CVS
PHYSIOLOGY

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كتابة: لمى أبو اسماعيل و أحمد مطارنة

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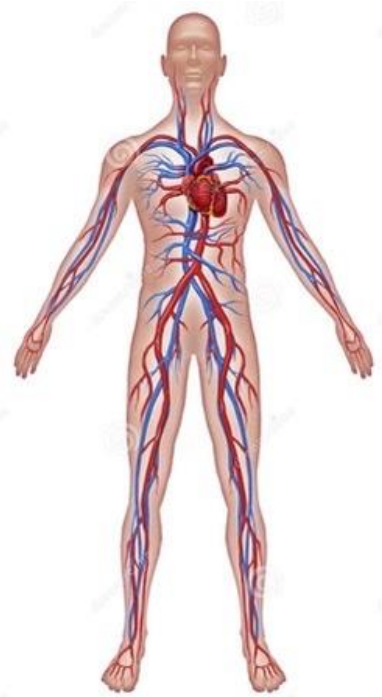
الدكتور: فاطمة ريالات.د

Cardiovascular Physiology

Fatima Ryalat, MD, PhD

Assistant Professor, Physiology and Biochemistry Department

School of Medicine, University of Jordan



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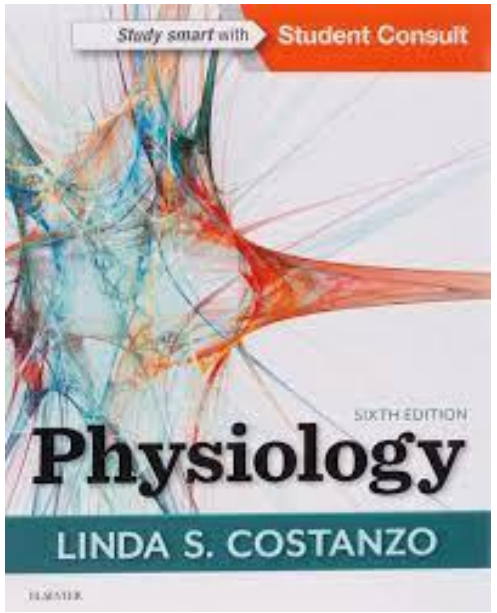
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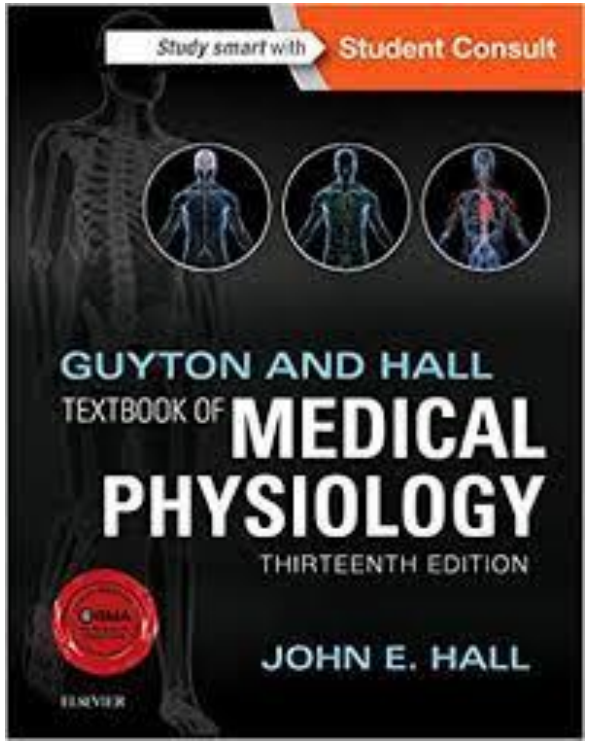
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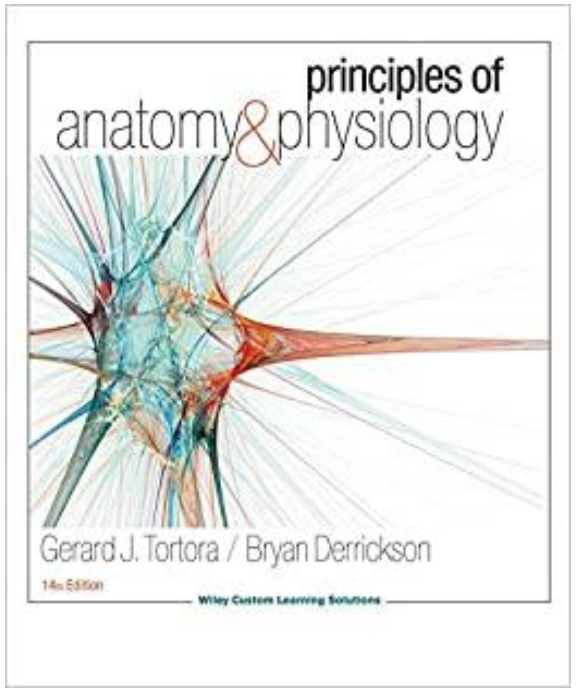
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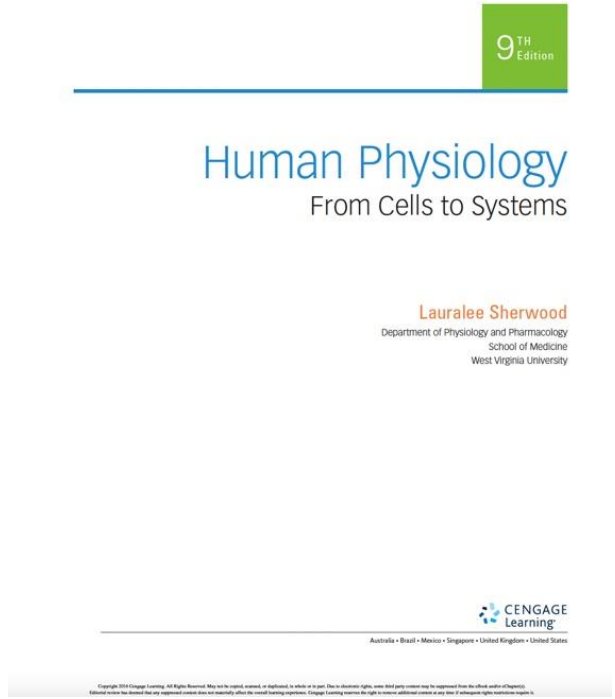
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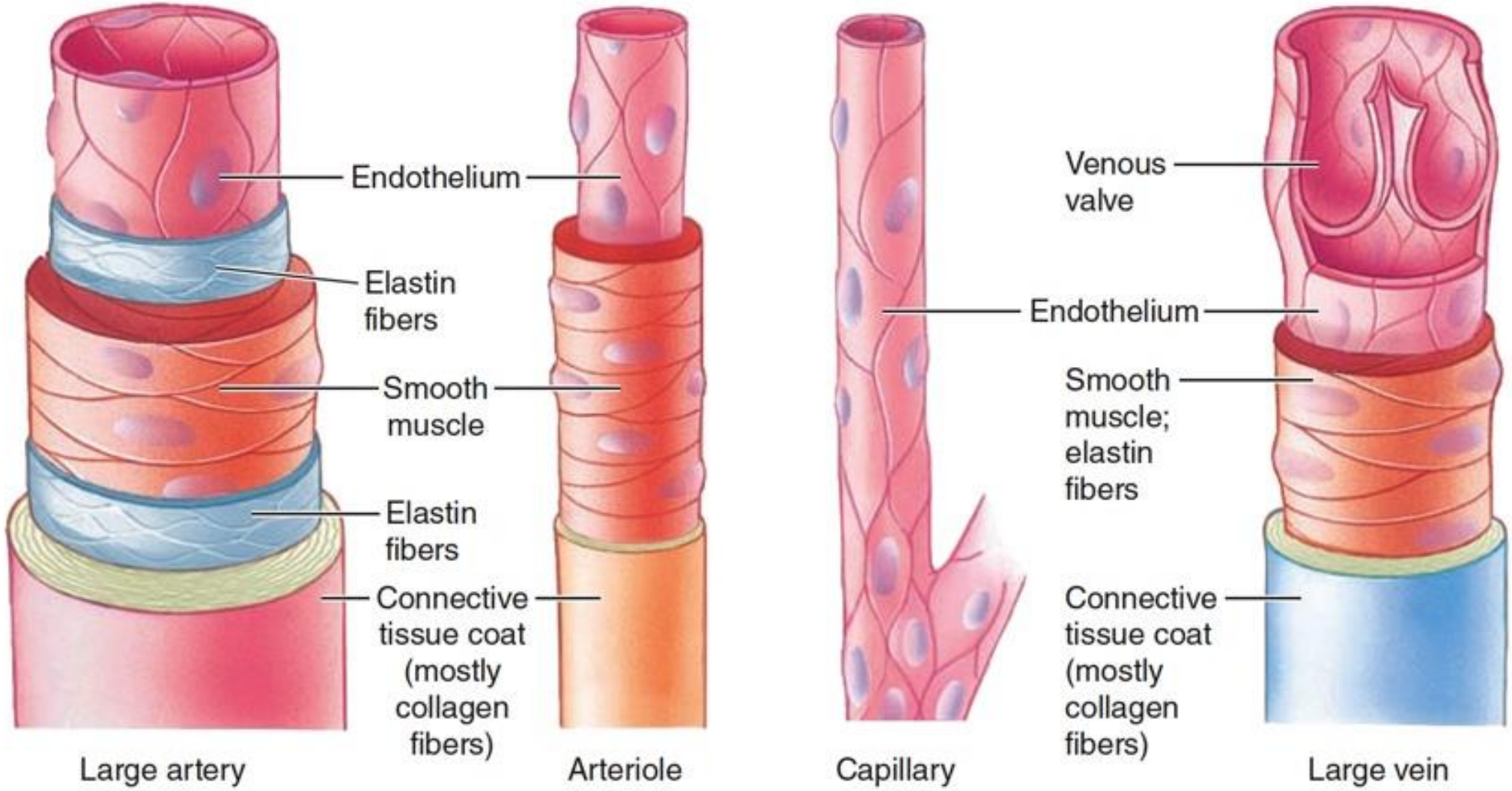
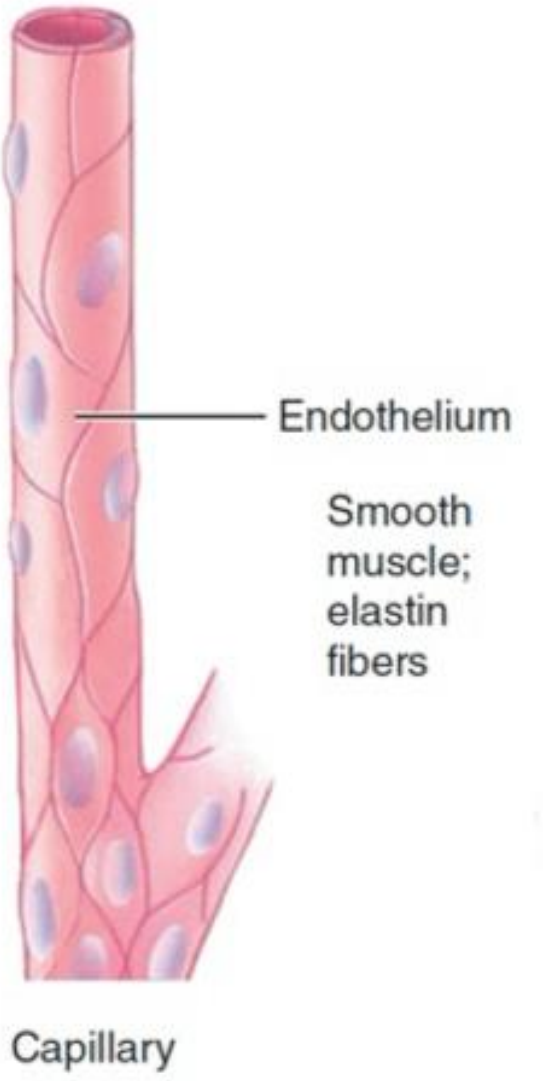
Capillaries and Lymphatics

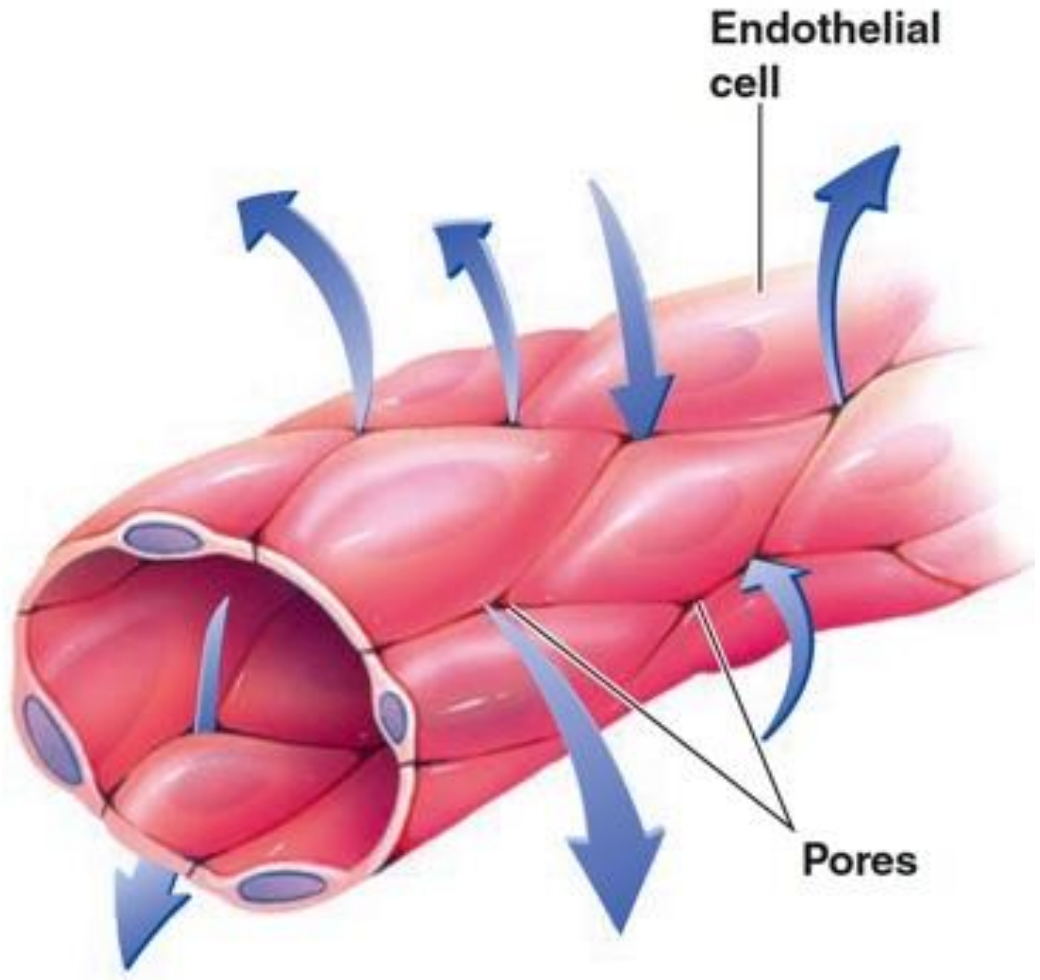
Guideline for the lecture :

- Capillary structure & how it serve the function (6-10)
- substances transmission between capillaries and cells (11-15)
- Types of capillaries (16-20)

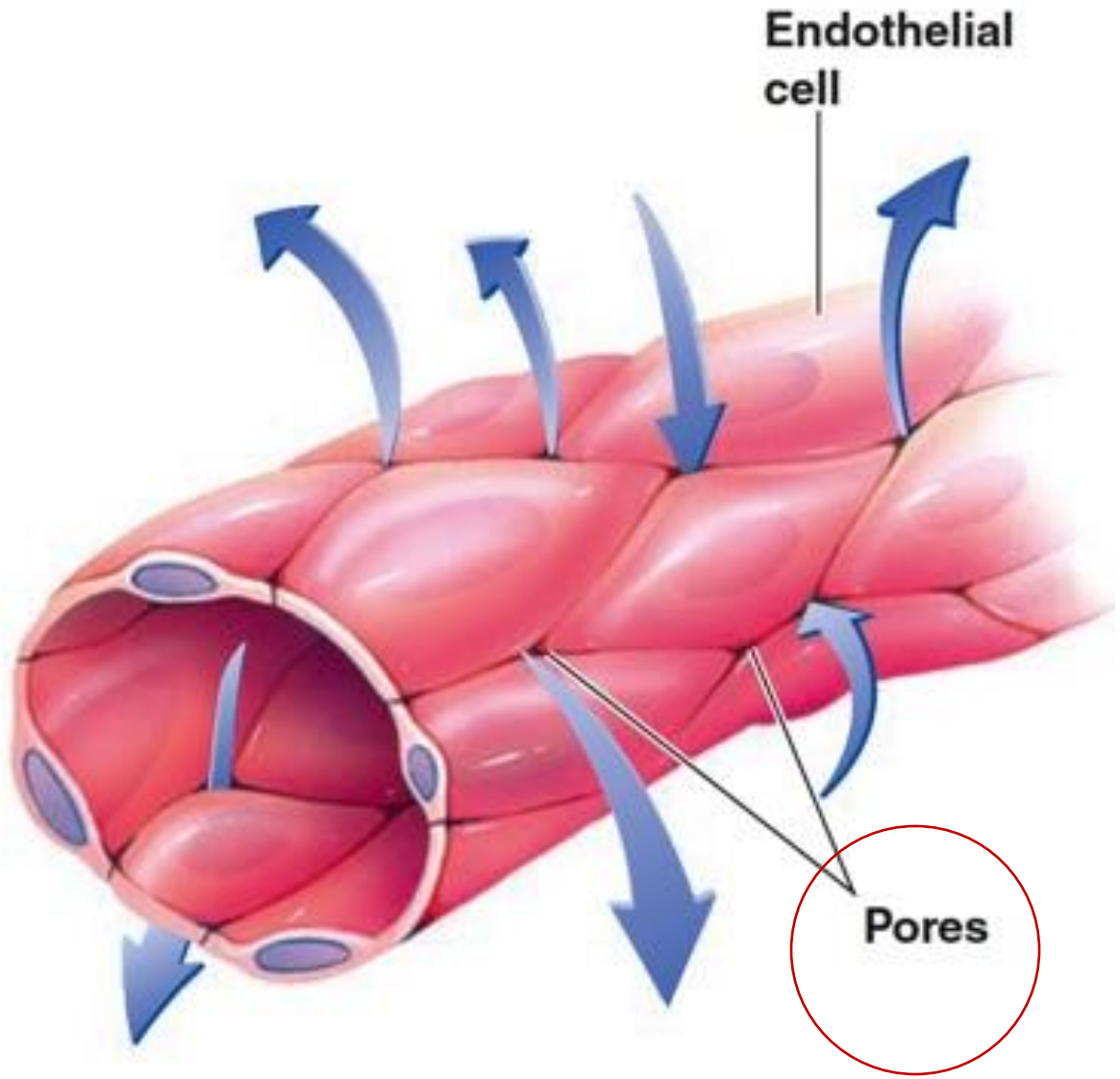

Endothelium
Elastin fibers
Smooth muscle
Elastin fibers
Connective tissue coat (mostly collagen fibers)
Large artery
Arteriole
Capillary
Venous valve
Endothelium
Smooth muscle; elastin fibers
Connective tissue coat (mostly collagen fibers)
Large vein



- As you can see here, this is capillary structure.
- What distinguish the capillary from other vessels is that it is composed of single layer of endothelial cells surrounded by a basal membrane. You can notice how thin it is and how its diameter is small , which serve its function as major exchange vessels.



- The most important mechanism for exchange of material between the capillary and the tissues is by simple diffusion (which is a passive mechanism in which substances can pass through a semi permeable membrane from media to another media down their concentration gradient) so there **SHOULD** be **difference in concentration** between the blood for that substance and the interstitium fluid.
- **Now let's talk about the factors in capillaries that enhance diffusion :**
- 1- Its thin wall (which minimize the distance for diffusion)
- 2- The radius or the diameter is small in the capillaries.
- 3- The extensive branches of the capillaries throughout the body make these capillaries in a close proximity of almost every cell in our body.
- Notice that all of these factors minimize diffusion distance.



- If you can recall from previous lecture, we said that capillaries have the highest cross-sectional area among vessels in our body ,therefore, they have the lowest velocity of blood flow (maximizing surface area for diffusion and time available for exchange).

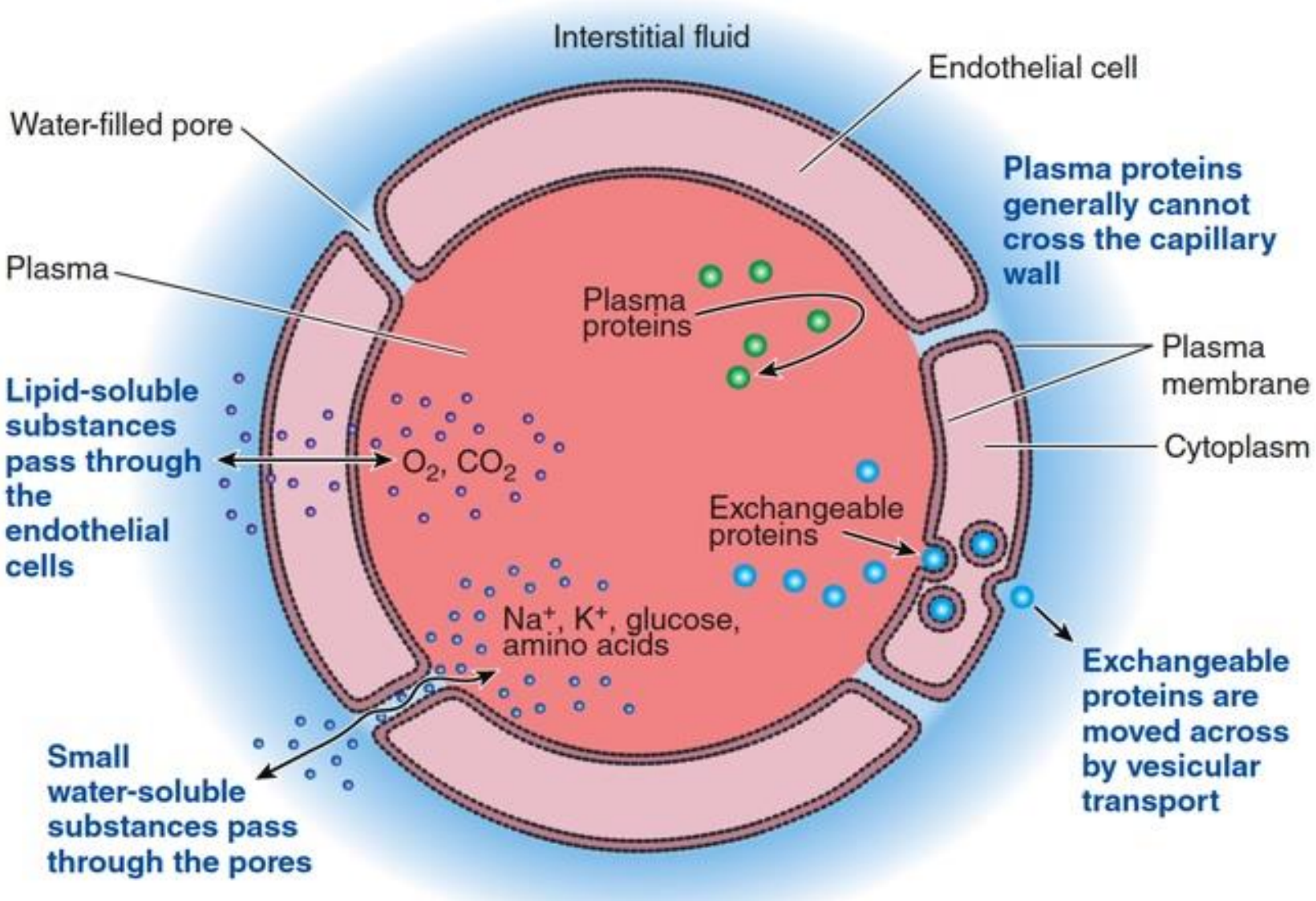
- Please notice here between these cells there are clefts or pores. These spaces allow the diffusion or the movement of substances to and from the capillary beds.

- So, let's sum up how structure serve the function:

1. minimizing diffusion distance via three things (thin wall, small radius, and high number of branches).
2. maximizing surface area for diffusion and time available for exchange (by hi Chris sectional area and slow velocity of the flow).

Capillaries

- Capillaries are the main sites for exchange of materials between blood and tissues.
- Materials are exchanged across capillary walls mainly by diffusion.
- Capillaries are ideally suited to enhance diffusion by:
- 1. Minimizing diffusion distances (thin capillary wall and small capillary diameter, coupled with the proximity of every cell to a capillary)
- 2. Maximizing surface area
- 3. Maximizing time available for exchange

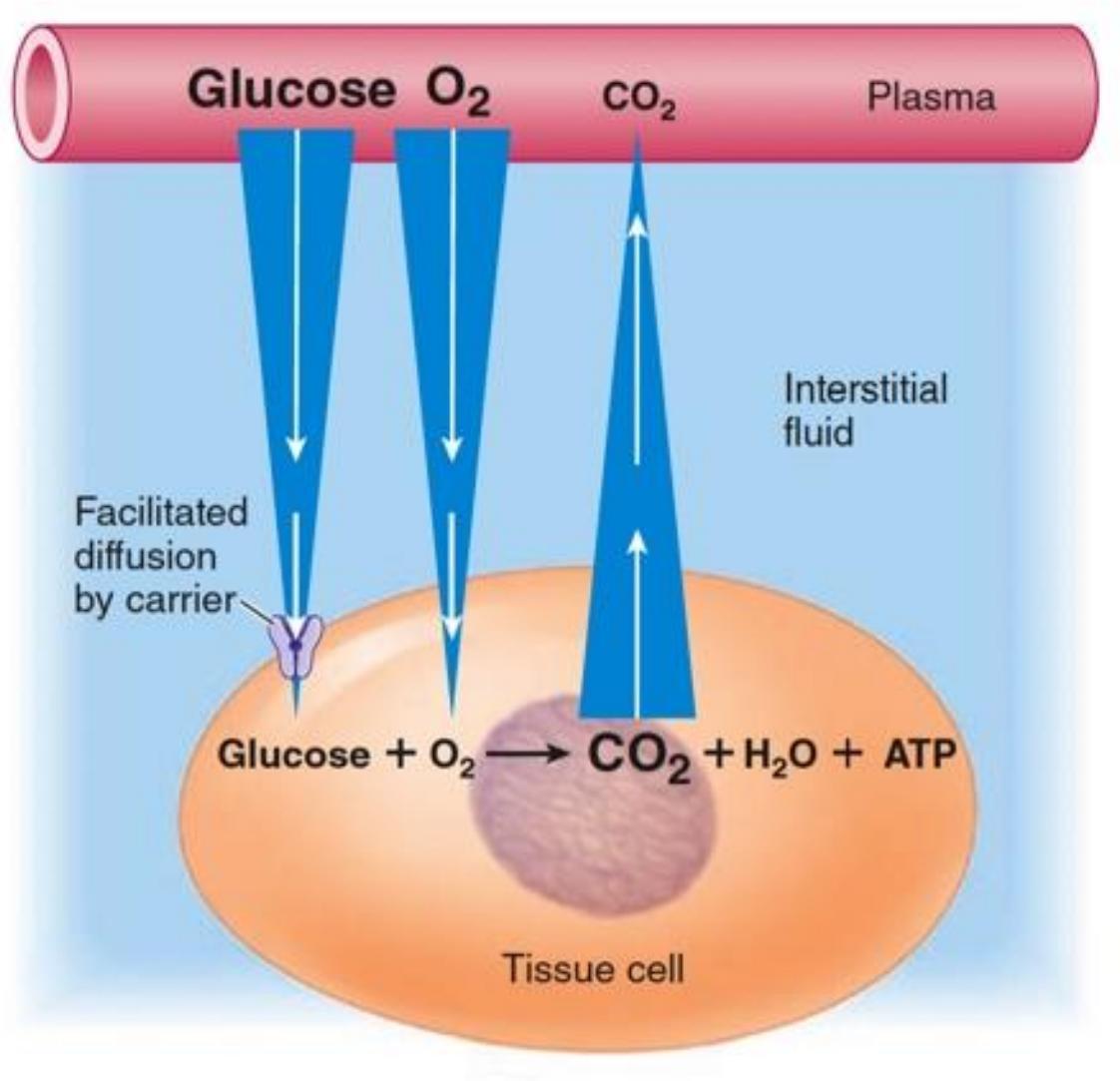

Interstitial fluid
Endothelial cell
Water-filled pore
Plasma proteins generally cannot cross the capillary wall
Plasma
Plasma proteins
Plasma membrane
Lipid-soluble substances pass through the endothelial cells
O_2, CO_2
Cytoplasm
Exchangeable proteins
Na^+, K^+, glucose, amino acids
Exchangeable proteins are moved across by vesicular transport
Small water-soluble substances pass through the pores

Diffusion of different substances

- substances in the blood are variable. We have lipid soluble and water soluble. Some of them have high molecular weight (or diameter) others are small molecules. They have to pass through these capillaries for exchange in different ways:

- In most capillaries, 1. small, water-soluble substances such as ions, glucose, and amino acids can readily pass through the water-filled pores.(because of their small size).
- But 2. large, water-soluble materials such as plasma proteins are kept from passing through. However, sometimes we need them to go to the tissues so they will be transported actively via transcytosis “also called vesicular transport”
- 3. Lipid-soluble substances, such as O2 and CO2, can readily pass through the endothelial cells themselves by dissolving in the lipid bilayer barrier of the plasma membrane surrounding the cells.

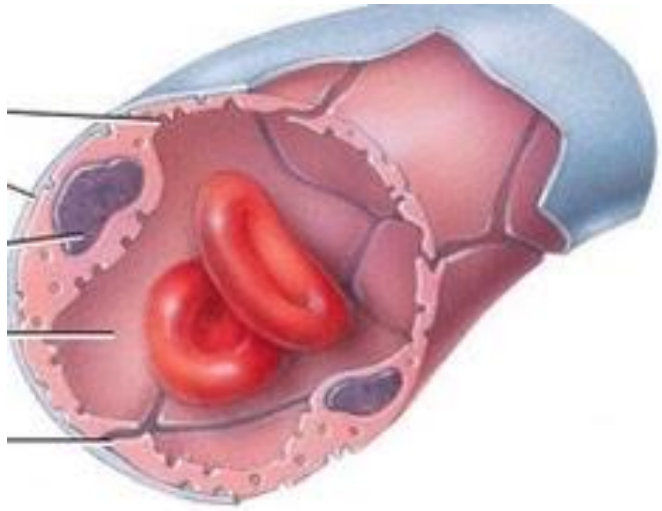
- Notice that there is no direct communication between capillaries and cells, there is always interstitial fluid in interstitial space.
- So, exchange is actually between plasma and interstitial fluid NOT DIRECTLY between plasma and cells but due to the " bulk flow" which means since there is minimal or no difference in composition between plasma and interstitium we say **it is between plasma and cell.**

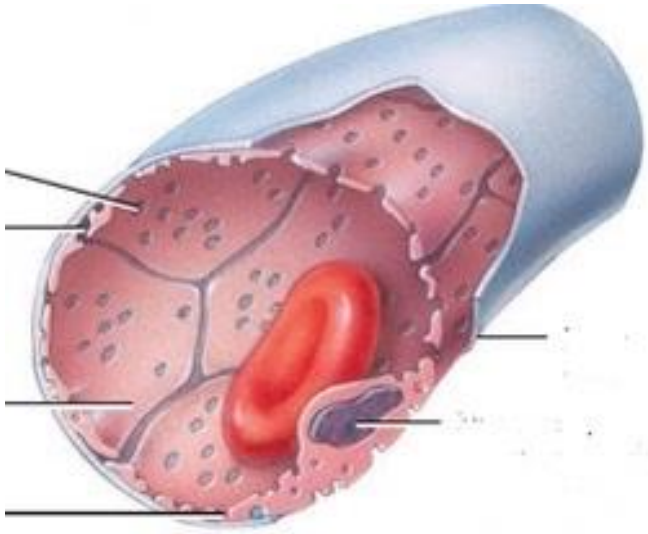


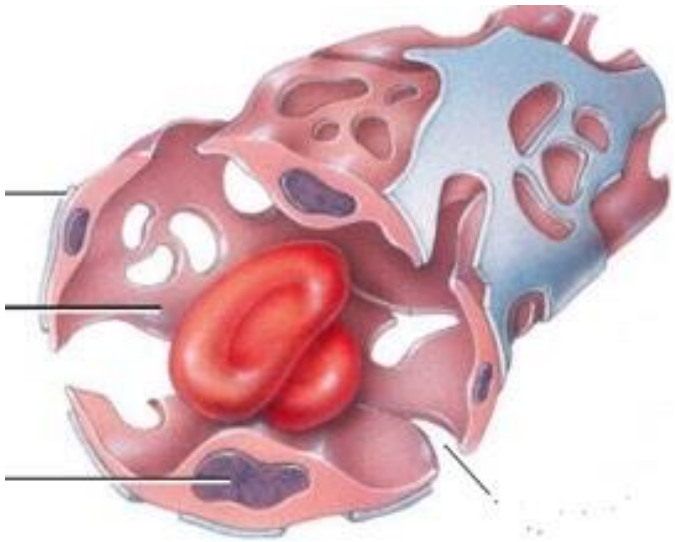
- This is showing the diffusion of different substances between the capillaries and cells
- For example, the oxygen usually because of reconditioning of the blood, it will be in higher concentration compared to its concentration in the cells where its've been used during metabolic processes, so oxygen will flow down the gradient from plasma into the cell.
- On the other hand, CO2, which its concentration is higher in the cell due to metabolic activity, will diffuse back from cell to the capillary.
- Glucose will diffuse from the blood to the cell

Transcytosis

- Vesicular transport also plays a limited role in passage of materials across the capillary wall.
- Large molecules that are not lipid-soluble, such as protein hormones that must be exchanged between blood and surrounding tissues, are transported from one side of the capillary wall to the other in endocytic–exocytic vesicles, a process called transcytosis.

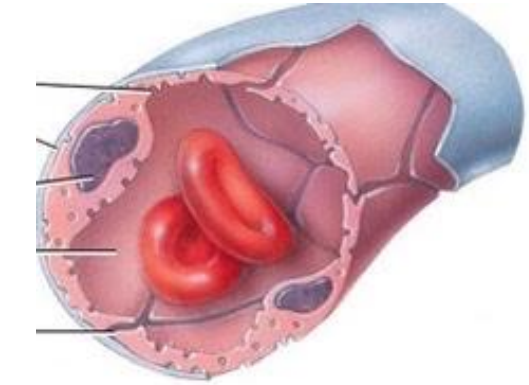


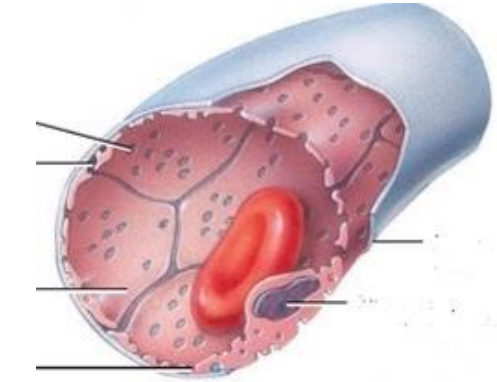


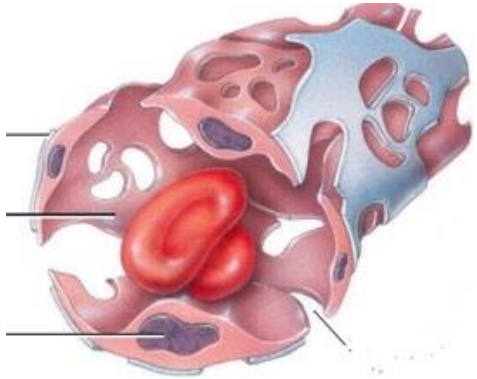


- The permeability of capillaries are different in different beds or different organs in our body, which means that the size of the pores will be different allowing larger sizes of molecules to pass through them.

Let's explain them further ⤵







- Most capillaries are " tight capillaries" so they have pores or cliffs that allows **only** small water-soluble molecules to pass through them.

- In some organs, we need larger molecules or proteinous molecules to pass through these capillaries to serve the function of the organ as in GIT or kidney, we need more exchange of substances that are larger than the pores, and therefore the walls here have larger holes "fenestrations" . so, capillaries in kidneys and GIT they're " fenestrated capillaries"

- larger pores for a large molecules like proteins such as in the liver. See how big are these holes "sinusoids" . the function of the liver is to synthesis different proteins, so **sinusoids** are needed for exchanging large molecules of protein & protein bound substances, such as lipids. so, they are permeable to these huge or larger molecules of proteins.

Notes about previous slide:

- Even within the same capillary sometimes circumstances happens so these pores size can change in diameter “increase in diameter so **permeability** will be increased”.
- For example, if there is a histamine release into the local tissue around this capillary ,it will cause the changes in endothelial cells “it will increase pores between these endothelial cells , and the capillaries **do not have smooth muscle cells** so there should be some kind of **intrinsic mechanism** within these endothelial cells “ECM or the fibrillary things” that will lead to some contractility within these endothelial cells. At the end, the pores size will increase ➡ more permeability of substances and fluids will be allowed in that capillary.

fenestrations

- Diffusion across capillary walls also depends on the walls' permeability to the materials being exchanged. The size of capillary pores varies from organ to organ.

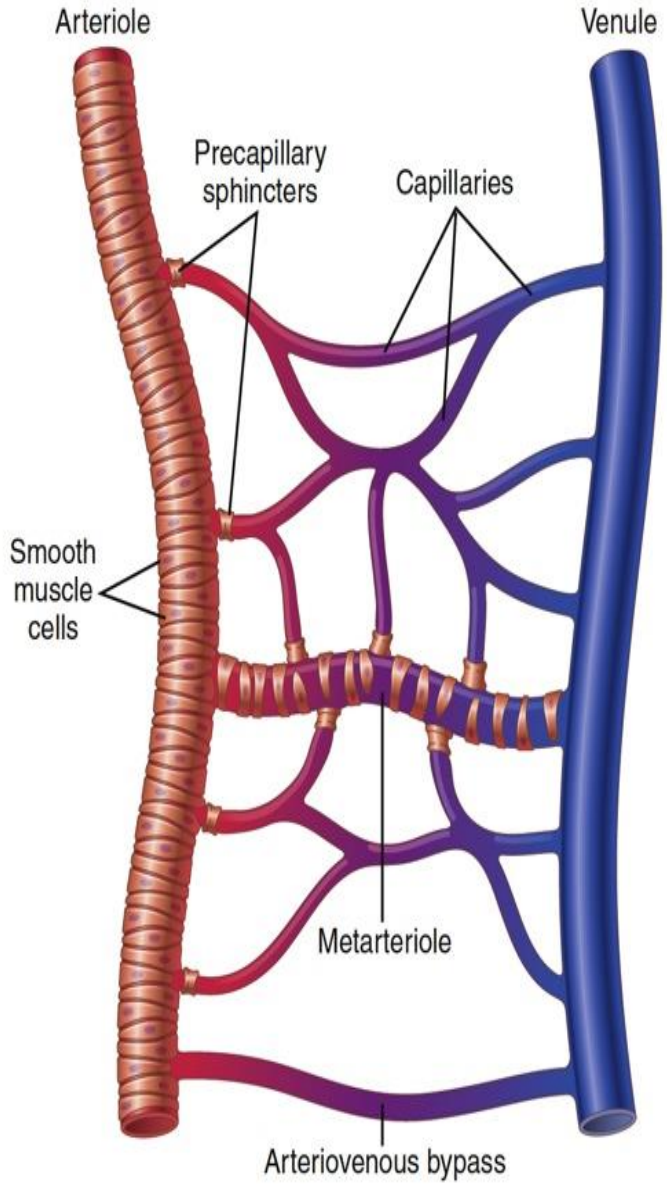
- In addition to having the narrow pores between endothelial cells, the leakier capillaries of the kidneys and intestines have larger holes known as fenestrations.
- They are important in the rapid movement of fluid across the capillaries in these organs during the formation of urine and during the absorption of a digested meal, respectively.

Sinusoids

- Endothelial cells of liver cells are discontinuous.
- Liver sinusoids have fenestrations and such large intercellular pores that even proteins pass through readily.
- This is adaptive because the liver’s functions include synthesis of plasma proteins and the metabolism of protein-bound substances such as cholesterol. These proteins must all pass through the liver’s capillary (sinusoid) walls.

Vasomotion

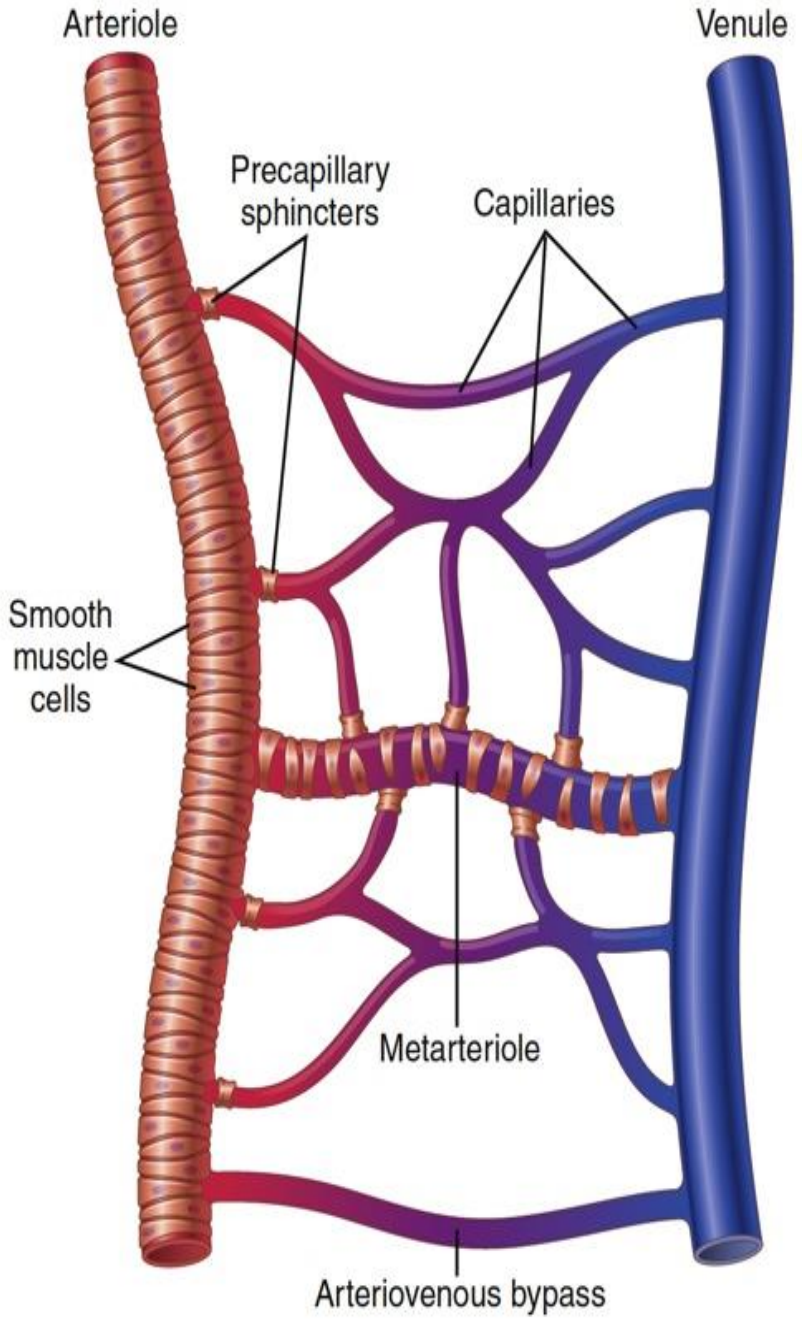
- Blood usually does not flow continuously through the capillaries. Instead, it flows intermittently, "turning on and off every few seconds or minutes". The cause of this intermittency is the phenomenon called vasomotion, which means intermittent contraction of the metarterioles and precapillary sphincters.
- The most important factor affecting the degree of opening and closing of the metarterioles and precapillary sphincters that has been found thus far is the concentration of oxygen in the tissues.



- Look at this structure of the capillary, so it comes **between the arteriole** (remember the smooth muscle cell surrounding their walls allowing them to adjust blood flow to the cells with vasoconstriction or vasodilation) **& venules**
- Notice here that:

1. Capillaries can come out of the arterioles then go back as a venules.
2. **OR** it may come from the arteriole but go back to metarteriole.
3. **OR** the blood flow from the arteriole directly through the metarteriole to the venules **without passing through the capillaries**

- See here metarterioles, they have smooth muscle cells surrounding their wall. They're not as extensive as the arterioles, but they do have some.

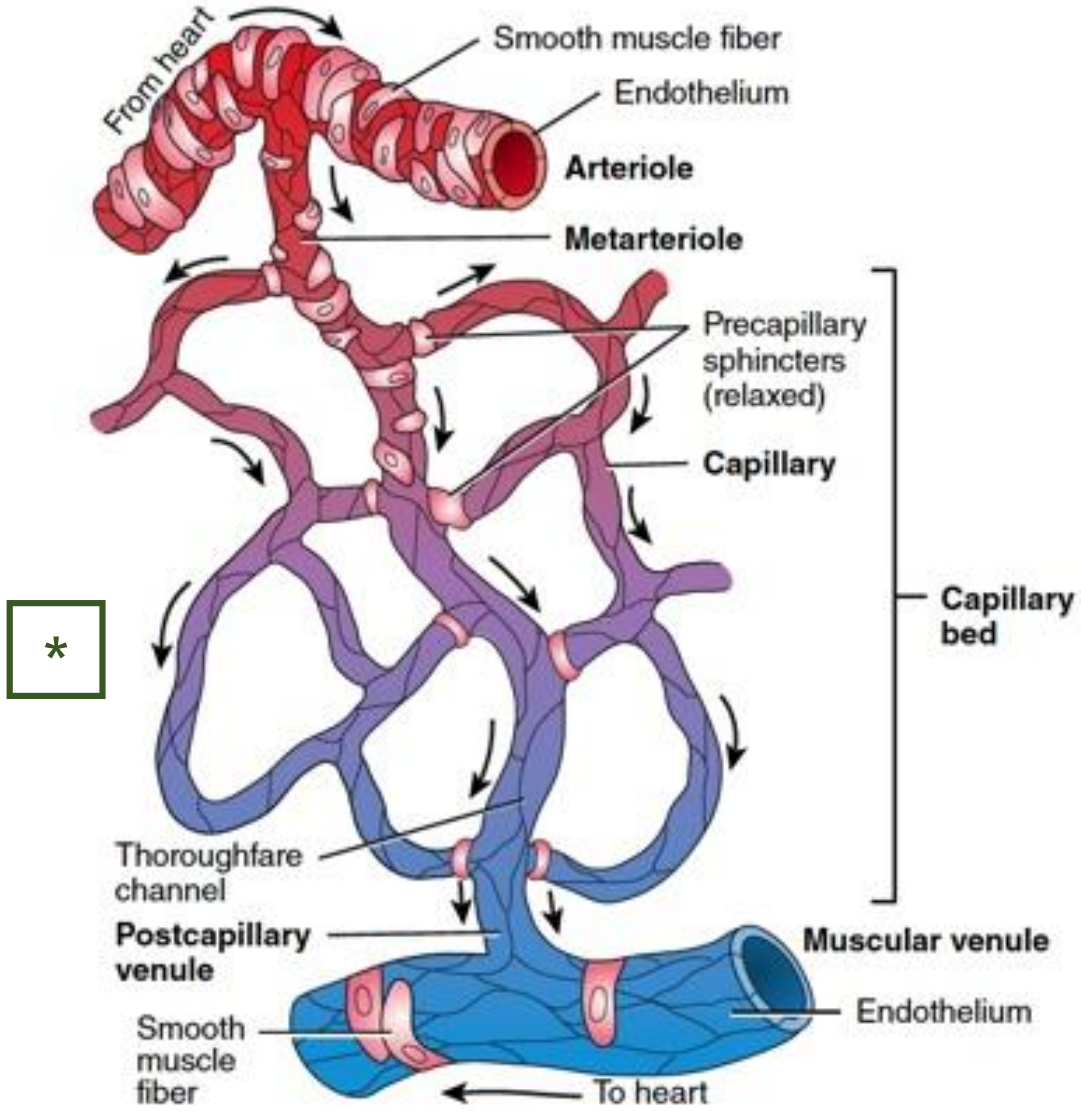


- Notice that between the arterioles and the start of the capillary, there is what we call it **pre-capillary sphincter**. It's a smooth muscle layer.so you know sphincter means that there will be changing in the opening so it will change if there will be blood flow to this capillary or not, depending on the needs of that tissue, because in our body, we have an enormous amount of capillaries, and they are so extensive SO there is no way to supply them with blood all the time. Tissues do not need that ,for example, in skeletal muscles there is a huge number of capillaries, but **At rest,** they won't use 10% of these capillaries while there is exercise, extra amount of capillary for exchange of the tissues will be used, we don't need to open all these capillaries and do exchange when no need for it.
- Who will adjust that is **arterioles** so when they constrict, less blood flow will come to the capillaries, especially if also the **pre-capillaries sphincter is constricted**

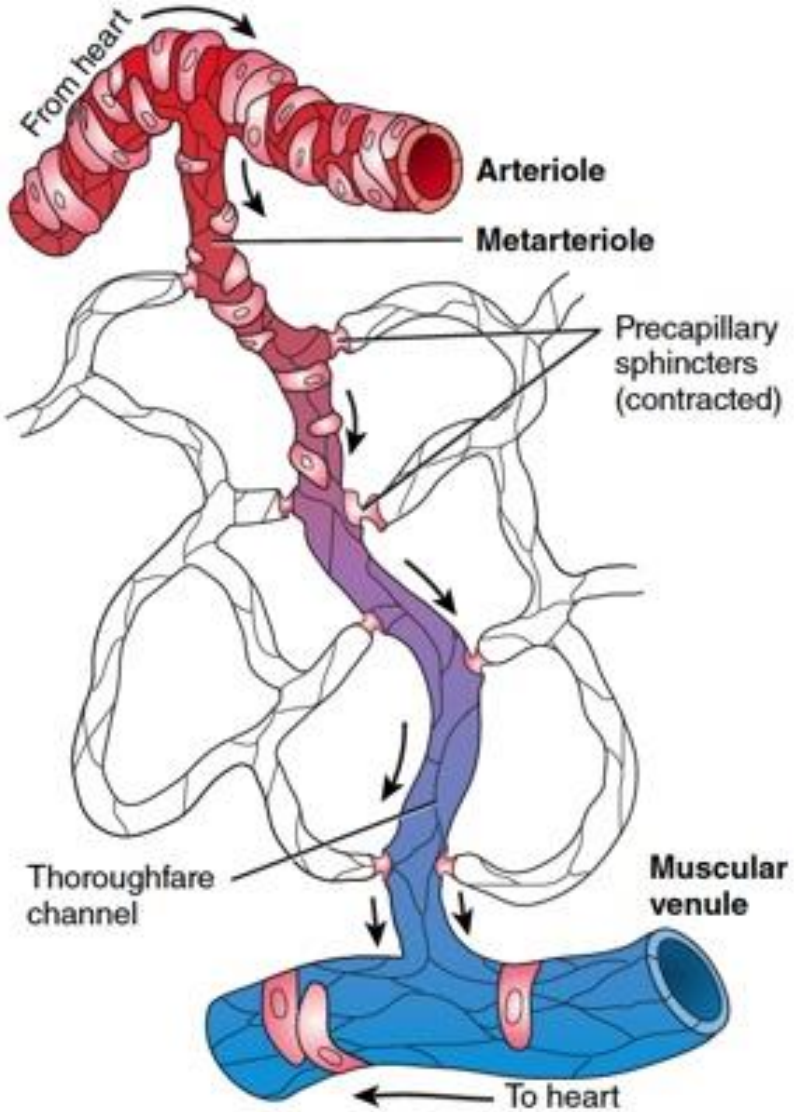
- Sometimes no need for blood flow to this area so the blood will go from the arteriole through the metarterioles and directly to the venules.

Metarterioles

- Many capillaries are not open under resting conditions.
- The branching and reconverging arrangement within capillary beds varies somewhat, depending on the tissue.
- Capillaries typically branch either directly from an arteriole or from a metarteriole, which runs between an arteriole and a venule.
- Likewise, capillaries may rejoin at either a venule or a metarteriole.



(a) Sphincters relaxed: blood flowing through capillaries



(b) Sphincters contracted: blood flowing through thoroughfare channel

Notes about previous slide:

- So lets explain vessel motion, more, which is the difference in the contractility of the smooth muscle cells in the pre-capillary sphincter metarterioles and arterioles as a start point

- let's say that this tissue (*) now is metabolically active and it's consuming so much of the O2, so its levels are decreasing. That is a local chemical effect that will induce and sensed by these smooth muscle cells & because they have myogenic activity, they will understand the low O2 means we need more blood supply to supply these cells so these precapillary sphincters will dilate. Also, smooth muscles in the metarterioles will dilate ➡ more blood flow will come ,more exchange of O2 and other substances And that will go back to the venules

- Now if this same tissue now it's not metabolically so the O2 levels are high & sufficient supply whatever they are doing in their functions now. SO, this pre-capillary sphincters and the smooth muscles in the metarterioles will constrict so no more blood is coming to these capillaries in the side because we don't need them .

Precapillary sphincters

- Precapillary sphincters are not innervated, but they have a high degree of myogenic tone and are sensitive to local metabolic changes.
- They act as stopcocks to control blood flow through the particular capillary that each one guards.
- Capillaries themselves have no smooth muscle, so they cannot actively participate in regulating their own blood flow.
- When tissue metabolic activity increases, the local metabolic changes bring about relaxation of precapillary sphincters in the vicinity, thereby increasing the number of open capillaries.
- When tissue activity decreases, the local precapillary sphincters contract.
- As a result, blood bypasses the capillary bed and flows only through the metarterioles.

Exchange between blood and tissues

- Exchanges across the capillary wall between the plasma and the interstitial fluid are largely passive. The only transport across this barrier that requires energy is the limited vesicular transport.
- Because capillary walls are highly permeable, exchange is so thorough that the interstitial fluid takes on essentially the same composition as incoming arterial blood, with the exception of the large plasma proteins that usually do not escape from the blood. Therefore, when we speak of exchanges between blood and tissue cells, we tacitly include interstitial fluid as a passive intermediary.
- Exchanges between blood and surrounding tissues across capillary walls are accomplished in two ways: (1) passive diffusion down concentration gradients, the primary mechanism for exchanging individual solutes, and (2) bulk flow.

Bulk flow

- The second means by which exchange is accomplished across capillary walls is bulk flow.
- A volume of protein-free plasma actually filters out of the capillary, mixes with the surrounding interstitial fluid, and then is reabsorbed back into the venous part of the capillary.
- This process is called bulk flow because the various constituents of the fluid (water and all solutes) are moving in bulk, or as a unit, in contrast to the discrete diffusion of individual solutes down concentration gradients.

Bulk flow

- Bulk flow does not play an important role in exchange of individual solutes between blood and tissues because the quantity of solutes moved across the capillary wall by bulk flow is extremely small compared to the larger transfer of solutes by diffusion.
- The composition of the fluid filtered out of the capillary is essentially the same as the composition of the fluid that is reabsorbed.
- Thus, ultrafiltration and reabsorption are not important in exchange of nutrients and wastes.
- Bulk flow is extremely important, however, in regulating the distribution of ECF between plasma and interstitial fluid, maintaining normal amounts or adjusting ECF of the plasma and interstitial fluid according to the needs of these vessels.
- Maintenance of proper arterial blood pressure depends in part on an appropriate volume of circulating blood.

Capillary hydrostatic pressure

➢Four forces influence fluid movement across the capillary wall:

1. Capillary blood pressure (P_c)

- is the fluid or hydrostatic pressure exerted on the inside of the capillary walls by blood.
- This pressure tends to force fluid out of the capillaries into the interstitial fluid. (positive + force)
- The fluid that get affected here is "protein-free"; because protein is larger than the pores in the walls of the capillary
- By the level of the capillaries, blood pressure has dropped substantially because of frictional losses in pressure in the high-resistance arterioles upstream.
- On average, the hydrostatic pressure is 37 mm Hg at the arteriolar end of a tissue capillary.
- It declines even further, to 17 mm Hg, at the capillary's venular end because of further frictional loss coupled with the exit of fluid through ultrafiltration along the capillary's length

Plasma colloid osmotic pressure

2. Plasma-colloid osmotic pressure (π_c)

- Also known as oncotic pressure, is a force caused by colloidal dispersion of plasma proteins; it encourages fluid movement into the capillaries **(negative - force)**.
- Because plasma proteins remain in the plasma rather than entering the interstitial fluid, a protein concentration difference exists between plasma and interstitial fluid.
- The oncotic pressure in the interstitial fluid (π_i) is almost zero, but in capillary (π_c) it's high
- Accordingly, a water concentration difference also exists between these two regions. Plasma has a higher protein concentration and a lower water concentration than interstitial fluid does. This difference exerts an osmotic effect that tends to move water from the area of higher water concentration in interstitial fluid to the area of lower water concentration in plasma.
- The other plasma constituents do not exert an osmotic effect because they readily pass through the capillary wall, so their concentrations are equal in plasma and interstitial fluid. This pressure averages 25 mm Hg.

Interstitial fluid hydrostatic pressure

3. Interstitial fluid hydrostatic pressure (P_i)

- is the fluid pressure exerted on the outside of the capillary wall by interstitial fluid.

- This pressure tends to force fluid into the capillaries. (negative - force)

Interstitial fluid colloid osmotic pressure

4. Interstitial fluid–colloid osmotic pressure (π_i)

- This pressure tends to force fluid out of the capillaries into the interstitial fluid **(positive + force)**.
- is another force that does not normally contribute significantly to bulk flow.
- The small fraction of plasma proteins that leak across the capillary walls into the interstitial spaces are normally returned to the blood by the lymphatic system.
- Therefore, the protein concentration in the interstitial fluid is extremely low, and the interstitial fluid–colloid osmotic pressure is essentially zero.

Net exchange pressure

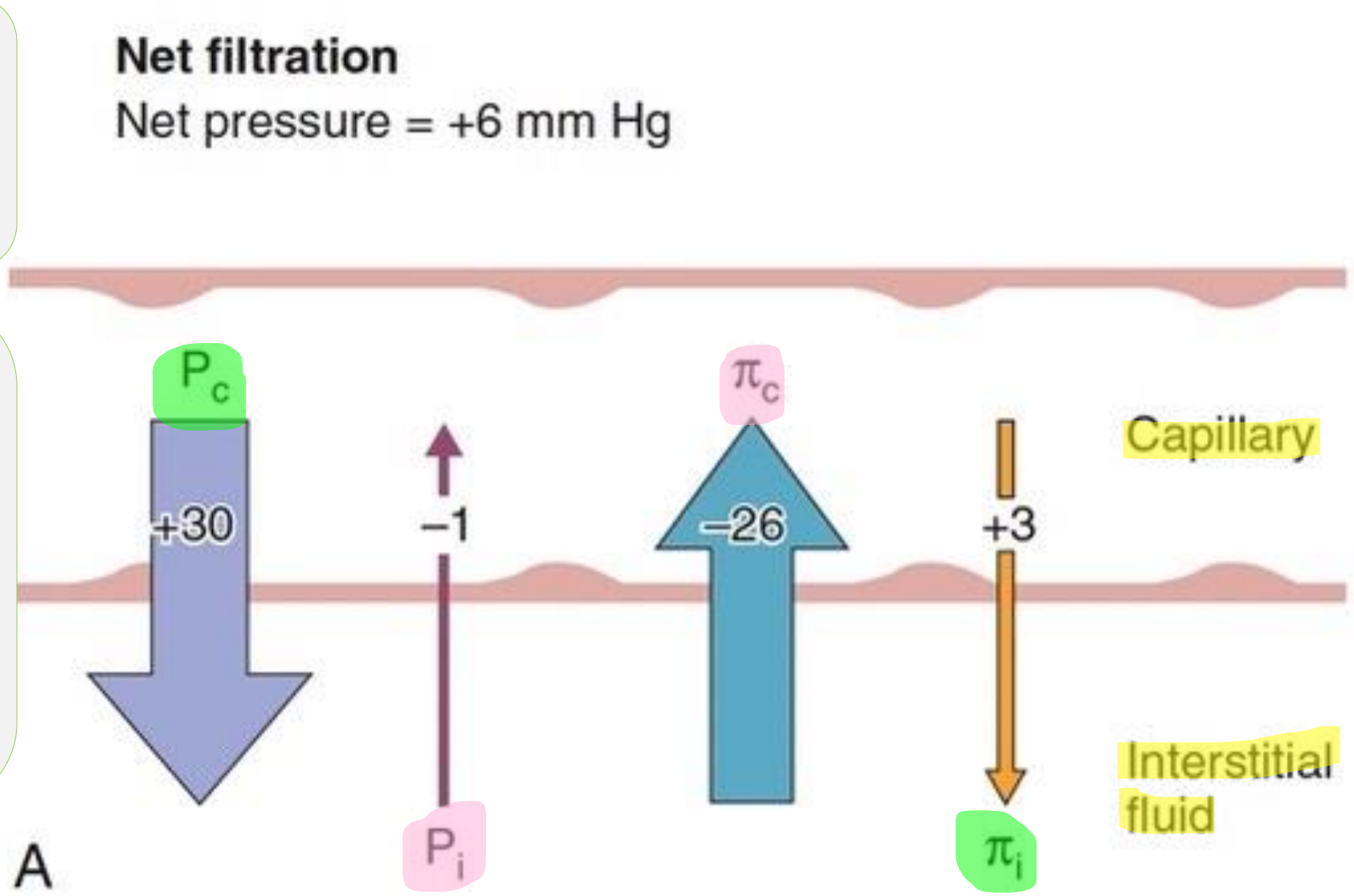
- A positive net exchange pressure (when outward pressure exceeds inward pressure) represents an ultrafiltration pressure.
- A negative net exchange pressure (when inward pressure exceeds outward pressure) represents a reabsorption pressure.
- At the arteriolar end of the capillary, Ultrafiltration takes place at the beginning of the capillary as this outward pressure gradient forces a protein-free filtrate through the capillary pores resulting progressive lowering in capillary blood pressure.
- By the time the venular end of the capillary is reached, capillary blood pressure has dropped but the other pressures have remained essentially constant. At this point, Reabsorption of fluid takes place (the fluid that have been filtered in the arteriolar end) as this inward pressure gradient forces fluid back into the capillary at its venular end.
- The capillary blood pressure is the main factor controller here of the exchange

Capillary blood pressure (P_c) and Interstitial fluid–colloid osmotic pressure (π_i) both favor outward flow or positive flow.

Plasma-colloid osmotic pressure (π_c) and Interstitial fluid hydrostatic pressure (P_i) both favor inward flow or negative flow.

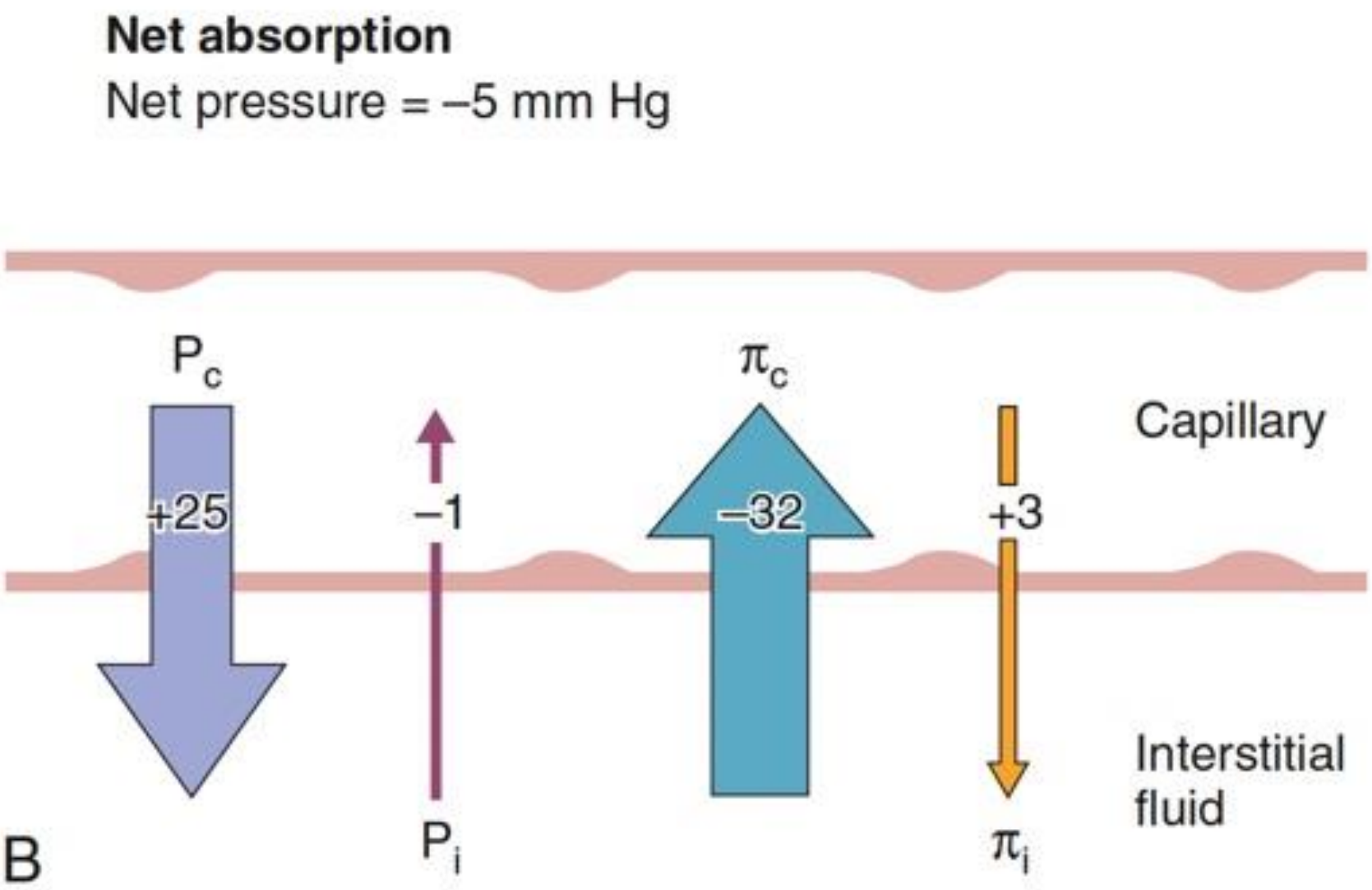
The most important factor controlling the bulk flow is Hydrostatic Capillary blood pressure (P_c) and Plasma-colloid osmotic pressure (π_c)

Here <u>at the arteriolar end of the capillary</u> the resultant of these four forces is positive → ultrafiltration (outflow)
Called ultrafiltration → because the quantity of solutes moved across the capillary wall by bulk flow is extremely small compared to the larger transfer of solutes by diffusion.



Here at the venular end of the capillary the resultant of these four forces is negative → reabsorption (inflow)
Note that:

- The Capillary blood pressure (P_c) is decreased
- Plasma-colloid osmotic pressure (π_c) is increased
- Other forces are the same



Net filtration pressure

- the NFP is slightly positive under normal conditions, resulting in a net filtration of fluid across the capillaries into the interstitial space in most organs.
- The rate of fluid filtration in a tissue is also determined by the number and size of the pores in each capillary, as well as the number of capillaries in which blood is flowing.
- These factors are usually expressed together as the capillary filtration coefficient (Kf).
- The Kf is therefore a measure of the capacity of the capillary membranes to filter water for a given NFP.

$$J_v = K_f[(P_c - P_i) - (\pi_c - \pi_i)]$$

where

J_v = Fluid movement (mL/min)

K_f = Hydraulic conductance (mL/min per mm Hg)

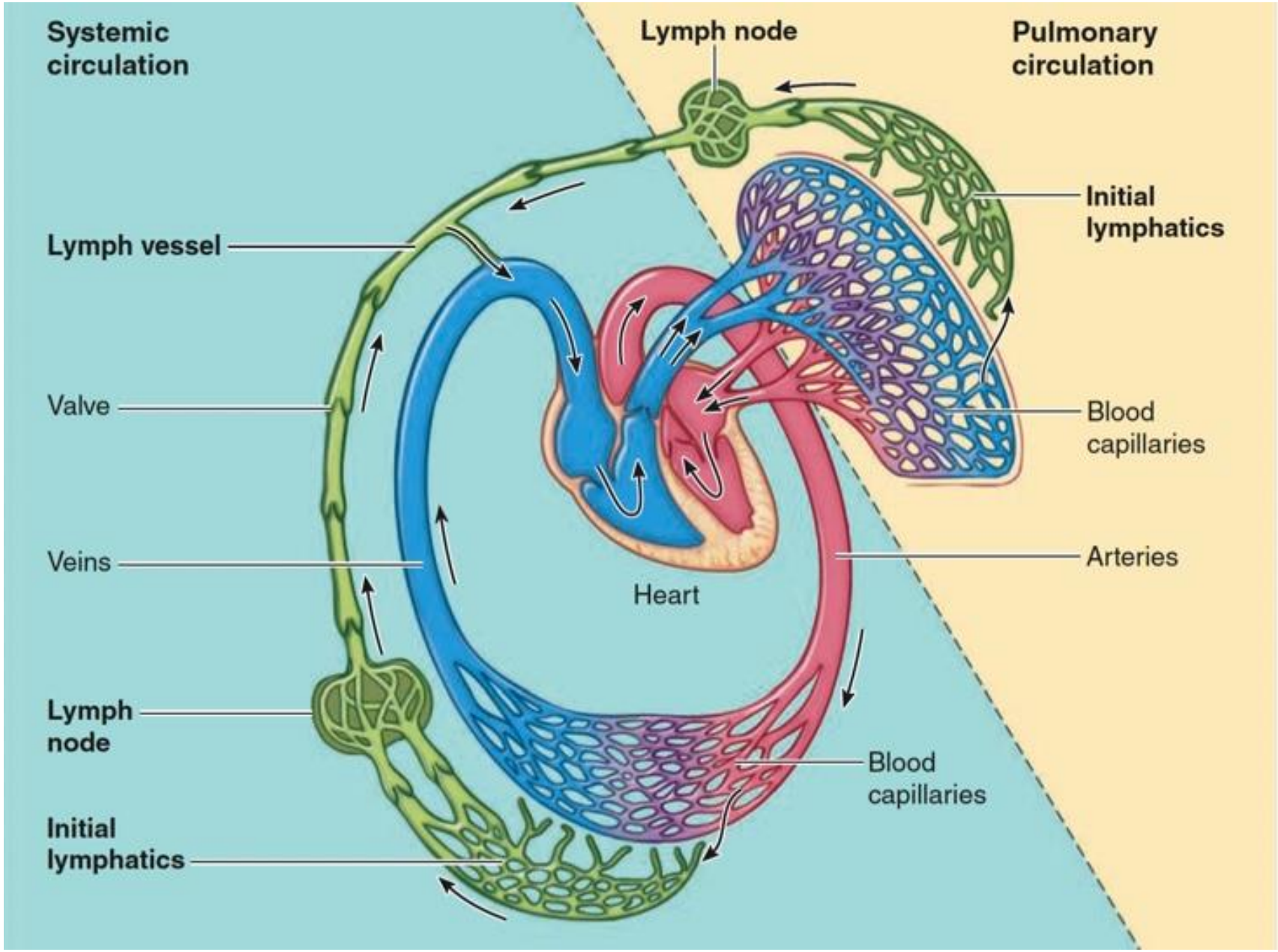
P_c = Capillary hydrostatic pressure (mm Hg)

P_i = Interstitial hydrostatic pressure (mm Hg)

π_c = Capillary oncotic pressure (mm Hg)

π_i = Interstitial oncotic pressure (mm Hg)

- Starling equation show how we use these four pressures to calculate the net exchange pressure
- The most important factor controlling the net exchange pressure as we said is Hydrostatic Capillary blood pressure (P_c) and Plasma-colloid osmotic pressure (π_c)
- Also, there is another "fifth factor" controlling the net exchange pressure → capillary filtration coefficient (Kf).

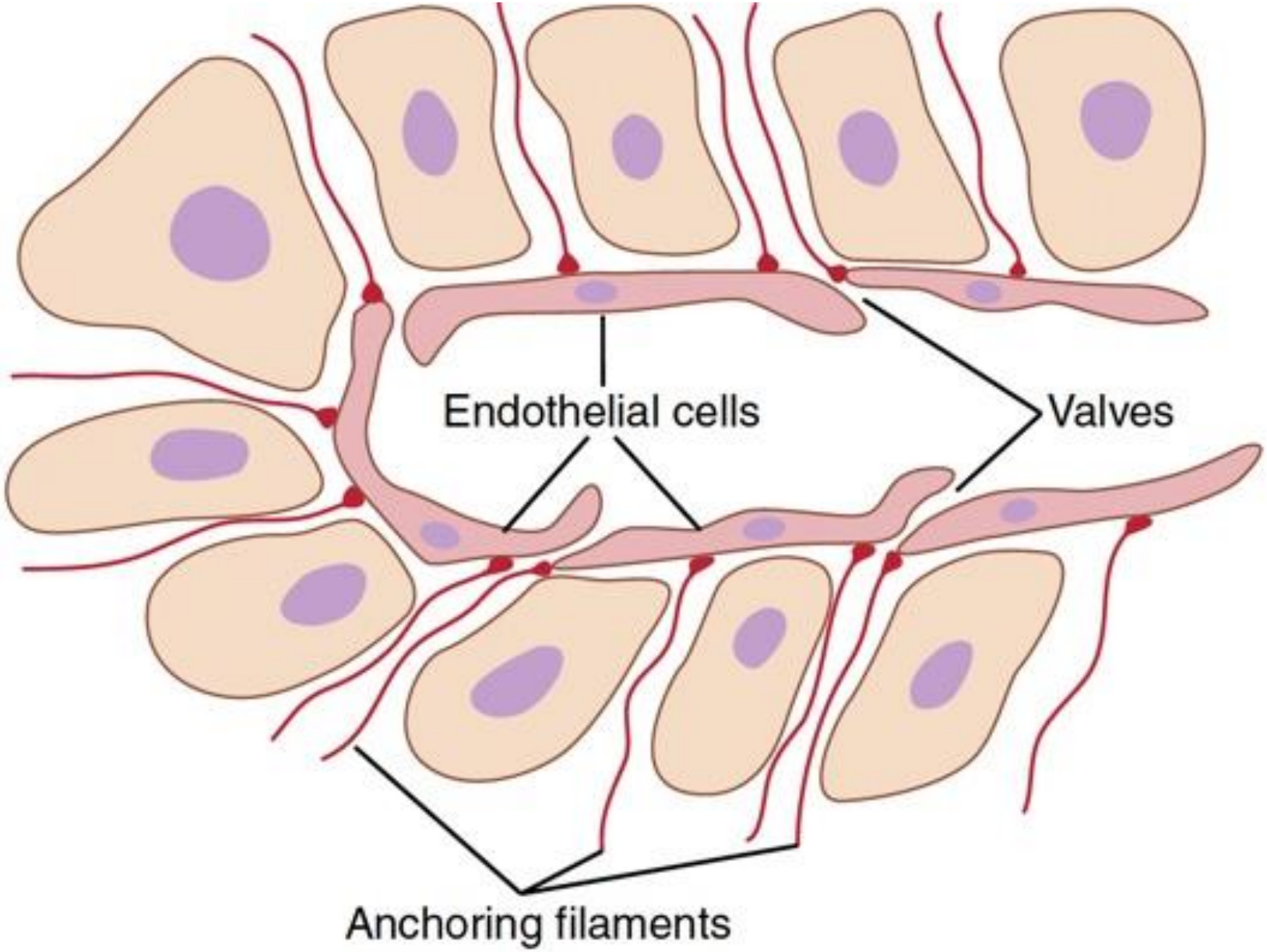

Systemic circulation
Lymph node
Pulmonary circulation
Initial lymphatics
Lymph vessel
Valve
Blood capillaries
Veins
Arteries
Heart
Lymph node
Blood capillaries
Initial lymphatics

The lymphatic system

- under normal circumstances, slightly more fluid is filtered out of the capillaries into the interstitial fluid than is reabsorbed from the interstitial fluid back into the plasma.

- The extra fluid filtered out So, this filtration– reabsorption imbalance is picked up by the lymphatic system.

- So, it will take these particles that cannot be taken by vascular system and send them back to the venous circulation.


Endothelial cells
Valves
Anchoring filaments

The lymphatic system

- Small, blind-ended terminal lymph vessels known as initial lymphatics permeate almost every tissue of the body.
- The endothelial cells forming the walls of initial lymphatics slightly overlap, with their overlapping edges being free instead of attached to the surrounding cells.
- This arrangement creates one-way, valvelike openings in the vessel wall.
- Fluid pressure on the outside of the vessel pushes the innermost edge of a pair of overlapping edges inward, creating a gap between the edges (that is, opening the valve).
- This opening permits interstitial fluid to enter.

The lymphatic system

- Once interstitial fluid enters a lymphatic vessel, it is called lymph.
- Fluid pressure on the inside forces the overlapping edges together, closing the valves so that lymph does not escape.
- These lymphatic valvelike openings are larger than the pores in blood capillaries.
- Consequently, large particles in the interstitial fluid, such as escaped plasma proteins and bacteria, can gain access to initial lymphatics but are excluded from blood capillaries.

The lymphatic flow

- Initial lymphatics converge to form larger lymph vessels, eventually empty into the venous system before it enters the right atrium.
- There is no “lymphatic heart” to provide driving pressure, but lymph is directed from the tissues toward the venous system in the thoracic cavity by two mechanisms.

1. Lymph vessels beyond the initial lymphatics are surrounded by smooth muscle, which contracts rhythmically as a result of myogenic activity. When this muscle is stretched because the vessel is distended with lymph, the muscle inherently contracts more forcefully, pushing the lymph through the vessel.

The lymphatic flow

- This intrinsic “lymph pump” is the major force for propelling lymph.

2. Stimulation of lymphatic smooth muscle by the sympathetic nervous system further increases the pumping activity of the lymph vessels.

- Because lymph vessels lie between skeletal muscles, contraction of these muscles squeezes the lymph out of the vessels.

- One-way valves spaced at intervals within the lymph vessels direct the flow of lymph toward its venous outlet in the chest.

Functions of the lymphatic system

- Return of excess filtered fluid.
- Defense against disease.
- Transport of absorbed fat.(in GIT)
- Return of filtered protein.

Edema

- Excessive interstitial fluid can accumulate when one of the physical forces acting across the capillary walls becomes abnormal for some reason.
- Swelling of the tissues because of excess interstitial fluid is known as edema.
- Whatever the cause of edema, an important consequence is reduced exchange of materials between blood and cells.

Certain pathological cases cause more fluid accumulated in the interstitial fluid, which could be caused by:

1. Decreased capillary oncotic pressure.
2. Changes in the permeability.
3. Increasing the outward capillary hydrostatic pressure.
4. Problem in the lymphatic function.

TABLE 4.6 Causes and Examples of Edema Formation

Cause	Examples
↑ P_c (capillary hydrostatic pressure)	Arteriolar dilation Venous constriction Increased venous pressure Heart failure Extracellular fluid volume expansion
↓ π_c (capillary oncotic pressure)	Decreased plasma protein concentration Severe liver failure (failure to synthesize protein) Protein malnutrition Nephrotic syndrome (loss of protein in urine)
↑ K_f (hydraulic conductance)	Burn Inflammation (release of histamine; cytokines)
Impaired lymphatic drainage	Standing (lack of skeletal muscle compression of lymphatics) Removal or irradiation of lymph nodes Parasitic infection of lymph nodes

Causes of Edema

Cause	Examples
↓ π_c (capillary oncotic pressure)	Decreased plasma protein concentration Severe liver failure (failure to synthesize protein) Protein malnutrition Nephrotic syndrome (loss of protein in urine)

1. A reduced concentration of plasma proteins decreases plasma oncotic pressure.

- Such a drop in the major inward pressure lets excess fluid filter out, whereas less-than-normal amounts of fluid are reabsorbed; hence, extra fluid remains in the interstitial spaces.

➢Edema can be caused by a decreased concentration of plasma proteins in several ways:

1. excessive loss of plasma proteins in urine, from kidney disease.
2. reduced synthesis of plasma proteins, from liver disease.
3. a diet deficient in protein.(malnutrition)

Causes of Edema

Cause	Examples
↑ K_f (hydraulic conductance)	→ Burn → Inflammation (release of histamine; cytokines)

2. Increased permeability of the capillary walls allows more plasma proteins than usual to pass from the plasma into the surrounding interstitial fluid:

- The resultant fall in capillary oncotic pressure decreases the effective inward pressure, whereas the resultant rise in interstitial oncotic pressure caused by excess protein in the interstitial fluid increases the effective outward force.

➢This imbalance contributes in part to the localized edema associated with injuries (for example, blisters) and allergic responses (for example, hives).

Causes of Edema

Cause	Examples
↑ P_c (capillary hydrostatic pressure)	Arteriolar dilation Venous constriction Increased venous pressure Heart failure Extracellular fluid volume expansion

3. Increased venous pressure, as when blood dams up in the veins, is accompanied by <u>increased capillary hydrostatic pressure.</u>

- Because the capillaries drain into the veins, damming of blood in the veins leads to a "backlog" of blood in the capillaries because less blood moves out of the capillaries into the overloaded veins than enters from the arterioles.
- more pressure in the capillaries favouring the filtration of fluids outside of the vascular system as a protective mechanism, but that will be accumulated in the tissues and causing edema.

A. The resultant elevation in outward hydrostatic pressure across the capillary walls is largely responsible for the edema seen with congestive heart failure.

B. It might be also iatrogenic that we give extra fluid volume intravascularly to these patients

C. Regional edema can also occur because of localized restriction of venous return.

- An example is the swelling often occurring in the legs and feet during pregnancy. The enlarged uterus compresses the major veins that drain the lower extremities as these vessels enter the abdominal cavity.
- The resultant damming of blood in these veins raises blood pressure in the capillaries of the legs and feet, which promotes regional edema of the lower extremities, especially in the third trimester.

Causes of Edema

Cause	Examples
Impaired lymphatic drainage	Standing (lack of skeletal muscle compression of lymphatics) Removal or irradiation of lymph nodes Parasitic infection of lymph nodes

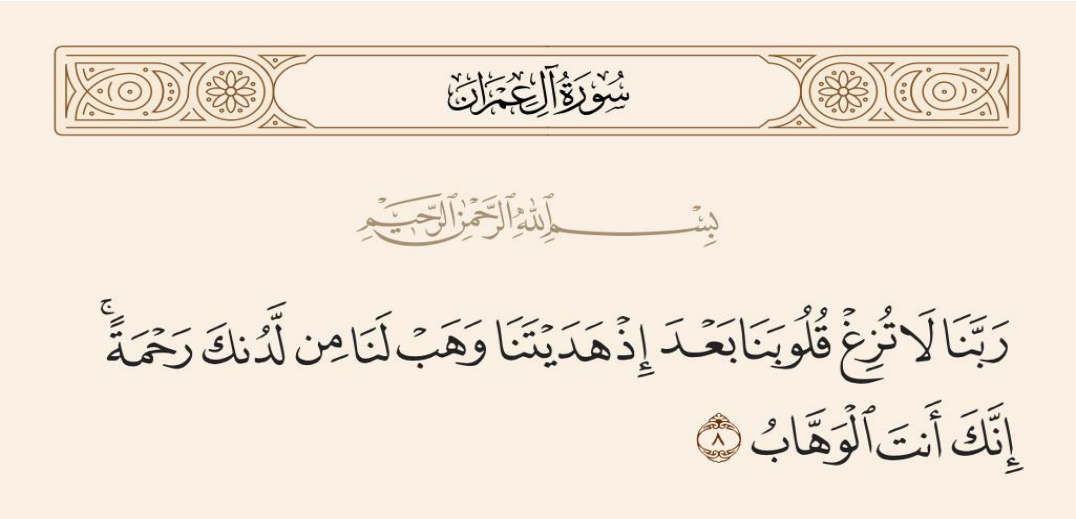
4. Blockage of lymph vessels produces edema because the excess filtered fluid is retained in the interstitial fluid rather than returned to the blood through the lymphatics. Protein accumulation in the interstitial fluid compounds the problem through its osmotic effect.

A. May be cause by increased gravity(e.g., standing) → lack of skeletal muscle compression

B. Local lymph blockage can occur, for example, in the arms of women whose major lymphatic drainage channels from the arm have been blocked as a result of lymph node removal during surgery for breast cancer, and you can see their arms swelled.

C. More widespread lymph blockage occurs with filariasis, a mosquito borne parasitic disease found predominantly in tropical coastal regions. In this condition, small, threadlike filaria worms infect the lymph vessels, where their presence prevents proper lymph drainage. The affected body parts, particularly the scrotum and extremities, become grossly edematous. The condition is often called elephantiasis because of the elephantlike appearance of the swollen extremities. (cause generalized edema).

Thank you



VERSIONS	SLIDE #	BEFORE CORRECTION	AFTER CORRECTION
V1→ V2			
V2→V3			

امسح الرمز و شاركنا بأفكارك لتحسين أدائنا!!