Microcirculation

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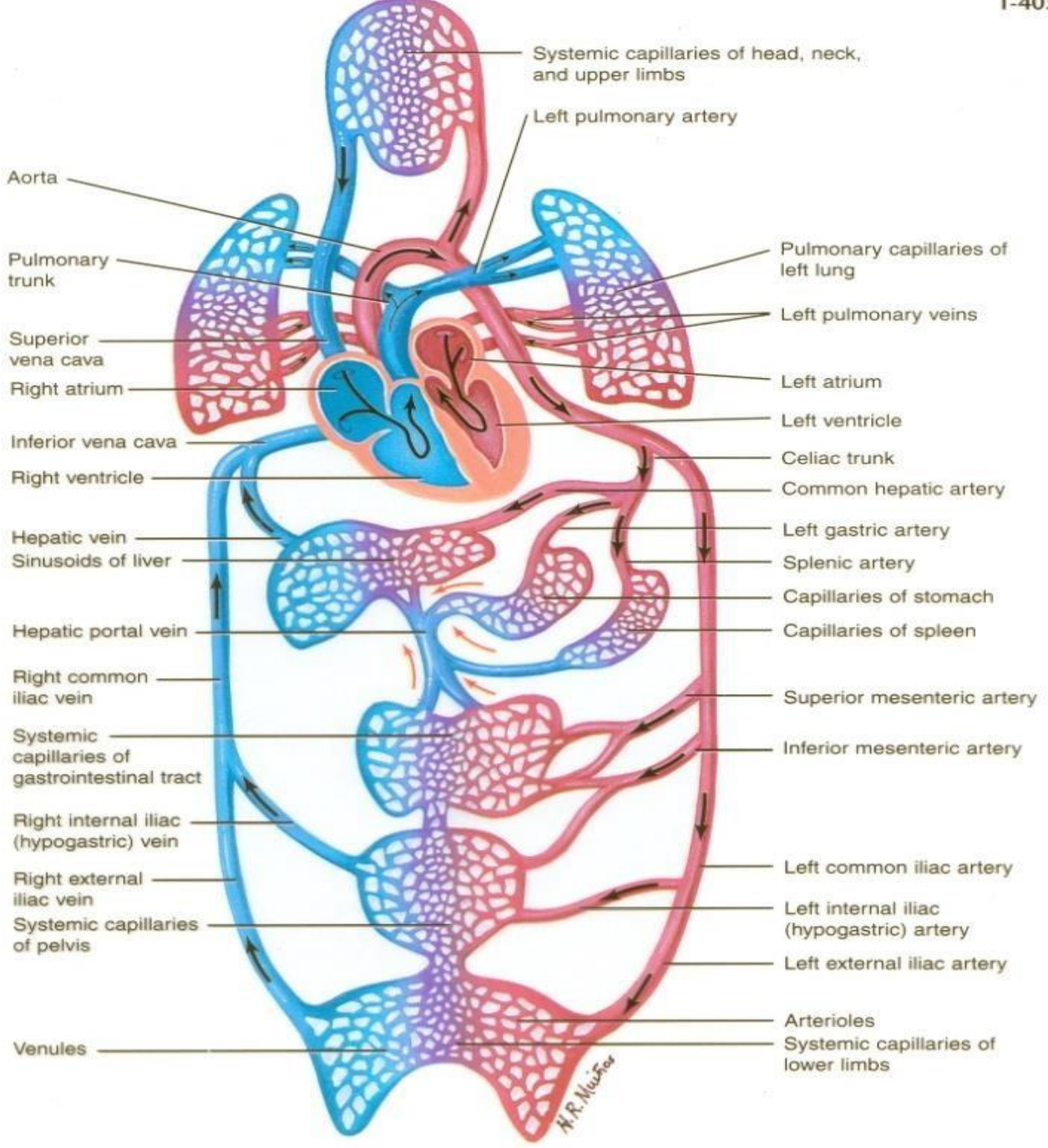
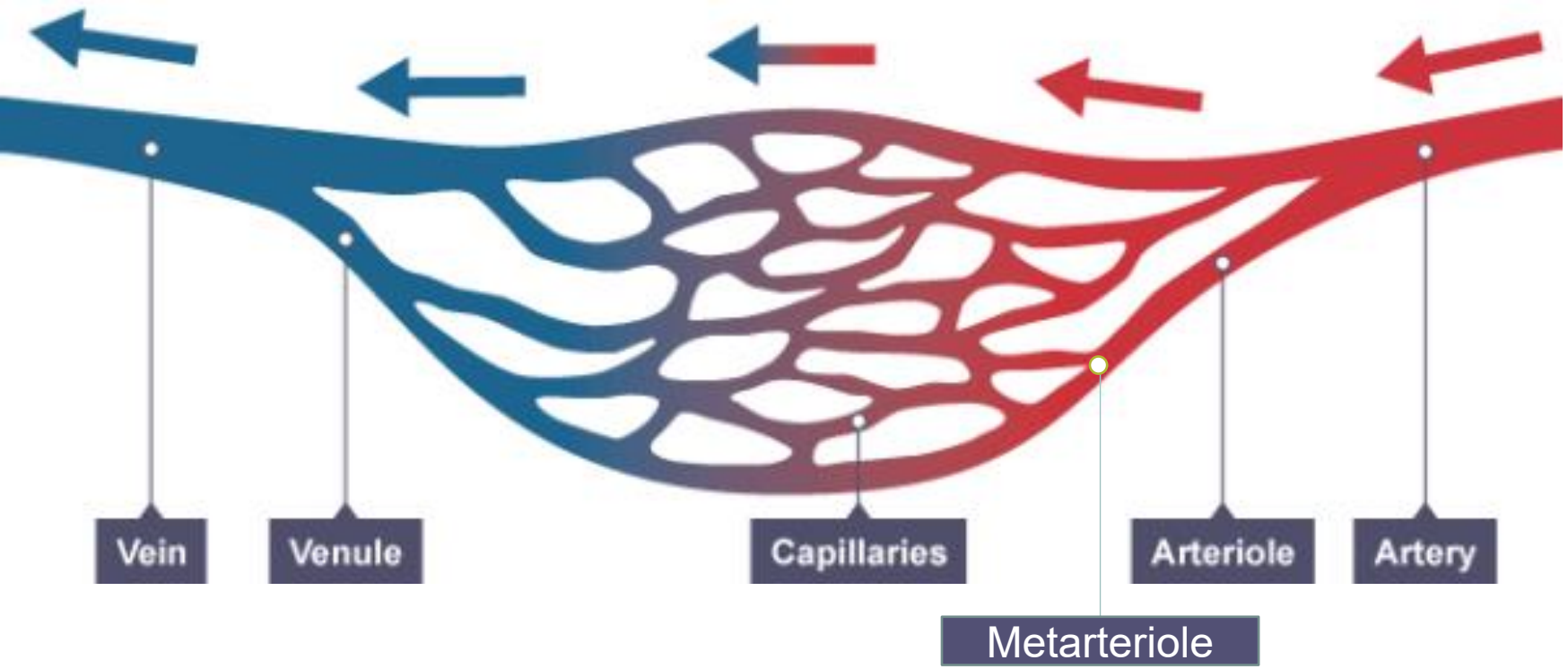
- 5- Capillary exchange
- 6- **Diffusion**
- 7- Transcytosis
- 8- Bulk Flow
- 9- NFP = (BHP + IFOP) – (BCOP + IFHP)

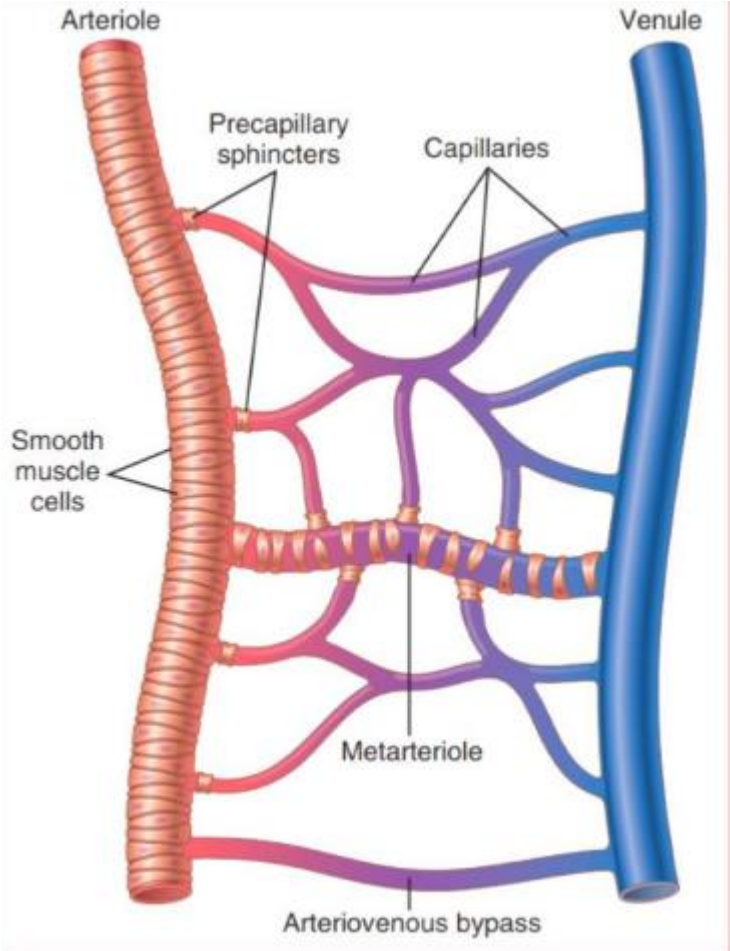
1- Introduction

- We can divide circulations into :
  1-systemic circulation or greater circulation
  2-pulmonary circulation (Lungs)
- 7% of our bodies weight is blood then 70kg person is about has 5 L of blood
- Blood consist of
  • cells (45%) & plasma (55%)
  • Then 5L of blood have (3L of plasma) and (2L of cells)
- blood is distributed in the cardiovascular system as follows:
  1- Systemic veins: 3000 mL
  2- Systemic arteries: 750 mL
  3- Pulmonary circulation (arteries+ capillaries+ veins): 450 mL
  4- Heart: 400 mL
  5- Systemic capillaries: 400 mL

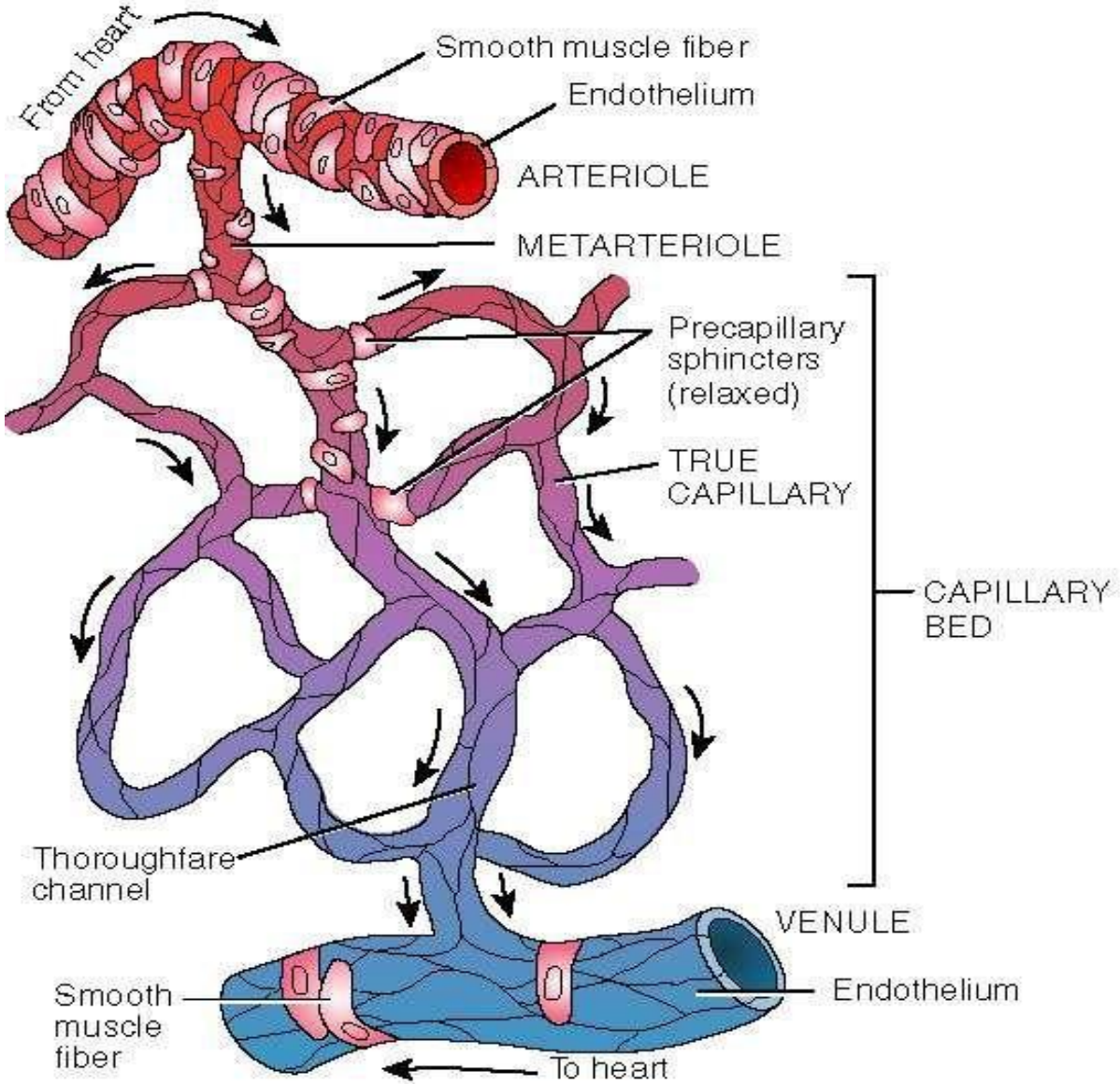


General plan of circulation

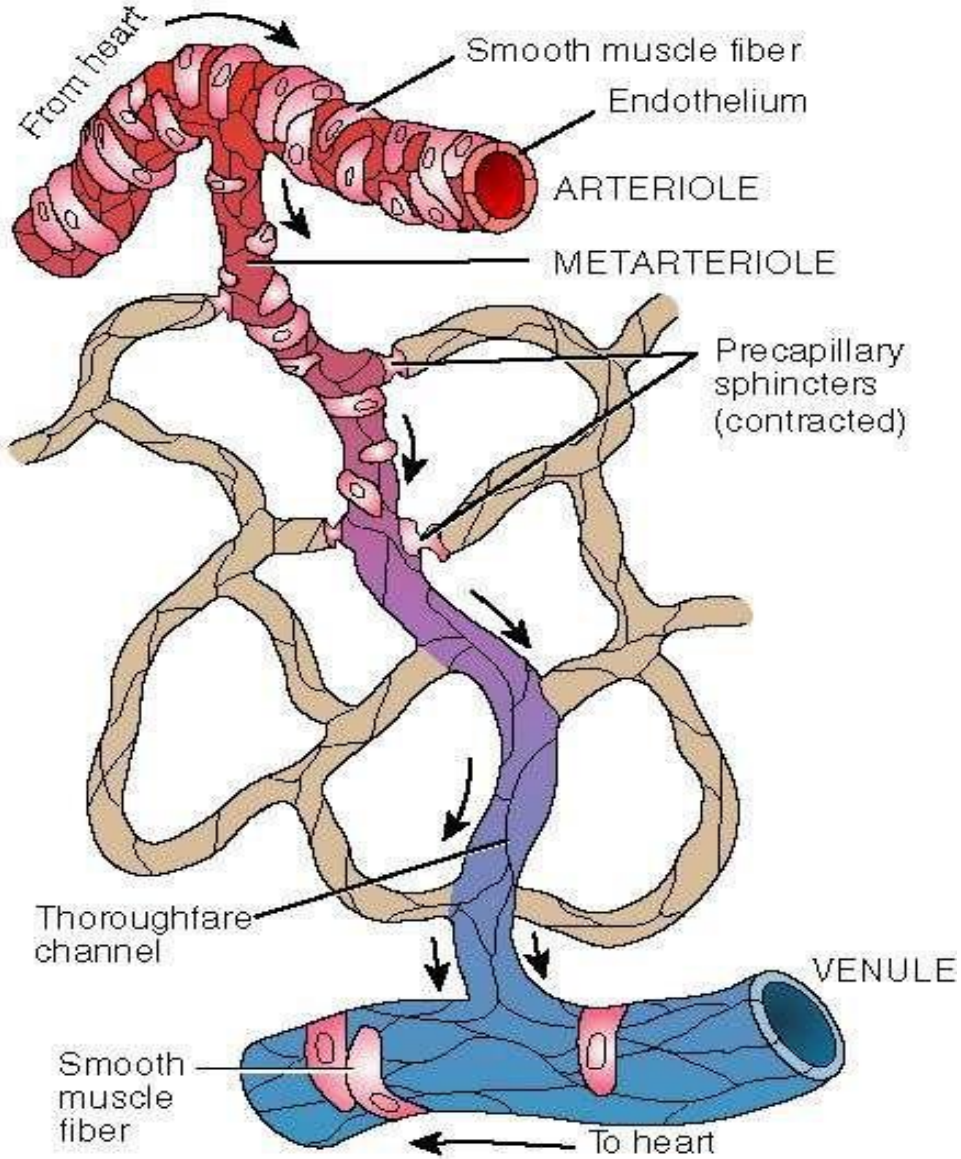




→ arterioles are highly muscular because blood pressure inside them is high
→ The metarterioles do not have a continuous muscular coat, but smooth muscle fibers encircle the vessel at certain points.
→ Capillaries have precapillary sphincters from where it originates, it closes and opens to control the movement of blood through it



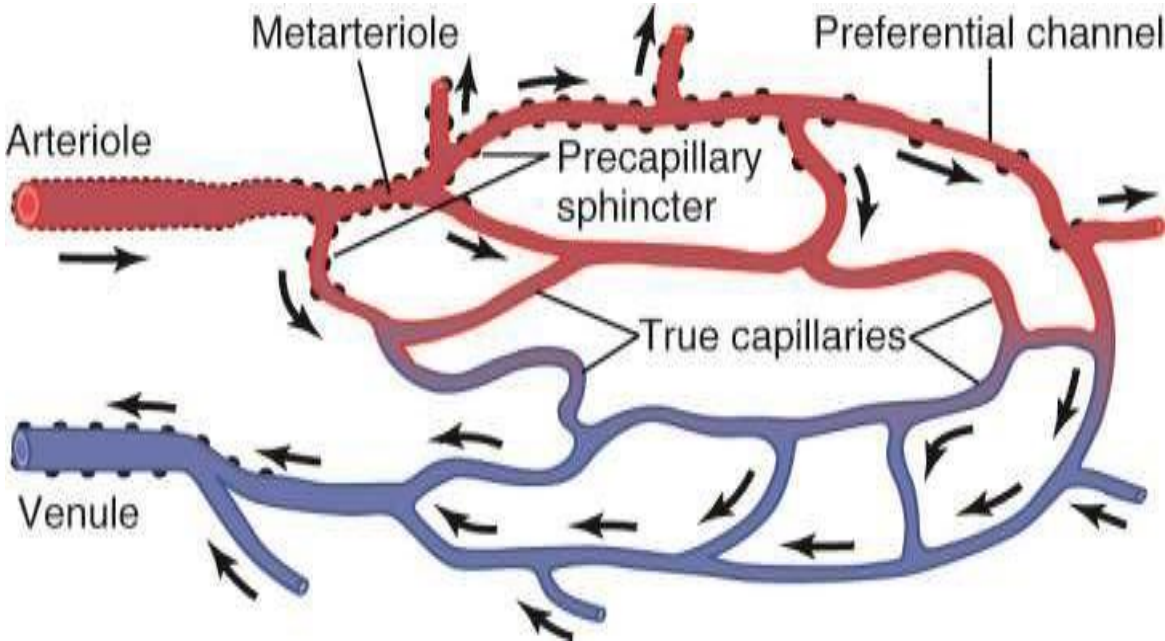
(a) Sphincters relaxed: blood flowing through capillary bed



(b) Sphincters contracted: blood flowing through thoroughfare channel

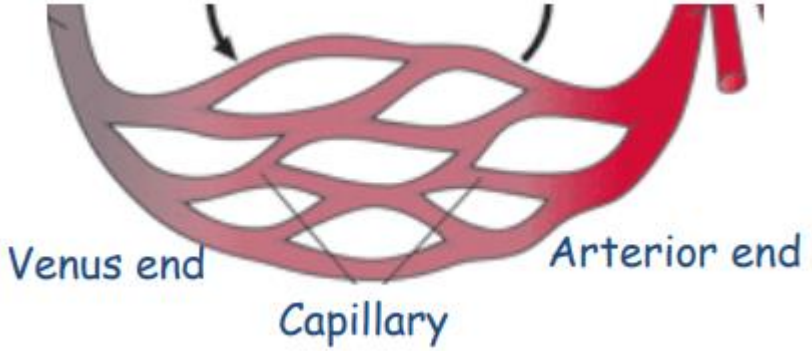
2- Microcirculation

- is the blood flow through the smallest vessels of the circulatory system
- Important in the transport of nutrients to tissues
- Site of waste product removal.
- Over 10 billion capillaries with surface area of 500-700 square meters perform function of solute and fluid exchange.
- Capillary exchange blood with interstitial fluid then the interstitial fluid exchange blood with cells



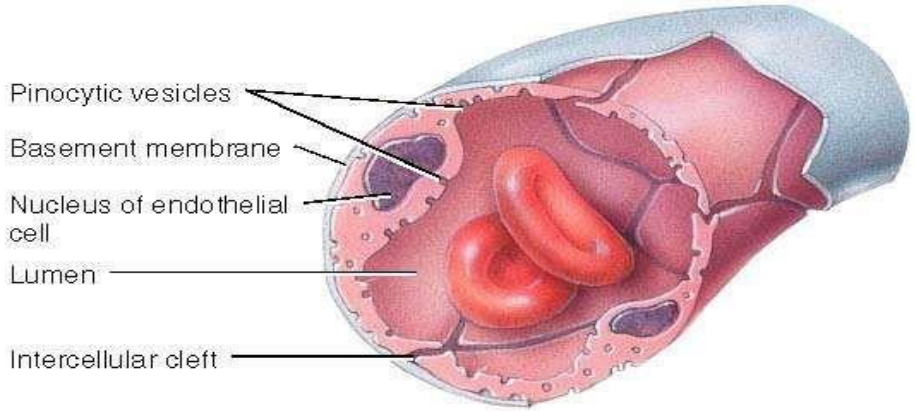
2- Microcirculation

- Each day in our Systemic cycle capillaries there is :
  - Filtration of 20L
  - Reabsorption of 17L by the capillary
  - Reabsorption of 3L by the lymphatics
- Lymphatics transport the fluid the lymph nodes inside the body for cleaning it, then to the blood vessels

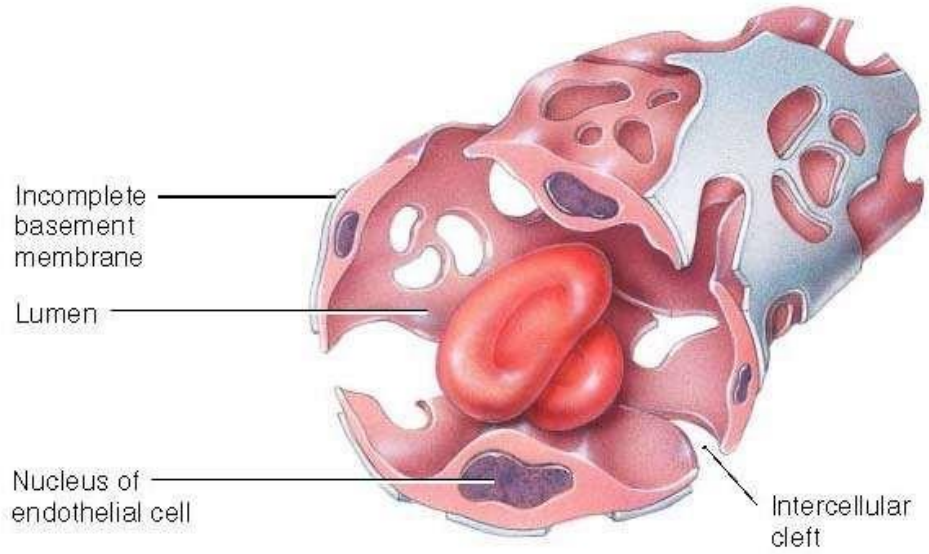


3- Types of capillaries

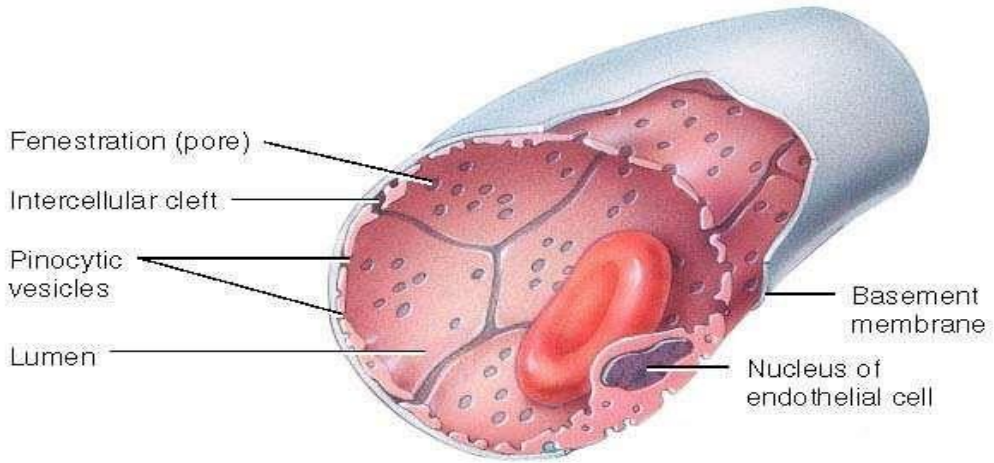
- Regarding structure:
  1) Continuous
  2) Fenestrated
  3) Sinusoid



(a) Continuous capillary formed by endothelial cells



(c) Sinusoid



(b) Fenestrated capillary

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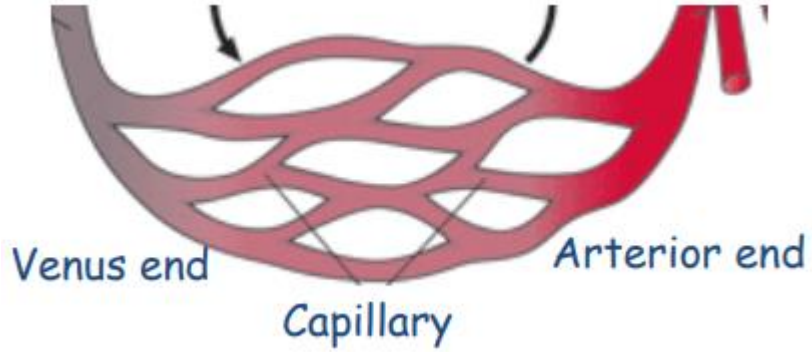
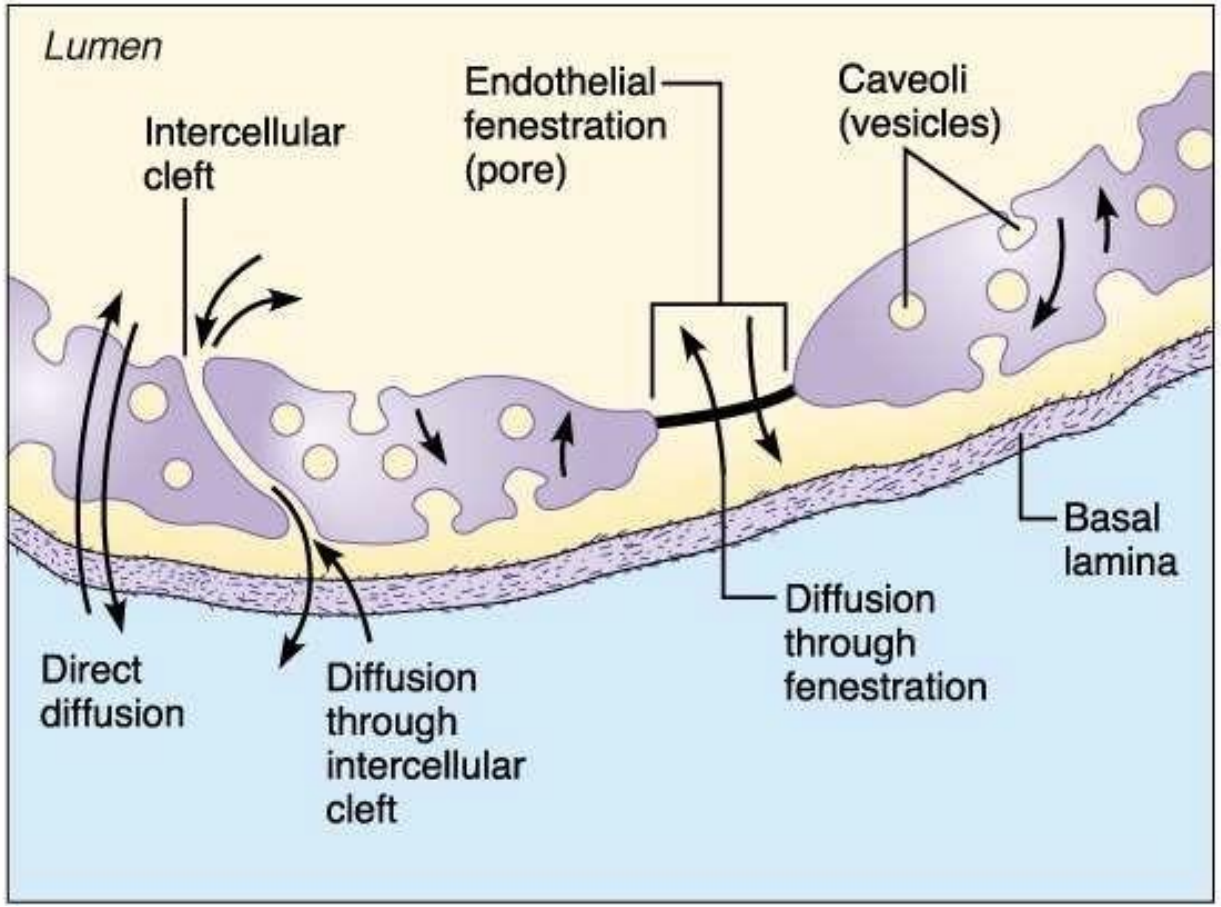
3- Types of capillaries

- Regarding structure:
  1) Continuous: In the brain and normal tissues, the junctions between the capillary endothelial cells are mainly tight junctions that allow only extremely small molecules such as water, oxygen, and carbon dioxide to pass into or out of the brain tissues
  2) Fenestrated: has a lot of Fenestrations (pores or windows) these pores increase the flow of nutrients, waste, and other substances
  3) Sinusoid: In the liver, contain sinusoids that allow cell to pass
- Regarding process:
  1. Glomerular Capillaries - In Kidney - only filtration
  2. In the GIT "gastrointestinal tract" - In intestine - only reabsorption
  3. Rest of the body - filtration at the Arterial end - reabsorption at the venous end



4- Structure of Capillary Wall

- Composed of unicellular layer of endothelial cells surrounded by a basement membrane.
- Diameter of capillaries is 4 to 9 microns.
- Solute and water move across capillary wall via intercellular cleft (space between cells) or by plasmalemma vesicles (Caveolae / can transport through pinocytosis or transcytosis), they can move through lipid bilayer if they are lipid soluble as well



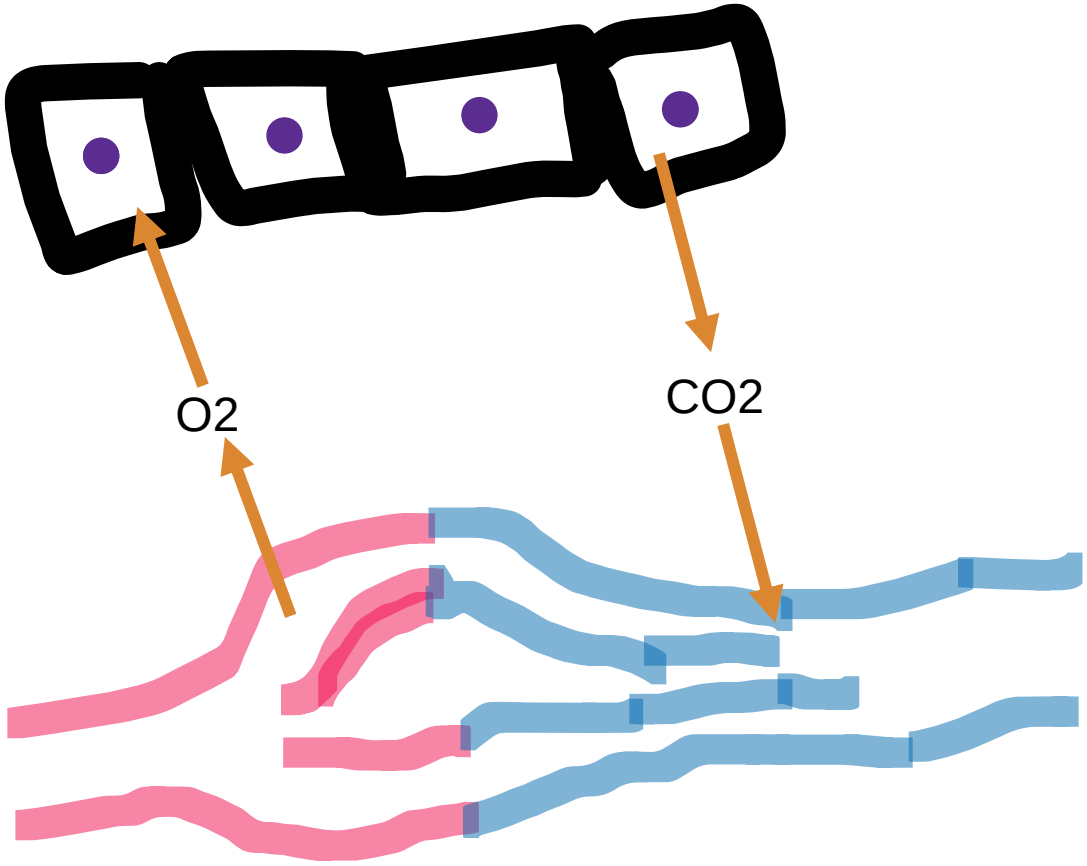
→ The width of capillary intercellular slit pores is 6 to 7 nanometers.

5- Capillary exchange

- Movement of substances between blood and interstitial fluid
- 3 basic methods
  1. **Diffusion**
  2. **Transcytosis**
  3. **Bulk flow**

6- Diffusion

- Substances move down their concentration gradient
- O2 and nutrients from blood to interstitial fluid to body cells
- CO2 and wastes move from body cells to interstitial fluid to blood
- Both O2 & CO2 pass through lipid bilayer
- O2 can cross any membrane 20 times easier than O2 because the solubility of CO2 is 20 more than the solubility of O2



6- Diffusion

- The rate of diffusion (J) OR FLUX, depends on 5 factors:
  1) P = Permeability
  2) D = Diffusion Coefficient
  3) A = Surface area
  4) C = Concentration
  5) X = Membrane thickness
- J = P x ΔC
- But P = $\frac{D\ x\ A}{\Delta X}$
- So J = $\frac{D\ x\ A\ x\ \Delta C}{\Delta X}$ and this is called fick's law

6- Diffusion

- Can cross capillary wall **through intercellular clefts, fenestrations or through endothelial cells**
  - **Most plasma proteins cannot cross**
  - **Except in sinusoids** – proteins and even blood cells leave
  - **Blood-brain barrier** – tight junctions limit diffusion

7- Transcytosis

- Small quantity of material
  - Substances in blood plasma become enclosed within **pinocytotic vesicles** that enter endothelial cells by endocytosis and leave by exocytosis
  - Important mainly for large, lipid-insoluble molecules that cannot cross capillary walls any other way

8- Bulk Flow

- Passive process in which large numbers of ions, molecules, or particles in a fluid move together in the same direction
- Based on pressure gradient
- **Diffusion** is more important for solute exchange
- **Bulk flow** more important for regulation of relative volumes of blood and interstitial fluid
- Filtration – from capillaries into interstitial fluid
- Reabsorption – from interstitial fluid into capillaries

9- NFP = (BHP + IFOP) – (BCOP + IFHP)

- ✓ Net filtration pressure (NFP) balance of 2 pressures
- ✓ Two pressures promote *filtration*

1. **Blood hydrostatic pressure** (BHP) generated by pumping action of heart

   Falls over capillary bed from 35 to 16 mmHg

2. **Interstitial fluid osmotic pressure** (IFOP) 1 mmHg

9- NFP = (BHP + IFOP) – (BCOP + IFHP)

2. Two pressures promote *reabsorption*
    1. **Blood colloid osmotic pressure** (BCOP) promotes reabsorption
        - Averages 28 mmHg
        - Due to presence of blood plasma proteins to large to cross walls
    2. **Interstitial fluid hydrostatic pressure** (IFHP)
        - Close to zero mmHg