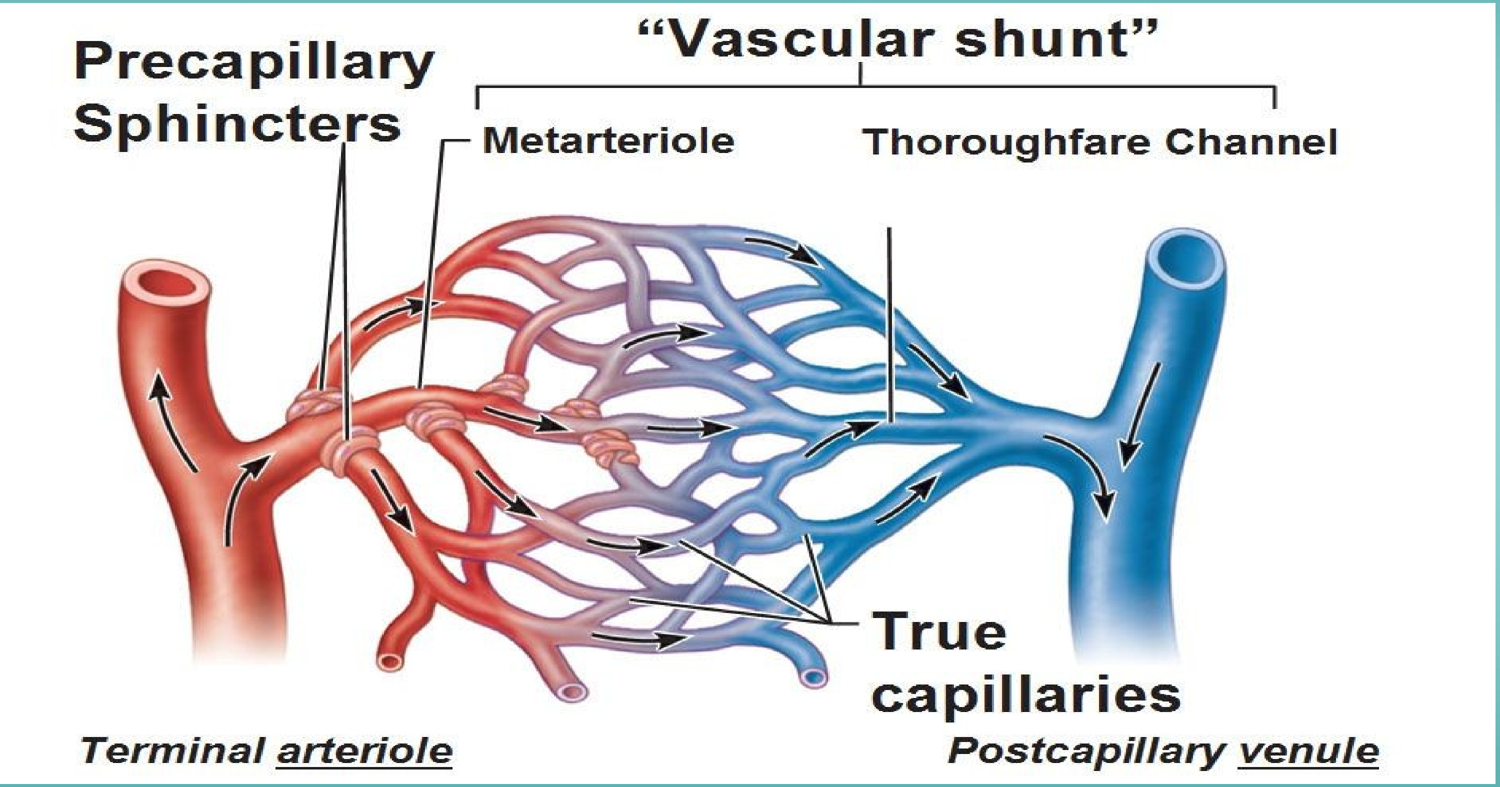
MICROCIRCULATION

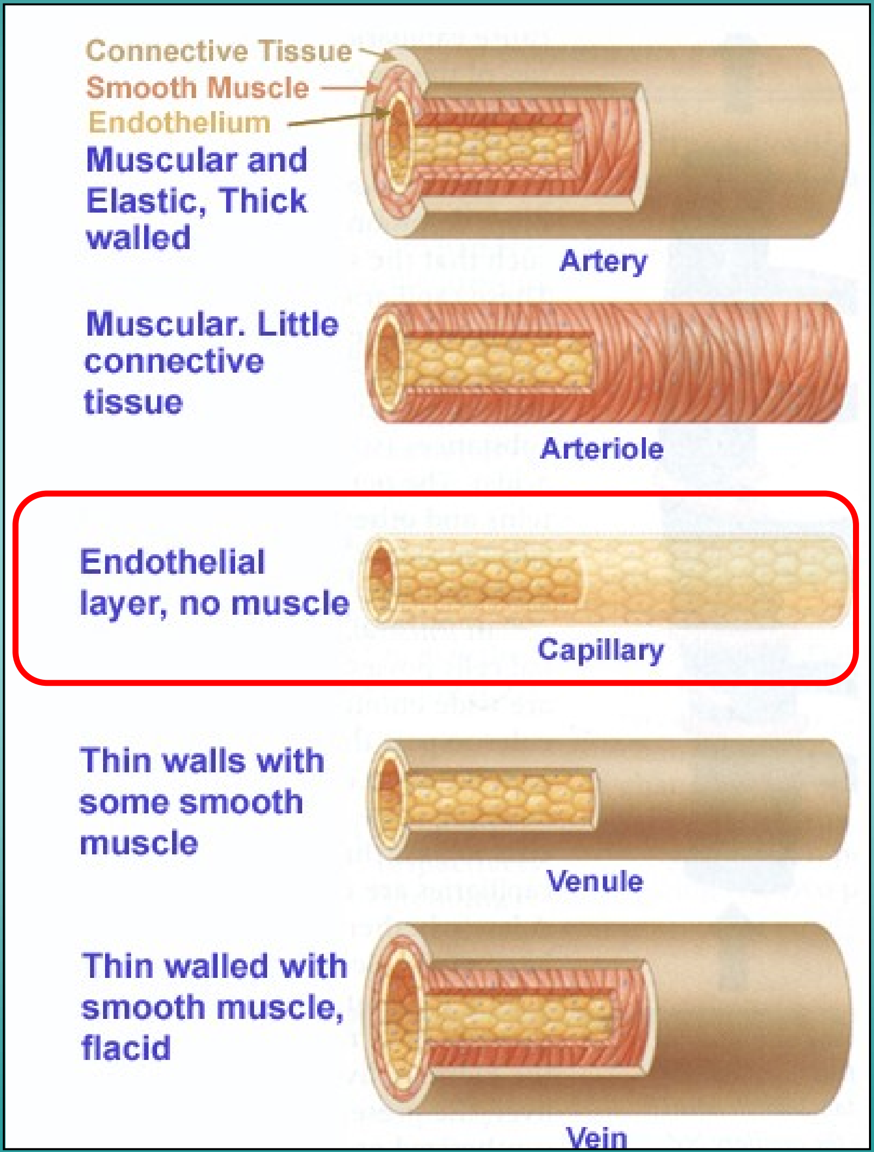
FUNCTIONAL ANATOMY

Microcirculation is circulation of the blood through the smallest vessels of the body – arteriols, capillaries and venules.



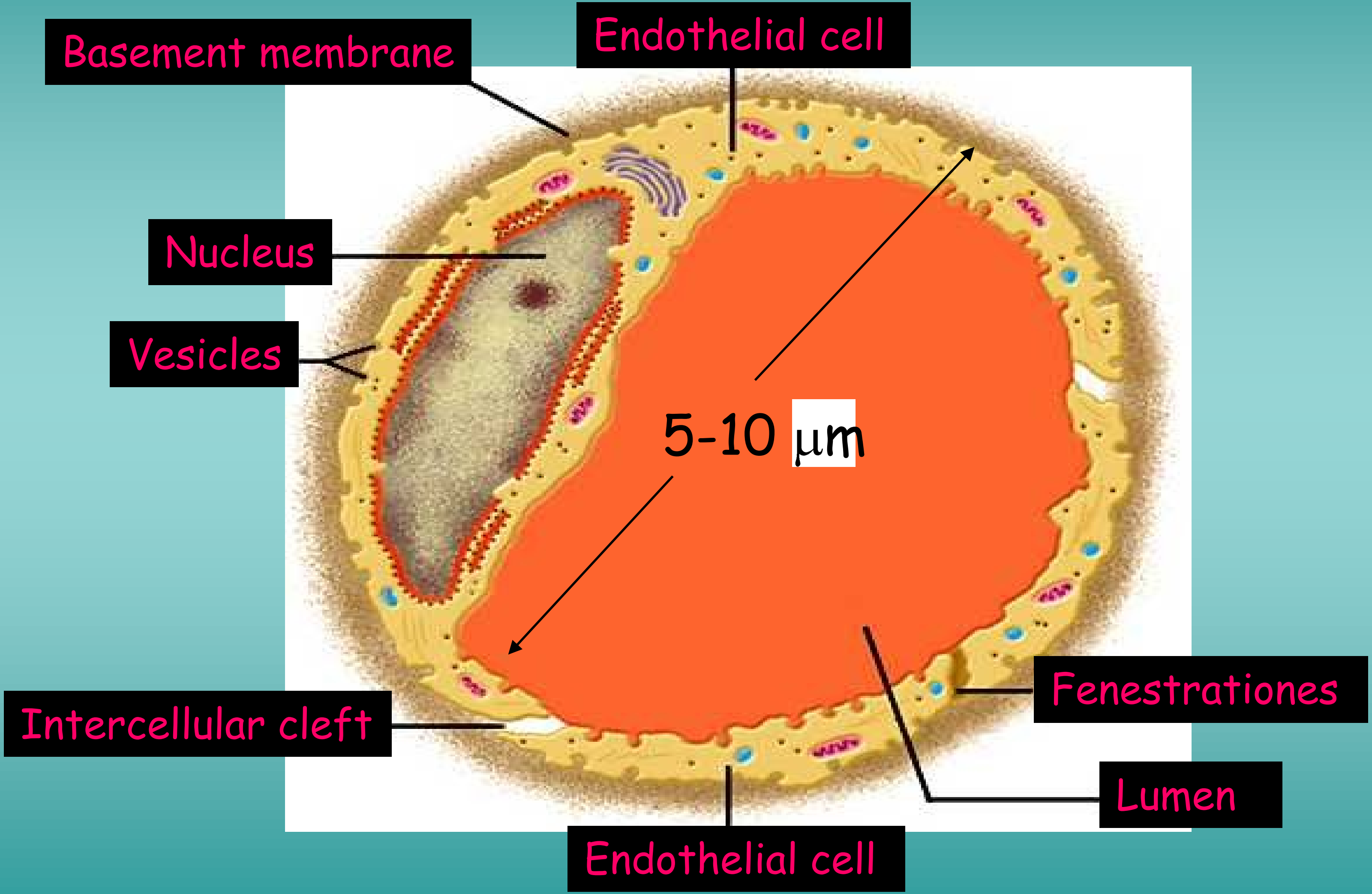
The principal function of the microcirculation is to permit the transfer of substances (water, solutes, gases) between the vascular system and the tissues.

STRUCTURE OF VESSEL WALL

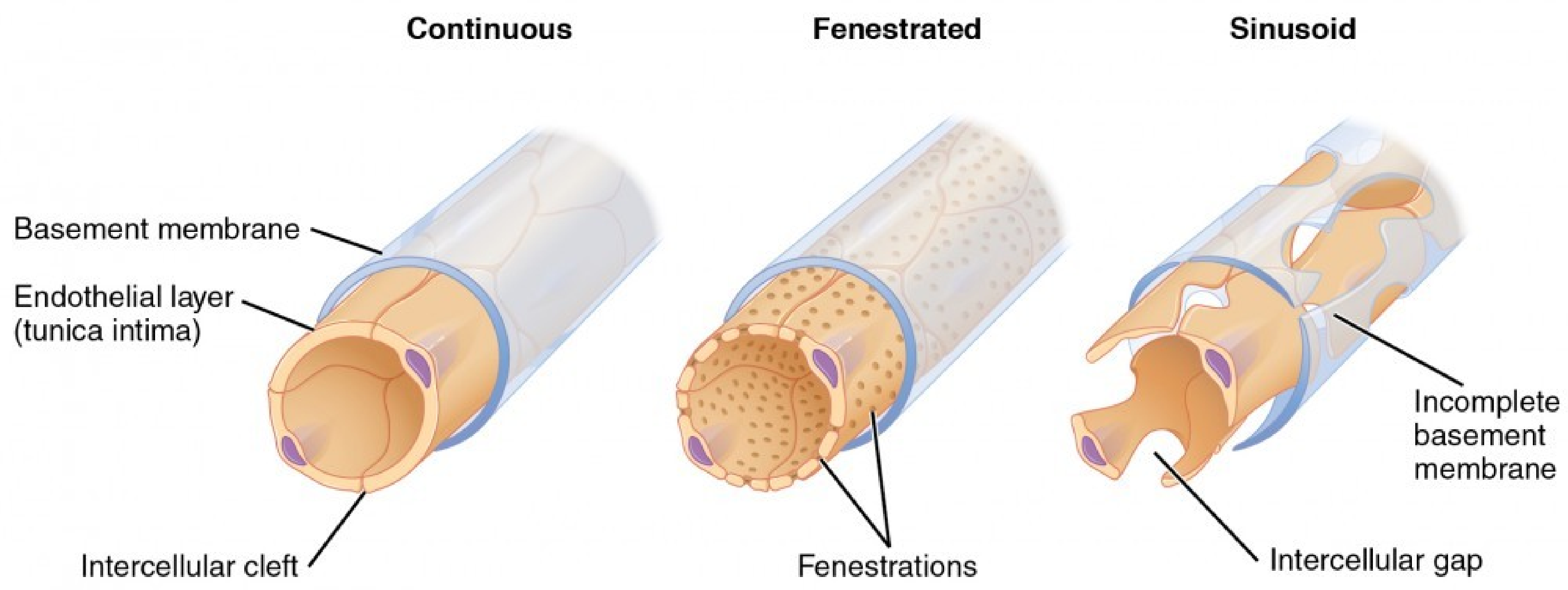


1. The capillary wall is about 1 µm thick.
2. The total area of all the capillary walls in the body exceeds 500 m^2.
3. The rate of blood flow in capillaries is 0.2 - 1 mm/s.
4. Transit time from arterial to venular end of a capillary is 1 - 2 seconds.

ULTRASTRUCTURE OF CAPILLARY

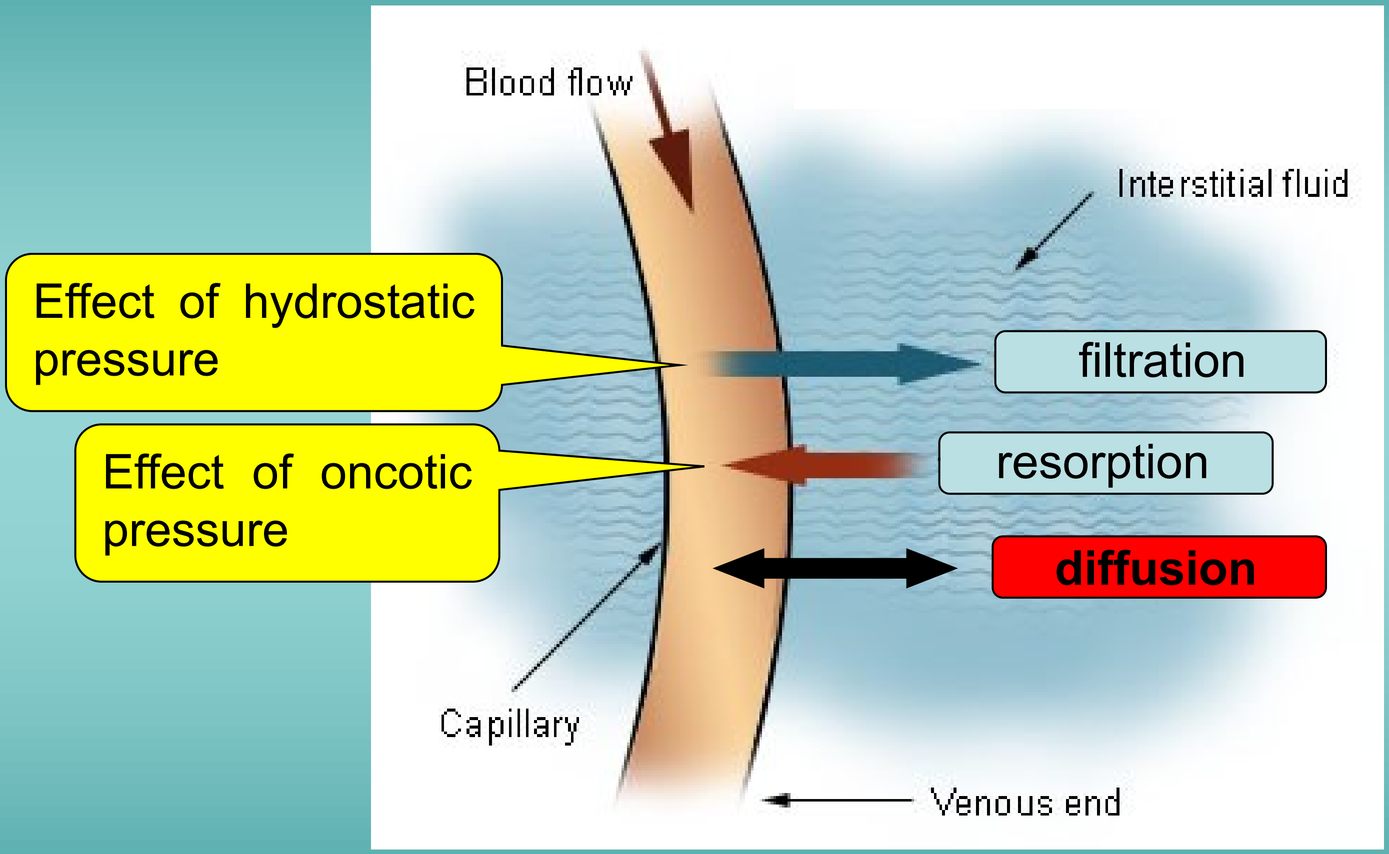


TYPES OF CAPILLARIS



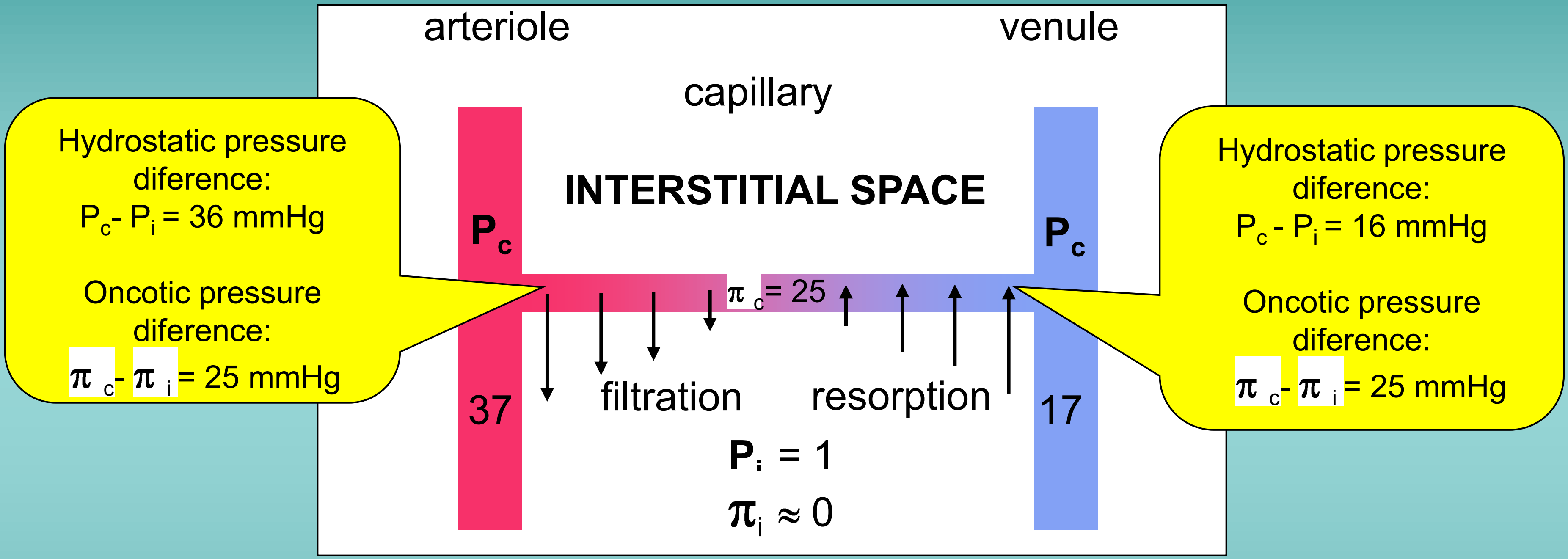
- **Continues capillaries** are in the brain, skin and muscle tissues and serve to transport water, glucose, ions, and small particles (cleft width is about 6 to 7 nanometers).
- **Fenestrated capillaries** are in kidneys, muscles, intestines, pancreas, and endocrine glands and serve to transport small molecular and ionic substances (diameter of fenestrations is 70 - 80 nanometers).
- **Sinusoid capillaries** are in the liver and bone marrow and contain wide open gaps, so that almost all dissolved substances of the plasma including the plasma proteins and even cells can pass from the blood into the interstitial space.

MOVEMENT OF FLUID ACCROSS CAPILLARY WALL



The diffusion, filtration and resorption of water across capillary wall occur through Intercellular clefts, pores and fenestrations.

PRESSURE GRADIENTS ACROSS THE WALL OF CAPILLARY



CAPILLARY HYDROSTATIC PRESSURE **P_c = 37 - 17 mmHg**

INTERSTITIAL HYDROSTATIC PRESSURE **P_i = 1 mmHg**

CAPILLARY ONCOTIC PRESSURE **π_c = 25 mmHg**

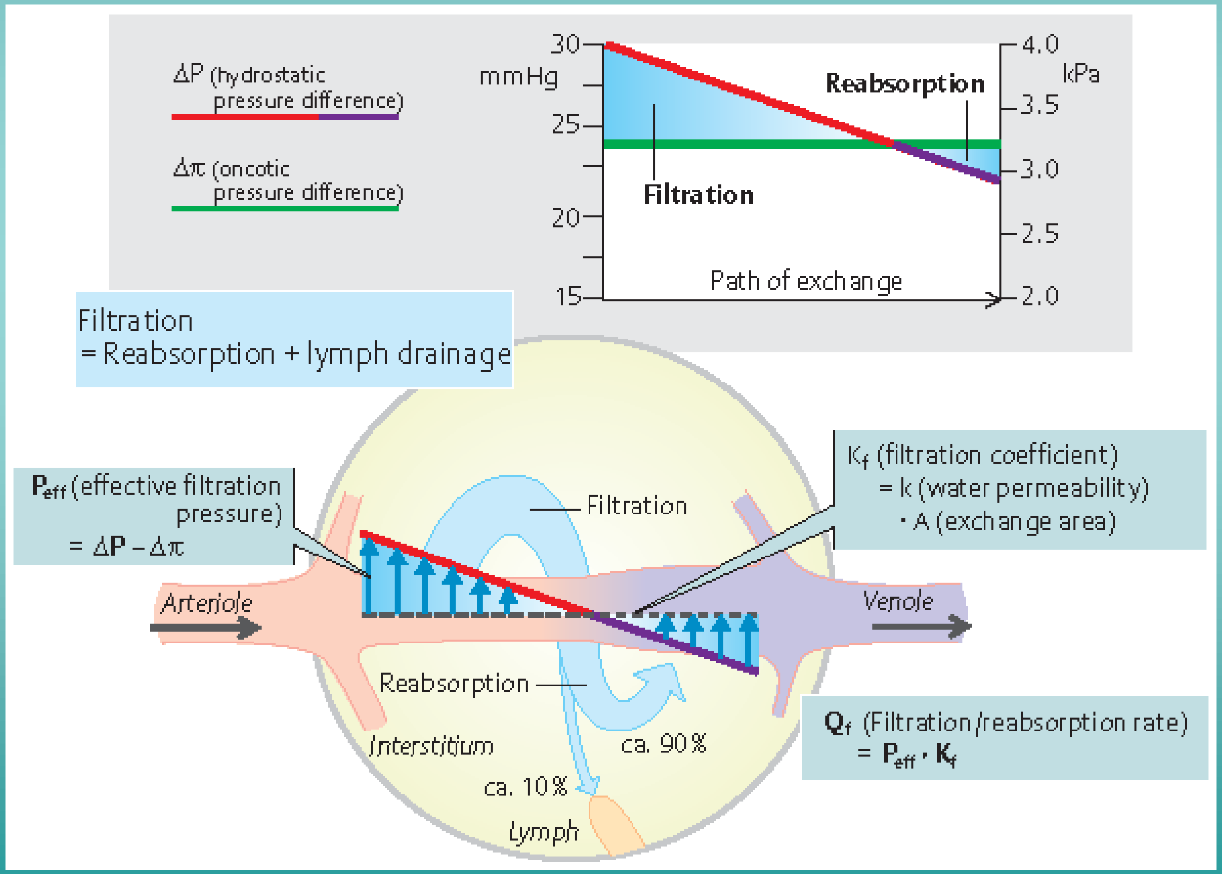
INTERSTITIAL ONCOTIC PRESSURE **$\pi_i \approx$ 0 mmHg**

EXCHANGE OF FLUID VIA CAPILLARIES

Hydrostatic pressure diference

Oncotic pressure diference

$([P_c - P_i] - \sigma\,[\pi_c - \pi_i])$ **- effective (net) filtration pressure**



STARLING'S EQUATION

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

J_v - NET FLUID MOVEMENT ACROSS CAPILLARY WALL

K_f - Filtration coefficient

P_c - capillary hydrostatic pressure

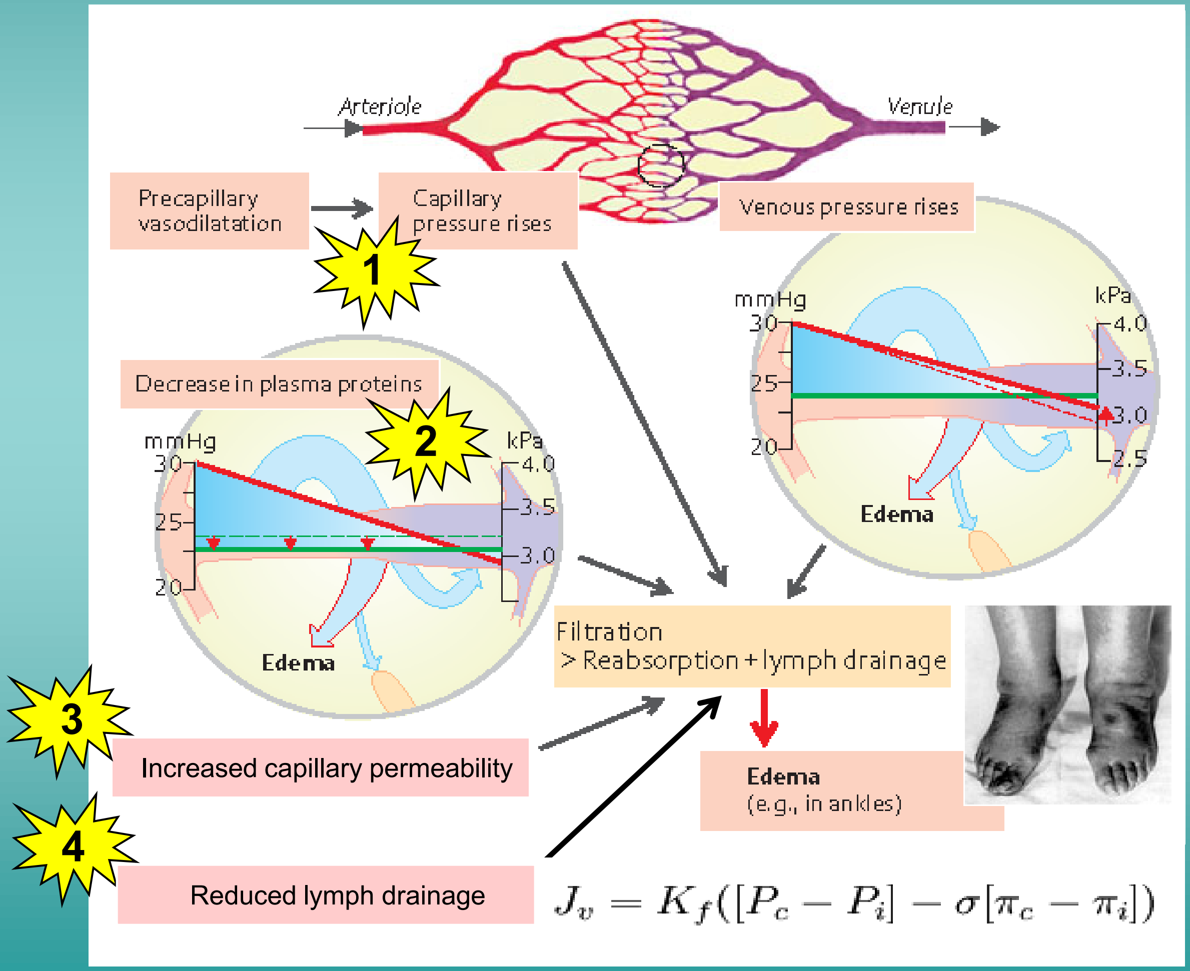
P_i - interstitial hydrostatic pressure

π_z - capillary oncotic pressure

π_i - interstitial oncotic pressure

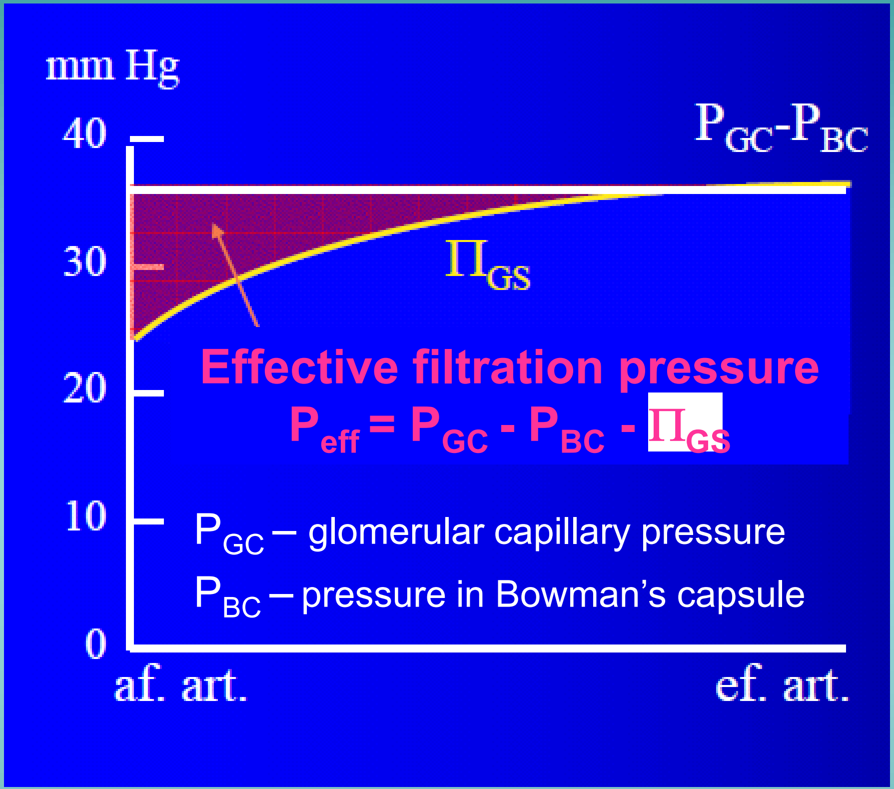
σ - coefficient permeabilty

CAUSES OF INCREASED INTERSTITIAL FLUID VOLUME (EDEMA)



SPECIAL CASES

- **Glomerular microcirculation**



P_{GC} and P_{BC} are ~45 and 10 mmHg, respectively. Effective filtration pressure (P_{eff}) at the arterial end of the capillaries equals 10 mmHg (red coloured area). Because of the high filtration fraction, the plasma protein concentration and, thus, glomerular oncotic pressure (Π_{GS}) along the glomerular capillaries increase and P_{eff} decreases. Thus, filtration ceases (near distal end of capillary) when Π_{GS} rises to about 35 mmHg, decreasing P_{eff} to zero.

- **Pulmonary microcirculation**

The hydrostatic and osmotic pressure gradients in the lung capillaries are small (~10 mmHg) and nearly balanced under physiological conditions ensuring equilibrium between filtration and reabsorption. Any excess of filtration over reabsorption is drained via pulmonary lymphatic.

MOVEMENT OF SOLUTES ACCROSS CAPILLARY WALL

- **DIFFUSION -** if there is, for a certain solute, a concentration difference between the plasma and interstitial space the solute diffuses across the capillary wall. Lipid-soluble molecules (e.g. O_2 ,CO_2) move across the capillary wall directly while lipid insoluble molecules (e.g. ions, urea) move across the capillary wall by Intercellular clefts, pores or fenestrations.

- **SOLVENT DRAG -** The dissolved particles are dragged through the capillary wall along with filtered and reabsorbed water.

!!! TO REMEMBER !!!

Four forces known as Starling forces determine net fluid movement across the capillary membranes.

$\mathbf{P_c}$= Capillary Pressure→ Tends to push fluid out of the capillary.

$\mathbf{P_i}$= Interstitial Fluid Pressure→ Tends to push fluid into the capillary.

$\boldsymbol{\pi_c}$ = Plasma Colloid Osmotic Pressure→ Tends to cause osmosis of fluid into capillary.

$\boldsymbol{\pi_i}$ = Interstitial fluid colloid osmotic pressure→ Tends to cause osmosis of fluid out of the capillary

$$\text{Effective filtration pressure} = ((P_c - P_i) - (\pi_c - \pi_i))$$

The diffusion is the key factor in providing exchange of gases, substrates and waste products between the capillaries and the tissue cells.

CAUSES OF EDEMA DEVELOPMENT:

↑ **Capillary Pressure** - P_c (↑hydrostatic pressure, heart failure)

↓ **Plasma Proteins** (nephrotic syndrome, liver cirrhosis)

↑ **Capillary Permeability** - K_f (infections, inflamations)

↓ **Lymph drainage**- π_i (lymphatic blockage)