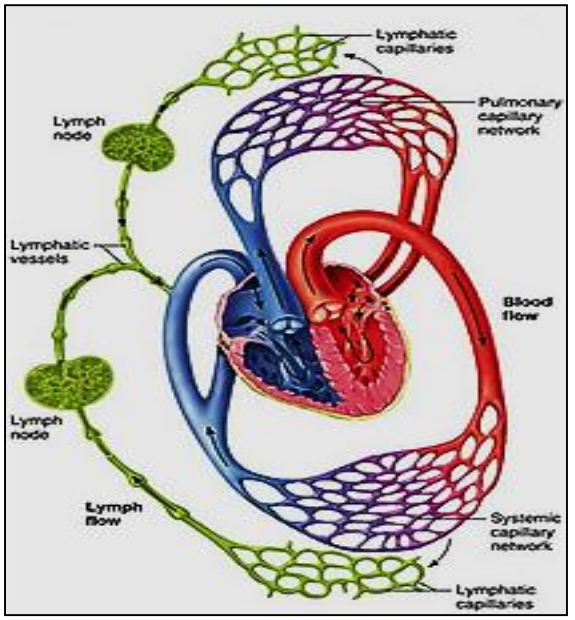
Lymph

- **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 <u>blood plasma</u> + <u>water + immune cells WBCs</u> (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

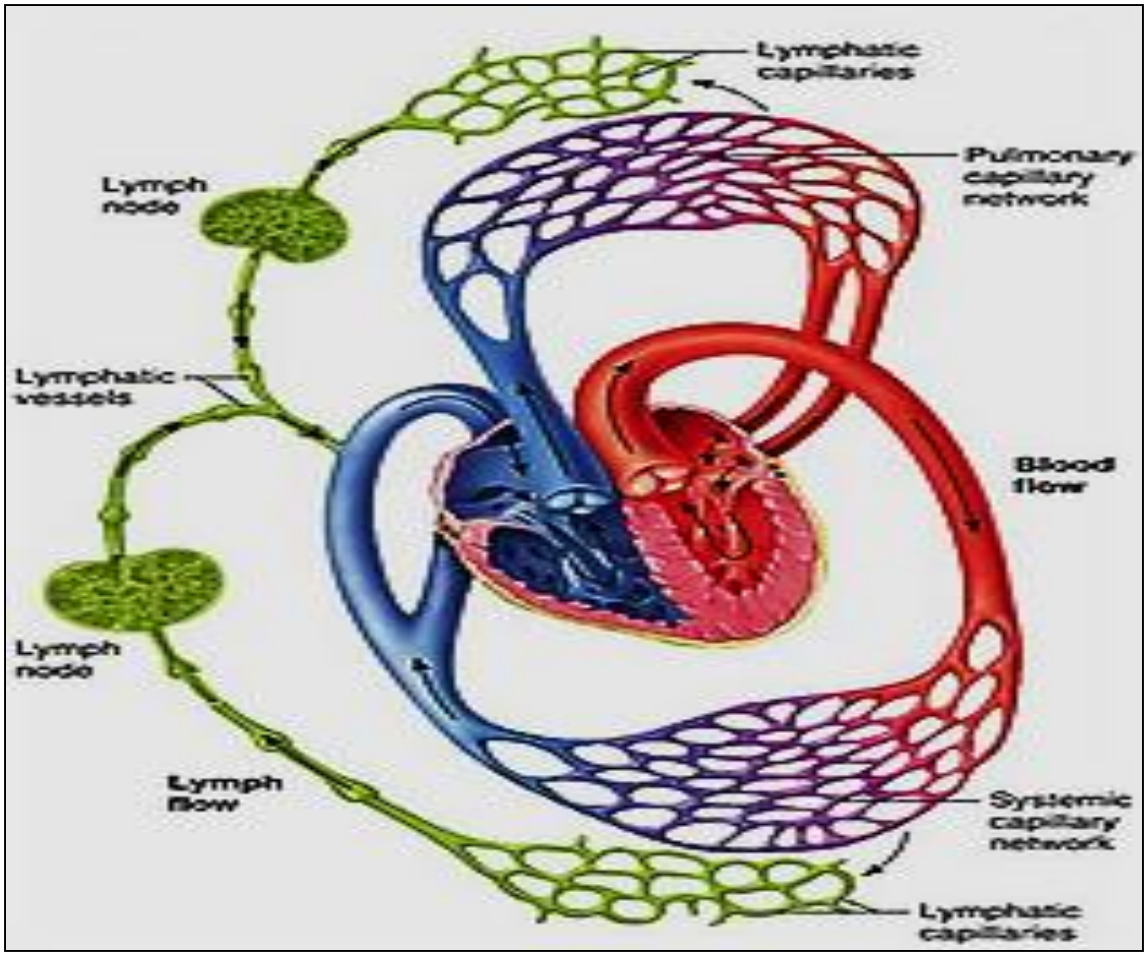
↓

Lymphatic vessels

↓

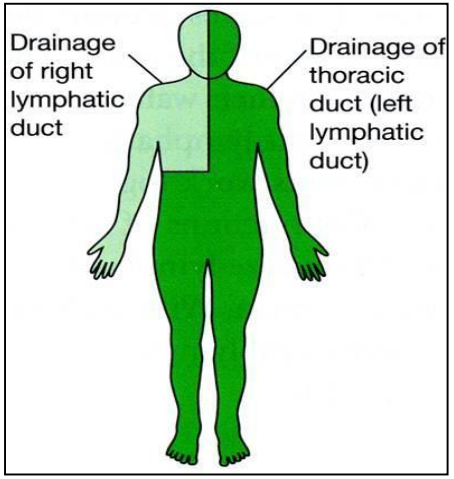
Lymphatic duct

↓



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

- lymph vessels similar to veins in structure
  One direction & contain valves

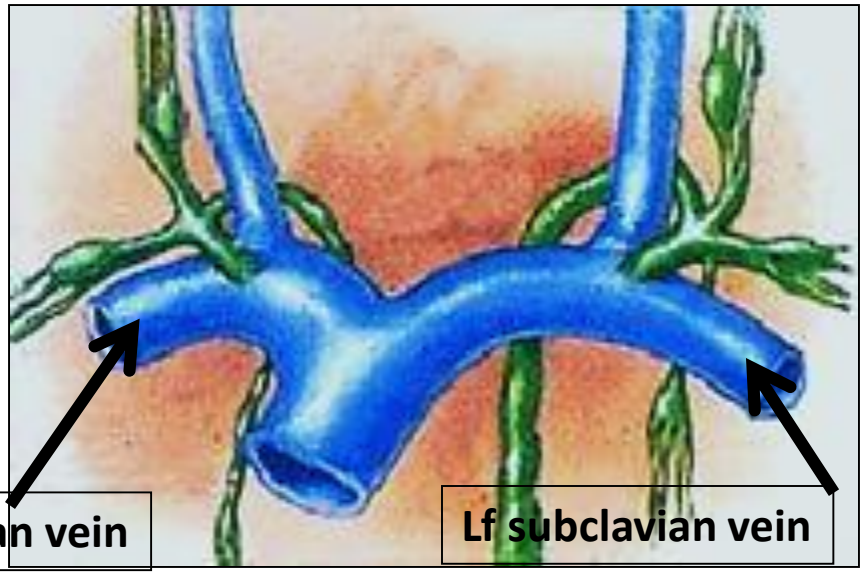


- they pass through the lymph nodes where filtration of the lymph from bacteria occurs

- Lymphatic vessels ultimately drain lymph into 2 main ducts:

➢ Right lymphatic duct

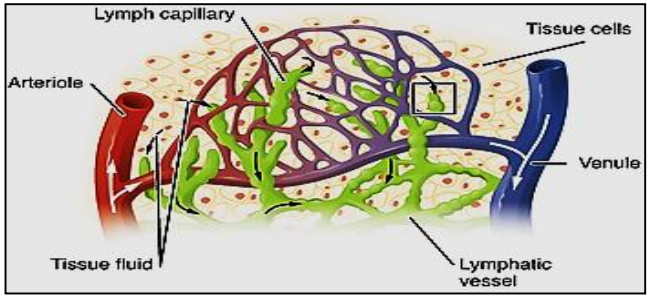
Drains right side of head & neck, right arm, right thorax → into the right subclavian vein



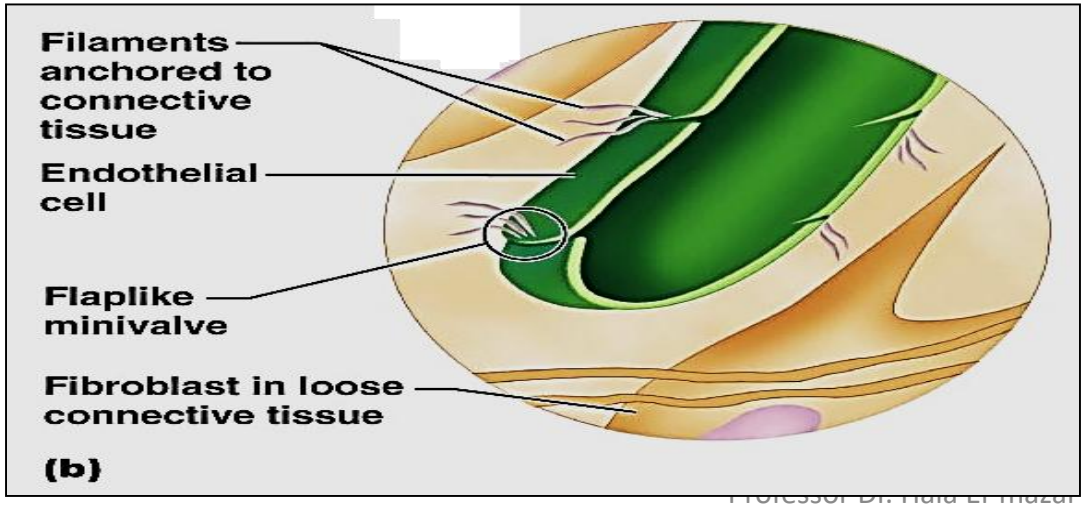
➢ Thoracic duct

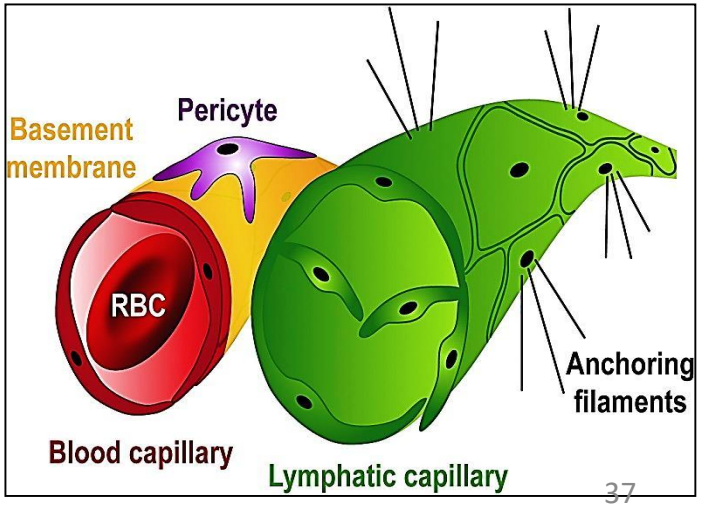
Drains the rest of the body → into the left subclavian vein

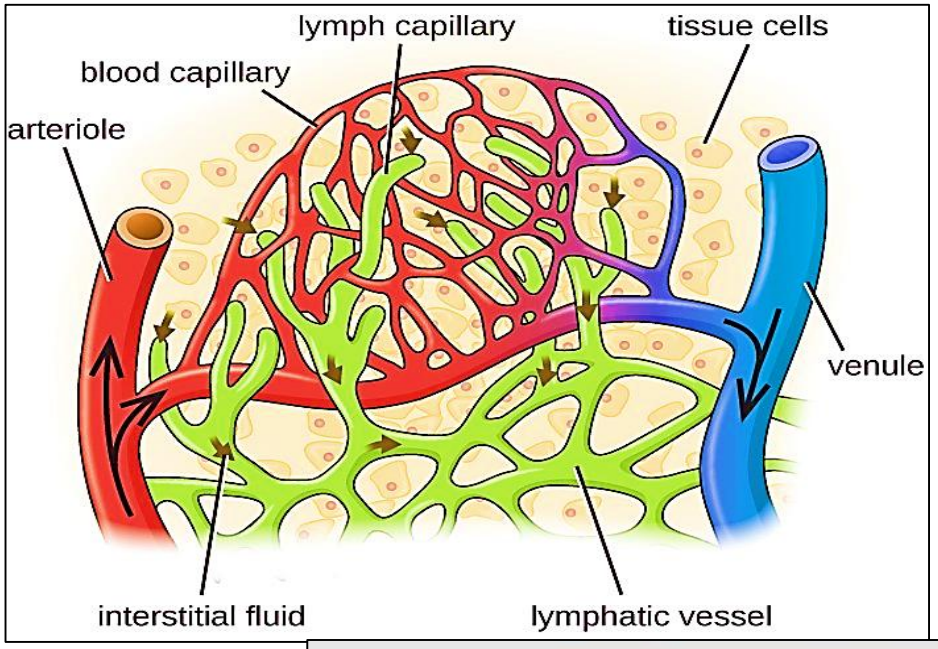
Structure of Lymphatic capillaries

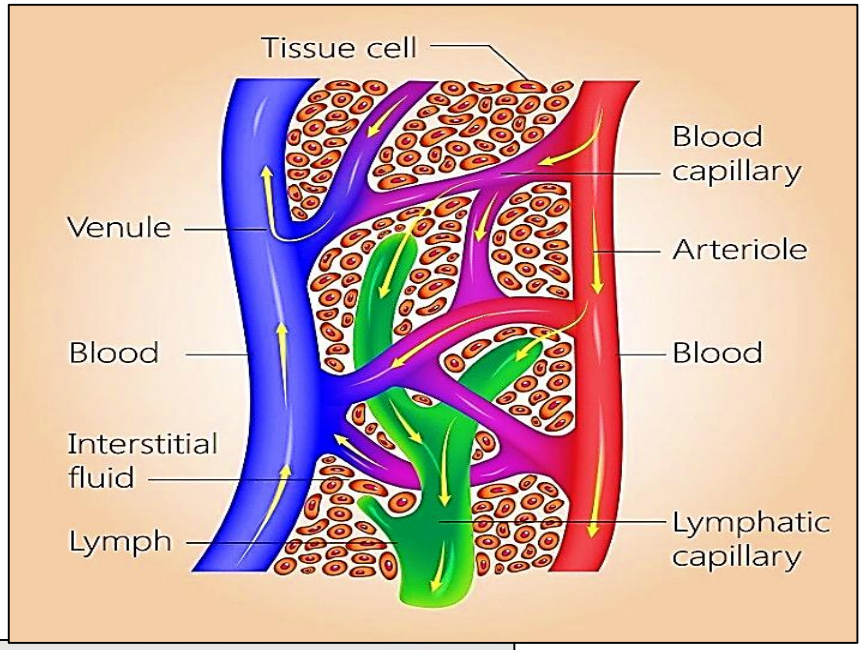


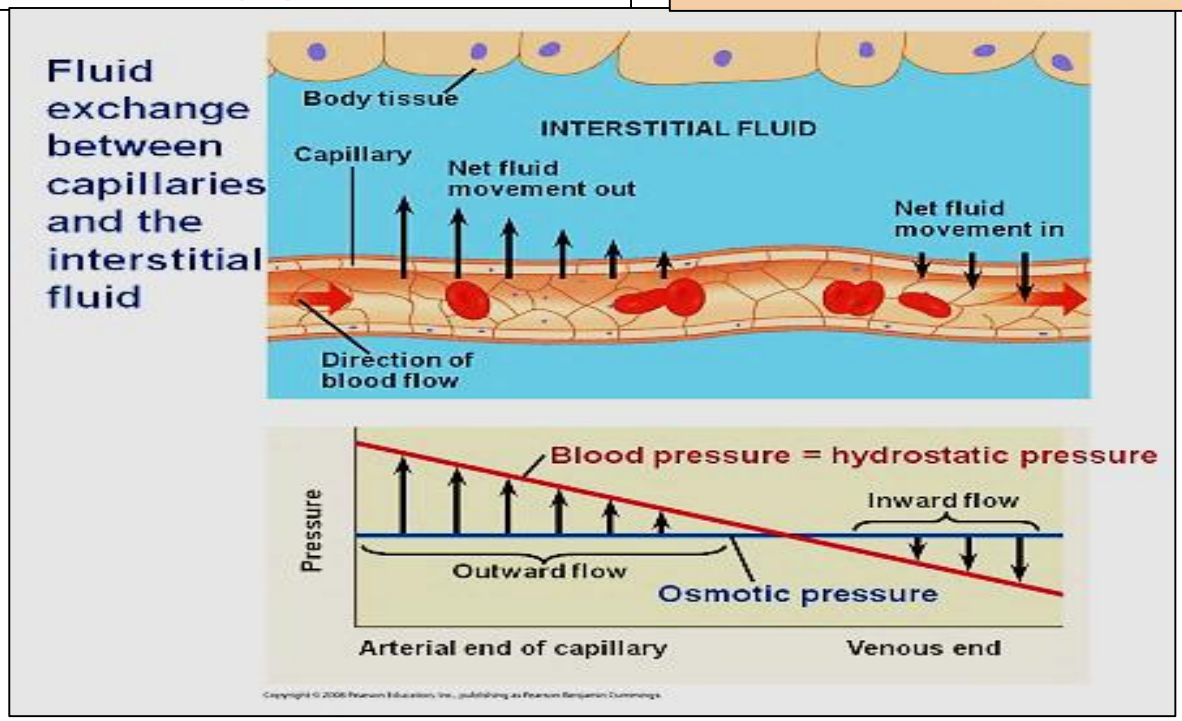
- Begin with a blind end
- Have similar structure to blood capillaries but larger & more permeable ,considered as **microcirculation**
- Made of single layer of overlapping endothelium with interrupted basal lamina
- its endoth. Has **NO** (fenestrae, tight junction, pericytes)






lymph capillary
tissue cells
blood capillary
arteriole
venule
interstitial fluid
lymphatic vessel

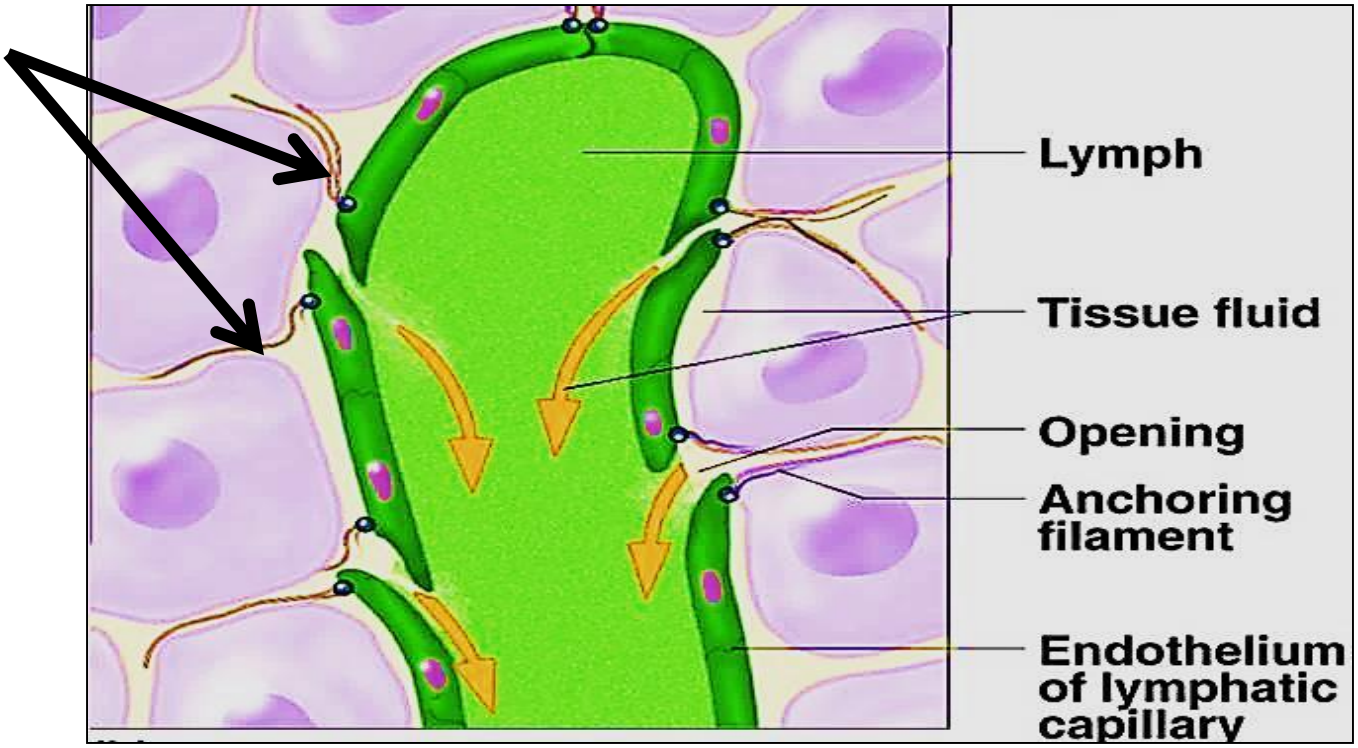

Tissue cell
Blood capillary
Venule
Arteriole
Blood
Blood
Interstitial fluid
Lymph
Lymphatic capillary


Fluid exchange between capillaries and the interstitial fluid
Body tissue
INTERSTITIAL FLUID
Capillary
Net fluid movement out
Net fluid movement in
Direction of blood flow
Blood pressure = hydrostatic pressure
Inward flow
Pressure
Outward flow
Osmotic pressure
Arterial end of capillary
Venous end

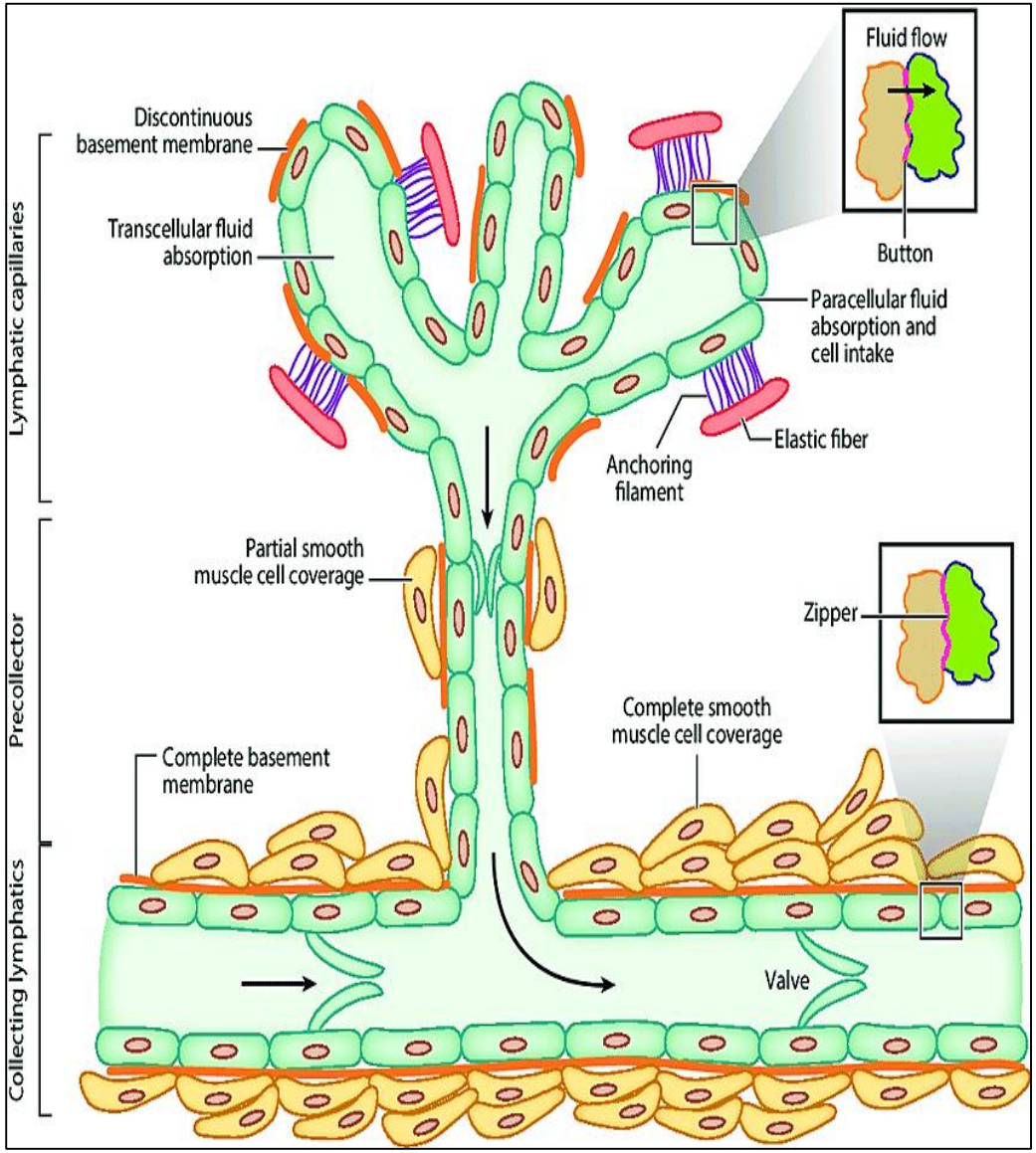
- Lymphatic endothelial cells attaches to anchoring filaments made of elastic fibers which:

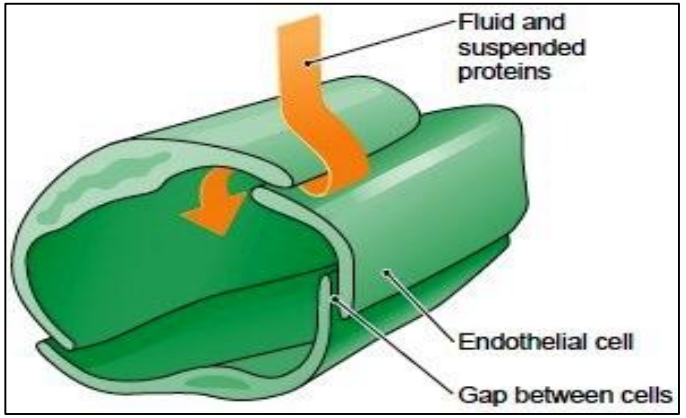
1- attach endothelial cells to surrounding tissue.

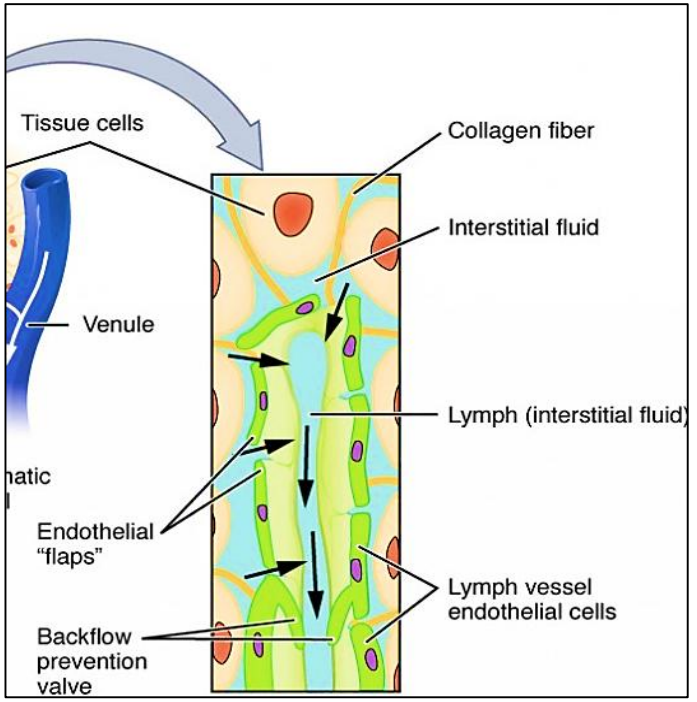
2- pull on → widen gap between endothelial cells→ draw more fluid into lymphatic capillary



Endothelial cells are one- way swinging door



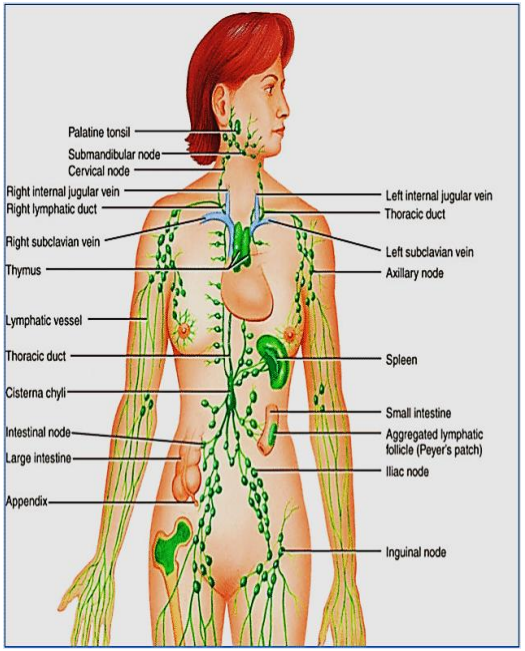




Lymphatic capillaries in relation to lymphatic vessels

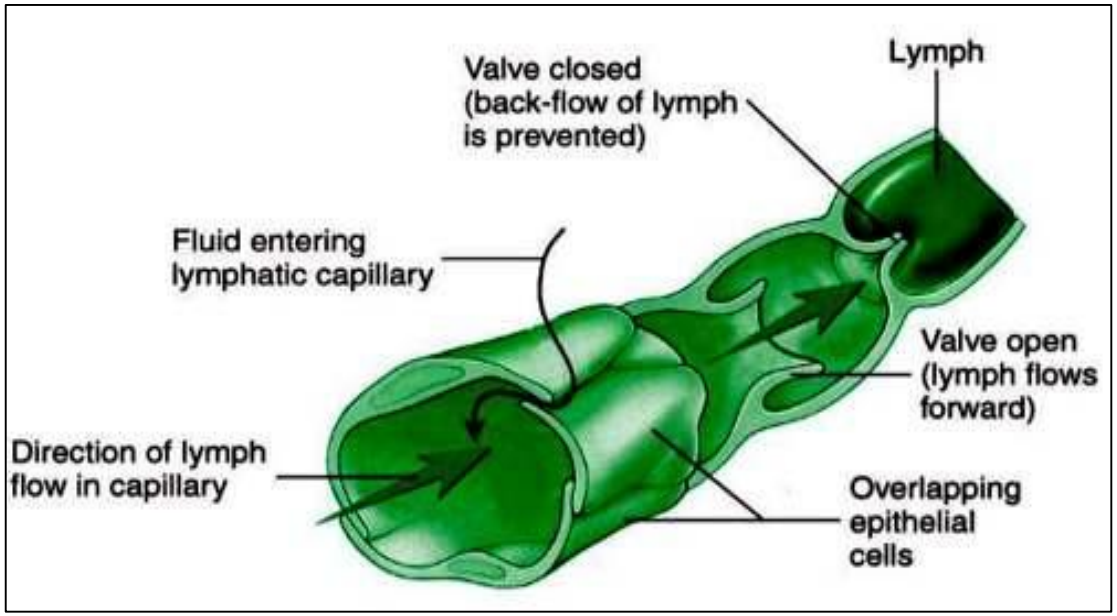
Structure of Lymphatic vessels:

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



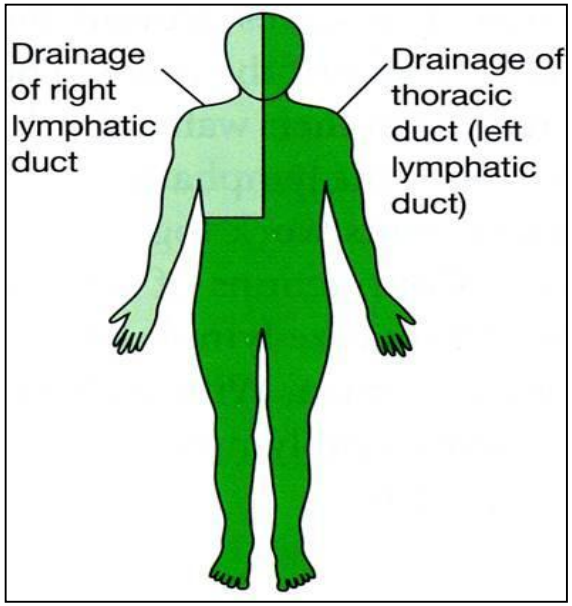
Structure:

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

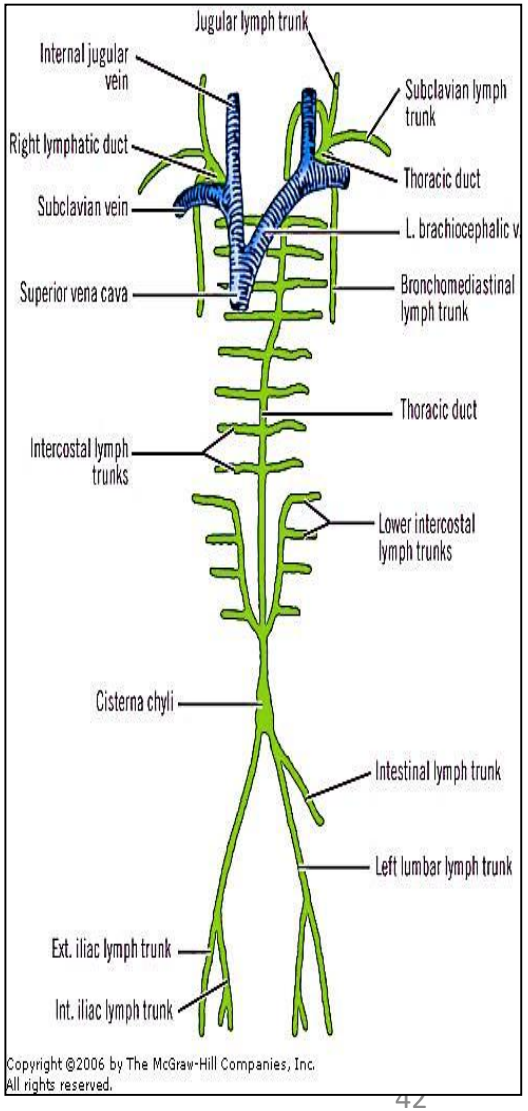


Structure of Lymphatic duct:

- 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