Functions of the circulation

To serve the needs of the tissues:

1- Transport nutrients & remove waste products.

2- Transport hormones, enzymes, body heat, electrolytes ---etc.

3- Maintain normal homeostasis for optimal survival &function of cells.

Functional Parts of the circulation

1- Arteries:

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

2- Arterioles:

Has strong muscular walls that can close the arteriole completely or dilate it several folds i.e. they alter blood flow to the capillaries in Response to needs.

Arterioles & small arteries are called (Resistance vessels).

3- 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).

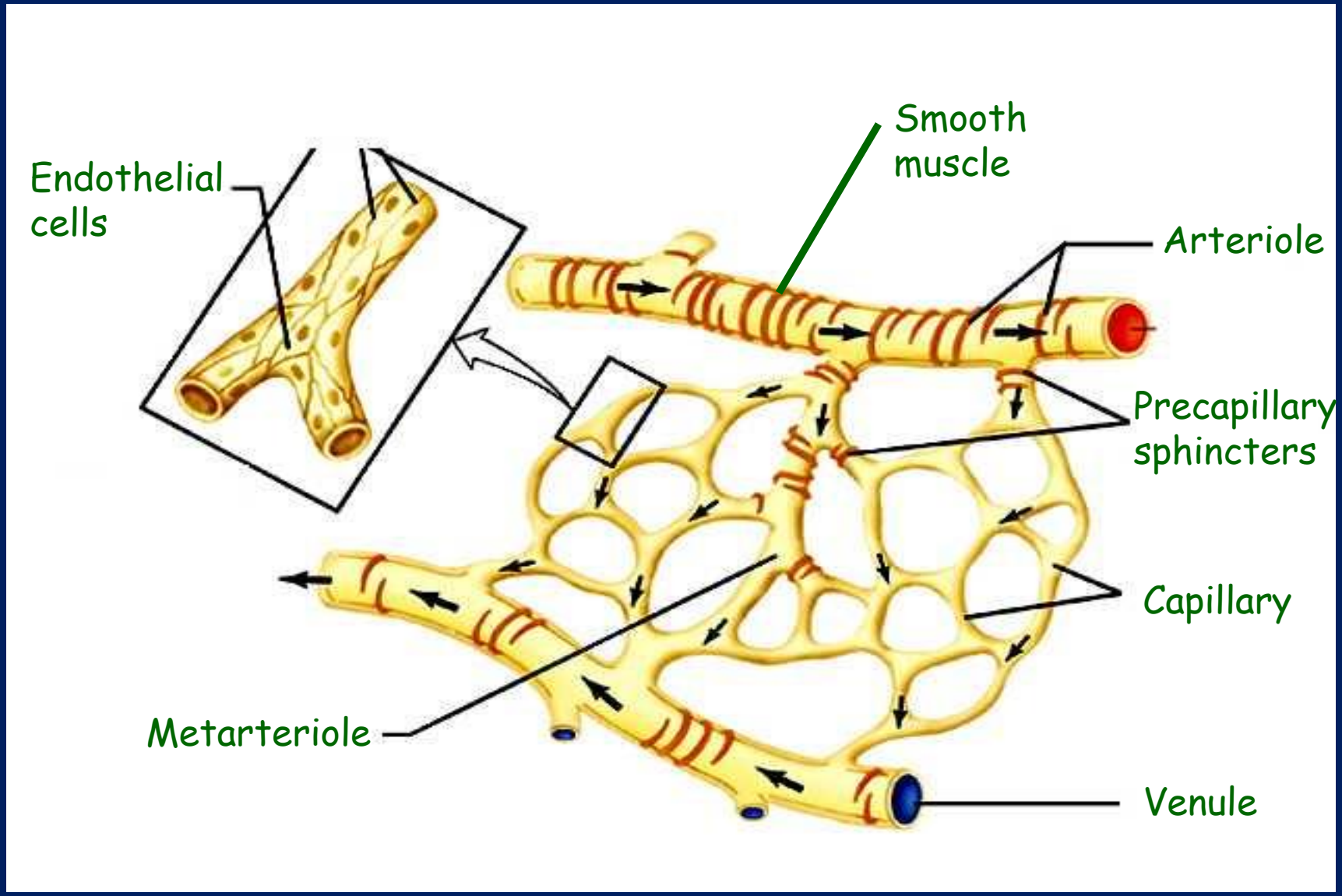
For exchange of gases, nutrients, waste products etc.

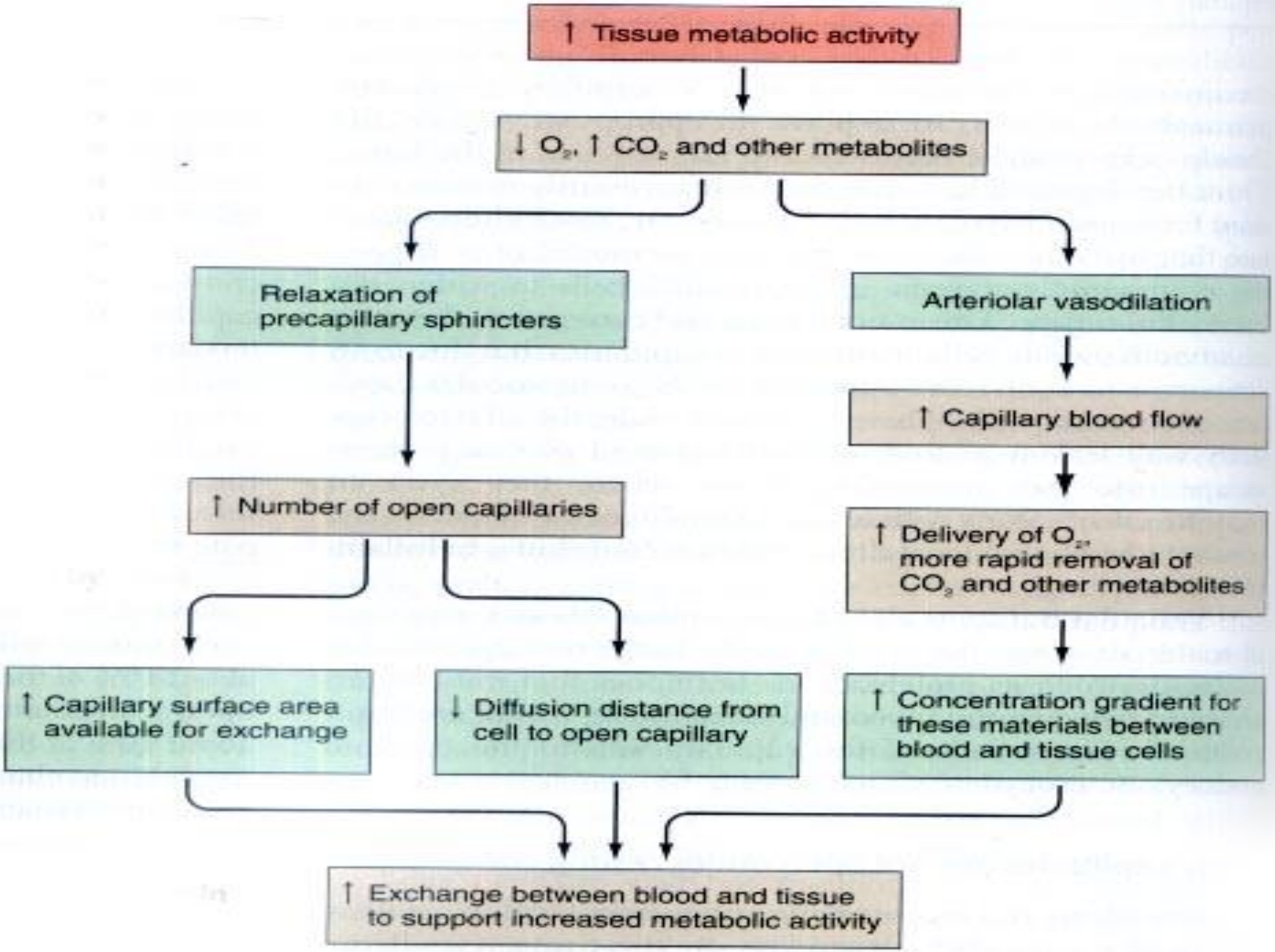
Blood flow is intermittent, turn on and off every few seconds or minutes (vasomotion), determined by oxygen demand.

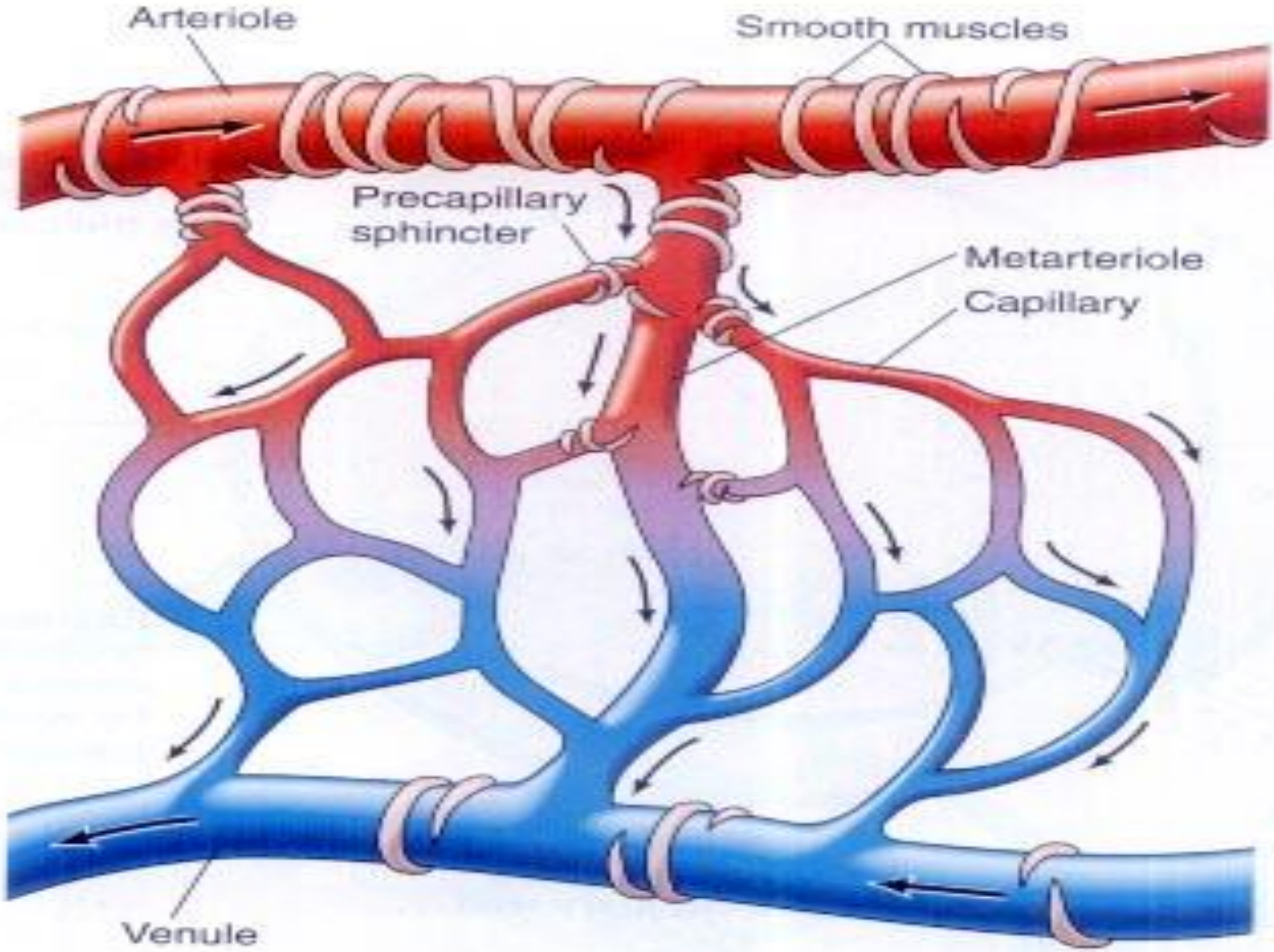
4- Venules & Veins:
(Capacitance Vessels)

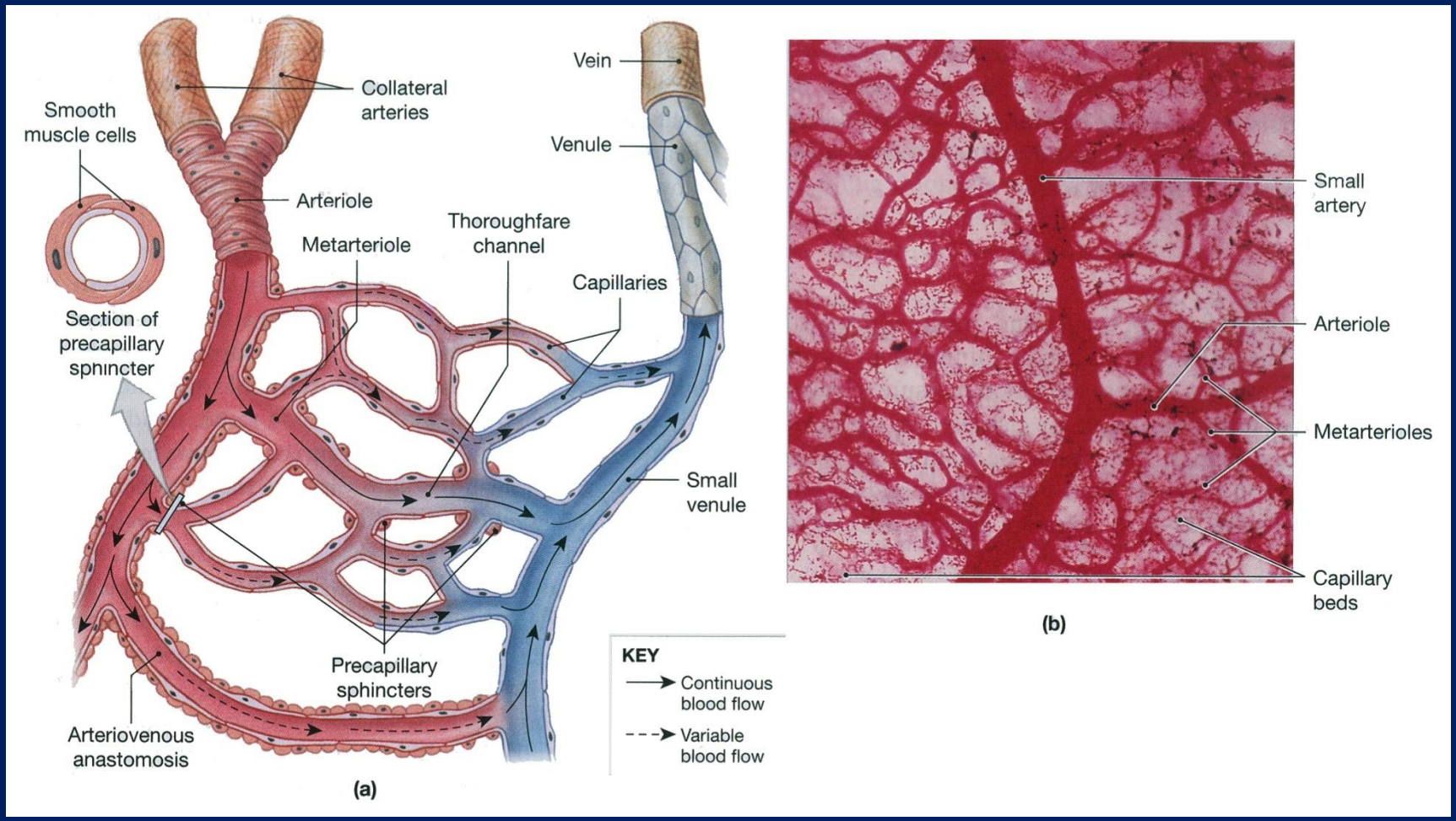
At rest more than ⅔rds. of total blood volume is found within the venous system. More than half of it is within venules.

Structure of the Microcirculation

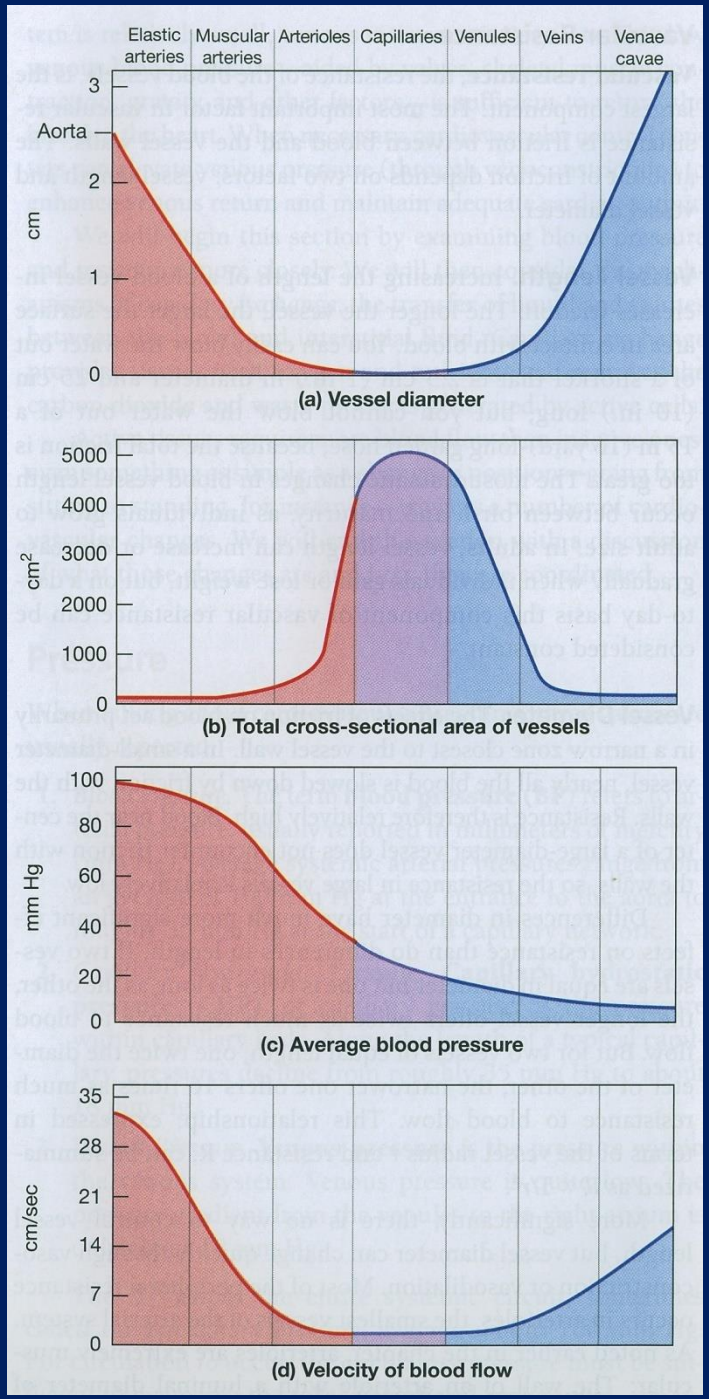



↑ Tissue metabolic activity
↓ O_2, ↑ CO_2 and other metabolites
Relaxation of precapillary sphincters
Arteriolar vasodilation
↑ Number of open capillaries
↑ Capillary blood flow
↑ Delivery of O_2, more rapid removal of CO_2 and other metabolites
↑ Capillary surface area available for exchange
↓ Diffusion distance from cell to open capillary
↑ Concentration gradient for these materials between blood and tissue cells
↑ Exchange between blood and tissue to support increased metabolic activity


Arteriole
Smooth muscles
Precapillary sphincter
Metarteriole
Capillary
Venule



The Organization of a Capillary Bed. (a) A typical capillary bed. Solid arrows indicate consistent blood flow; dashed arrows indicate variable or pulsating blood flow. (b) A micrograph of a number of capillary beds.



Relationships among Vessel Diameter, Cross-Sectional Area, Blood Pressure, and Blood Velocity.

Capillary pressures and capillary exchange

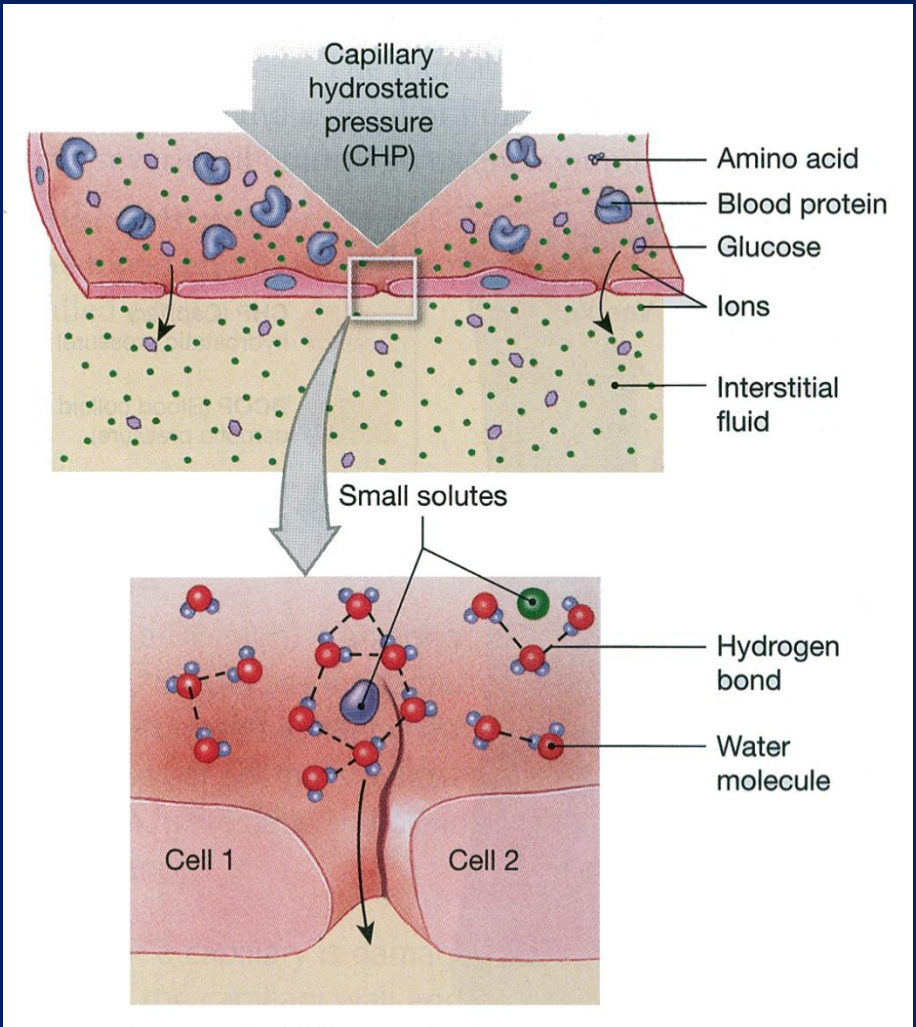
Capillary exchange plays important role in homeostasis.

The important processes that move Materials across capillary walls are:

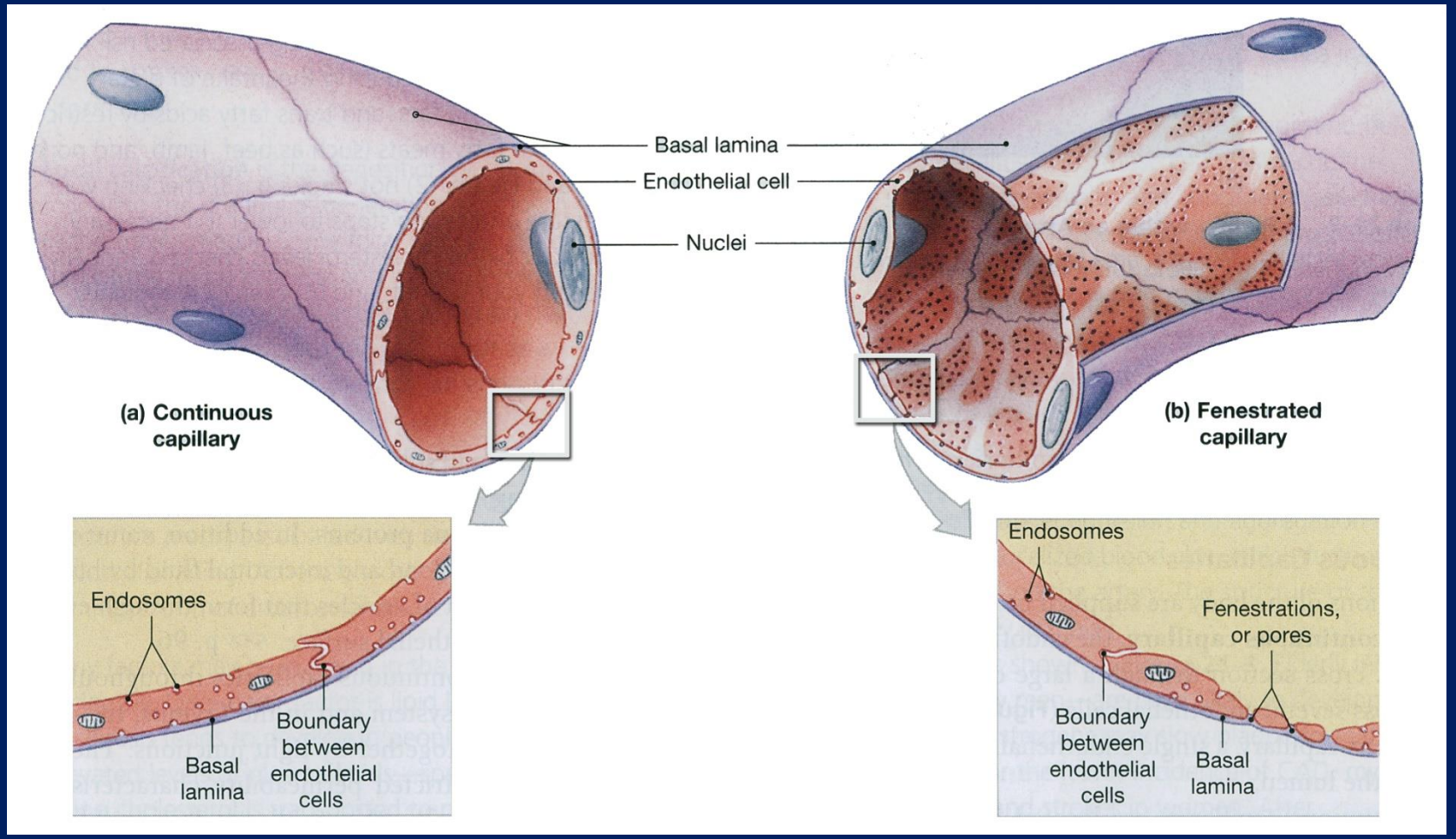
1- Diffusion

2- Filtration

3- Reabsorption

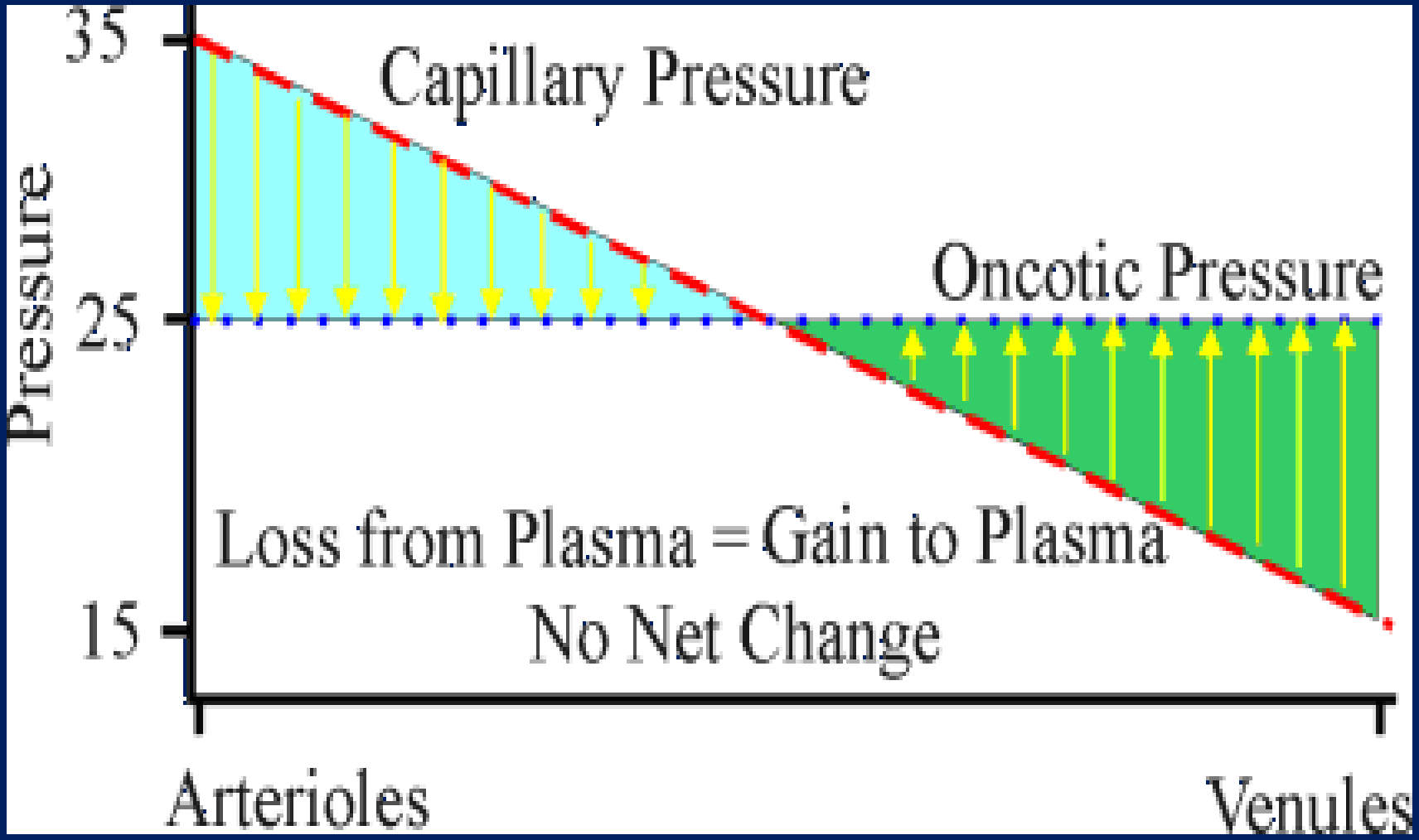


Capillary Filtration. Capillary hydrostatic pressure (CHP) forces water and solutes through the gaps between adjacent endothelial cells in continuous capillaries. The sizes of solutes that move across the capillary wall are determined primarily by the dimensions of the gaps.



Capillary Structure. (a) A continuous capillary. The enlargement shows routes for the diffusion of water and solutes. (b) A fenestrated capillary. Note the pores, which facilitate diffusion across the endothelial lining.

Graphic Representation of Capillary Filtration



Four Forces known as Starling Forces Determine Fluid Movement Across the Capillary Membranes.

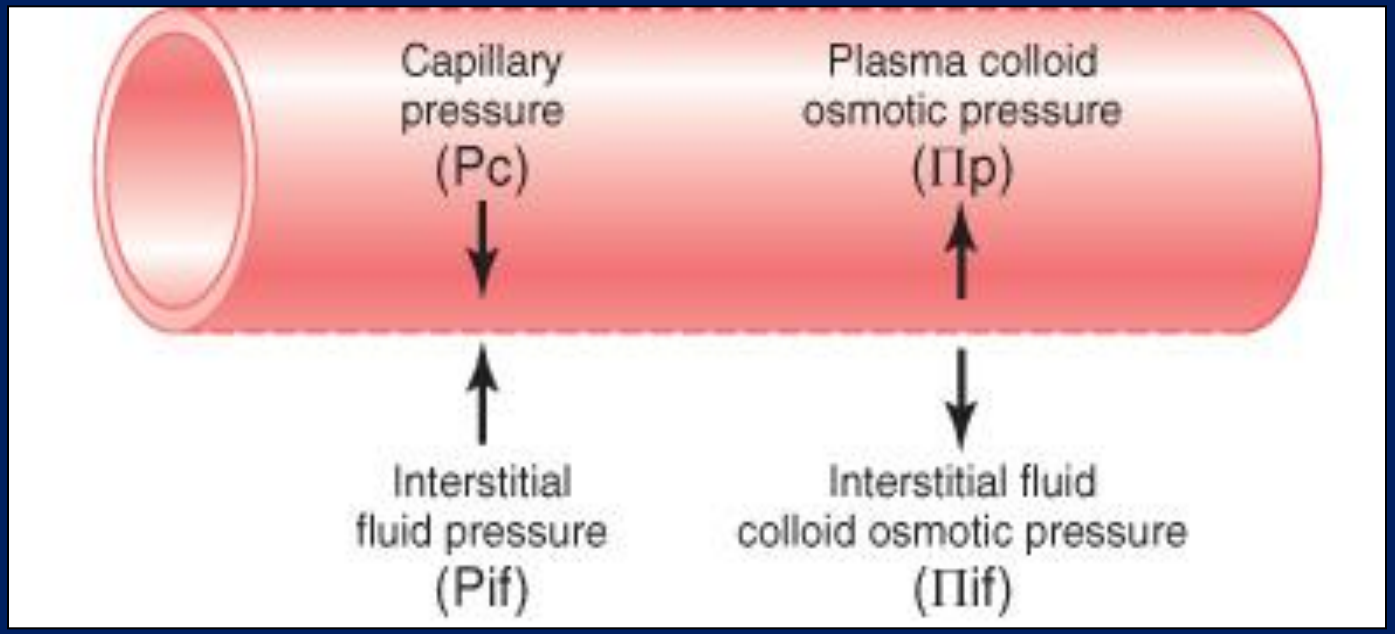
Pc = Capillary Pressure→ Tends to move fluid out of the capillary

Pi = Interstitial Fluid Pressure→ Tends to move fluid into the capillary.

Πc = Plasma Colloid Osmotic Pressure→ Tends to cause Osmosis of fluid into capillary.

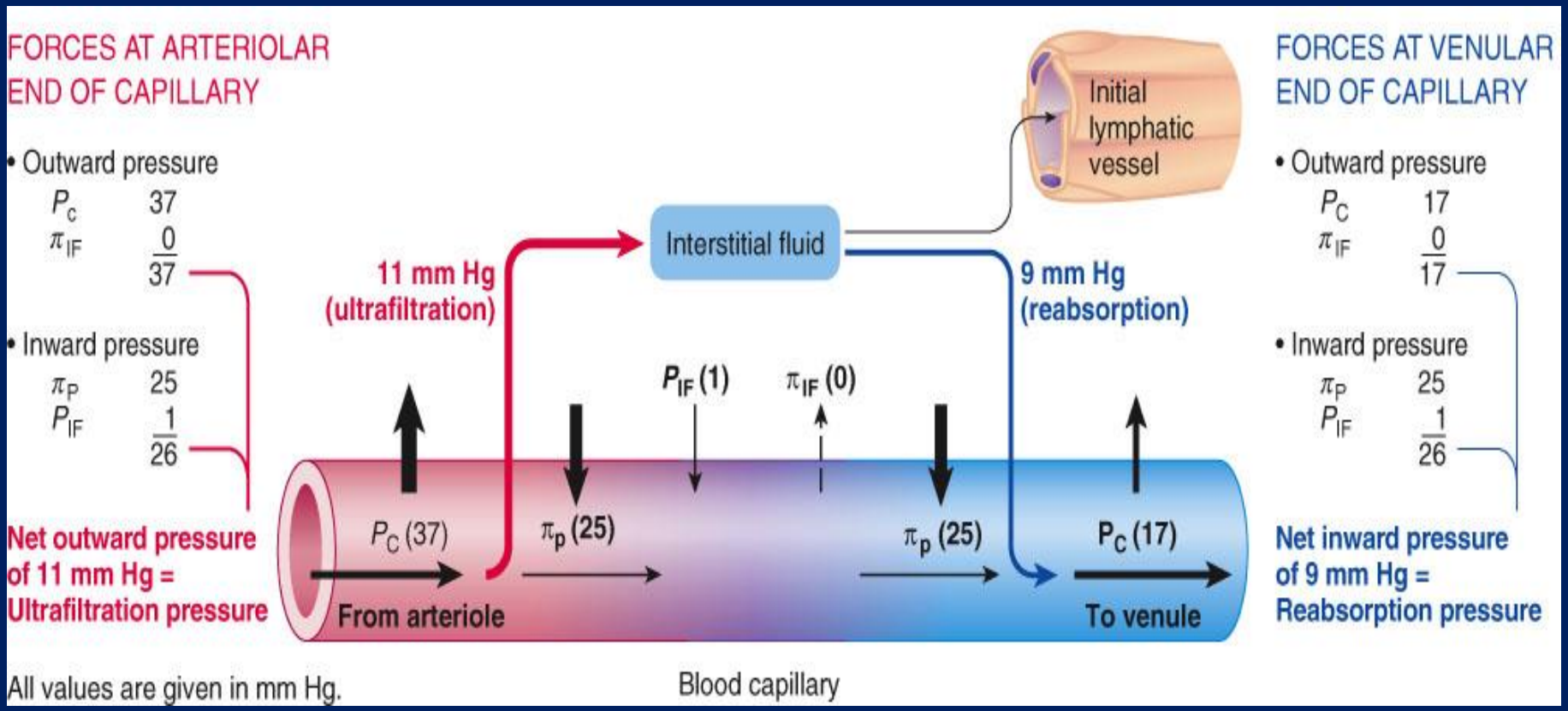
Πi = Interstitial fluid colloid osmotic pressure→ Tends to cause osmosis of fluid out of the capillary.

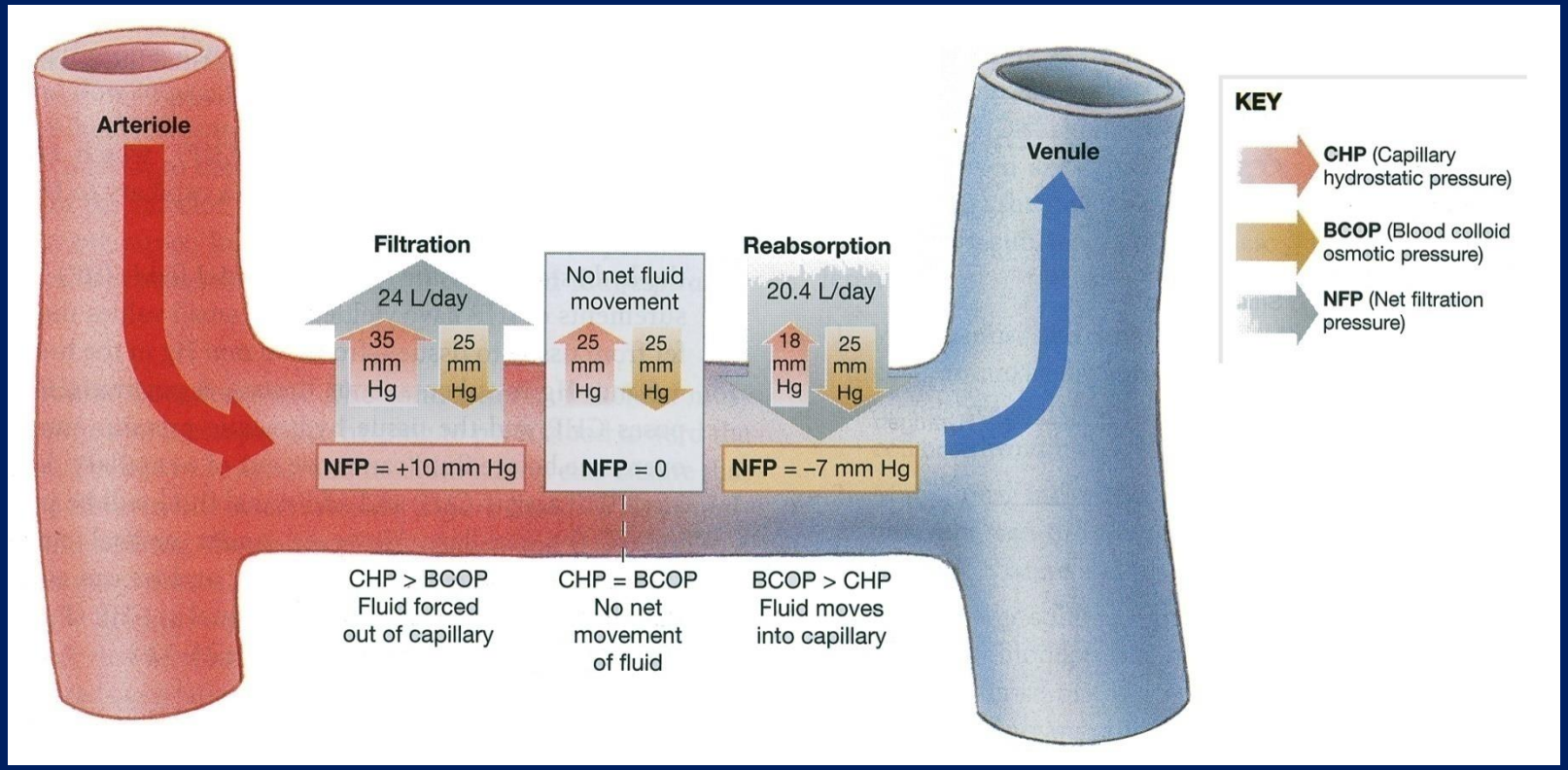
Net Filtration Pressure = Pnet= ((Pc-Pi) – (Πc- Πi))



Fluid movement = Kf [(Pc – Pi) – (Πc - Πi)

Kf = filtration coefficient


FORCES AT ARTERIOLAR END OF CAPILLARY
• Outward pressure
P_C 37
π_{IF} 0
37
• Inward pressure
π_P 25
P_{IF} 1
26
Net outward pressure of 11 mm Hg = Ultrafiltration pressure
Initial lymphatic vessel
Interstitial fluid
11 mm Hg (ultrafiltration)
9 mm Hg (reabsorption)
P_{IF} (1)
π_{IF} (0)
P_C (37)
π_p (25)
π_p (25)
P_C (17)
From arteriole
To venule
FORCES AT VENULAR END OF CAPILLARY
• Outward pressure
P_C 17
π_{IF} 0
17
• Inward pressure
π_P 25
P_{IF} 1
26
Net inward pressure of 9 mm Hg = Reabsorption pressure
All values are given in mm Hg.
Blood capillary



Forces Acting across Capillary Walls. At the arterial end of the capillary, capillary hydrostatic pressure (CHP) is greater than blood colloid osmotic pressure (BCOP), so fluid moves out of the capillary (filtration). Near the venule, CHP is lower than BCOP, so fluid moves into the capillary (reabsorption). In this model, interstitial fluid colloid osmotic pressure (ICOP) and interstitial fluid hydrostatic pressure (IHP) are assumed to be 0 mmHg and so are not shown.

More filtration than reabsorption occurs along the capillary.

The extra amount of fluid in the interstitial spaces is carried by the lymphatic Vessels → venous circulation.

This will help in:

1- Constant exchange of fluid.

2- Accelerate distribution of substances.

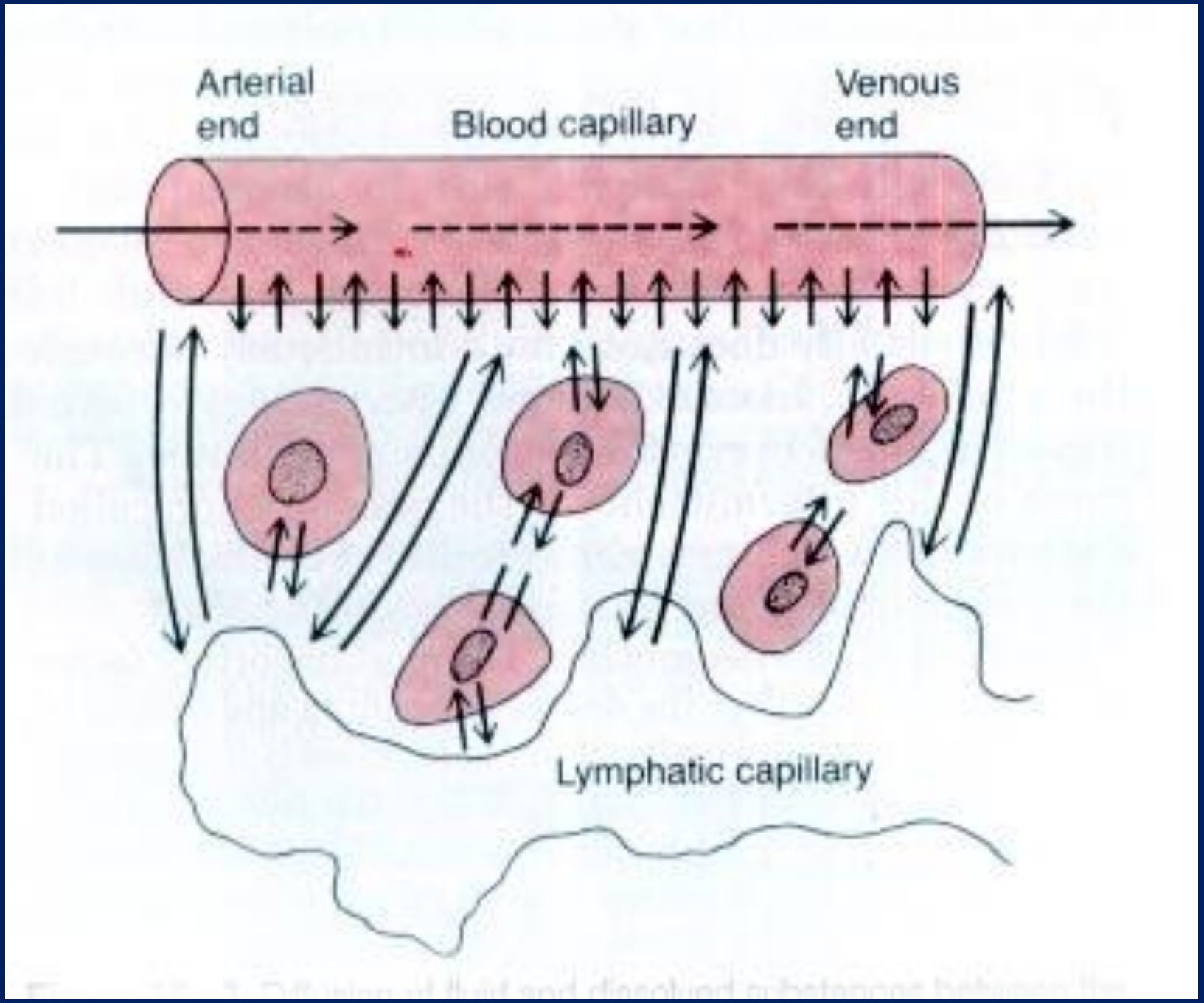
3- Transport insoluble lipids & tissue proteins.

4- Carry bacterial toxins to lymphoid tissues → provide immunity.

Lymphatic circulation

- Lymphatic system is responsible for bringing the interstitial fluid to vascular compartment.
- Normal 24 hrs lymph flow is 2- 4 L

- Lymphatic capillaries lie in interstitial fluid close to vascular capillaries ,these capillaries merge into large lymphatic vessels & eventually into largest vessel, thoracic duct which empties into large veins .


Arterial end
Blood capillary
Venous end
Lymphatic capillary

Edema

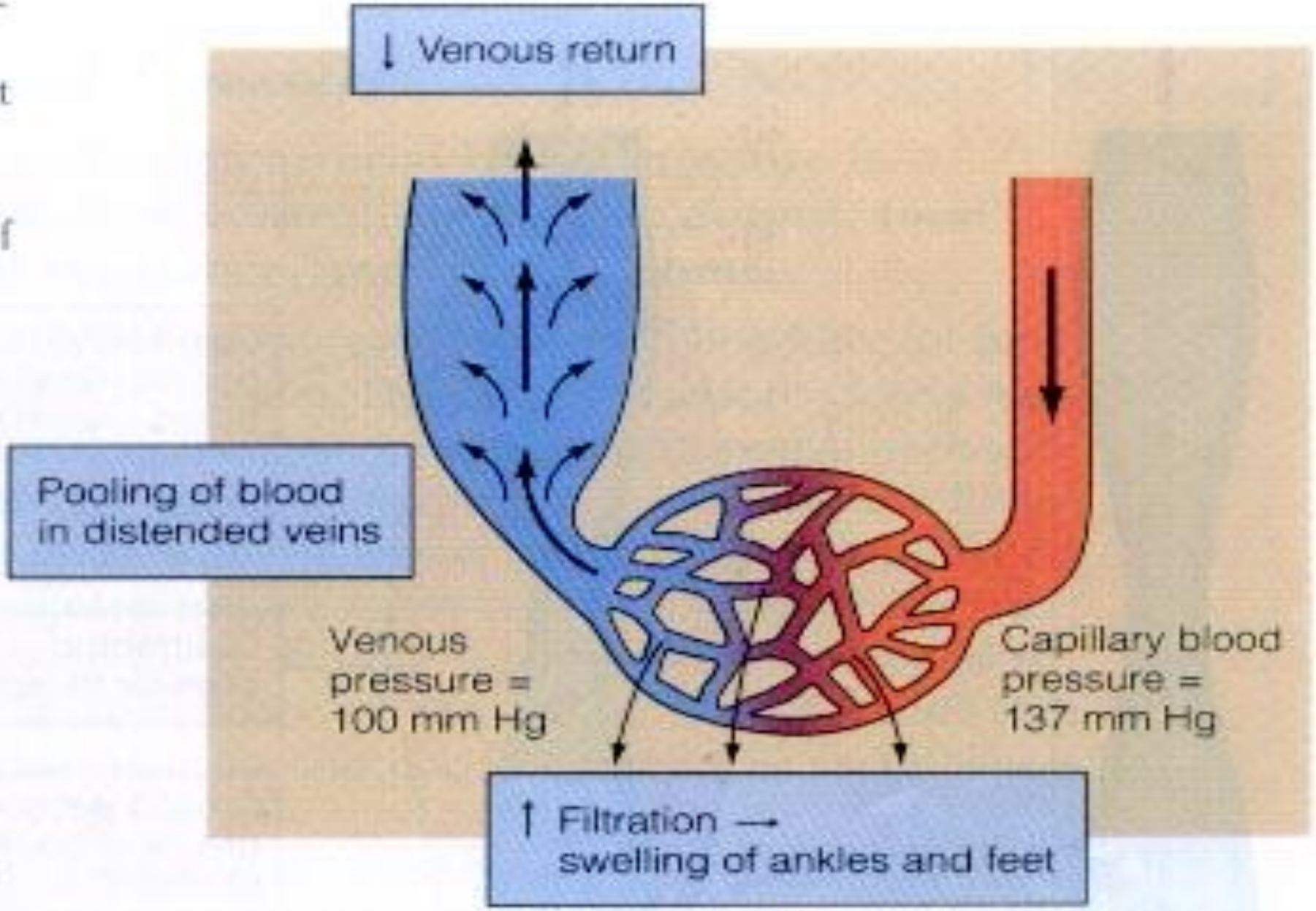
Is an excessive amount of fluid in the interstitial Spaces caused by:

1- ↑ Capillary hydrostatic pressure e.g. heart failure, local venous block, failure of venous pumps, etc.

2- ↓ Plasma proteins due to e.g:
A- Nephrosis. B- Burns & wounds.
C- Liver disease D- Malnutrition.

3- ↑ Capillary permeability e.g. in allergic reactions & burns.

4- Blockage of lymph return by, e.g. infection or cancer.


↓ Venous return
Pooling of blood in distended veins
Venous pressure = 100 mm Hg
Capillary blood pressure = 137 mm Hg
↑ Filtration → swelling of ankles and feet

(b)

Pitting Edema of the Feet

A Pit forms where the skin is pressured. It may remain there for a few minutes

Elephantiasis or Lymphatic Filariasis

Elephantiasis of the legs due to filariasis (CDC).

Causes of edema

1- Increased hydrostatic blood pressure

heart failure (left or right),

excess fluid in the blood.

2- Decreased blood osmotic pressure

Liver, kidney diseases,

malnutrition (kwashiorkor),

burn injuries.

3- Increased interstitial hydrostatic pressure (lymphatic capillary blockage)

breast cancer surgery,

Elephantiasis.

4- Leaking capillary wall

histamine release during

allergic reaction.