

Capillary Circulation & Edema Formation

Dr. Eman El Eter

Functions of capillaries

Exchange between blood & tissues:

Nutrients,

Oxygen

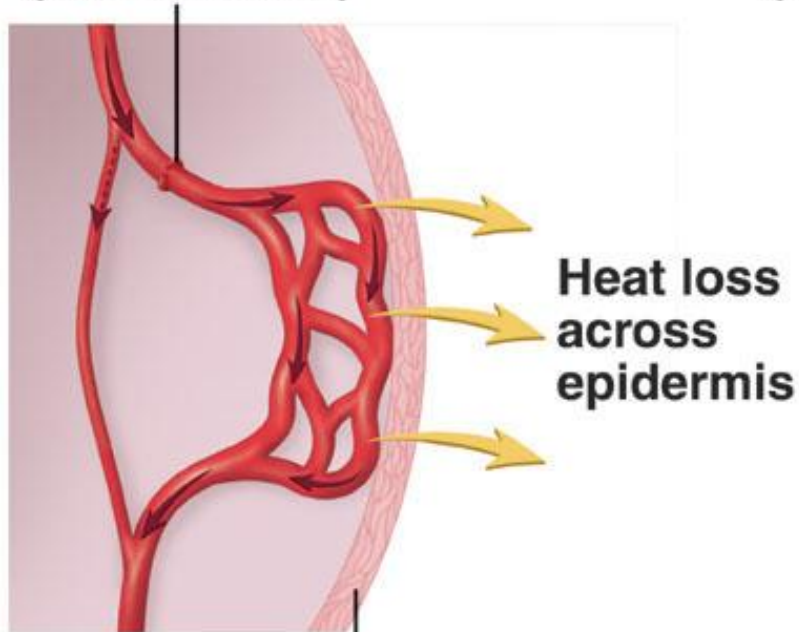
Drainage of waste products: tissues...to
blood

Capillary tone

Temperature regulation

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**Blood vessel dilates
(vasodilation)**

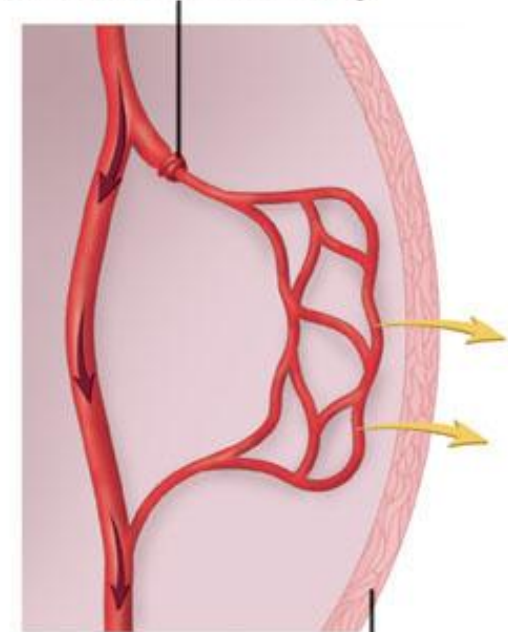


Epidermis

Increased heat loss

(a)

**Blood vessel constricts
(vasoconstriction)**

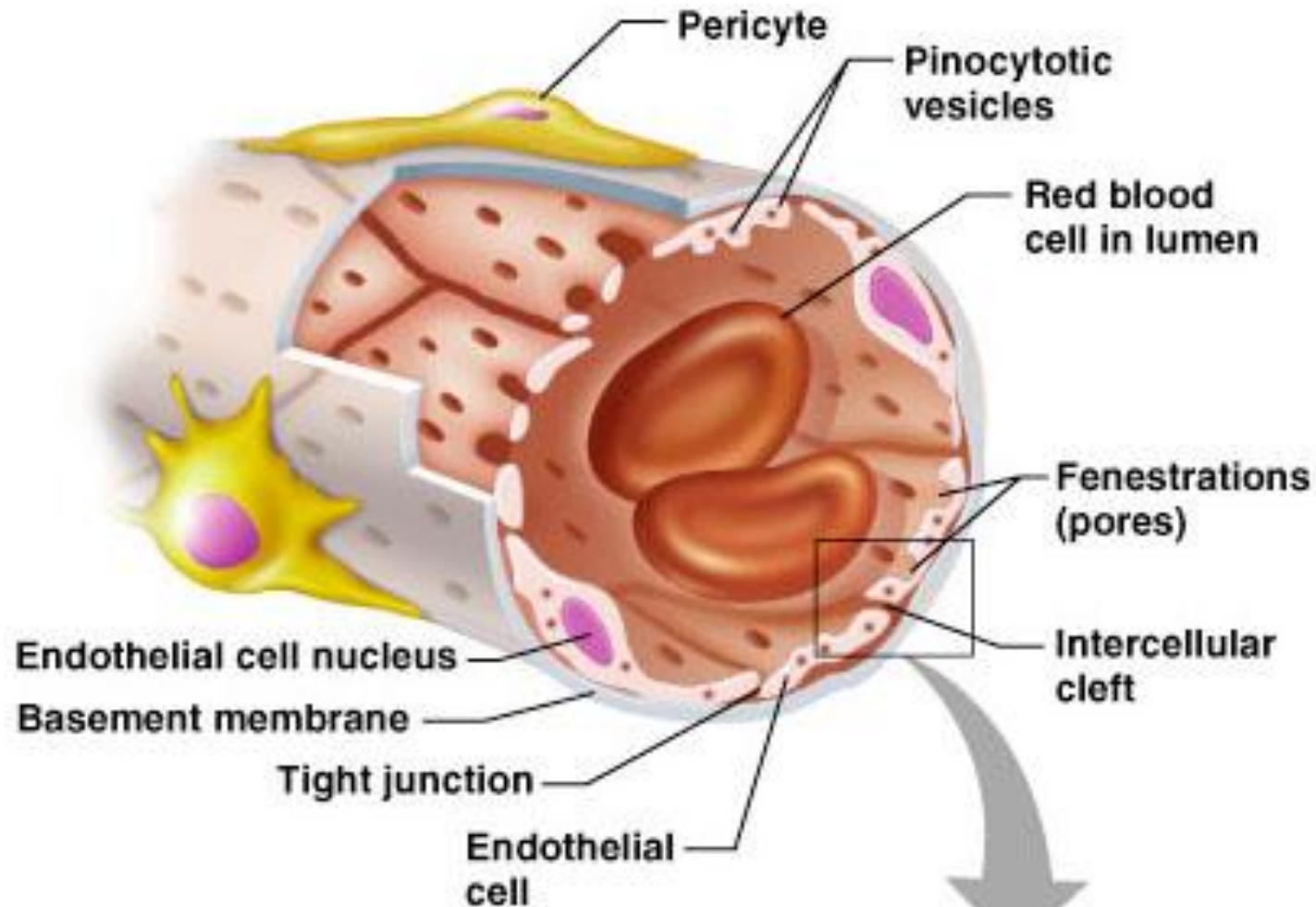


Epidermis

Heat conservation

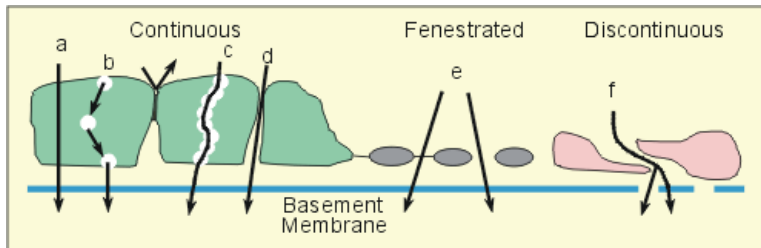
(b)

Capillary exchange of gases & nutrients

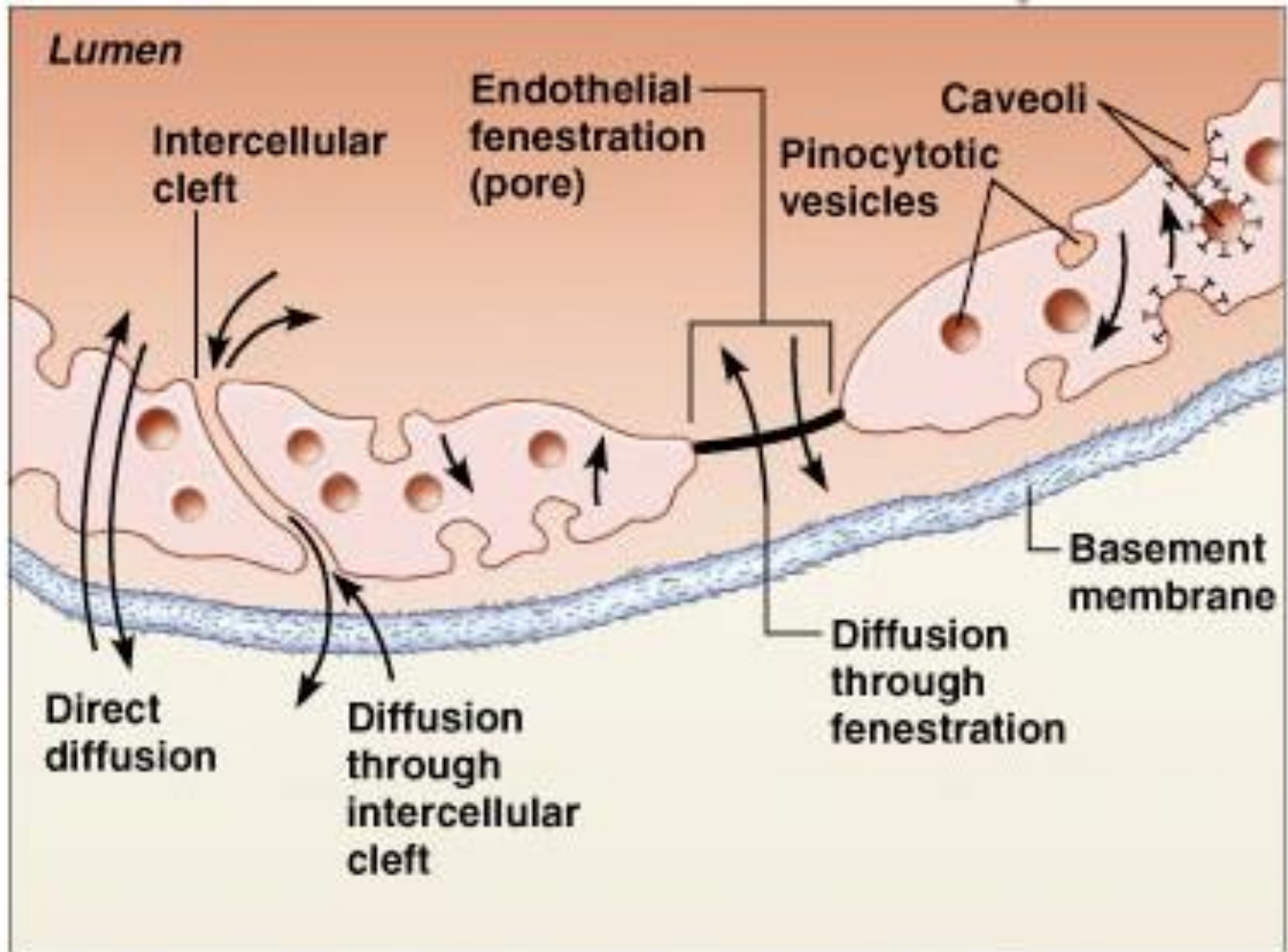


Movement across capillaries

- 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.



Capillary exchange of gases & nutrients

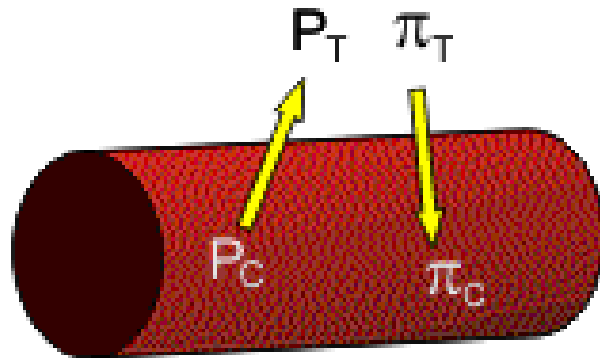


Forces determining tissue fluid formation

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



RLK '02

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

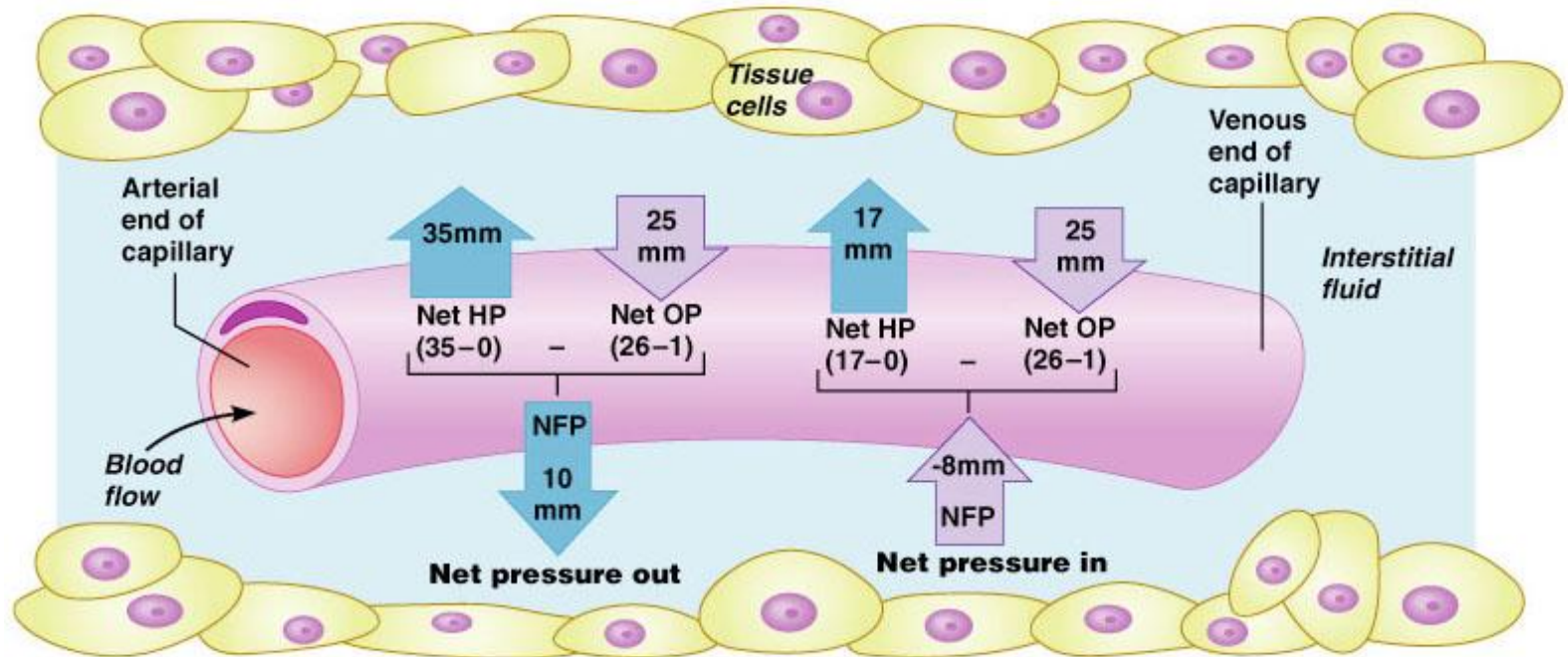
$$\text{NDF} = (P_C - P_T) - \sigma (\pi_C - \pi_T)$$

When $\text{NDF} > 0 \rightarrow$ Filtration

When $\text{NDF} < 0 \rightarrow$ 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.

Net Filtration Pressure



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

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 |

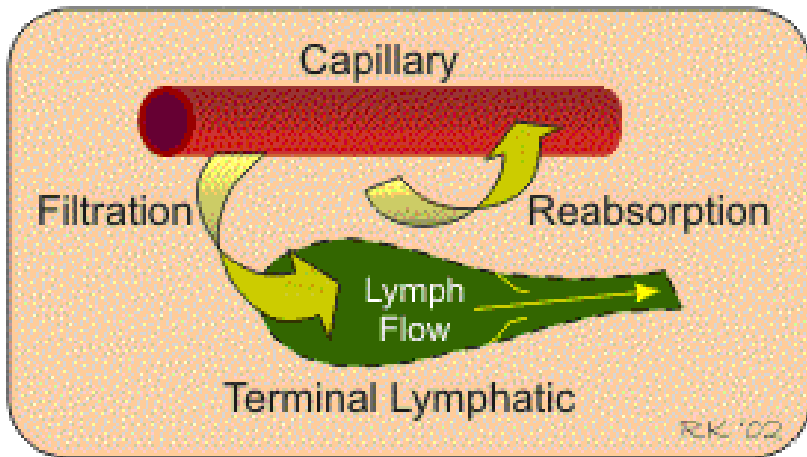
Forces tending to move fluid inward:

| | | |
|-----------------------------------|----------------|----------------|
| Plasma colloidal osmotic pressure | 28 mmHg | 28 mmHg |
|-----------------------------------|----------------|----------------|

Net Force:

| | |
|---|---|
| $41 - 28 = 13 \text{ mmHg}$ This is an outward force helping filtration at arteriolar end | $28 - 21 = 7 \text{ mmHg}$ This is an inward force helping absorption at venular end. |
|---|---|

Edema Formation



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

- **Factors Precipitating Edema**
- 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(

Causes of Edema:

Edema means accumulation of fluid in the ECF space

Causes:

A. Increased capillary pressure:

I. Excess retention of salt and water by kidney:

- a. Renal failure
- b. Excess aldosterone.
- c. Heart failure.

Causes of edema, continued,...

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.

Causes of edema, continued,...

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.

Causes of edema, continued,...

C. Increased capillary permeability:

1. Release of histamine in allergy.
2. Toxins.
3. Infections
4. Vit C deficiency
5. Burns

Causes of edema, continued,...

D. Lymphatic obstruction:

1. Cancer
2. Filaria
3. congenital