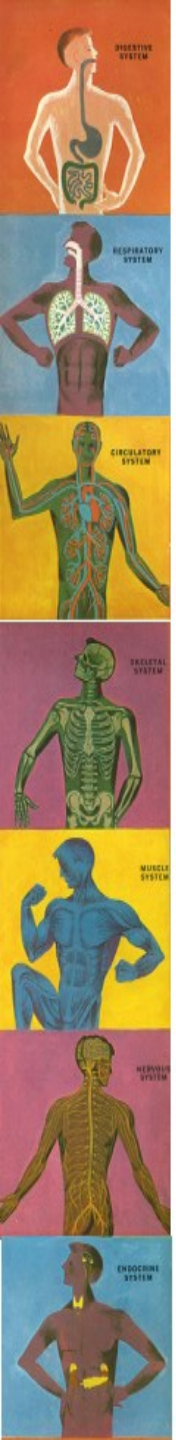

Edema

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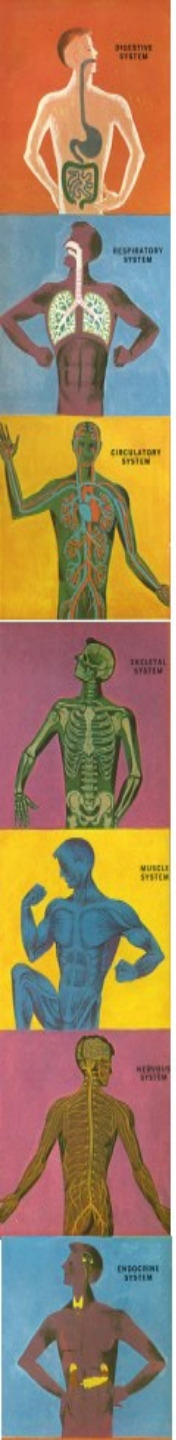
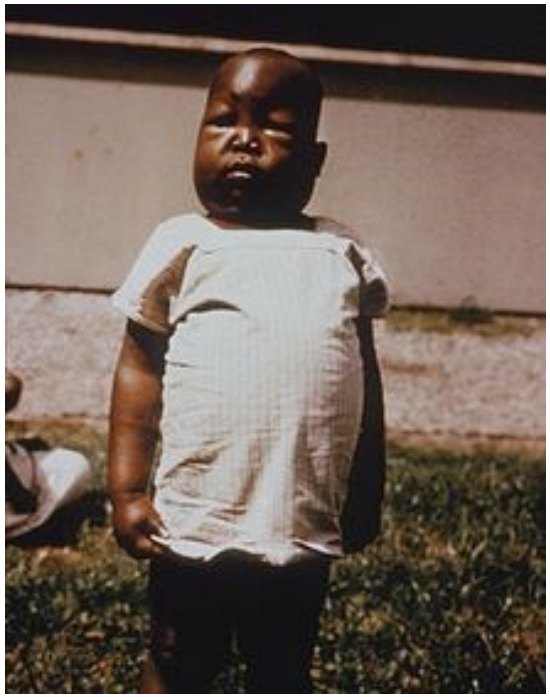


Objectives

- Define edema and describe its different types.
- Discuss and describe the Starling forces governing fluid exchange across capillary walls.
- Link changes in hydrostatic and osmotic pressures to the pathogenesis of edema.

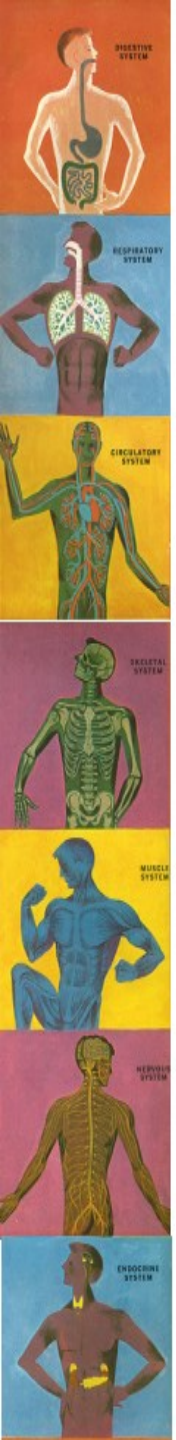
Study source for this lecture:
(Guyton & Hall Textbook of Medical Physiology, 13th ed, pages: 316-320 & 191-201)

Edema



- **What is "*edema*"?**
  - Edema = swelling
  - The presence of abnormally large amounts of fluid in the intercellular tissue spaces of the body.

(Dorland's illustrated medical dictionary, 28th ed)



Types of Edema

Edema occurs mainly in the ECF compartment, but it can involve the ICF compartment as well.

Edema

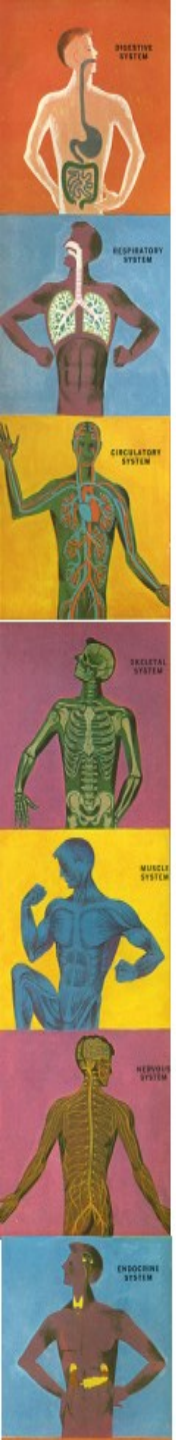
Intracellular

- Due to intracellular swelling.
- ***Caused by:***
  - Hyponatremia.
  - Depressed metabolism
  - Lack of nutrition to the cells.
  - Inflammation.

Extracellular

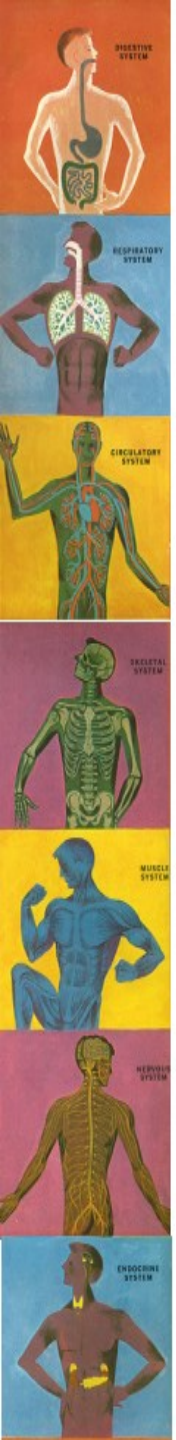
- More common clinically
- Due to accumulation of fluid in the extracellular space.
- Can be caused by many conditions.

(Guyton & Hall Textbook of Medical Physiology; 13th ed, Chapter 25)



Extracellular Edema

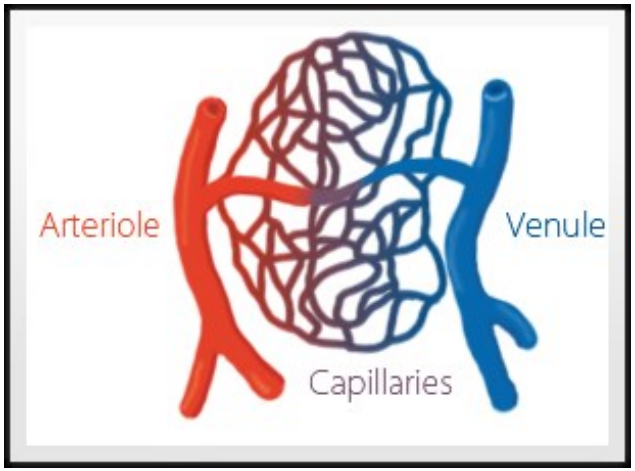
- Extracellular edema = the abnormal accumulation of fluid in intercellular tissue space (i.e. interstitial space).
- Normally, fluid is constantly moving in & out of the interstitial space to allow ECF to distribute between plasma and IF.
- This process happens without fluid accumulating between the cells.
- What happens to cause fluid to accumulate between the cells leading to edema?
- To understand EC edema one must first understand how fluid exchange occurs between capillaries and tissue cells.

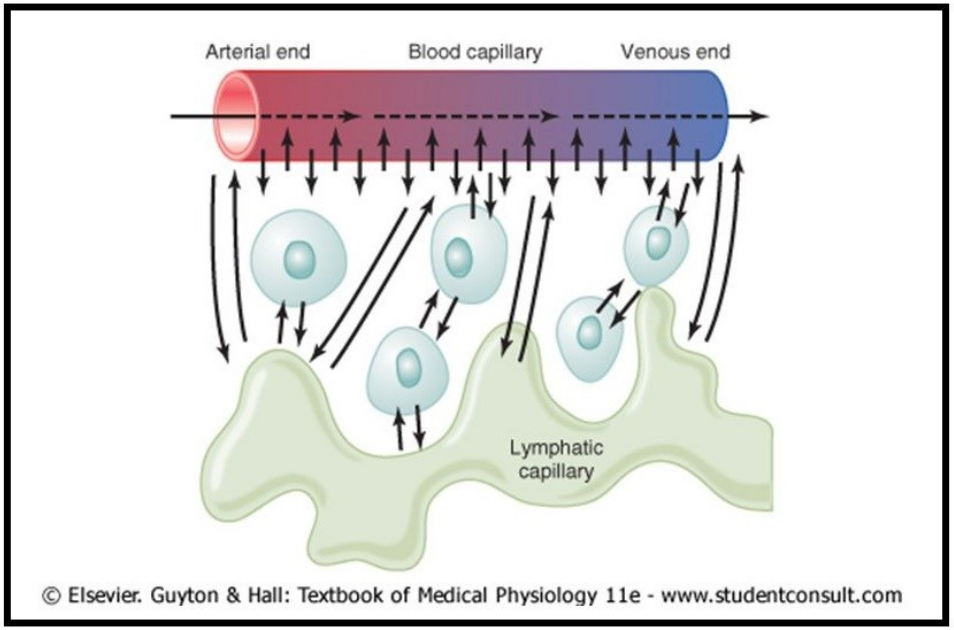


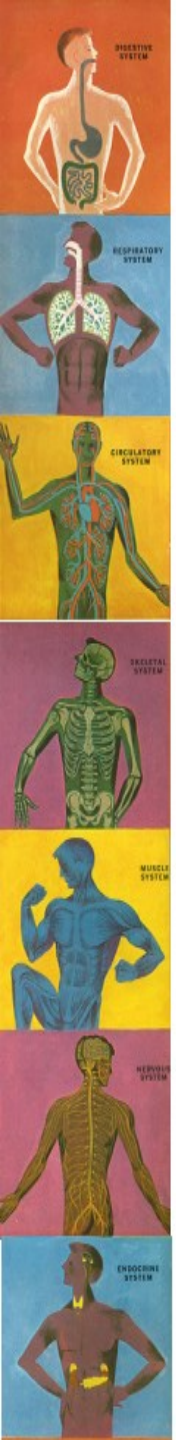
Fluid Exchange Between Blood & Interstitial Fluid

Fluid Exchange Between Blood & Interstitial Fluid

- Fluid exchange between blood and tissue cells occurs at the level of the capillaries.
- The capillaries are the smallest blood vessels in our vascular tree.
- These vessels are very small and have a very thin wall allowing easy exchange of fluid across the walls.



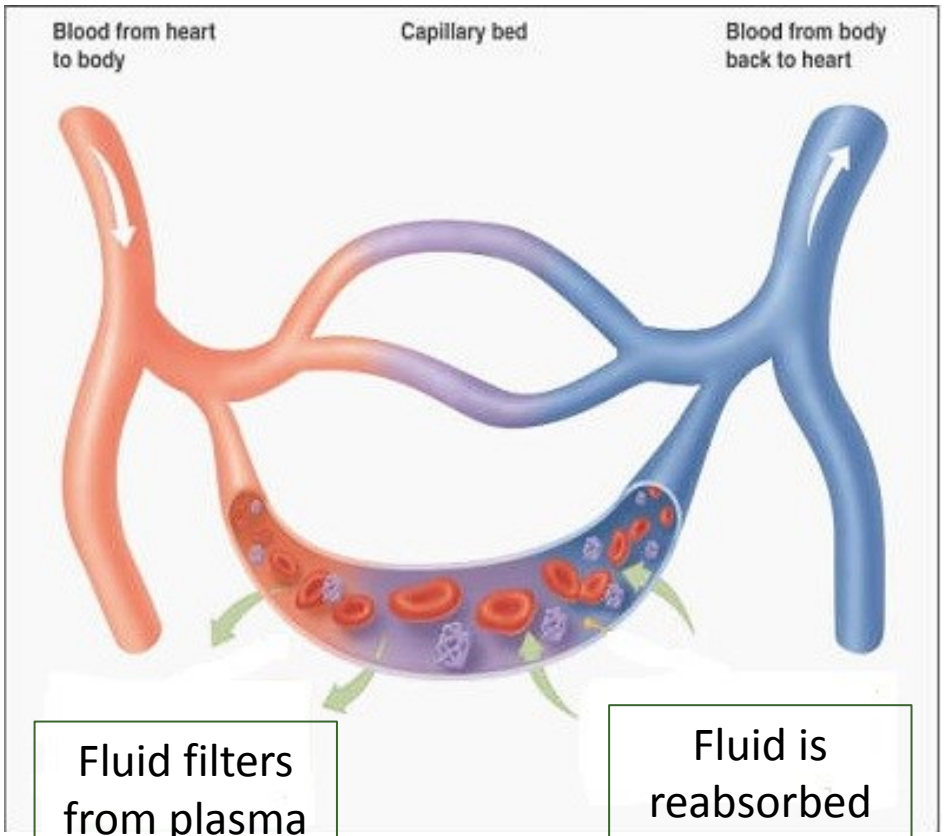




Fluid Filtration Across Capillaries

In simple words!

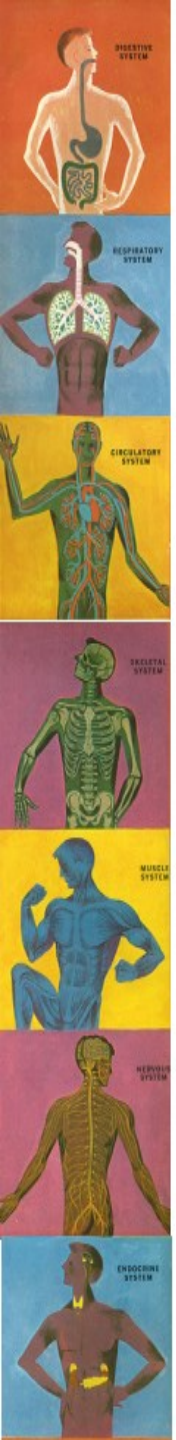
As blood passes through capillaries



Fluid filters from plasma to interstitium

Fluid is reabsorbed from interstitium into plasma

How does this process happen?
OR
What are the mechanisms controlling fluid exchange across capillaries?



Factors Controlling Fluid Filtration Across Capillary Walls

Movement of fluids across capillary walls depends on the balance of starling forces acting across the capillary wall.

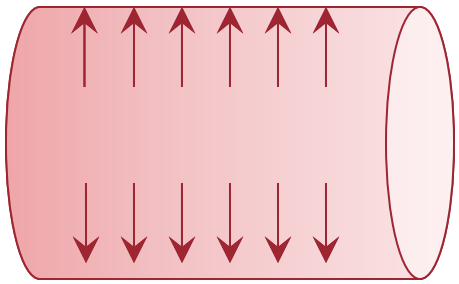
What are starling forces?

Starling Forces

Starling Forces
Forces that control movement of fluid in/out of a capillary

Hydrostatic pressure (P)

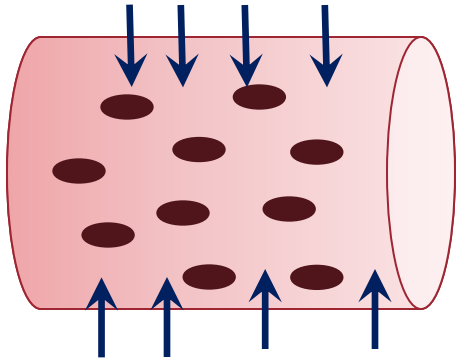
The pressure exerted by blood (water) on the walls of the blood vessel



Pushes fluid ***OUTSIDE***

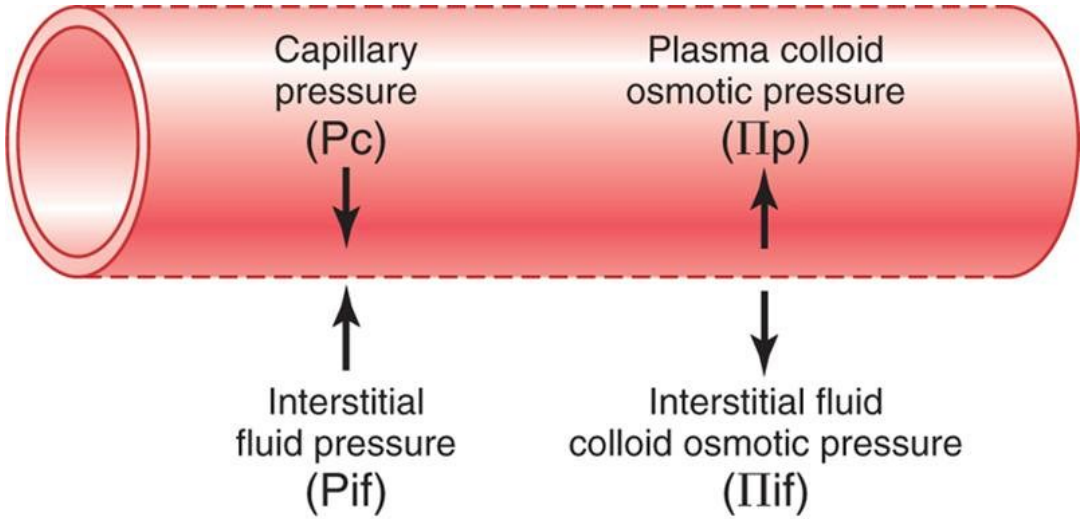
Colloid osmotic (oncotic) pressure (π)

The osmotic pressure created by the non-diffusible plasma proteins inside the blood vessel

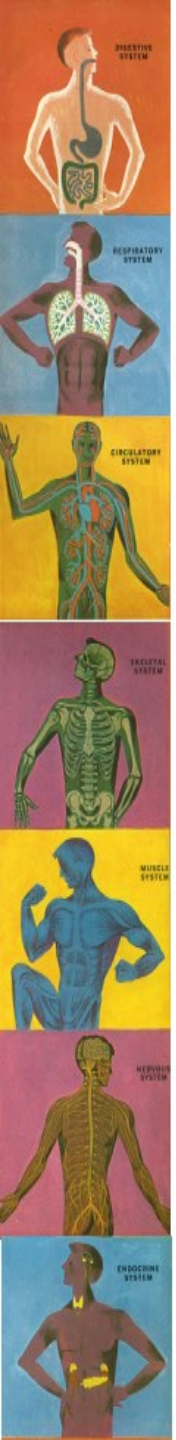


Pulls fluid ***INSIDE***

Starling Forces Acting Across Capillary Membrane



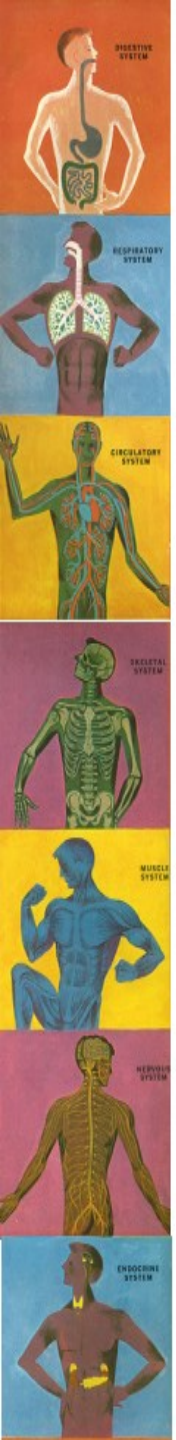
- Four primary forces determine whether fluid moves in or out of blood "***Starling forces***":
  - Capillary "***hydrostatic***" pressure → out of blood.
  - IF "***hydrostatic***" pressure → into blood.
  - Plasma ***colloid osmotic*** pressure → into blood.
  - IF ***colloid osmotic*** pressure → out of blood.

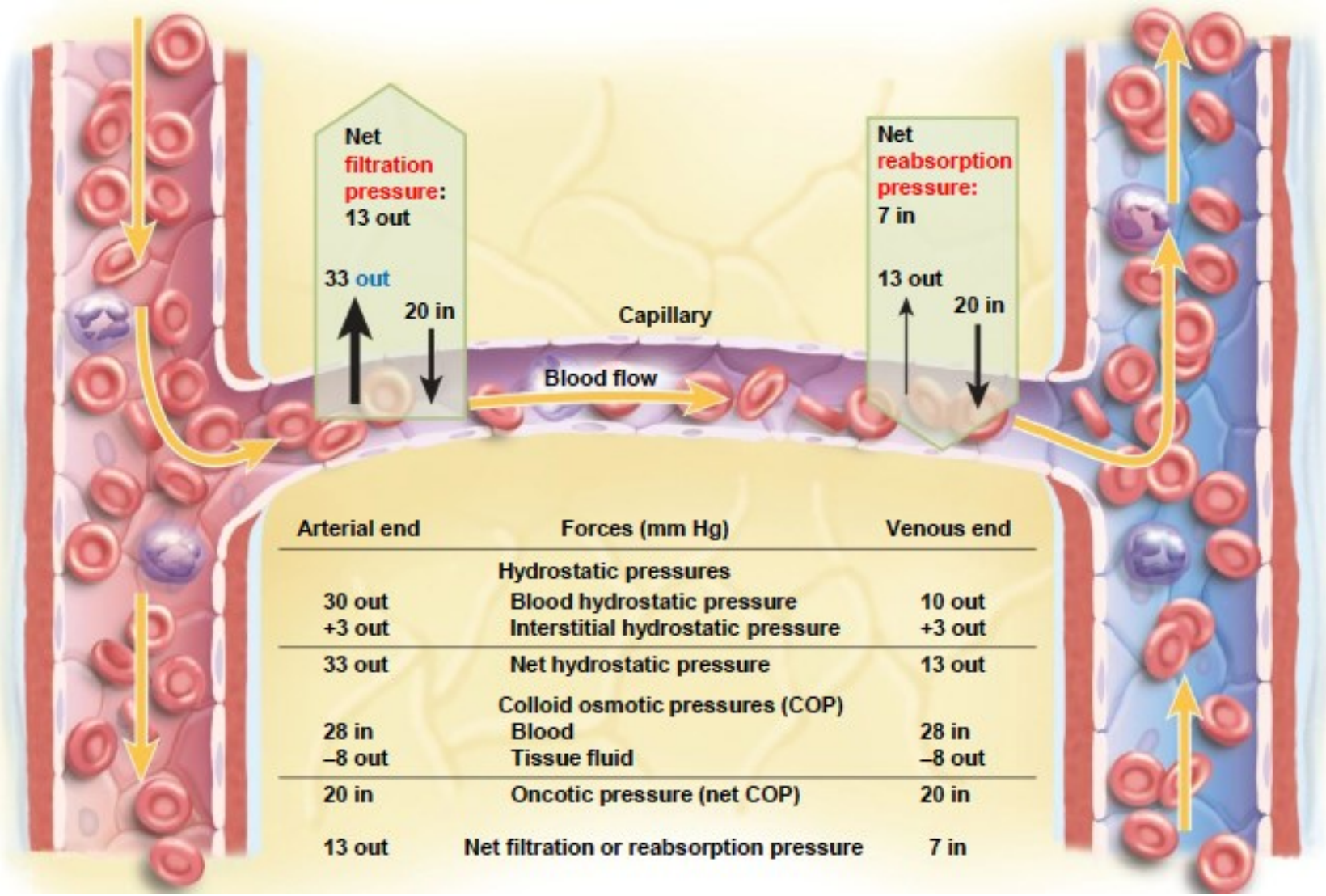


Starling Forces Acting Across Capillary Membrane

- Capillary ***hydrostatic pressure (Pc)***:
  - Arterial end = 30 mmHg
  - Venous end = 10 mmHg (usually 15-25 mmHg less than arterial end).
- IF ***hydrostatic pressure (P_{if})*** is usually subatmospheric in loose connective tissue (≈ -3 mmHg).
- Plasma ***colloid osmotic pressure (π_p)*** = 28 mmHg.
- IF ***colloid osmotic pressure (π_{if})*** = 8 mmHg.

Forces that Determine Fluid Movement through Capillary Membrane



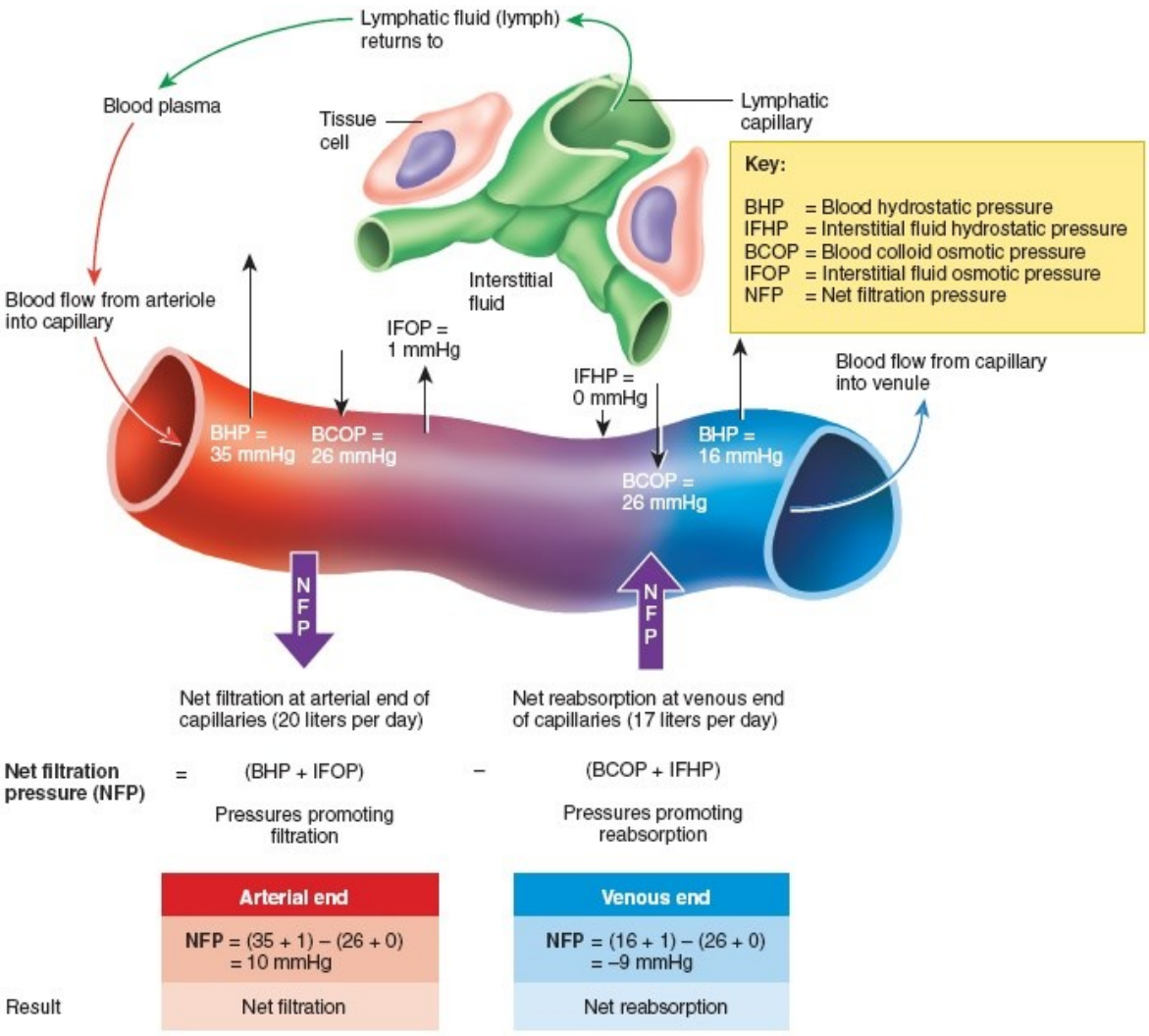


Arterial end	Forces (mm Hg)	Venous end
	Hydrostatic pressures	
30 out	Blood hydrostatic pressure	10 out
+3 out	Interstitial hydrostatic pressure	+3 out
33 out	Net hydrostatic pressure	13 out
	Colloid osmotic pressures (COP)	
28 in	Blood	28 in
–8 out	Tissue fluid	–8 out
20 in	Oncotic pressure (net COP)	20 in
13 out	Net filtration or reabsorption pressure	7 in

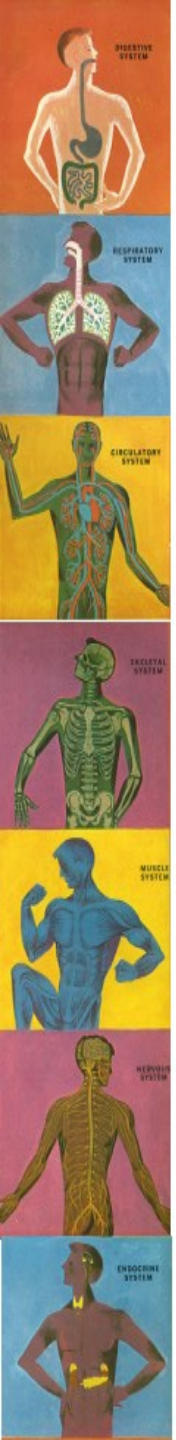
The Lymphatic System

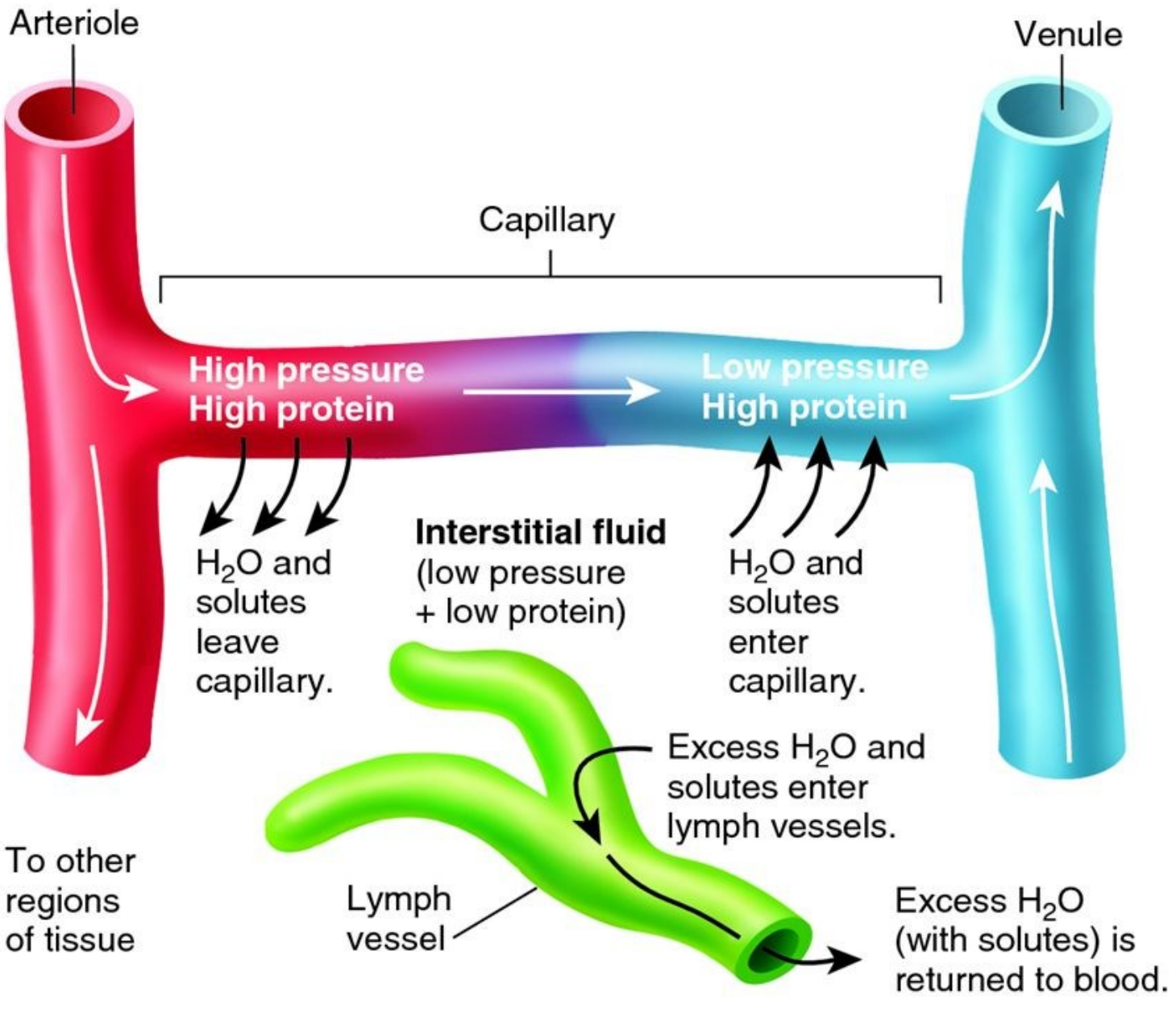
The reabsorption pressure causes 9/10 of the filtered fluid to be reabsorbed while 1/10th remains in the IF.. ***What happens to this 1/10th?***

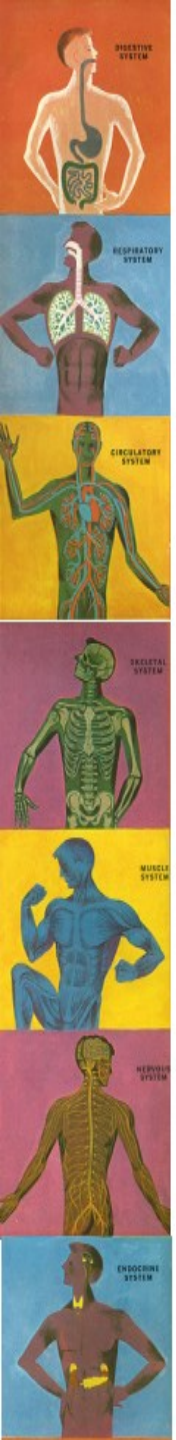
The total quantity of lymph ≈ 2-3L/day.



Summary



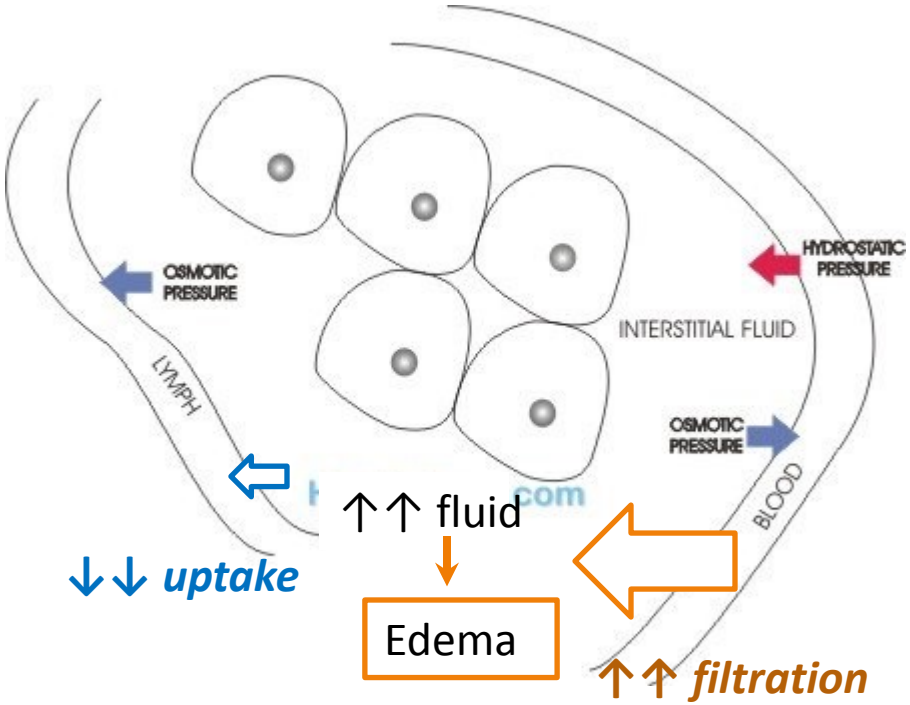

Arteriole
Venule
Capillary
High pressure
High protein
Low pressure
High protein
H_2O and solutes leave capillary.
Interstitial fluid
(low pressure + low protein)
H_2O and solutes enter capillary.
Excess H_2O and solutes enter lymph vessels.
To other regions of tissue
Lymph vessel
Excess H_2O (with solutes) is returned to blood.

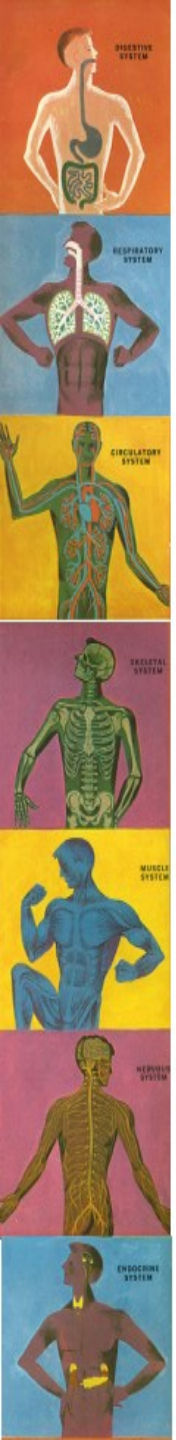


Edema

- Edema = excessive accumulation of fluids in the EC space.

- ***Two main reasons***:
  1. Abnormal leakage of fluid from plasma to interstitial space.
  2. Failure of lymphatic uptake.





Edema

Increase capillary filtration

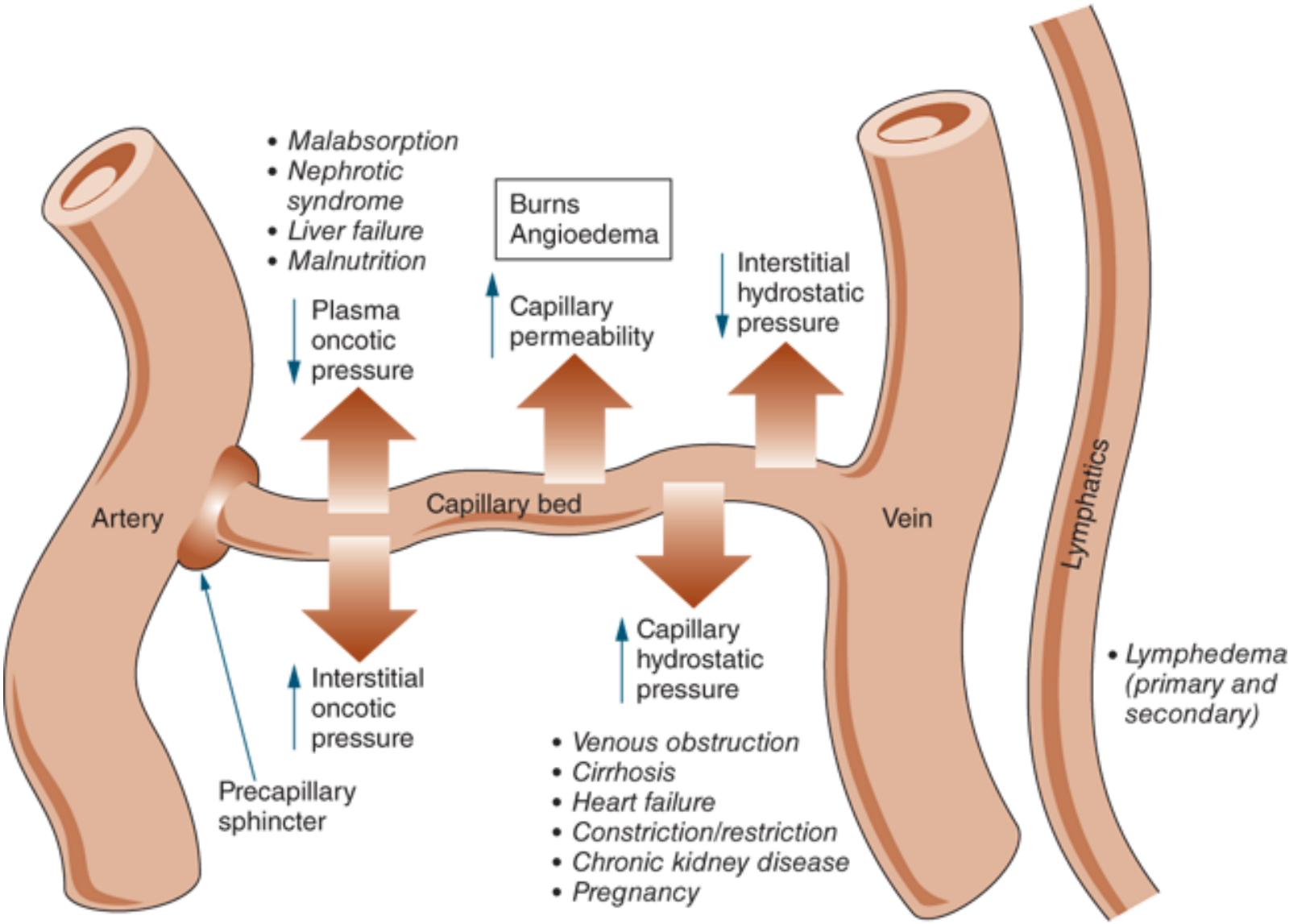
1. ***Increased capillary pressure***
   - Kidney failure
   - Heart failure.
   - Venous obstruction
2. ***Decreased plasma oncotic pressure***
   - Loss of proteins (nephrotic syndrome, burns).
   - Inability to synthesize proteins (liver failure, malnutrition).
3. ***Increased capillary permeability***
   - Inflammation
   - Infection.
   - Immune reactions.

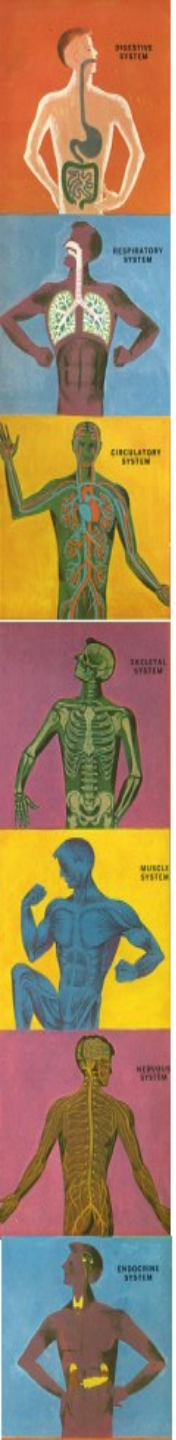
Decrease lymph uptake

Lymphatic obstruction

- Infection (filaria).
- Surgery.
- Congenital absence.
- Cancer.

Edema


• Malabsorption
• Nephrotic syndrome
• Liver failure
• Malnutrition
Plasma oncotic pressure
Burns
Angioedema
Capillary permeability
Interstitial hydrostatic pressure
Artery
Capillary bed
Vein
Lymphatics
Interstitial oncotic pressure
Precapillary sphincter
Capillary hydrostatic pressure
• Venous obstruction
• Cirrhosis
• Heart failure
• Constriction/restriction
• Chronic kidney disease
• Pregnancy
• Lymphedema (primary and secondary)


DIGESTIVE SYSTEM
RESPIRATORY SYSTEM
CIRCULATORY SYSTEM
SKELETAL SYSTEM
MUSCLE SYSTEM
NERVOUS SYSTEM
ENDOCRINE SYSTEM

Thank you