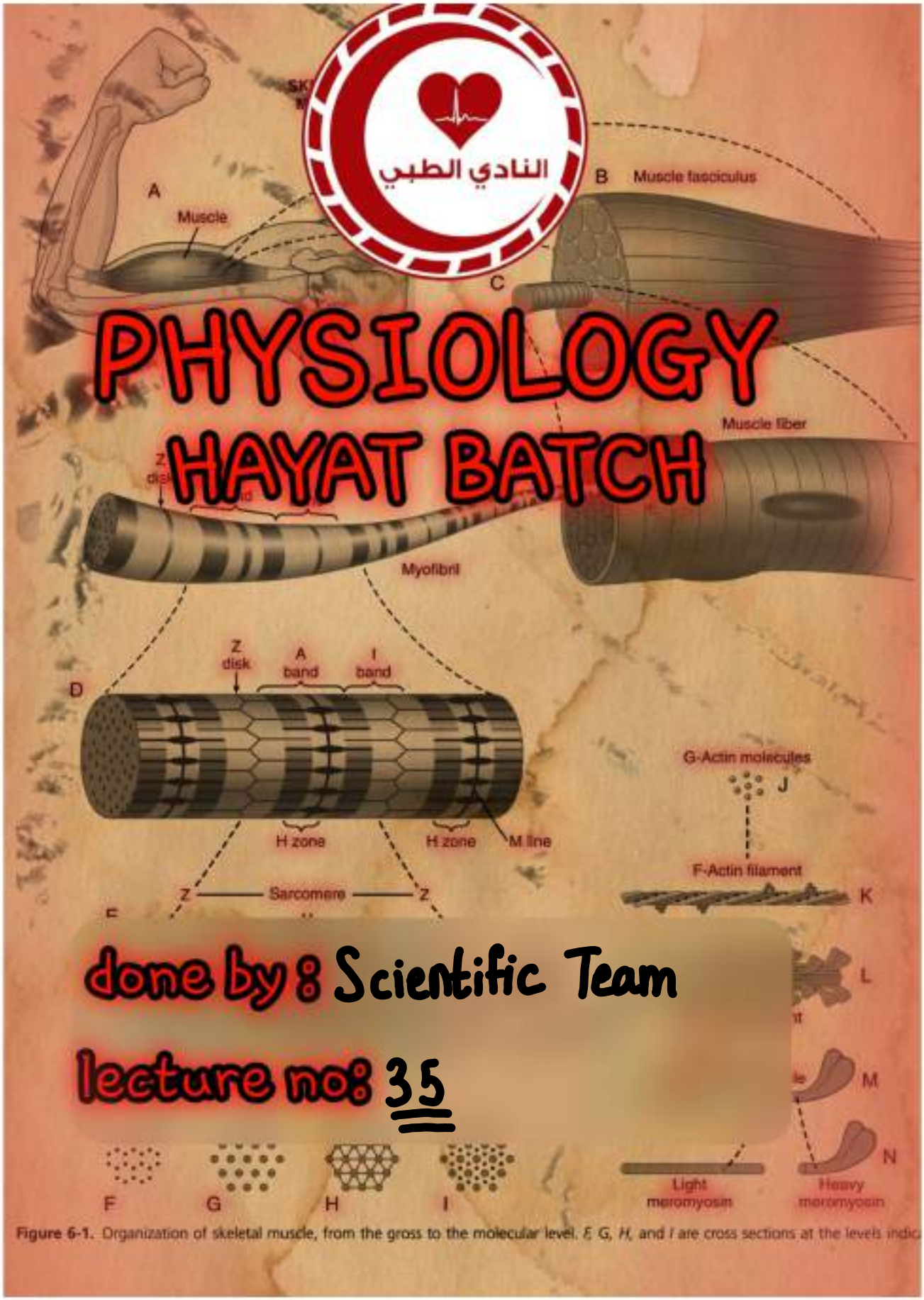

Figure 6-1. Organization of skeletal muscle, from the gross to the molecular level. *E*, *G*, *H*, and *I* are cross sections at the levels indic

General Physiology: Edema & Lymphatic system

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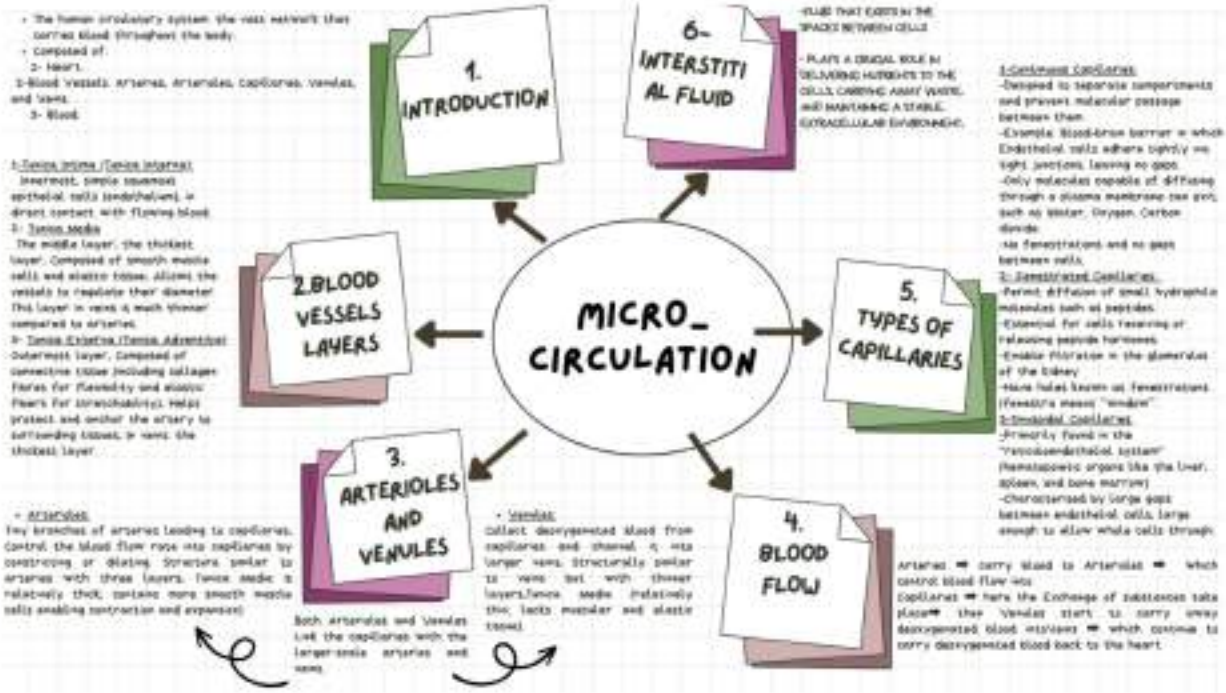
Objectives:

- ✓ Quick Recap for the last lecture.
- ✓ Edema:
- Definition
- Causes And Mechanisms:
  1- Increased capillary hydrostatic pressure
  2- The permeability of the capillary (Represented by K).
  3- Decreased capillary oncotic pressure
  4- Lymphatic system blockage or breakdown
- Clinical Examples
- ✓ Lymphatic system:
- Lymph
- Lymph Nodes
- Lymphatic organs
- Lymphatic vessels
- Lymphatic system functions.

Here is quick recap for the last lecture:



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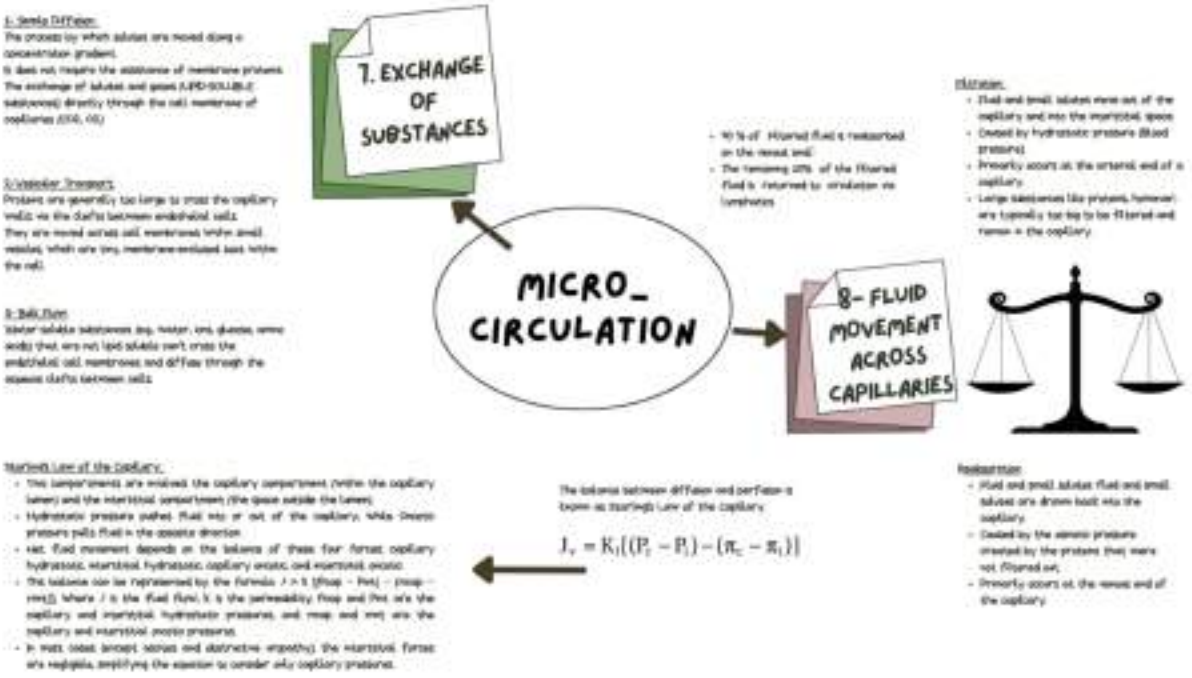


Edema: Definition

- Definition: An increase in interstitial fluid volume.
- It can be localised or generalised.
- It can be pitting and non-pitting.
- Edema can form when there are:

1. Increased filtration
2. Decreased reabsorption
3. Impaired lymphatic drainage: when the volume of interstitial fluid (due to filtration out of the capillaries) exceeds (يتخطى ويتجاوز) the ability of the lymphatics to return it to the circulation
4. increase the permeability of capillaries

Edema: Causes

- To understand different causes of edema let's have another look at the Sterling equation:

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

- **The main factors in this equation are:**

- **K_f**= is the water permeability of the capillary wall. It varies among different types of tissues, depending on the anatomic characteristics of the capillary wall.
- The hydrostatic pressure (filtration process).
- The Oncotic pressure (reabsorption process).

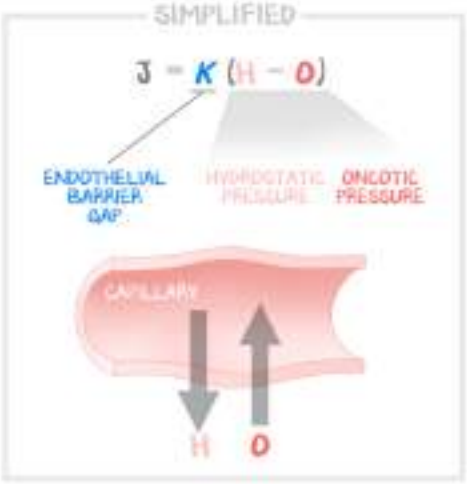
Edema: Causes

1- *Increased capillary hydrostatic pressure* → filteration → high Systolic Blood Pressure >160

2- The permeability of the capillary (Represented by K).

3- Decreased capillary oncotic pressure

4- Lymphatic system blockage or breakdown



Edema: Causes

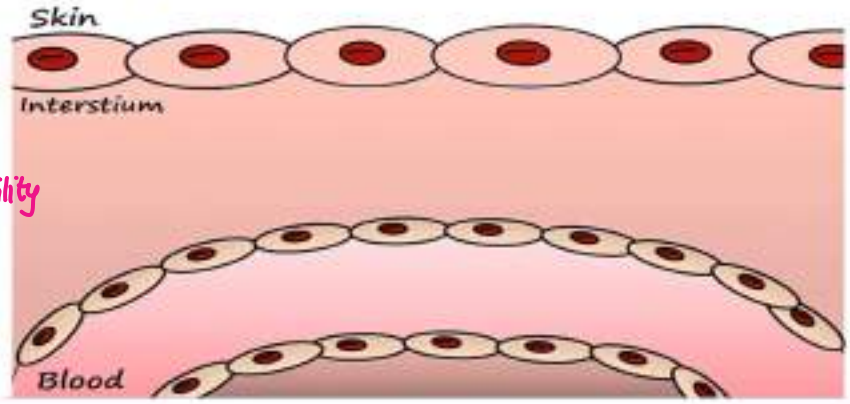
1- Increased hydrostatic pressure:

- Hydrostatic pressure is the pressure exerted by a fluid at rest due to the force of gravity.
- Blood pressure is the primary driver of hydrostatic pressure in the capillaries. When blood pressure rises, it increases the capillary's hydrostatic pressure, pushing more fluid into the interstitial space (space between cells) (affects Hydrostatic pressure at the arterial blood of the capillary).
- Conditions in which there is an increase in Blood pressure: Excessive kidney retention of salt and water, Acute or chronic kidney failure.
- Changes in venous pressure also affect Hydrostatic pressure (at the venous end of the capillary).
- Examples for the increased Venous pressure: Heart failure, Venous obstruction

Edema: Causes

2- The permeability of the capillary (Represented by K).

- Physical trauma → رض
- Toxins
- Burn
- Inflammation
  ↓
  Histamine → contraction of endothelial cells & this will increase permeability



•Sinusoidal capillaries have high permeability (high 'k') due to their larger fenestrations and gaps between cells.

•Tight capillaries have a low permeability (low 'k') because they have fewer and smaller fenestrations.

•The permeability 'k' can change due to various factors.

•An example of such a change: Inflammation, burn, and Toxins.

•Inflammation → Release of Histamine → Endothelial Contraction → Edema

Edema: Causes

3- Decreased capillary oncotic pressure:

- Oncotic pressure is a form of osmotic pressure exerted by ***proteins***, mainly albumin, in the capillary.
- Conditions that decrease protein concentration in the body lead to decreased capillary oncotic pressure.
- Examples:

مكشوف

- Loss of protein from denuded skin areas (Burns, wounds).
- Loss of proteins in urine (nephrotic syndrome)
- Failure to produce proteins (liver disease (e.g., cirrhosis).
- Serious protein or caloric malnutrition.

Edema: Causes

4- Lymphatic system blockage or breakdown

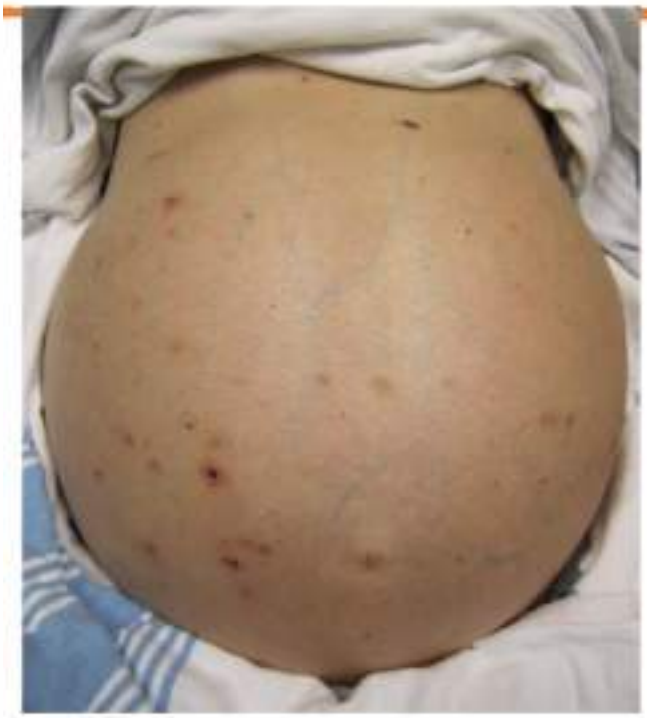
Conditions:

Removal or irradiation of lymph nodes (cancer).

Parasitic infection of lymph nodes

lymphedema of the left arm after mastectomy (surgical removal of the breast) and axillary lymphadenectomy (surgical removal of the axillary L.N

Peri-orbital edema due to inflammation / insects / trauma



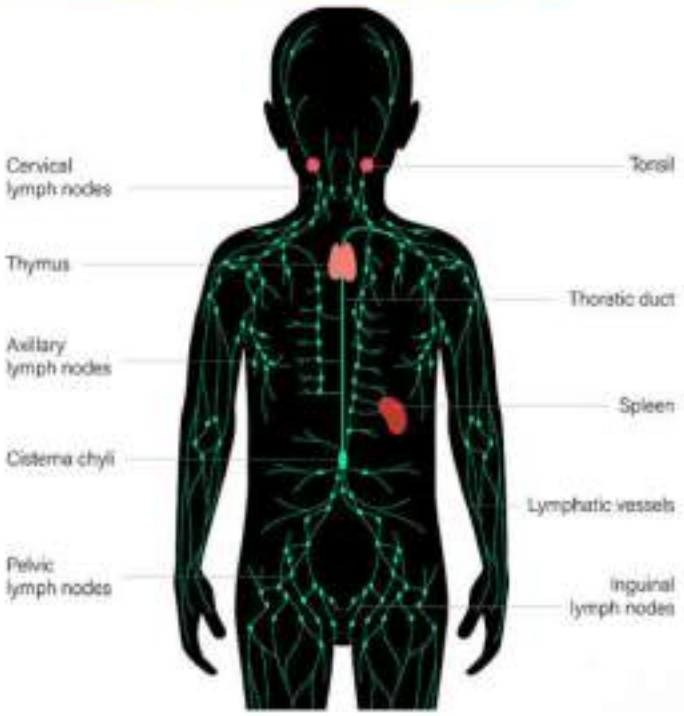
The abdomen of a person with cirrhosis that has resulted in massive ascites

Edema due to heart failure

Lymphatic System:

Components:

1- Lymph
2- Lymphatic Vessels
3- Lymphatic organs
4- Lymph Nodes



1- Lymph:

- Lymph is a fluid similar to blood plasma (It's derived from blood plasma).
- Accumulated interstitial fluid is picked up by lymphatic vessels.
- Once inside the lymph capillaries, the fluid is called lymph.
- Returning this fluid to the blood prevents edema.
- This process helps maintain normal blood volume and pressure.

اللمفاويات في الدم

2- Lymphatic organs (thymus, spleen, tonsils and bone marrow):

- Lymphatic organs contain clusters (تجمعات) عناقيد of lymphocytes and other cells like macrophages.
- When the body is exposed to foreign substances, lymphocytes proliferate ينتشر in these organs.
- These lymphocytes are then dispatched إرسال to the invasion هجوم site via the blood.
- This is part of the immune response aimed at destroying the invading هجوم agent.

Lymphatic System:

➢ **Components of the Lymphatic System**

3- Lymph Nodes:

•Lymph nodes: small, bean-shaped structures in the lymphatic system.

•Distributed throughout the body along lymphatic vessels.

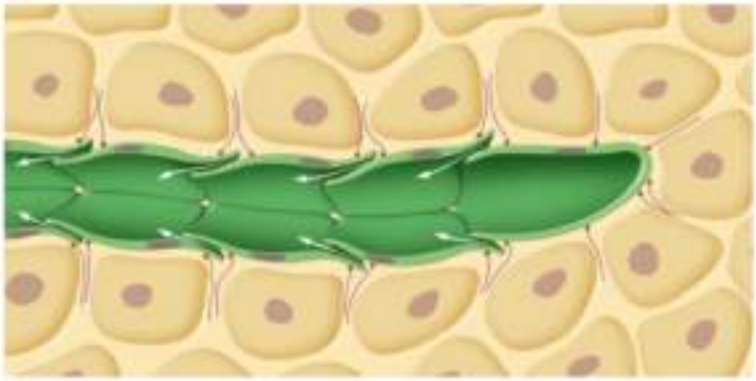
•Function as filters for lymph, removing harmful substances.

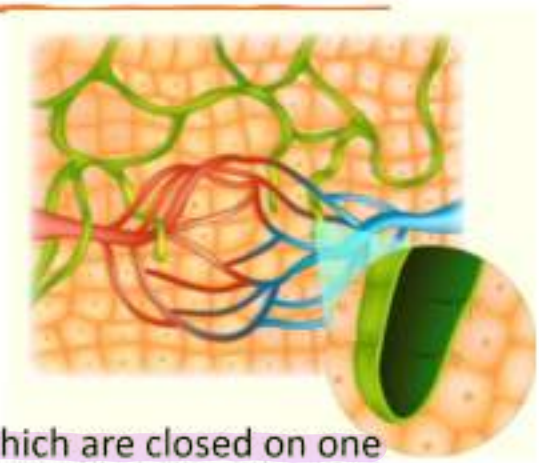
•Lymph nodes are key sites for the initiation of the immune response.

4- Lymphatic Vessels:

- Lymphatic vessels only carry fluid away from tissues.
- The smallest vessels are lymph capillaries, which start as blind-ended sacs in tissue spaces.
- The capillary wall is composed of overlapping endothelium forming a one-way valve.
- This permits fluid entry but prevents lymph from leaving the vessel.

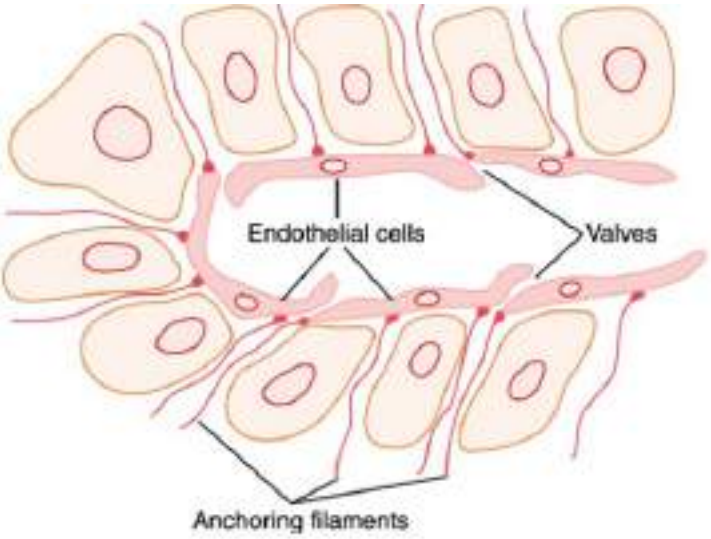
Lymphatic Vessels:



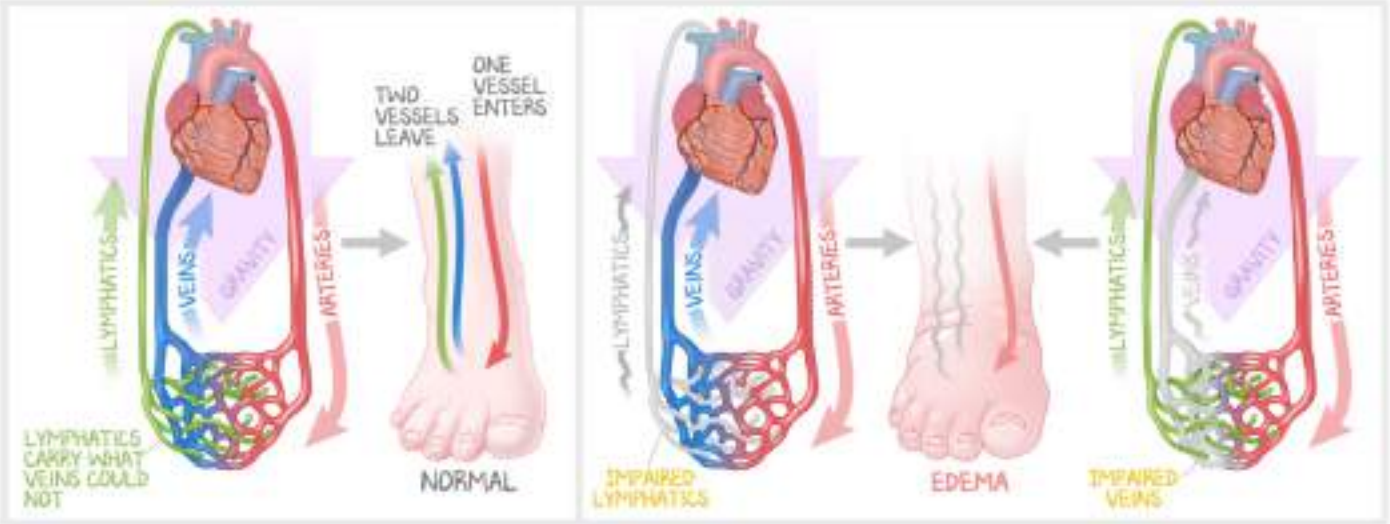


- Lymphatic vessels begin as lymphatic capillaries, which are closed on one end.
- Lymphatic capillaries are close to vascular capillaries within the interstitial fluid.
- These capillaries have one-way flap valves, allowing entry but not exit of interstitial fluid and protein.

- The edge of one endothelial cell overlaps with an adjacent cell, creating a flap that forms a minute valve.
- This valve opens inward to the lymphatic capillary, allowing interstitial fluid and suspended particles to enter.
- Backflow is prevented as it causes the flap valve to close, stopping the fluid from leaving the capillary.



Fluid in is Arterial, while Fluid Out Is Both Veins and Lymphatics



Lymphatic System Functions: Summary

1. ***Immunity:*** The lymphatic system plays a major role in the body's immune response. It produces, stores, and carries white blood cells, particularly lymphocytes, which protect the body against infection and disease.
2. ***Fluid Balance:*** It helps maintain fluid balance in the body by collecting excess fluid and particles from tissues and returning them to the blood.
3. ***Absorption of Dietary Fats:*** The lymphatic system in the small intestine absorbs dietary fats that are not directly taken up by the bloodstream.
4. ***Filtration:*** The lymph nodes filter lymph, a fluid containing white blood cells, to remove bacteria, viruses, and other foreign particles.
5. ***An accessory route*** by which fluid and protein can flow from interstitial spaces to the blood