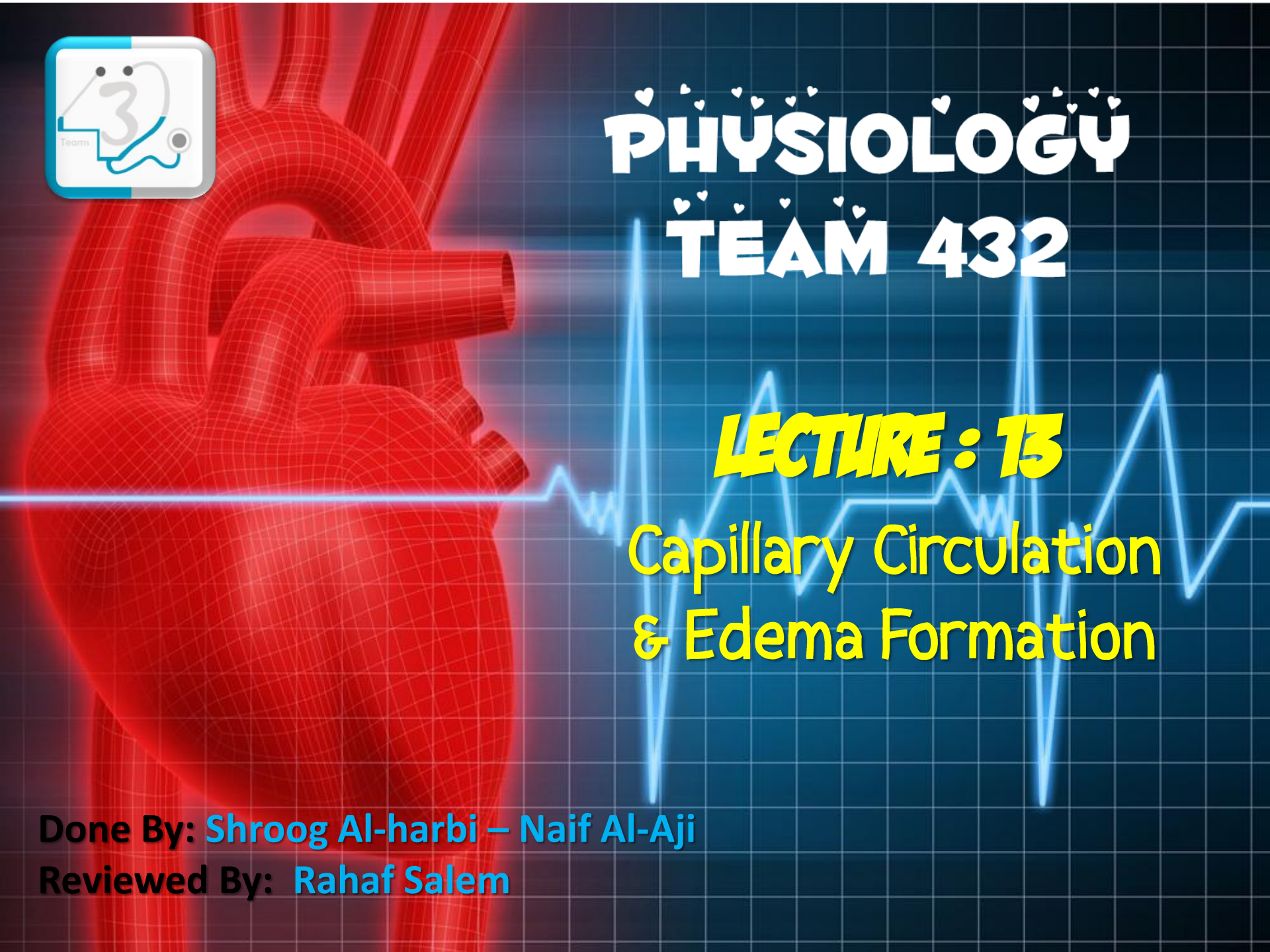


PHYSIOLOGY TEAM 432

LECTURE : 13

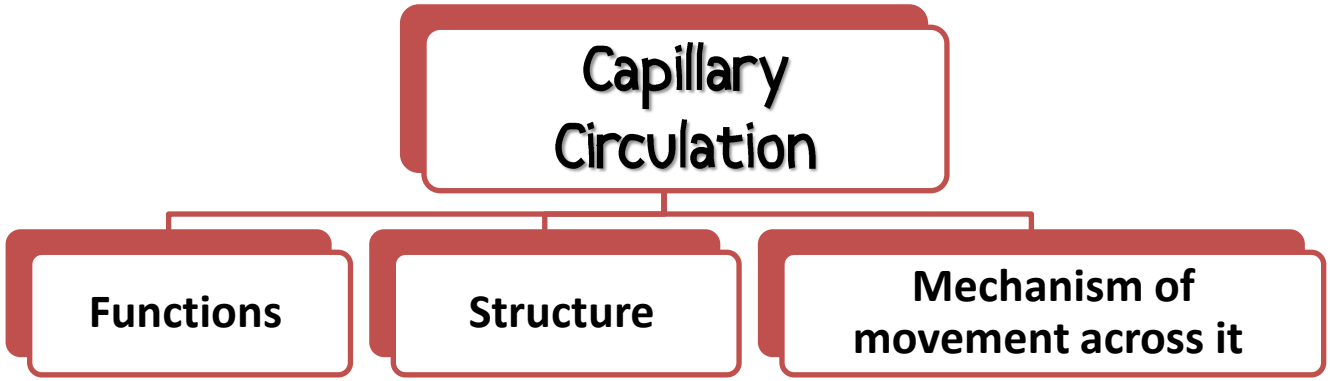
Capillary Circulation & Edema Formation

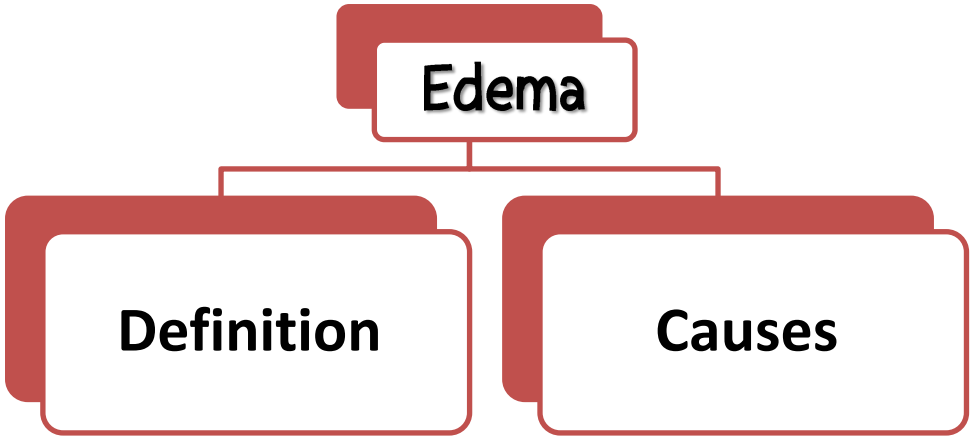
Done By: Shroog Al-harbi – Naif Al-Aji
Reviewed By: Rahaf Salem

OBJECTIVES

Were not given

MIND MAP


Capillary Circulation
Functions
Structure
Mechanism of movement across it


Edema
Definition
Causes

A) Capillary Circulation

Functions of capillaries:

1- Exchange between blood tissues (Nutrients, Oxygen) … and have additional function according to it's location :

- Lung => gas exchange
- Kidney => filtration
- Liver => detoxification

2- Drainage of waste products (from tissues to blood)

3- Capillary tone

- refers to the number of closed capillaries at rest. Normally about 80%-85% of the capillaries are closed and 20%-15% are open.
- If 50% of capillaries are opened, this leads to shock.
- Capillary tone is important because it maintain pressure for perfusion.
  - Only 5% of blood found in the capillaries.

Types of capillary:

1) Continuous:

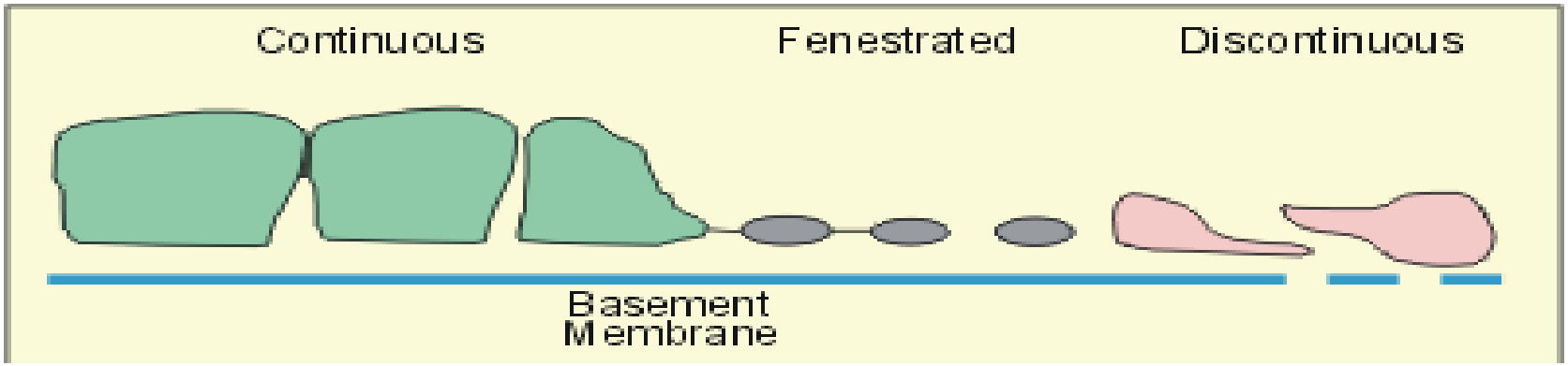
muscles, lungs, adipose tissue, and central nervous system

2) Fenestrated:

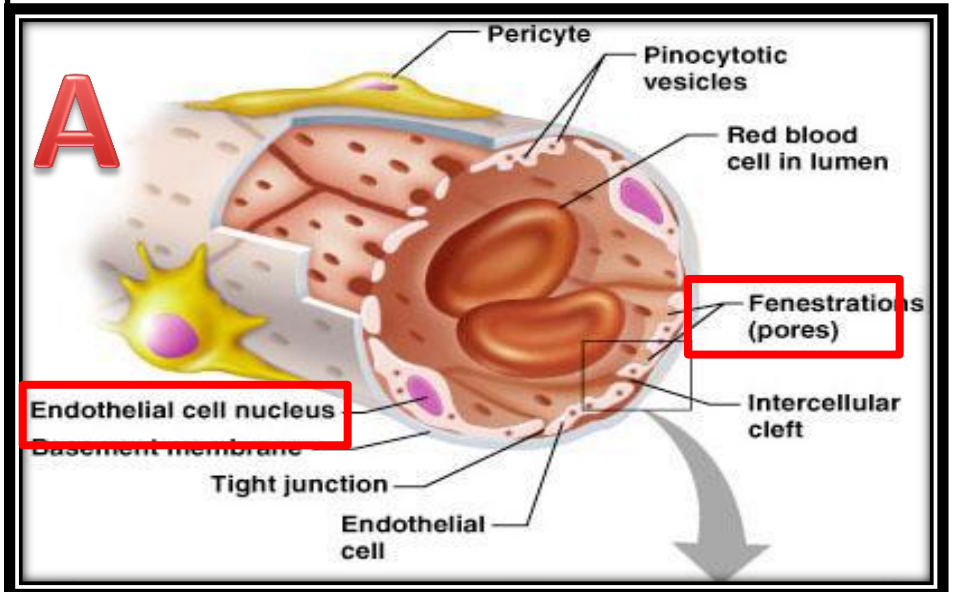
kidneys, endocrine glands and intestines

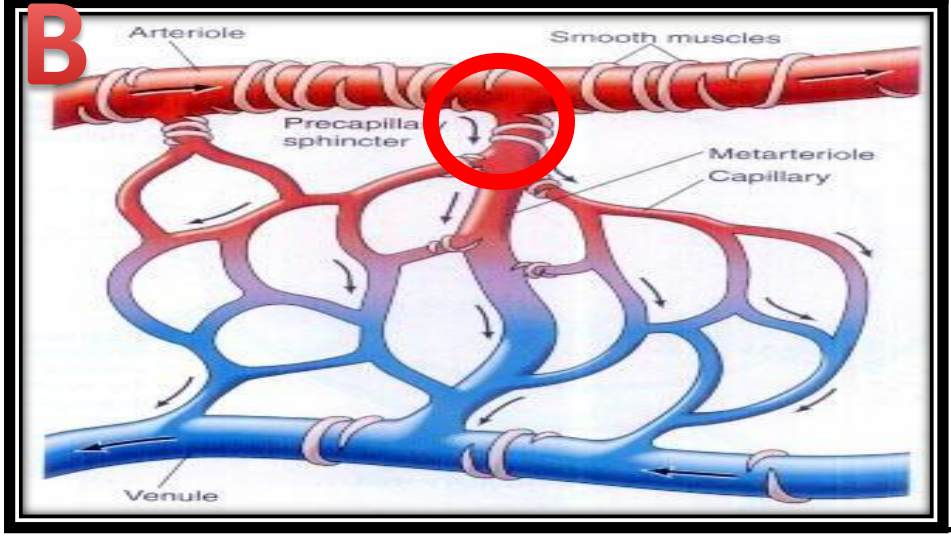
3) Discontinuous:

bone marrow, liver, and spleen



Structure of capillaries:





A) Structure that help in exchange materials:

1- Single layer of squamous endothelial Cells .

2- fenestrations (pores).

B) Structure that help in controlling blood amount that pass to the capillary network :

precapillary sphincter .

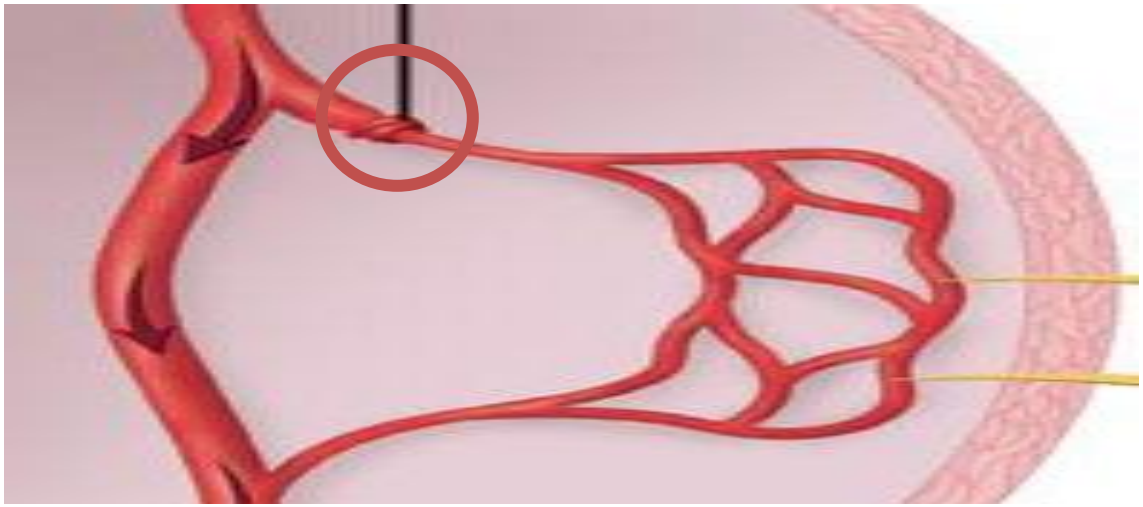
… Role of precapillary sphincter:

-- It is a muscular ring that contact and relax according to the metabolic needs of the tissue

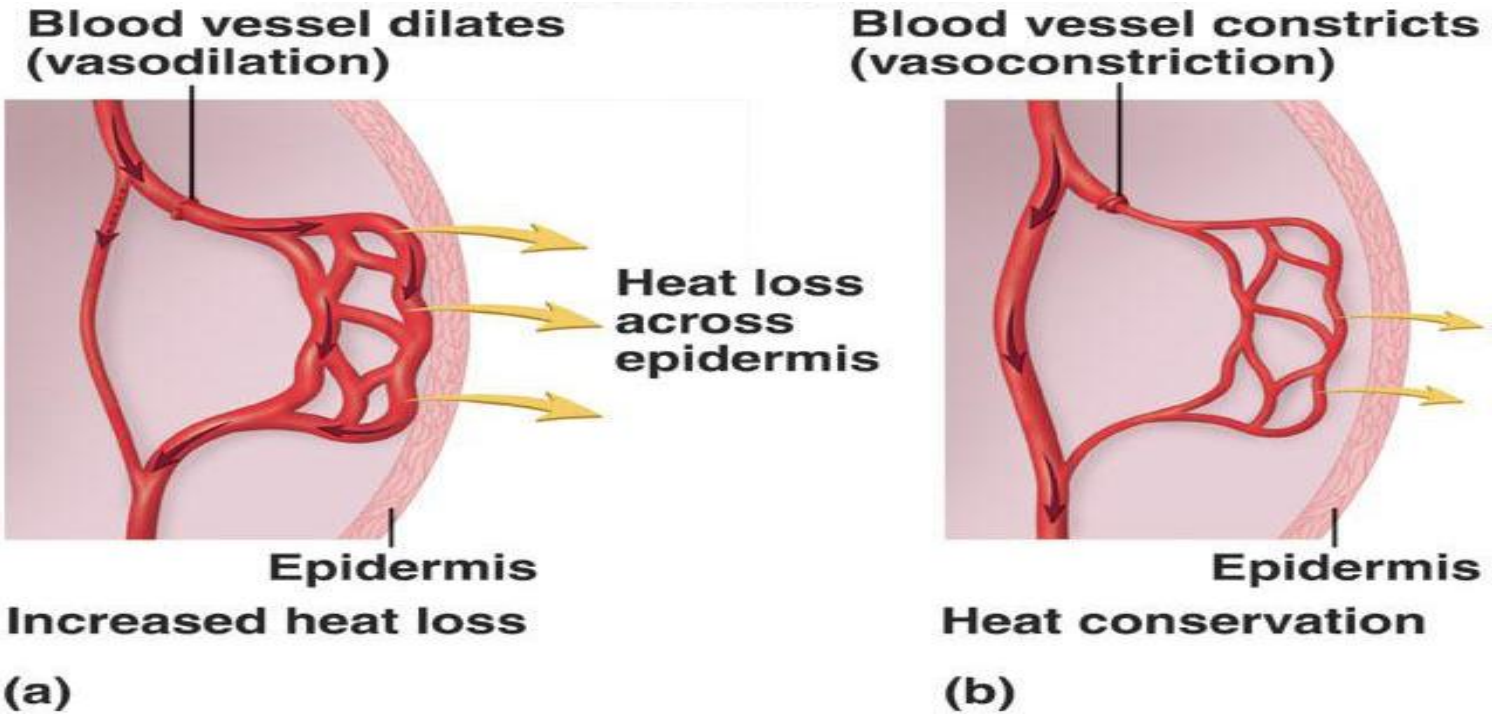
-- Capillary doesn't have a vascular smooth muscle except the sphincter

--The precapillary sphincter is sensitive to oxygen and carbon dioxide.

If the tissue contains low amount of Oxygen and high amount of Carbon Dioxide, the smooth muscles will relax and more blood will flow to the tissue. And vice versa



Temperature regulation

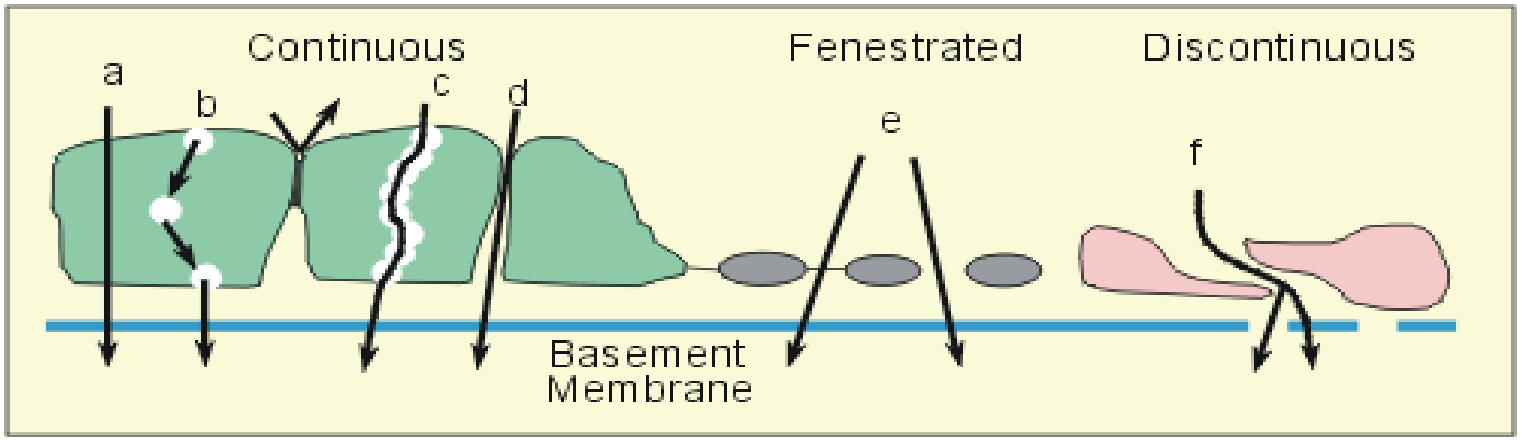


	(A)	(B)
sphincter	relaxes	contracts
blood flow	increase	decrease
excess heat	get rid of excess heat	conserve heat

Movement across capillaries

-- Fluid, electrolytes, gases, small and large molecular weight substances can transverse the capillary endothelium by several different mechanisms : diffusion, bulk flow, vesicular transport, and active transport.

-- Interstitial fluid (Extracellular Fluid) is continuously exchanged, it never stays in stagnant state .

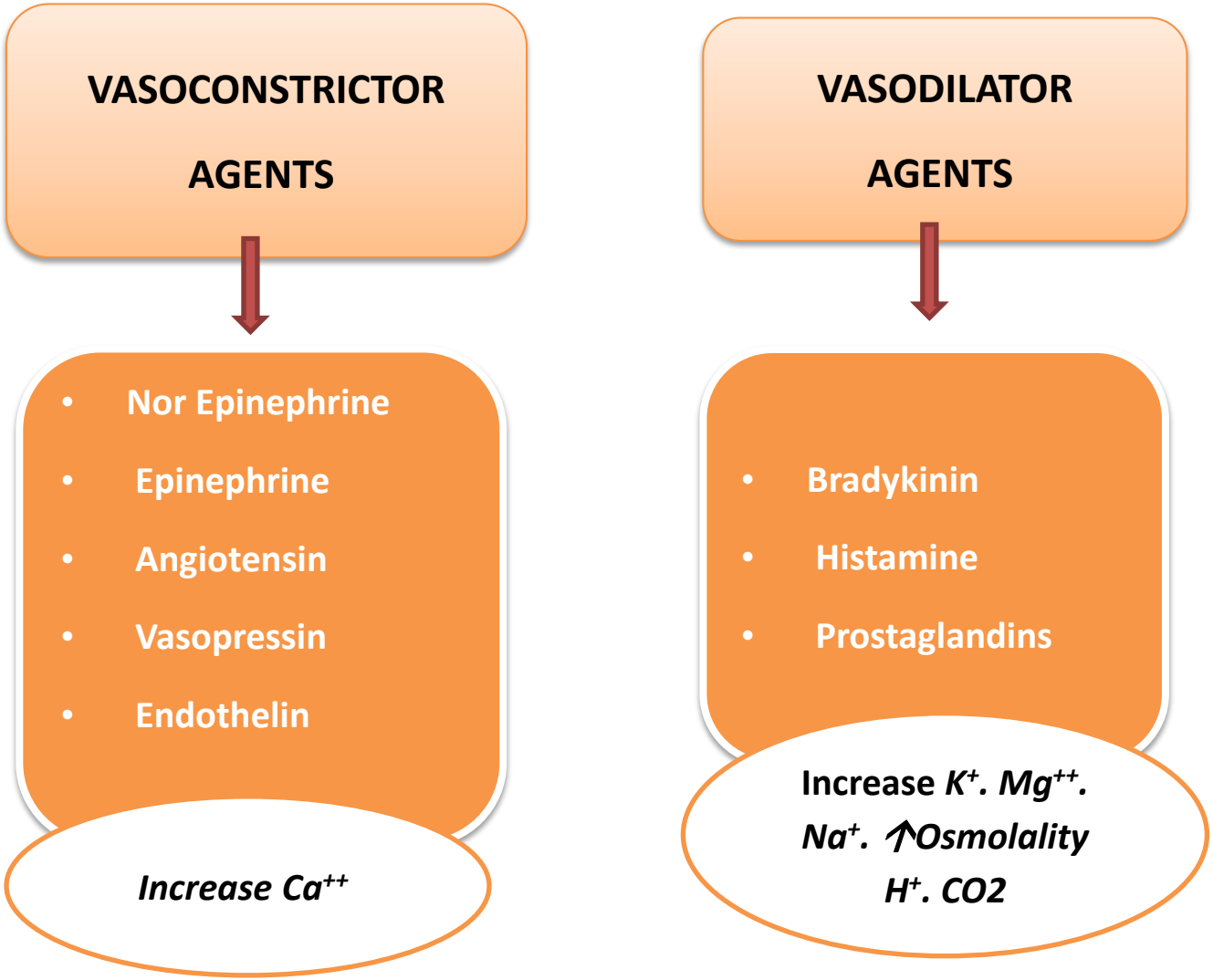


There are two type of materials diffuse through the capillary wall:

- 1- lipid-soluble→ Through the Cell

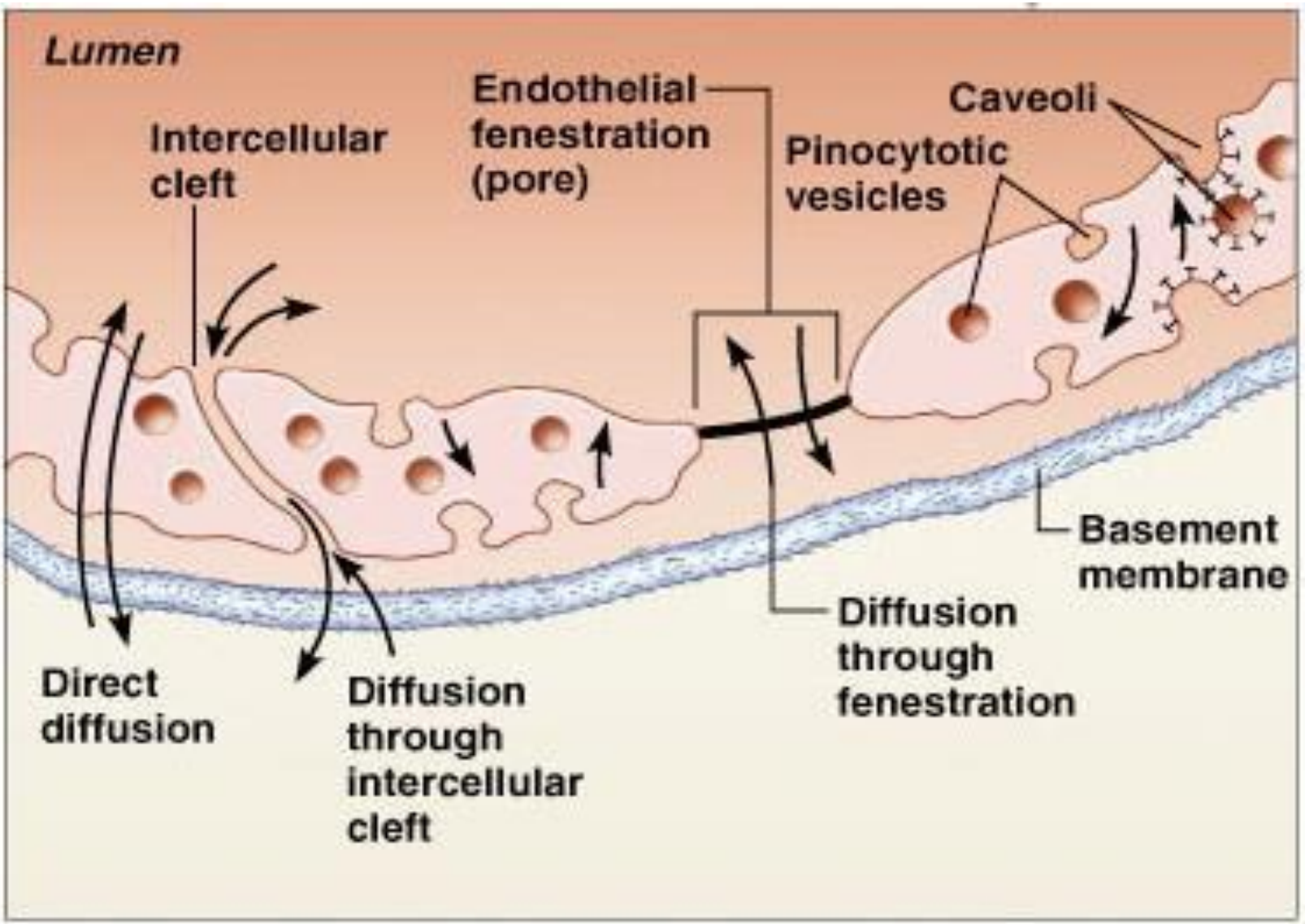
Membranes of the Capillary Endothelium

- 2- non-lipid-soluble (water-soluble)
  →Through Intercellular "Pores" in the Capillary Membrane


VASOCONSTRICTOR AGENTS
Nor Epinephrine
Epinephrine
Angiotensin
Vasopressin
Endothelin
Increase Ca^{++}
VASODILATOR AGENTS
Bradykinin
Histamine
Prostaglandins
Increase K^{+}. Mg^{++}. Na^{+}. ↑Osmolality H^{+}. $CO2$

Terms	Definitions
Vasoconstrictor Agents	Norepinephrine and Epinephrine. -Angiotensin II. -Vasopressin.Endothelin—A Powerful Vasoconstrictor in Damaged Blood Vessels
Vasodilator Agents	Bradykinin histamine
Vascular Control by Ions and Other Chemical Factors	ca,k,mg,h
vasoconstriction	An increase in calcium ion concentrationThis results from the general effect of calcium to stimulate smooth muscle contraction,
vasodilation	increase in potassium ion concentrationThis results from the ability of potassium ions to inhibit smooth muscle contraction
powerful vasodilation	increase in magnesium ion concentrationinhibit smooth muscle contraction.
dilation of the arterioles	increase in hydrogen ion concentration
arteriolar constriction.	slight decrease in hydrogen ion
Anions that have significant effects on blood vessels	acetate and citrate, both of which cause mild degrees of vasodilation.
An increase in carbon dioxide concentration causes	moderate vasodilation in most tissues.marked vasodilation in the brain
carbon dioxide in the blood, acting on the brain vasomotor center, has an extremely powerful indirect effect,	transmitted through the sympathetic nervous vasoconstrictor system, to cause widespread vasoconstriction throughout the body.

Rahaf salem


Lumen
Intercellular cleft
Endothelial fenestration (pore)
Caveoli
Pinocytotic vesicles
Basement membrane
Diffusion through fenestration
Direct diffusion
Diffusion through intercellular cleft

Forces determining tissue fluid formation(Starling's Forces)

To understand the next slides please see these links:

one :)

two :)

three :)

four :)

Forces determining tissue fluid formation Starling's Forces

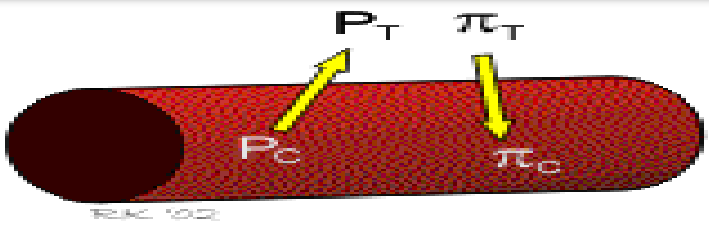
There is a free exchange of water, electrolytes, and small molecules between the intravascular and extravascular compartments of the body.

The primary site of this exchange is capillaries and small post-capillary venules.

Several mechanisms are involved in this exchange; however, the most important are bulk flow and diffusion.

The rate of exchange, in either direction, is determined by Starling 's Forces..

Forces determining tissue fluid formation Starling's Forces



P_C = capillary hydrostatic pressure
P_T = tissue hydrostatic pressure
π_C = capillary plasma oncotic pressure
π_T = tissue fluid oncotic pressure

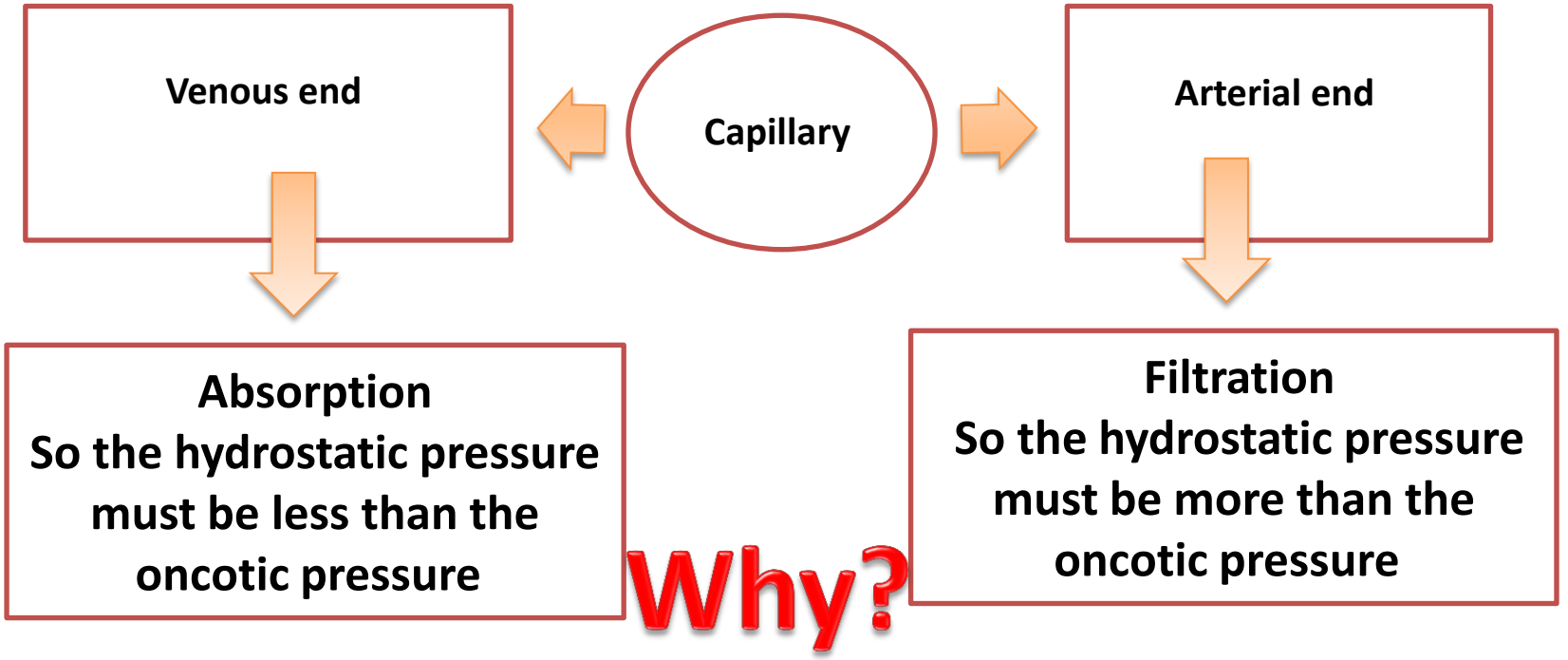
$$NDF = (P_C - P_T) - \sigma(\pi_C - \pi_T)$$

When NDF > 0 → Filtration
When NDF < 0 → Reabsorption

Hydrostatic (P) and oncotic (π) pressures within the capillary and tissue interstitium (T) determine the net driving force (NDF) for fluid movement into the capillary (reabsorption) or out of the capillary (filtration). The oncotic pressure difference is multiplied by the reflection coefficient (σ) that represents the permeability of the capillary barrier to the proteins responsible for generating the oncotic pressure.

Capillary Hydrostatic P (CHP) or (Pc):	**pressure caused by blood flow in capillary.**
Tissue Hydrostatic P.:	**pressure caused by intestinal fluid in interstitial space.**
Capillary plasma oncotic P	**pressure caused by proteins in plasma.**
Tissue plasma oncotic P.	**pressure caused by proteins in intestinal fluid**

Continue….



Because …

The hydrostatic pressure excluding blood, through the gaps (pores) between adjacent endothelial cells in capillaries to extra cellular fluid ECF (in interstetium) to reach cells Whereas the oncotic pressure it tend to drag fluids back to the center of capillaries.

	Arteriolar end	Venus end
Forces tending to move fluid outward:		
Capillary hydrostatic pressure	30 mmHg	10 mmHg ★
Negative interstitial fluid pressure	3 mmHg	3 mmHg
Interstitial fluid colloidal osmotic pressure	8 mmHg	8mmHg
Outward force	41 mmHg	21 mmHg
Forces tending to move fluid inward:		
Plasma colloidal osmotic pressure	28 mmHg	28 mmHg ★

No change

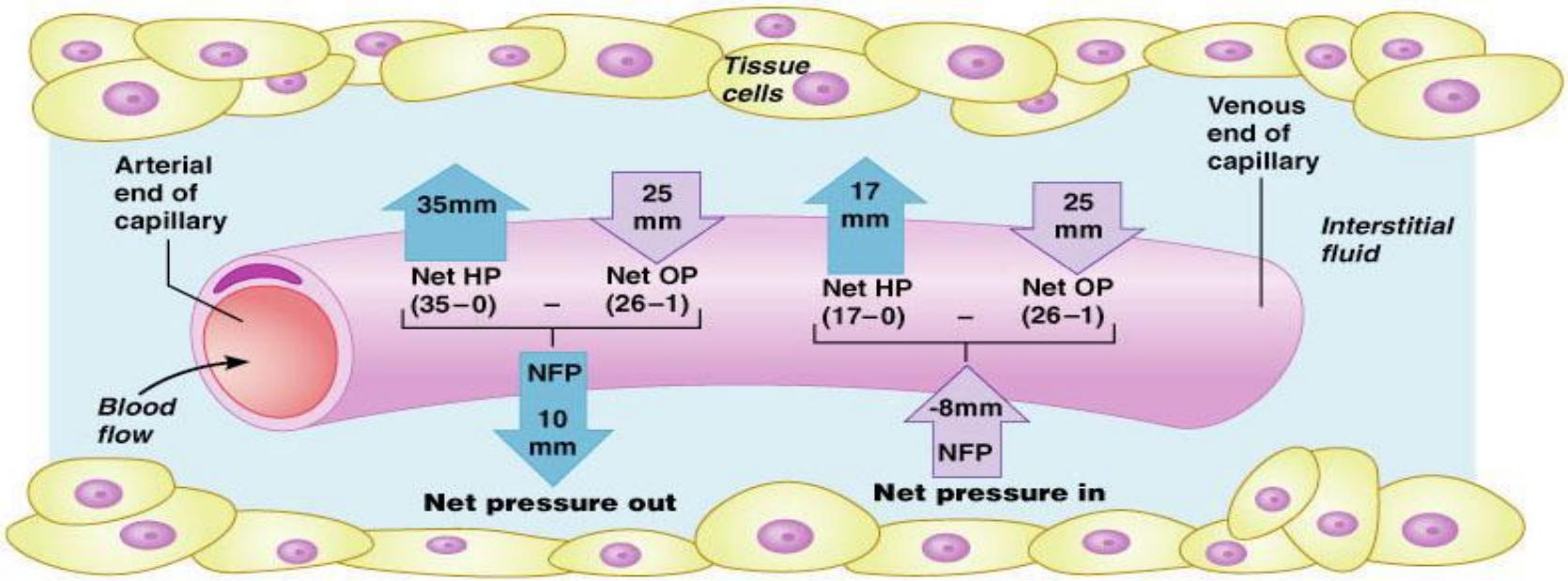
Net Force:

41- 28 = 13 mmHg This is an outward force helping filtration at arteriolar end	28 – 21 = 7 mmHg This is an inward force helping absorption at venular end.

the hydrostatic pressure is more than the oncotic pressure in the arteriolar end => filtiratoin

The opposite ☺

Example:-



Key to pressure values:

HP_c at arterial end = 35 mm Hg
HP_c at venous end = 17 mm Hg

HP_{if} = 0 mm Hg
OP_c = 26 mm Hg

OP_{if} = 1 mm Hg

This will help in :-

1- Constant exchange of fluid.
2- Accelerate distribution of substances.
3- Transport insoluble lipids & tissue proteins.
4- Carry bacterial toxins to lymphoid tissues → provide immunity.

B) Edema Formation

1.Edema: excessive amount of fluid in the interstitial spaces.

2.Factors Precipitating Edema:

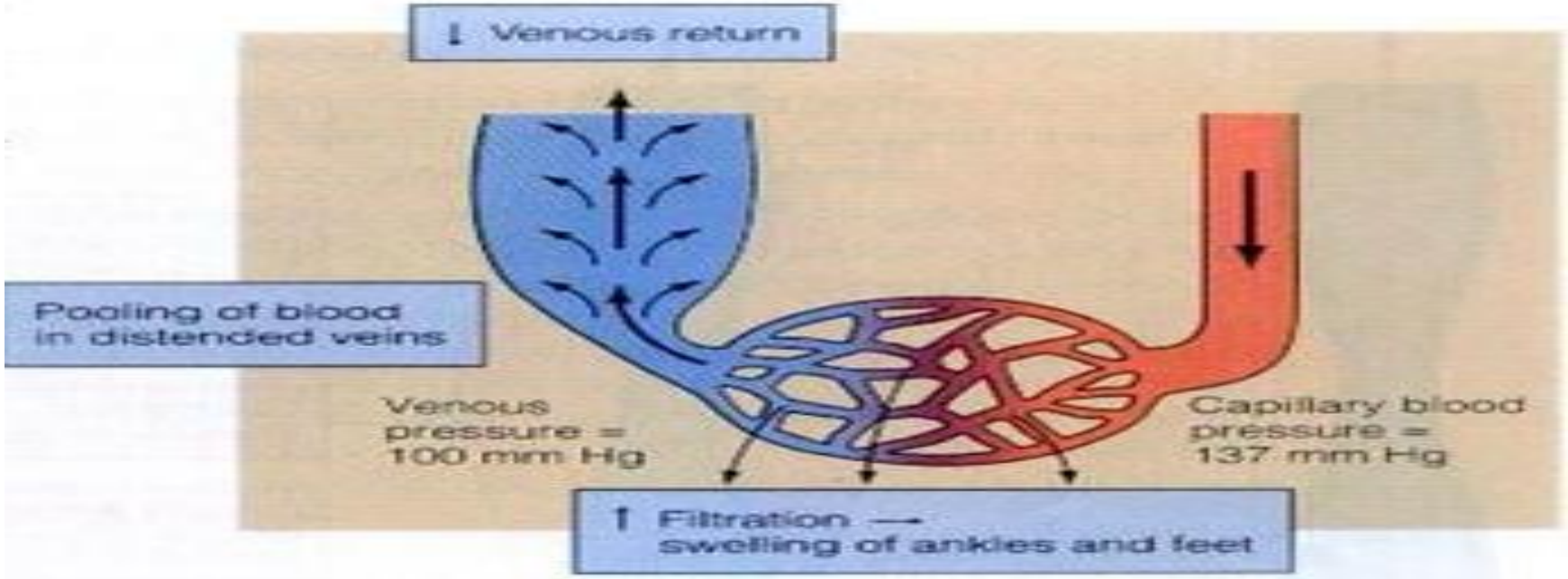
A) capillary hydrostatic pressure

B) plasma oncotic pressure

C) capillary permeability

D) Lymphatic obstruction

Let's study them one by one ☺



3.Causes of Edema:

A. Increased capillary pressure:	Excess retention of salt and water by kidney	a. Renal failure b. Excess aldosterone. c. Heart failure.
	Increased venous pressure	a. Heart failure b. Venous obstruction. e.g. thrombus, pregnancy, tumor, etc.. c. Failure of venous pump e.g. varicose veins.
	Decreased arteriolar resistance	a. Vasodilator drugs. b. Excess body heat.
B. Low plasma proteins:	1. Loss of proteins in urine. 2. Loss from the skin (burns) 3. Failure to produce: (Liver diseases , Malnutrition).	
C. Increased capillary permeability:	1. Release of histamine in allergy. 2. Toxins. 3. Infections 4. Vit. C deficiency 5. Burns	
D. Lymphatic obstruction:	1. Cancer 2. Filaria 3. congenital	

LYMPHATIC SYSTEM:

Carry protein and large particulate matter can flow from the interstitial spaces into the blood Absorption of nutrients from the gastrointestinal tract, especially for absorption of virtually all fats in food.

SUMMARY

1.Functions of capillaries is => exchange the (Nutrients, Oxygen &waste products) between blood & tissues.

2. fenestrations (pores)& precapillary sphincter are play an important role in the capillaries .

3.Several mechanisms are involved in this exchange; however, the most important are bulk flow and diffusion.

4.Starling's Forces :

Capillary Hydrostatic P (CHP) or (Pc) ,Tissue Hydrostatic P,Capillary plasma oncotic P Tissue plasma oncotic P.

5.The hydrostatic pressure excluding blood, through the gaps (pores) between adjacent endothelial cells in capillaries to extra cellular fluid ECF (in interstetium) to reach cells whereas the oncotic pressure it tend to drag fluids back to the center of capillaries

6.High hydrostatic pressure =arterial end =filtration

7.High oncotic pressure = Venus end= Absorption

8.Edema caused by:

A. Increased capillary pressure:

B. Low plasma proteins:

C. Increased capillary permeability:

D. Lymphatic obstruction:

THE END

If there are any problems or suggestions
Feel free to contact:

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THANK YOU

Actions speak louder than Words