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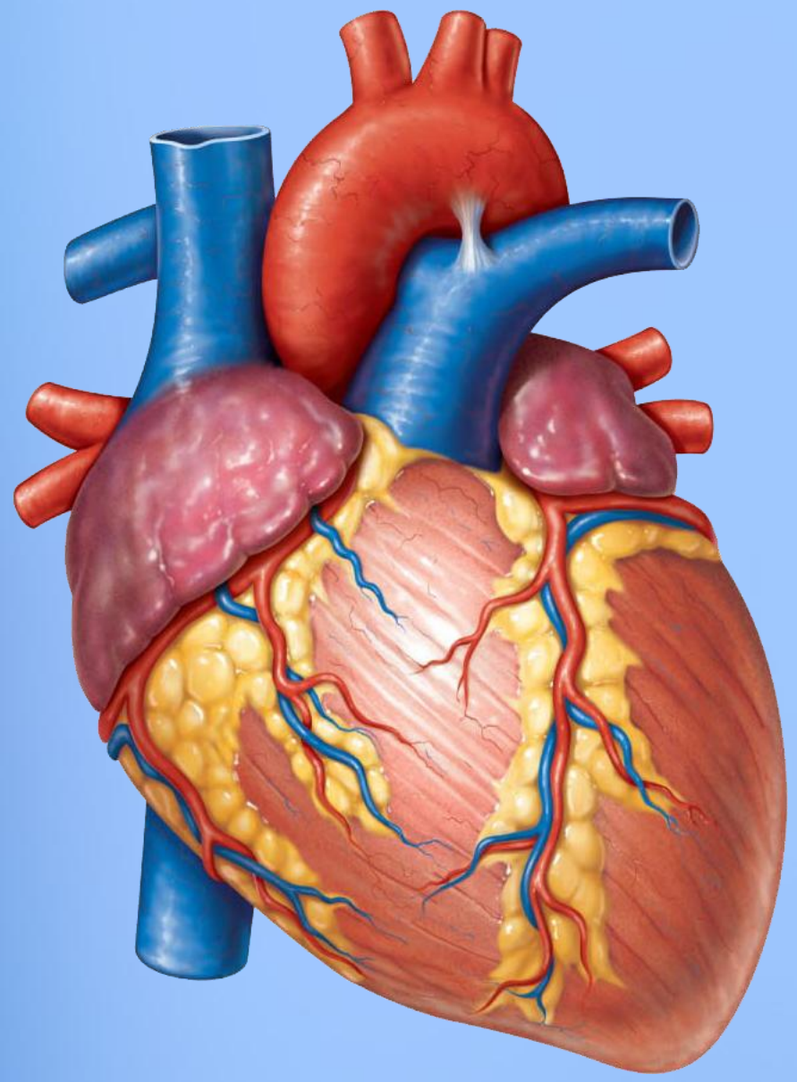
CAPILLARY CIRCULATION



Cardiovascular Block

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Capillary circulation

Capillaries structure & exchange of gases & nutrient

Movement across capillaries
- Vesicular transport
- diffusion
- Bulk flow
- Active transport

Starling's Forces
- P_c
- P_T
- π_c
- π_t

Functions of capillaries
- Drainage of waste products
- Capillary tone
- Exchange

Temperature regulation
- Heat conservation
- Increase heat loss

Net Filtration Pressure
- OP
- HP

Forces at arteriolar end and venular end of capillaries

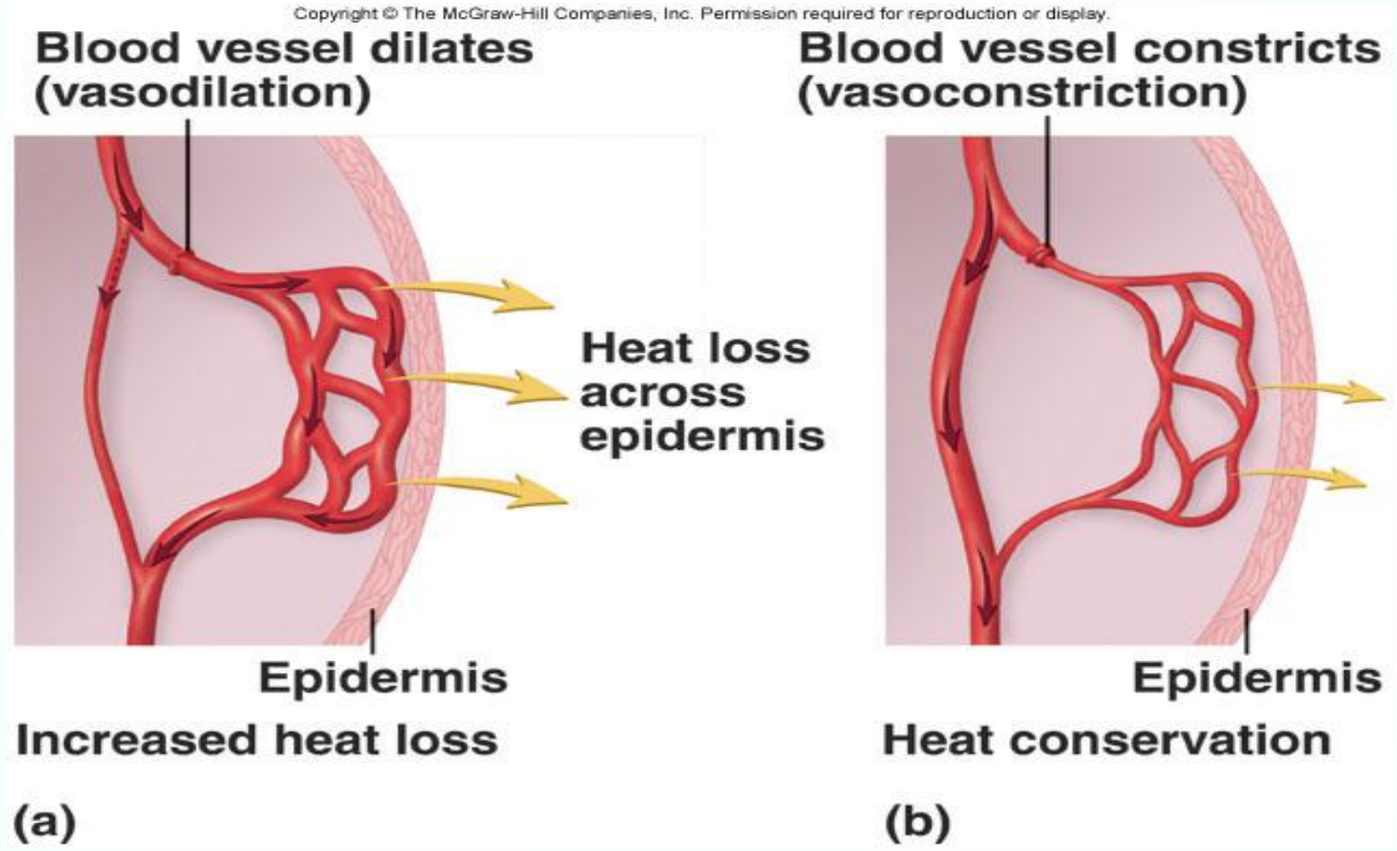
Formation & causes of edema

Functions of capillaries

- Exchange between blood & tissues:
  - Oxygen
  - Nutrient
- Drainage of waste products: tissues….to blood
- Capillary tone → At anytime 80-85% of capillaries are closed and the rest are opened
- Transport hormones, enzymes, body heat, electrolytes ---etc.

Temperature regulation

a) Increase blood volume , so that a lot of blood paces through the capillaries (causes vasodilation) and causes loss of heat



b) Decrease blood volume paces through the capillaries (vasoconstriction) and loss of heat start to decrease

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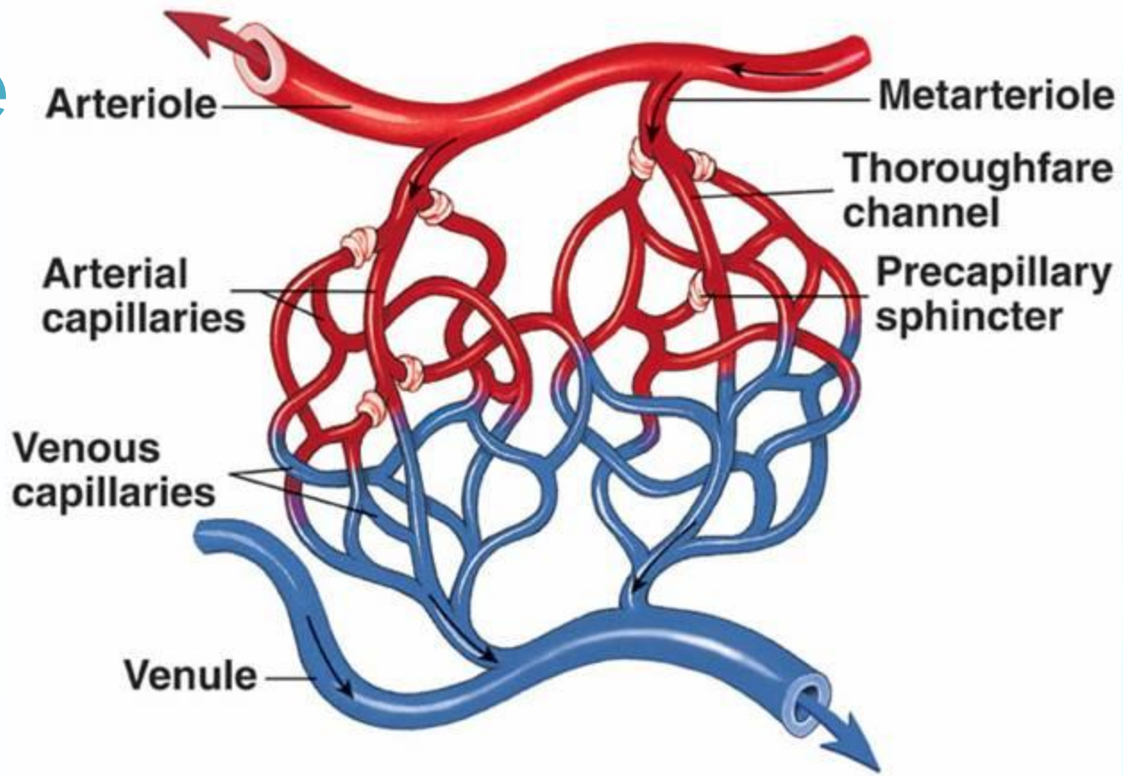
Functional Parts of the circulation



Arteries:

- Has strong muscular walls.
- Transport blood Rapidly under high pressure to the tissues.

Arterioles:

- Has strong muscular walls.
- Can close the arteriole completely or dilate it several folds
- So, they alter blood flow to the capillaries in Response to needs.

Venules & Veins:

(Capacitance Vessels)

- At rest more than ⅔rds. of total blood volume is found within the venous system.
- More than half of it is within venules

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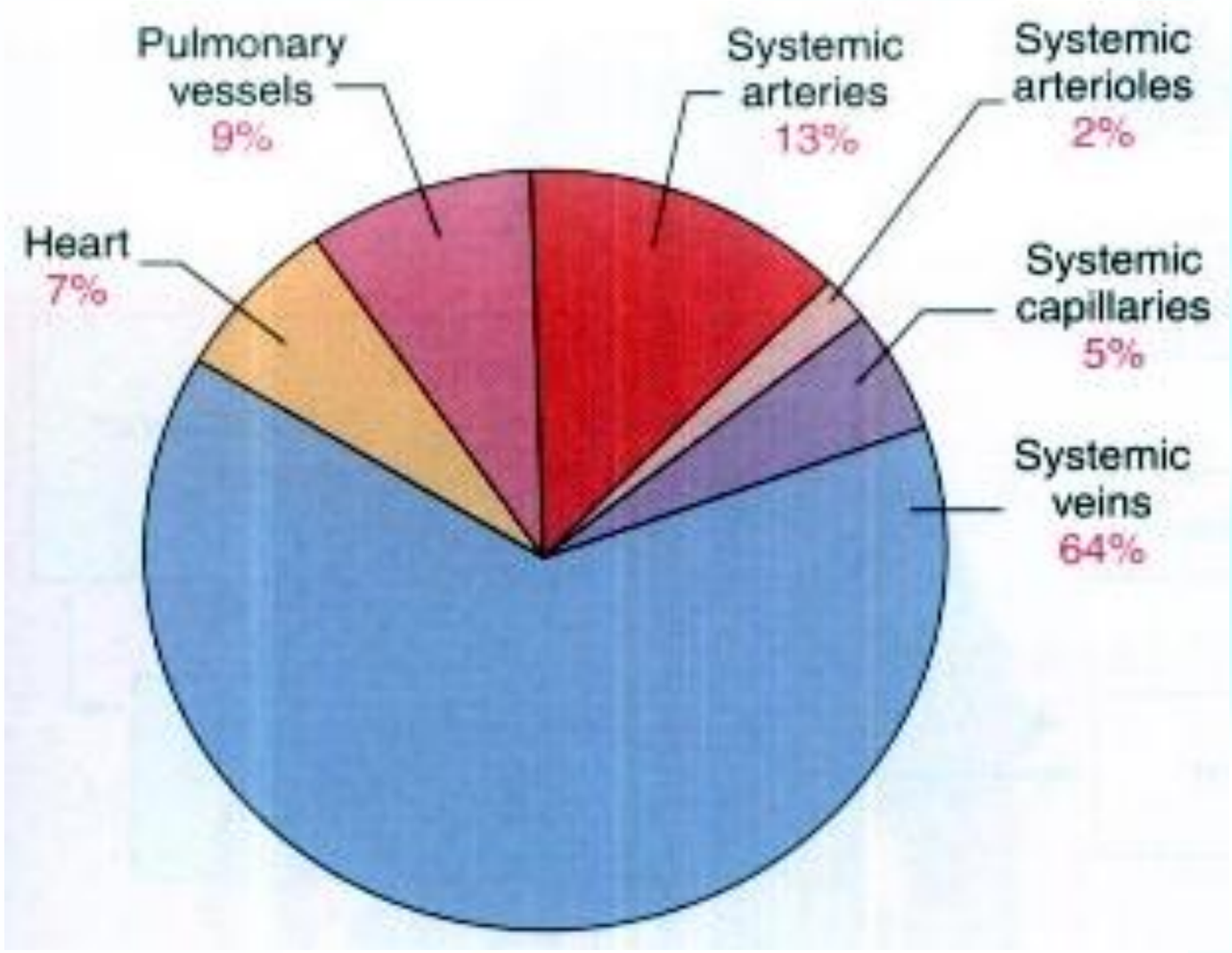
Capillaries

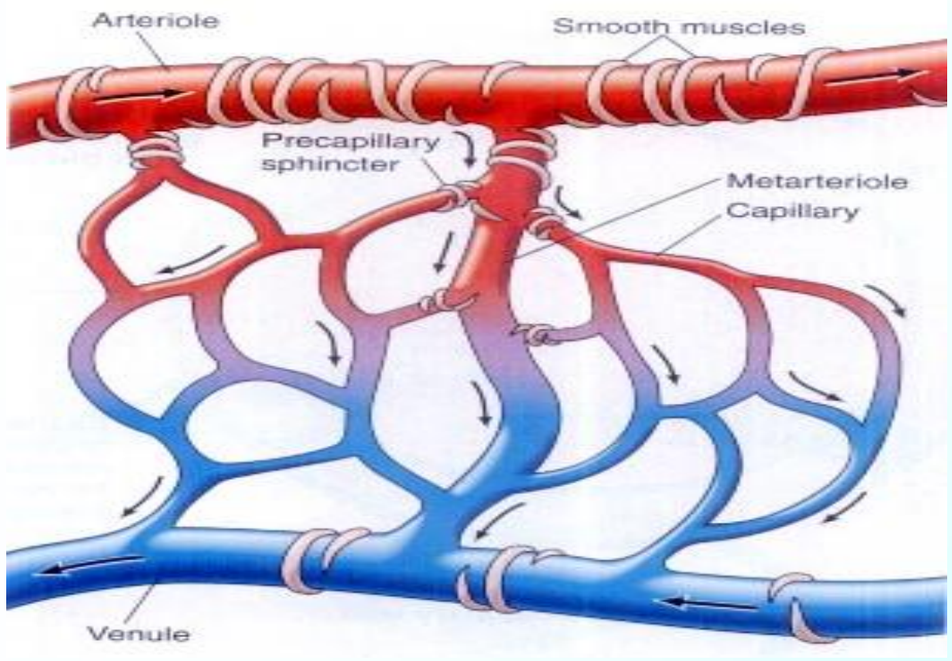
- Very thin wall
- unicellular layer of endothelial cells
- Very small internal diameter.
- Have numerous Capillary pores and very large surface area

(exchange blood vessels).

Blood flow is intermittent, turn on and off every few seconds or minutes (vasomotion), determined by oxygen demand.



Note : Arterioles & small arteries are called (Resistance vessels).



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Tissue metabolic Activity

↑ O2, ↓ Co2, and other metabolites

Relaxation of precapillary sphincters

↑ Number of open capillaries

↑ Capillary surface area available for exchange

↓ Diffusion distance from cell to open capillary

Arteriolar vasodilation

↑ Capillary blood flow

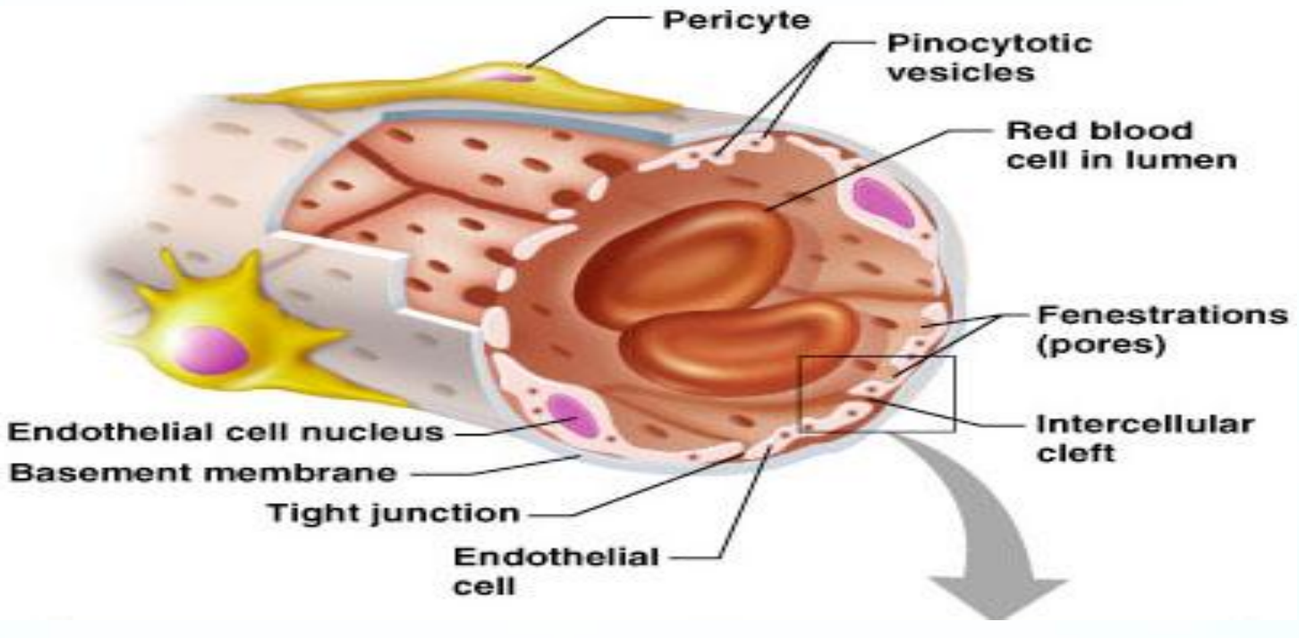
↑ Delivery of O2 more rapid removal of Co2 and other metabolites

↑ Concentration gradient foe these materials between blood and tissue cells

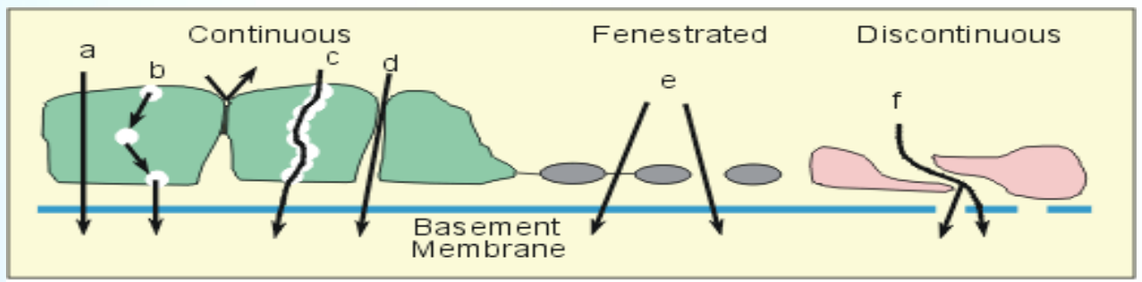
↑ Exchange between blood and tissue to support increased metabolic activity

Capillary exchange of gases & nutrients

Capillaries structure



Movement across capillaries



Fluid, electrolytes, gases, small and large molecular weight substances can transverse the capillary endothelium by several different mechanisms: diffusion, vesicular transport, and active transport and bulk flow.
The rate of movement of fluid in either direction (into or out of capillaries) is determined by Starling's forces.

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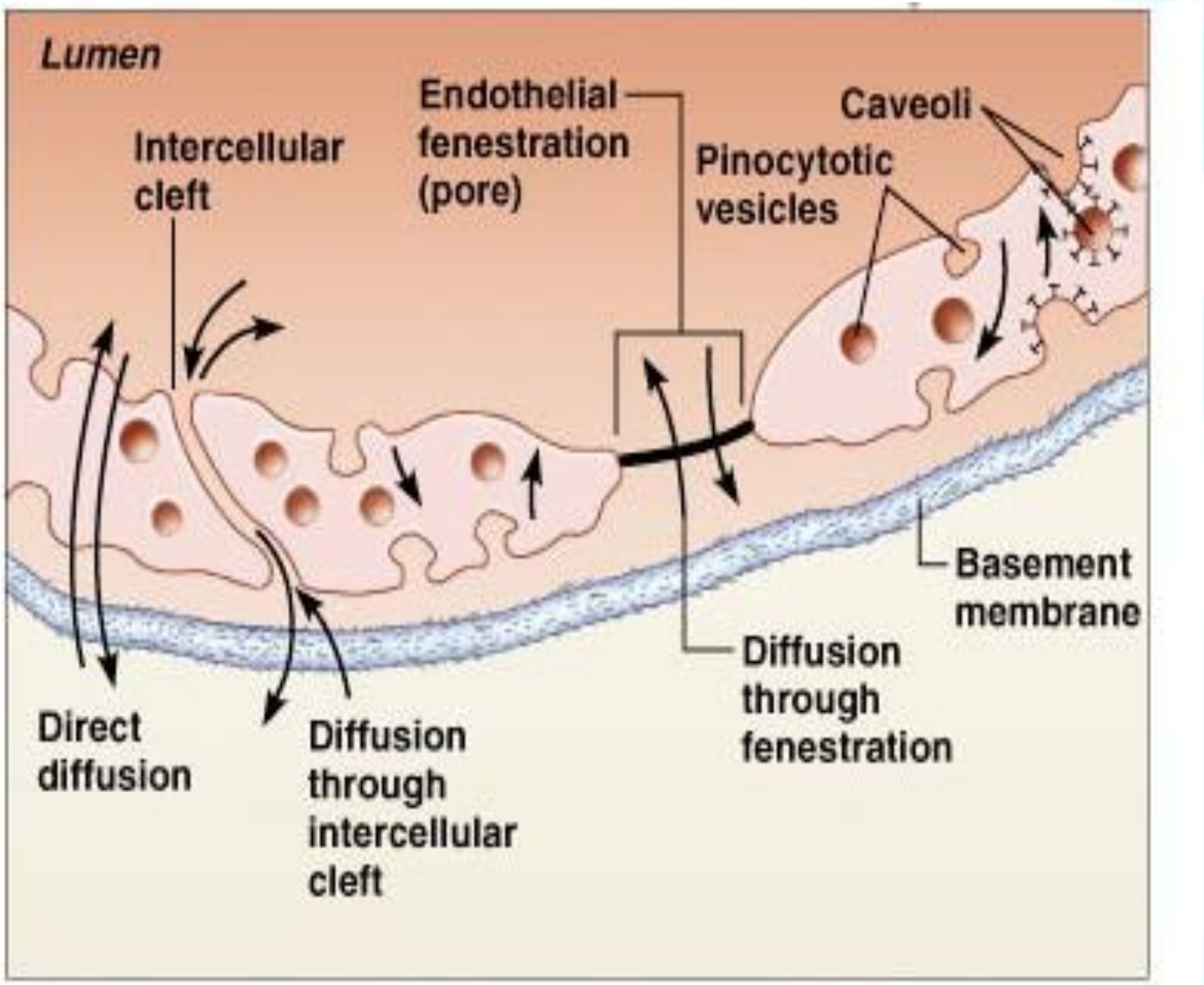
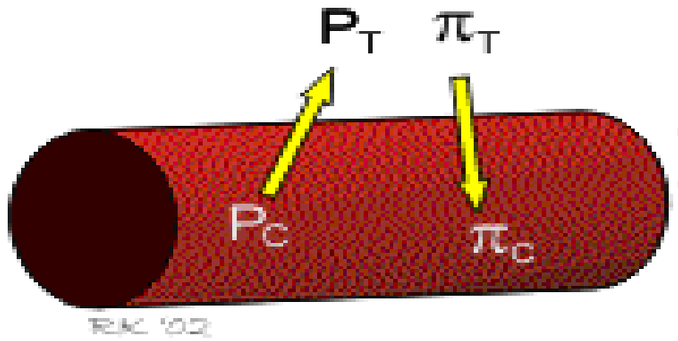
Capillary exchange of gases & nutrients



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.

The names of all forces in the capillaries and EC are the same but the values are different .

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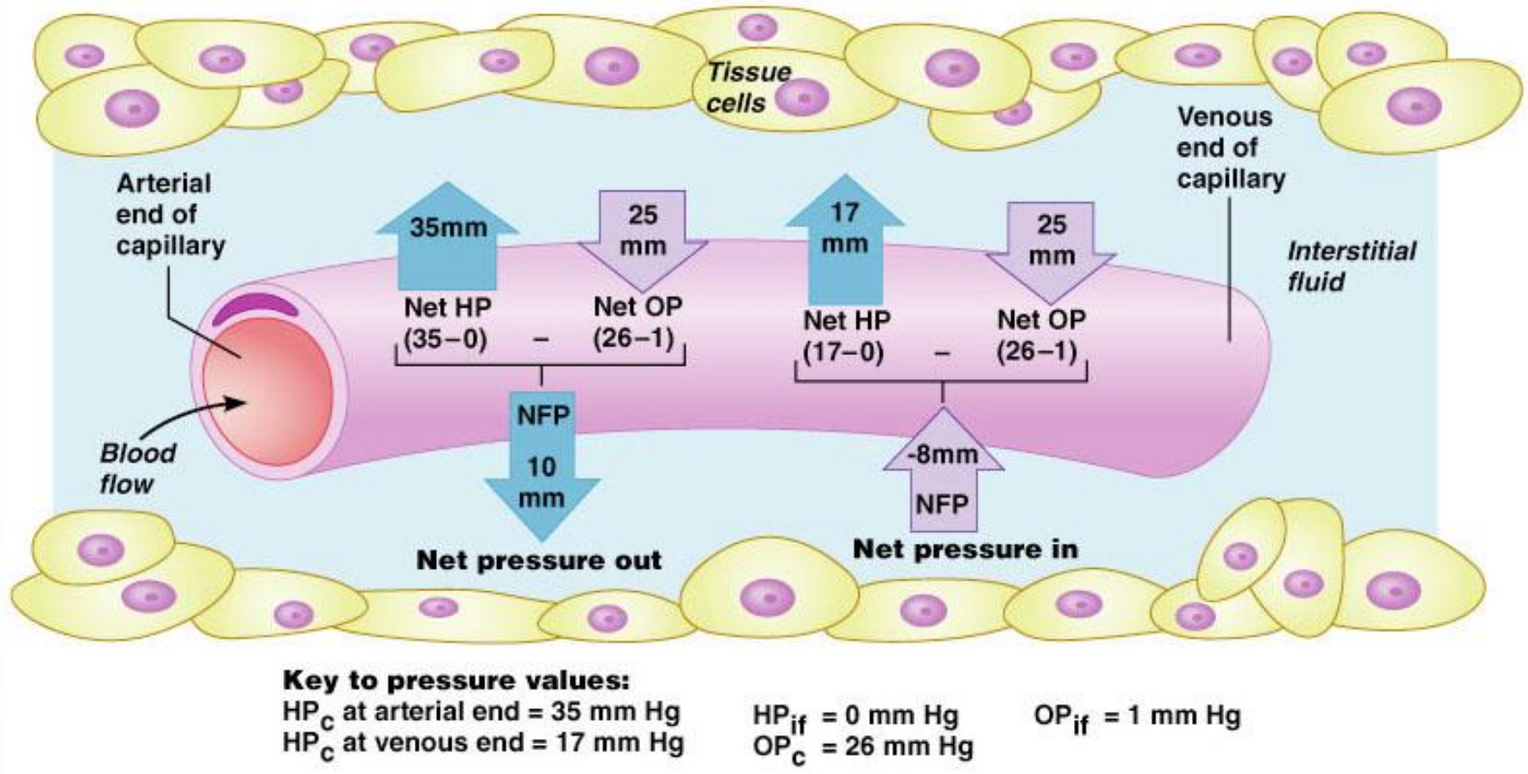
Net Filtration Pressure

HP is a repulsive force (قوة طاردة) works on the lateral walls causing net pressure out



OP because it contains proteins , works as an attractive force (قوة جاذبة) causing net pressure in

If we block the venous end the HP will increase and the fluids will go out to EC and causing edema

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Forces at arteriolar end and venular end of capillaries

Analysis of forces causing filtration at the arteriolar end of the capillary	Analysis of forces causing reabsorption at the venular end of the capillary

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

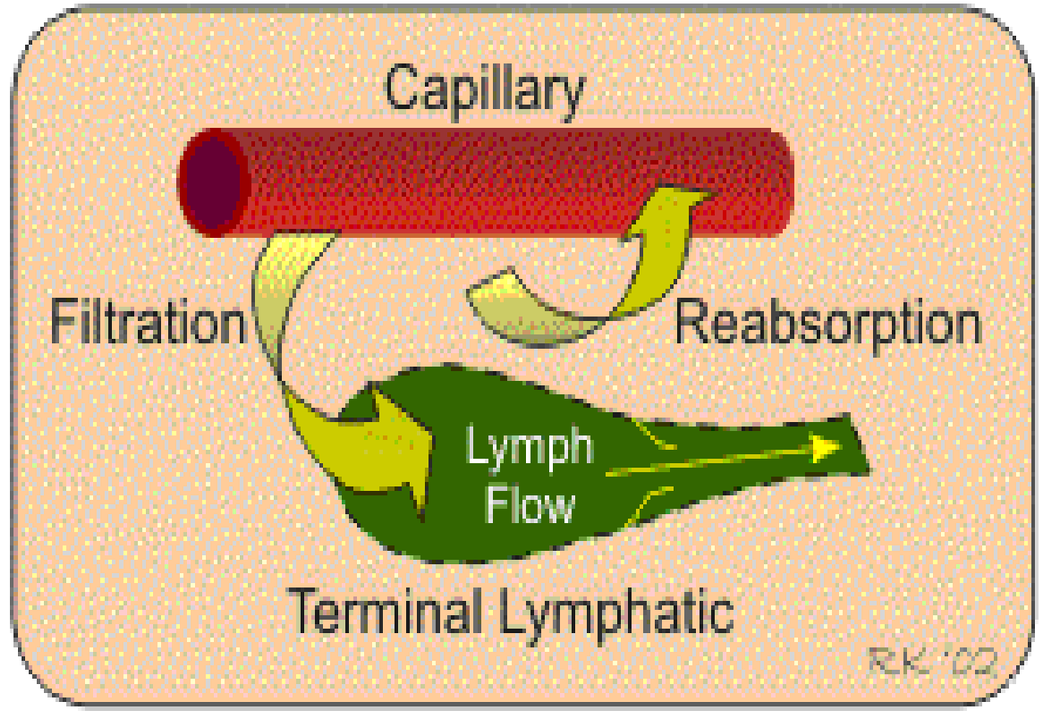
Net Force:

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.

OP in systemic capillaries is almost the same but HP is different

Edema Formation: Mechanisms

- **Increased capillary hydrostatic pressure** (as occurs when venous pressures become elevated by gravitational forces, in heart failure or with venous obstruction)
- **Decreased plasma oncotic pressure** (as occurs with hypoproteinemia during malnutrition)
- **Increased capillary permeability caused by proinflammatory mediators** (e.g., histamine, bradykinin) **or by damage to the structural integrity of capillaries so that they become more "leaky"** (as occurs in tissue trauma, burns, and severe inflammation)
- **Lymphatic obstruction** (as occurs in filariasis or with tissue injury)



The interstitial volume (bounded area) depends on the rates of filtration, reabsorption, lymph flow, and the compliance of the interstitial compartment.

Causes of Edema:

Edema means accumulation of fluid in the ECF space

A) Increased capillary pressure:

1. Excess retention of salt and water by kidney:

a. Renal failure

b. Excess aldosterone.

c. Heart failure.

2. Increased venous pressure:

a. Heart failure

b. Venous obstruction. e.g. thrombus, pregnancy, tumor, etc..

c. Failure of venous pump e.g. varicose veins.

3. 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:

a. Liver diseases

b. 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

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MCQs

1-A patient with body temperature of 36 which of the following adaptions inside the body will help regulating his temperature?

A. **Capillaries vasodilatations**
B. **Decrease workload of heart**
C. **Capillaries vasoconstriction**
D. **Increase oxygen consumption**

2-The exchange in continuous capillaries will be through:

A. **Gaps in the endothelial lining**
B. **Fenestrated pores in the walls**
C. **Active channels**
D. **All of them**

3-Hydrostatic pressure refers to : Exerts of fluids on the walls of blood vessels

A. **Permeability of plasma protein through endothelial lining**
B. **Hydrogen concentration in the blood**
C. **Concentration of fluids in Extracellular matrix**

4-Oncotic pressure refers to :

A. Exerts of fluids on the walls of blood vessels
B. **Permeability of plasma protein through endothelial lining**
C. Hydrogen concentration in the blood
D. Concentration of fluids in Extracellular matrix

5-A patient diagnosed with varicose veins in the medial side of his leg, which of the following factors it will increase and cause edema?

A. **arteriolar resistance**
B. **capillary pressure**
C. **plasma proteins**
D. **venous pressure**

6-Which of the following factors will decrease arteriolar resistance?

A. **Vasoconstrictor drugs**
B. **Excess body heat**
C. **Vitamin C deficiency**
D. **Toxins**

7-A patient diagnosed with parasitic infection cause filariasis, which of the following factors will cause edema?

A. **Increased capillary hydrostatic pressure**
B. **Decreased plasma oncotic pressure**
C. **Lymphatic obstruction**
D. **Increased capillary permeability**

8-If you know that, the capillaries hydrostatic pressure is 29 mmHg and interstitial hydrostatic pressure is 2 mmHg, while capillaries oncotic pressure is 23 and interstitial oncotic pressure is 0.5. Calculate the net force and what will happen?

A. **5.5 (filtration)**
B. **4.5 (filtration)**
C. **4.5 (reabsorabtion)**
D. **– 4 (reabsorbation)**

1- C	2- A	3-A	4-B
5-D	6-B	7-C	8-B

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