جامعة الملك سعود
King Saud University

# Capillary Circulation

Index:
Red: important Grey: extra information Green: doctor's notes yellow: numbers
Purple: only in female slides Blue: only in male slides

Physiology Team437



MED437
KING SAUD UNIVERSITY

# OBJECTIVES

by the end of this lecture you will be able to:

- Outline the parts of the microcirculation, and list types of blood capillaries and differentiate between them.

- Explain regulation of flow in the capillary beds.
- Compare and contrast diffusion and filtration.
- State Starling forces acting on the capillary wall.
- Define edema,state its causes and discuss its mechanisms.
- Describe the role of the microcirculation in temperature regulation.

ONLY in female slides

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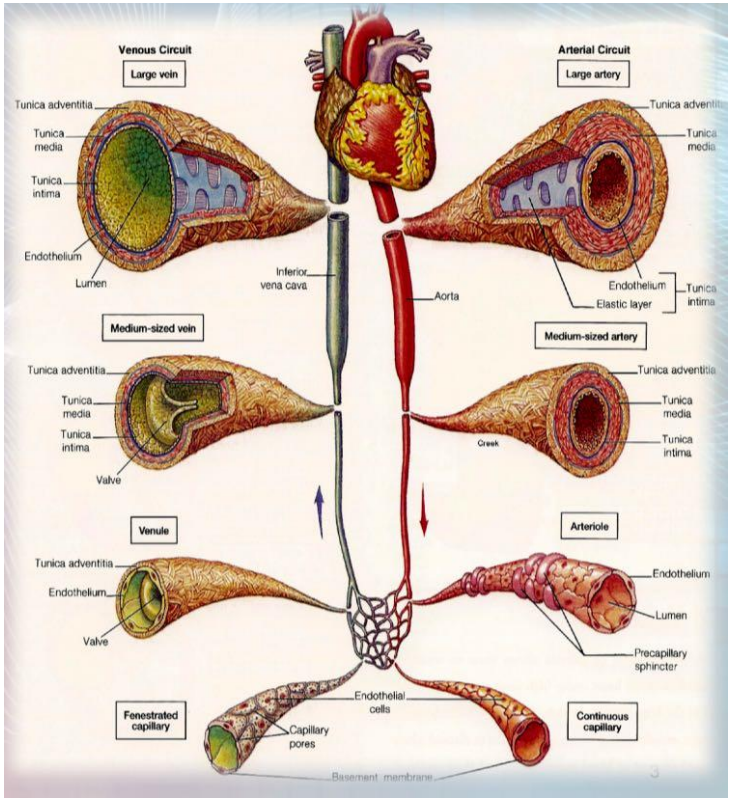
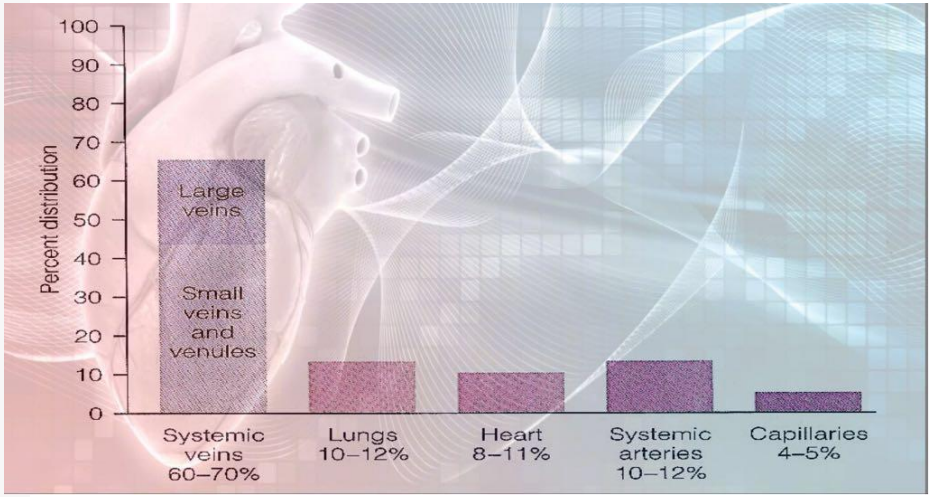
# Capillaries

- Capillaries are the smallest blood vessels (microcirculatory vessels) in the vascular System.
- 5% of circulating blood volume is present in the Capillaries.
- Over 10 billion capillaries in the body.



# DISTRIBUTION OF BLOOD IN THE DIFFERENT PARTS OF CIRCULATORY SYSTEM



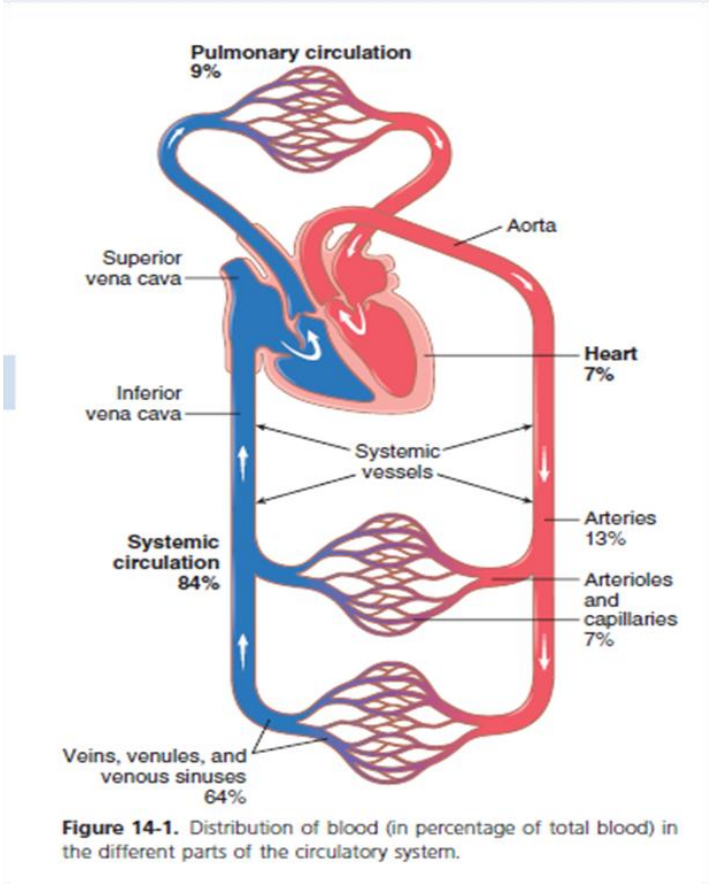
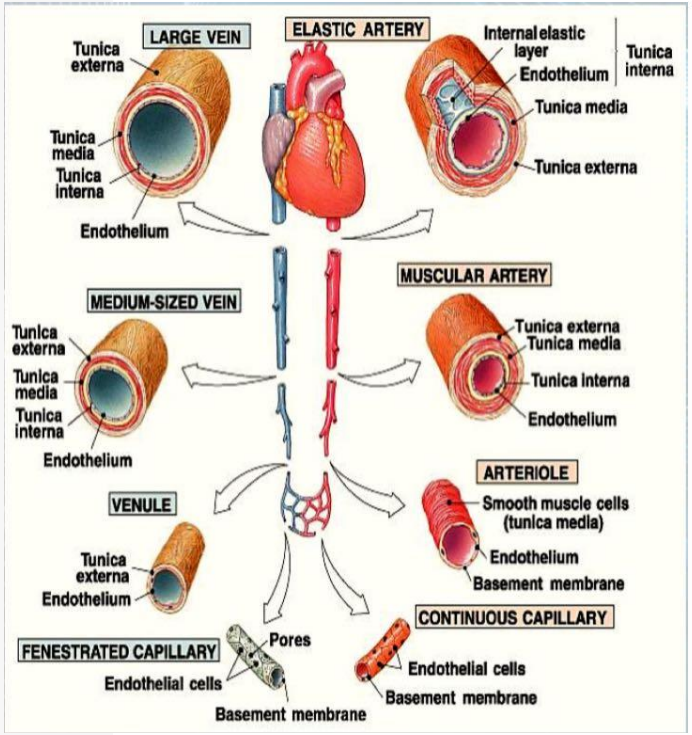
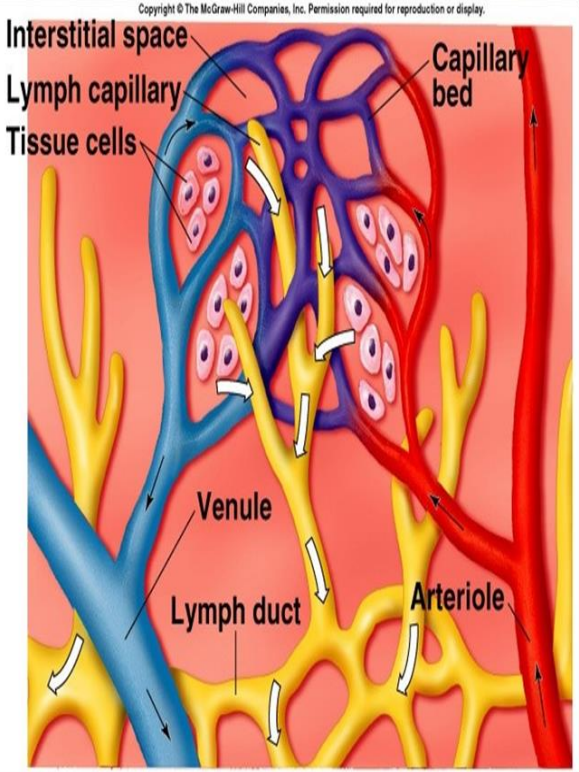
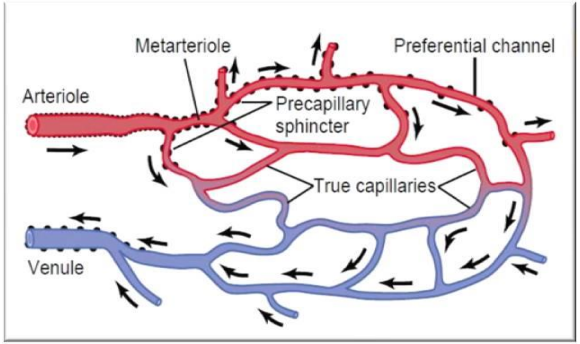




**Figure 14-1.** Distribution of blood (in percentage of total blood) in the different parts of the circulatory system.

# COMPONENTS OF MICROCIRCULATION



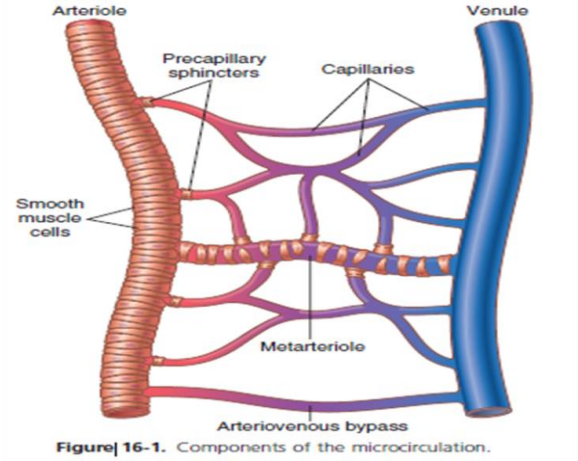




Figure 16-1. Components of the microcirculation.

# COMPONENTS OF MICROCIRCULATION

**Aorta:** Elastic recoil
**Arteries**: Muscular, low resistance vessels
**Arterioles**: High resistance vessels
**Capillaries**: Exchange vessels
**Veins and Venules:** Capacitance vessels

**Capillaries:**

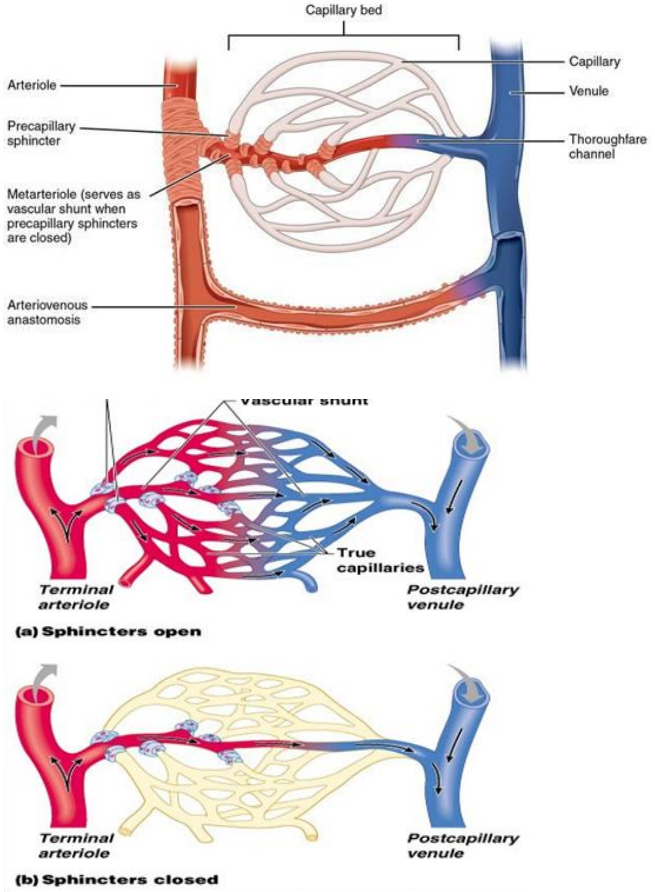
**Smallest blood vessels**
**Exchange vessels:** Provide direct access to cells.
**Most permeable:** Permits exchange of nutrients & wastes

# FUNCTIONS OF CAPILLARIES

- They form a selectively permeable barrier between the circulatory system and the tissue supplied.
- Play a metabolic role - produce pgl2, growth factors for blood cells, fibroblast GF, platelet GF, and in the lungs; angiotensin converting enzyme.
- Inactivation of intercellular messenger.
- Antithrombotic function.
- Exchange vessels between blood & tissues:
  - Provide direct access to the cells.
  - Most permeable.
  - Transport nutrients & O2 from blood to the tissues.
  - Remove CO2 & cellular waste products from the tissues to the blood.
- Capillary tone.
- Play role in temperature regulation:
  - Blood vessel dilatation (vasodilatation)
  - Increase heat loss across epidermis.
  - Blood vessel constriction (vasoconstriction).
  - Heat conservation across epidermis.

# CAPILLARY BED

- Capillaries are arranged in capillary beds.
- Arterioles divides into a number of metarterioles, which do not have a continuous smooth muscle coat.
- Blood flow through the metarteriole to enters capillary bed via precapillary sphincters.
- Venules drain capillary network.
- Arteriolar smooth muscle, metarterioles, & precapillary sphincters regulate the blood flow in capillary network.




**Capillary bed consist of two types of vessels:**

**1- Vascular shunt:** Directly connects an arteriole to a venule
**2- True capillaries:** Exchange vessels.
Oxygen (O2) & nutrients cross to cells
Carbon dioxide(Co2) & metabolic waste products cross into blood

# TYPES OF CAPILLARIES

**Types based on diameter and or permeability:**

1. **Continuous Capillaries**

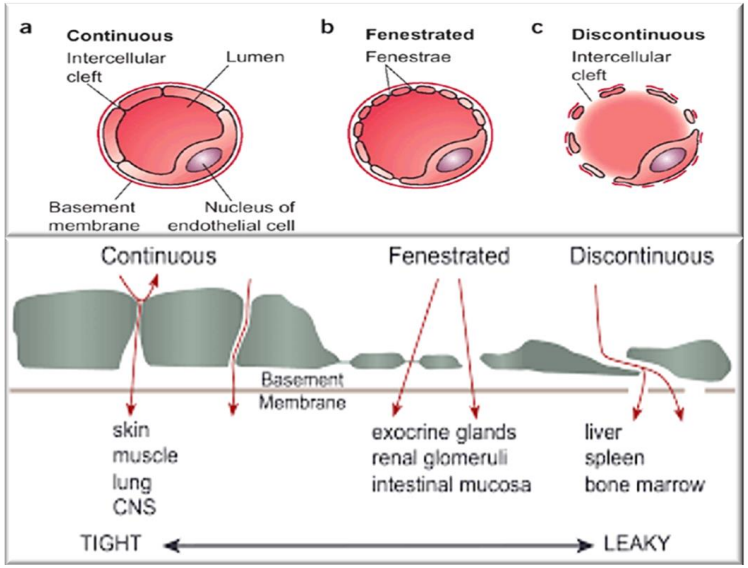
Do not have fenestrae. Muscle, lung, and adipose tissue.

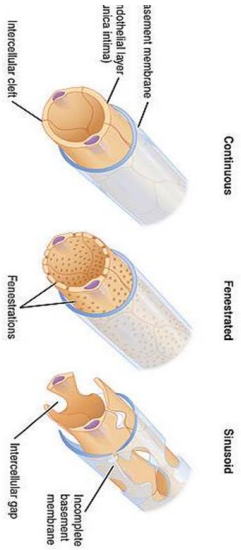
2. **Fenestrated Capillaries**

Found in kidney glomeruli, small intestine, and endocrine glands. Have pores, allow large substances to pass but not plasma proteins.

3. **Sinusoidal Capillaries**

Large diameter with fenestrae. Liver, spleen, bone marrow, lymphoid tissue, some endocrine glands.



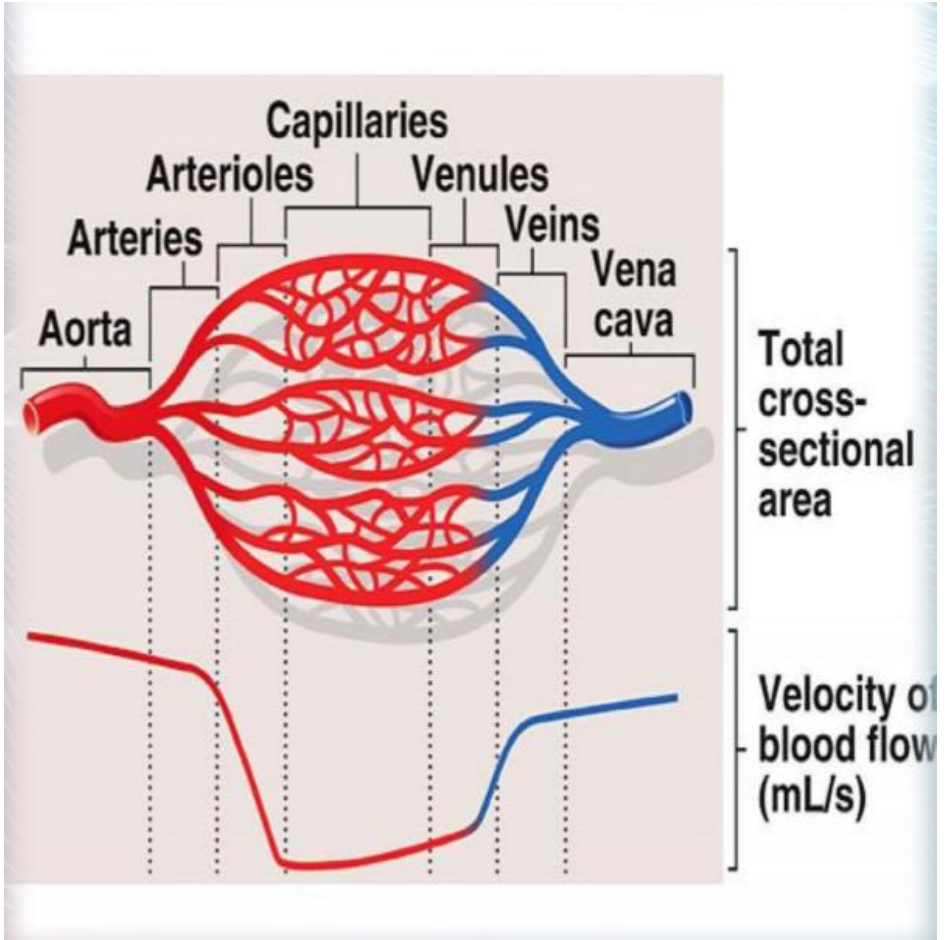



# Cross- Sectional Area

**The velocity of blood flow within each segment of the circulatory system is inversely proportional to the total cross-sectional area of the segment. Because the aorta has the smallest total cross-sectional area of all circulatory segments, it has the highest velocity of blood flow.**

As diameter of vessels decreases, the total cross sectional area increases & velocity of blood flow decreases.

Total capillary surface area of 700-1000 $m^2$



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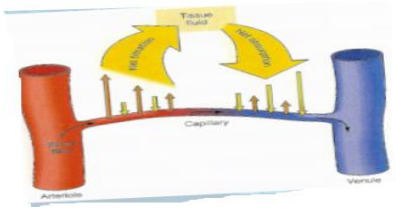
# Interstitial Fluid

Capillary Exchange & Interstitial Fluid Volume Regulation

1. Blood pressure, capillary permeability & osmosis affect movement of fluid from capillaries.
2. A net movement of fluid occurs from blood into tissues.
3. Fluid gained by tissues is removed by lymphatic system.




Interstitial Fluid formation

1. High content of proteins in plasma accounts for its higher osmotic pressure compared to that of the IF.
2. High plasma osmotic pressure will attract fluid & dissolved substances into the circulation from tissue spaces.
3. Opposing this force pressure of the blood which tends to force fluids out of the circulation & into the tissue spaces.
4. Equilibrium is always maintained.

# Mechanisms of Transcapillary Exchange

- Simple diffusion: of lipid soluble gases ($O_2$ and $CO_2$) according to concentration gradient.
- Filtration: bulk flow for fluid transfer by starlings forces according to pressure gradient.
- Vesicular transport: Transcytosis.
- Mediated (Membrane) transport: occurs only in capillaries of the brains, and involves secondary active transport, e.g. transport of glucose moves by co-transporters in cell membrane.

# Diffusion at Capillary Beds (Fluid Balance) – Starlings Forces

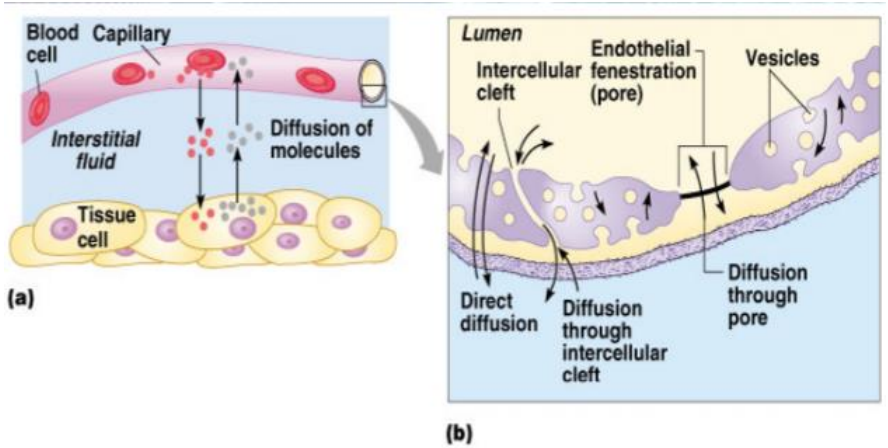
Outward Forces:

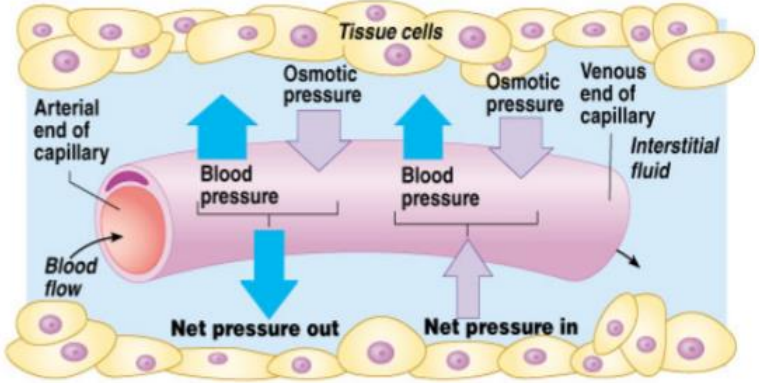
1. Capillary hydrostatic pressure (Pc = 30-35 to 10-15 mmHg)
2. Interstitial hydrostatic pressure (PIF = 0 mmHg)
3. Interstitial oncotic (colloid osmotic) pressure (Osmotic pressure) (μIF = 3 mmHg)

TOTAL = 38 to 18 mmHg

Inward Force:

1. Plasma colloid osmotic pressure (μC = 25 mmHg)



# Fluid filtration & reabsorption in normal microcirculation

At arterial end:
Water moves out of the capillary (pores) with a NFP of 5 to 10 (13) mmHg.
Hydrostatic pressure dominates at the arterial end & net fluid flows out of the circulation.

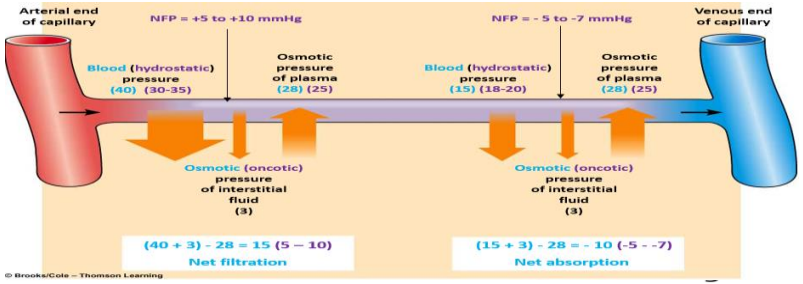
13 mmHg filtration pressure causes on average about 1/200 of the plasma in the flowing blood to filter out of the arterial ends of the capillaries into the interstitial spaces

At venous end:
Water moves into the capillary with a NF (Net filtration) P of -5 to -7 mmHg.
Oncotic pressure dominates at the venous end & net fluid will flow into the bloodstream.

## Interstitial hydrostatic pressure

Varies from one organ to another:

- Subcutaneous tissue: Subatmospheric (-2 mmHg)
- Liver, kidney: Positive
- Brain: As high as 6 mmHg




| | |
|---|---|
| **Forces Tending to Move Fluid Outward** | |
| Capillary pressure (arterial end of capillary) | 30 |
| *Negative* interstitial free fluid pressure | 3 |
| Interstitial fluid colloid osmotic pressure | 8 |
| TOTAL OUTWARD FORCE | 41 |
| **Forces Tending to Move Fluid Inward** | |
| Plasma colloid osmotic pressure | 28 |
| TOTAL INWARD FORCE | 28 |
| **Summation of Forces** | |
| Outward | 41 |
| Inward | 28 |
| NET OUTWARD FORCE (AT ARTERIAL END) | 13 |

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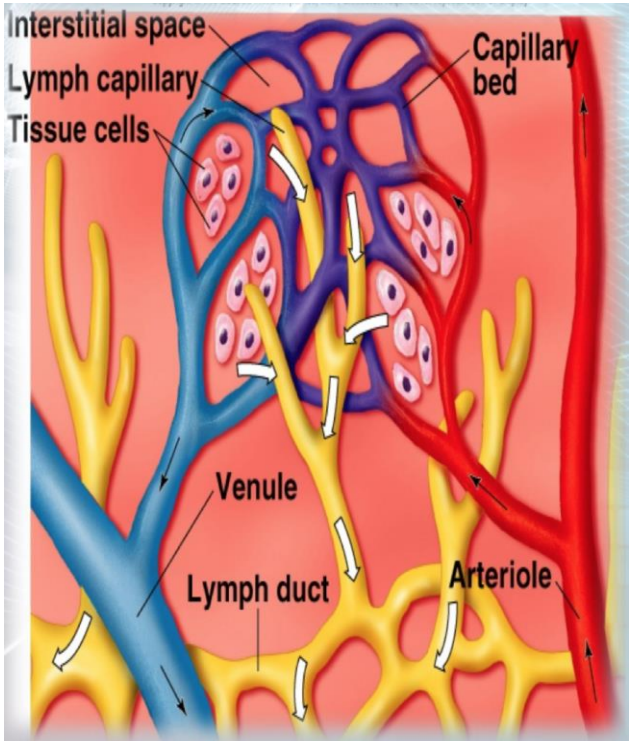
# Lymphatic Capillaries System




- Lymphatic vessels present between capillaries**.**
- Interstitial fluid enter the lymphatic capillaries through loose junctions between endothelial cells.
- Lymph flow back to the thoracic duct by contraction of smooth muscle in the wall of lymphatic vessels & contraction of surrounding skeletal muscle
- Failure of lymphatic drainage can lead to edema
- **3 basic functions:**
  - Drain excess interstitial (tissue)fluid back to the blood, in order to maintain original blood volume.
  - Transport absorbed fat from small intestine to the blood
  - Help to provide immunological defenses against pathogens

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# Edema

- Is the term used to describe unusual accumulation of interstitial fluid

- Occurs when an alteration in Starling's forces balance:
  - Any decrease in plasma protein (albumin) concentration, will lead to a decrease in plasma osmolarity, allowing fluid to escape from circulation to the interstitial space.
  - Any increase in capillary hydrostatic pressure.

- Occurs secondary to Histamine or Bradykinin administration , where they increase capillary permeability leading to edema.

## Hormones involved in edema :

- Renin angiotensin aldosterone system : secondary hyperaldosteronism
- ADH (vasopressin)
- ANP (Atrial natriuretic peptide)

# Thank you for checking our work

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عمر الفوزان
فهد الحسين
نايف المطيري
نواف اللويمي
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روان مشعل
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نورة الحربي
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مجد البراك
لينا العوهلي
عهد القرين
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مها بركة
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**Any questions?**

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