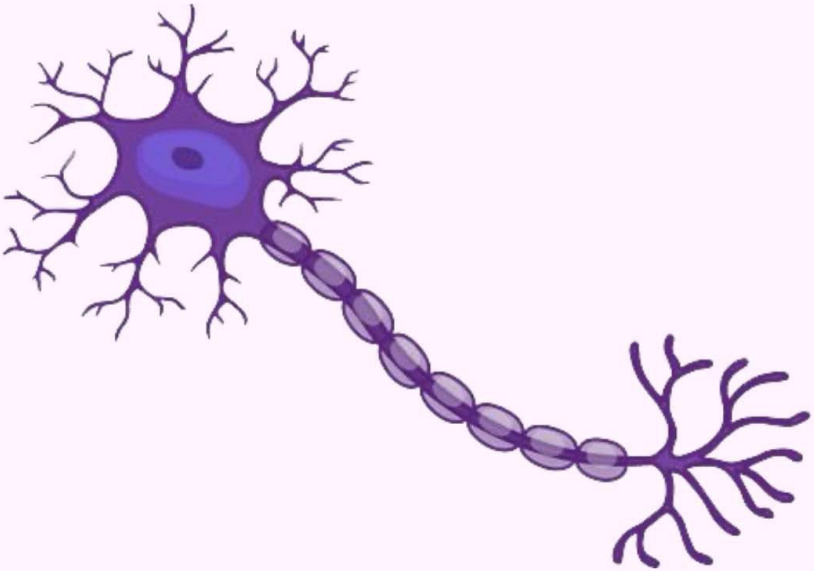
النادي الطبي

PHYSIOLOGY



LEC NO. : 4

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وقل رب زدني علماً

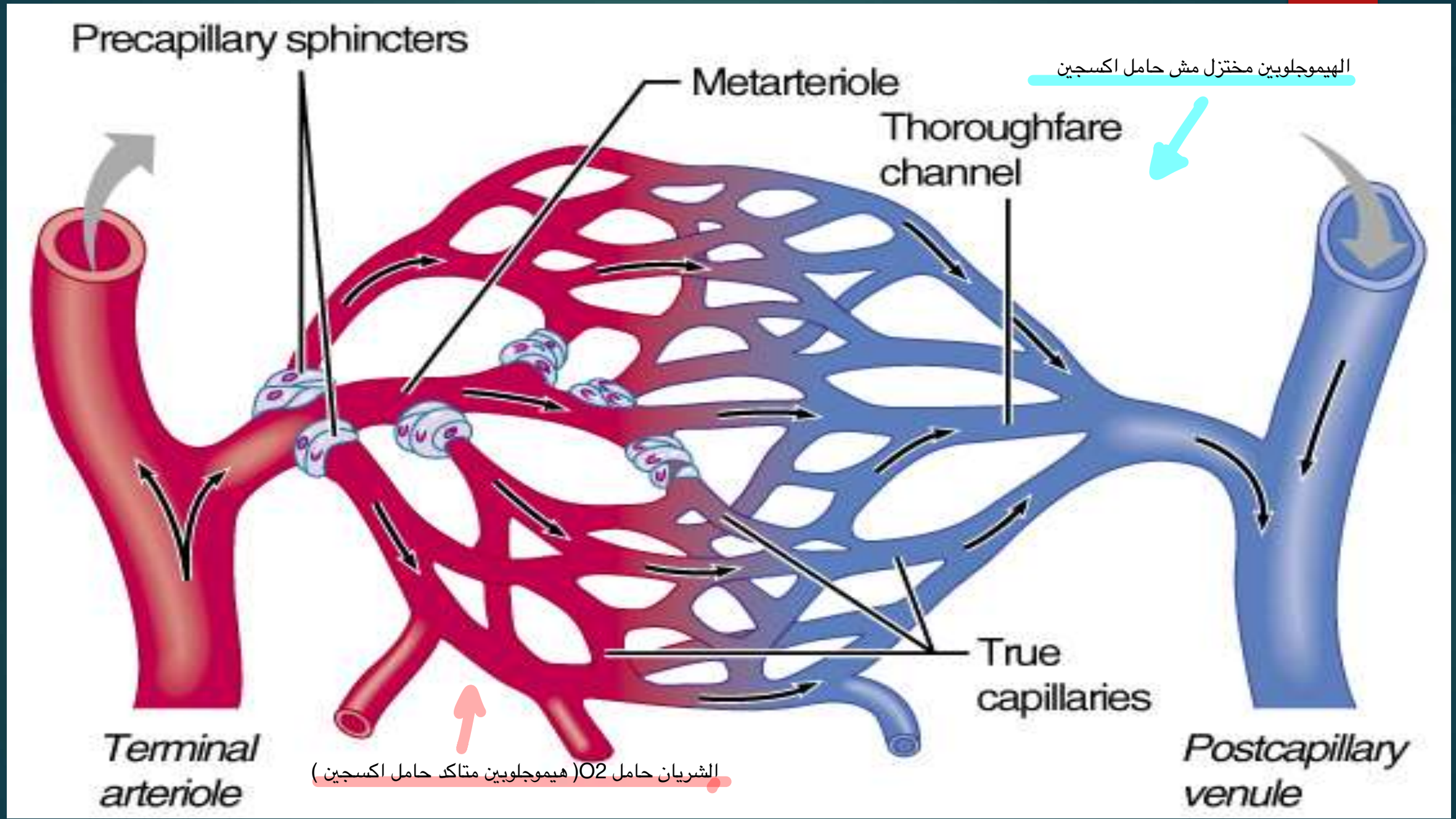
Capillaries

Capillaries are exchangeable vessels

- About 10 billion capillaries with total surface area of 500 to 700 square meters provide this function for the whole body.
- The blood enters the capillaries through an arteriole and leaves by the way of a venule.
- From the arterioles the blood passes into metarterioles → capillaries → venules → veins.

خط السير للدم
Artie > arteriole > capillary > venule > veins

The main function of the blood : 1— Z تغذية الانسجة ، nutrients (carbohydrates /fat/ protein) بعدين بتتاكسد و بتتحول لطاقة عشان الشخص يتحرك
2– transfer regularities الي بتنظم عمل الخلايا (enzymes / vitamin/ hormonies)
فالدم بصير بينو و بين الانسجة exchange. للمواد ، بيعطيها الي بدها اياه و بياخد منها المواد العدمة زي ثاني اكيد الكربون ، ure و غيره
هاد التبادل بصير عن طريق الشعيرات الدموية (capillaries)


Precapillary sphincters
Metarteriole
الهيموجلوبين مختزل مش حامل اكسجين
Thoroughfare channel
True capillaries
Terminal arteriole
الشريان حامل O2(هيموجلوبين متاكد حامل اكسجين)
Postcapillary venule

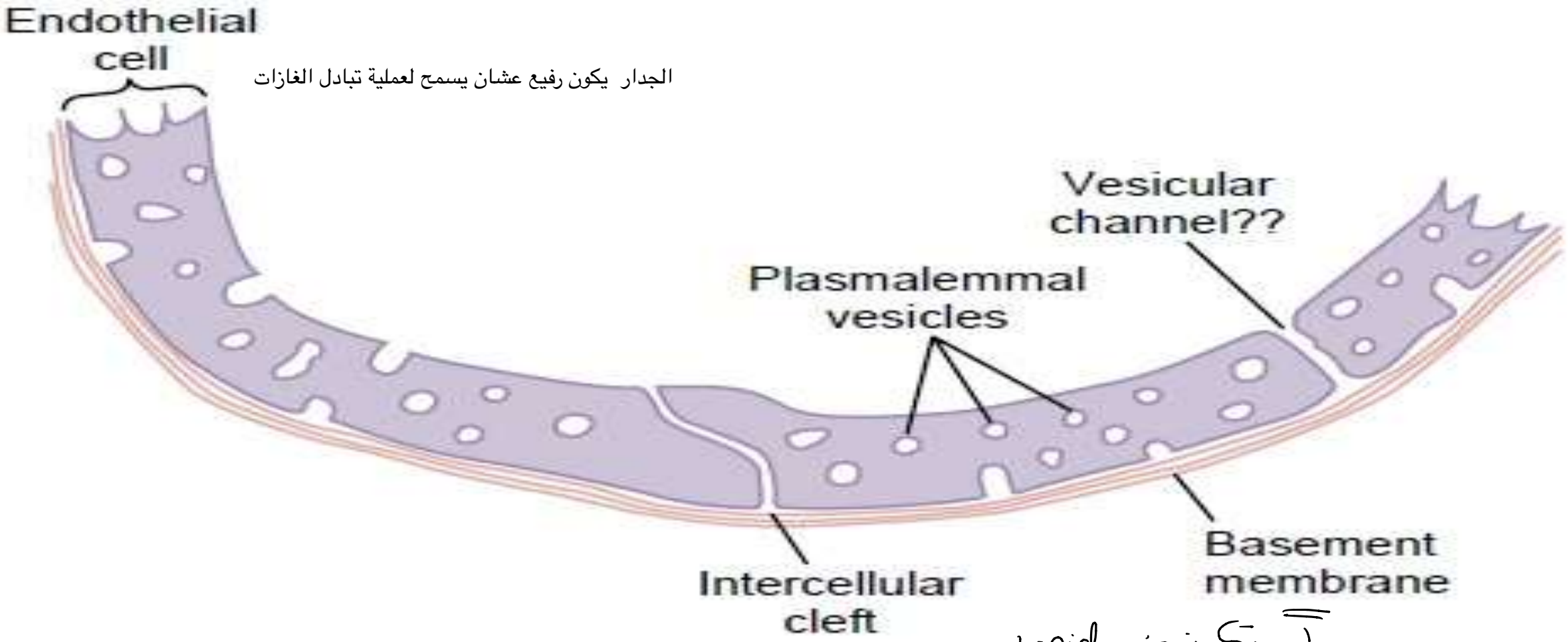


Figure 16–2

Structure of the capillary wall. Note especially the *intercellular cleft* at the junction between adjacent endothelial cells; it is believed that most water-soluble substances diffuse through the capillary membrane along the clefts.

Mechanisms of trans-capillary exchange of substances

- **Exchange of substances across the capillary wall occurs by diffusion, filtration, osmosis, vesicular transport**

I. Diffusion: → الانتقال من التركيز الأعلى الى التركيز الأقل من غير حاجة طاقة , تمر المواد بسهولة لخاصية الفتحات .

- It is **the most important means by which water and dissolved substances are transferred between the plasma and interstitial fluid.**
- **It is a passive process which depends on the following factors:**

* Diffusion is the most important because it is the easier.

It is a passive process which depends on the following factors:

1

1. Concentration gradient: كل ما زاد فرق التركيز كل ما كان ال diffusion اكبر

- Diffusion **of a substance occurs from higher to a lower concentration.**

2. Surfaces Area:

- The greater the **surface area available for diffusion, the more will be the diffusion of the substance.**

3. Capillary permeability:

- The capillary wall **behaves as a semipermeable membrane through which diffusion** of different substances occurs . كل ما كان الجدار نفاذ كل ما كان ال diffusion اكبر

So these capillaries are high permeable especially lungs capillaries

Filtration:

- **Filtration is the passage of a bulk flow of fluid across the capillary membrane under the control of hydrostatic and osmotic pressure difference.**
- **Starling 's principle states that: " the rate & direction of fluid movement is proprotional to the algabric sum of hydrostatic and osmotic forces“**
- **Four primary factors determine whether fluid move out of the blood into the interstitial fluid or in the opposite direction; these factors are.**

: diffusion / filtration الفرق بين ال

Diffusion هوه انتقال المواد بين الفتحات

ممكن تكون فتحات بالجدار ممكن يكون في فتحات بين ال molecules ، فهوه بسبب فرق التركيز بنتقل و هوه العمليه الاسهل

Filtration is a bulk flow of fluid (يعني ترشيح للماء)

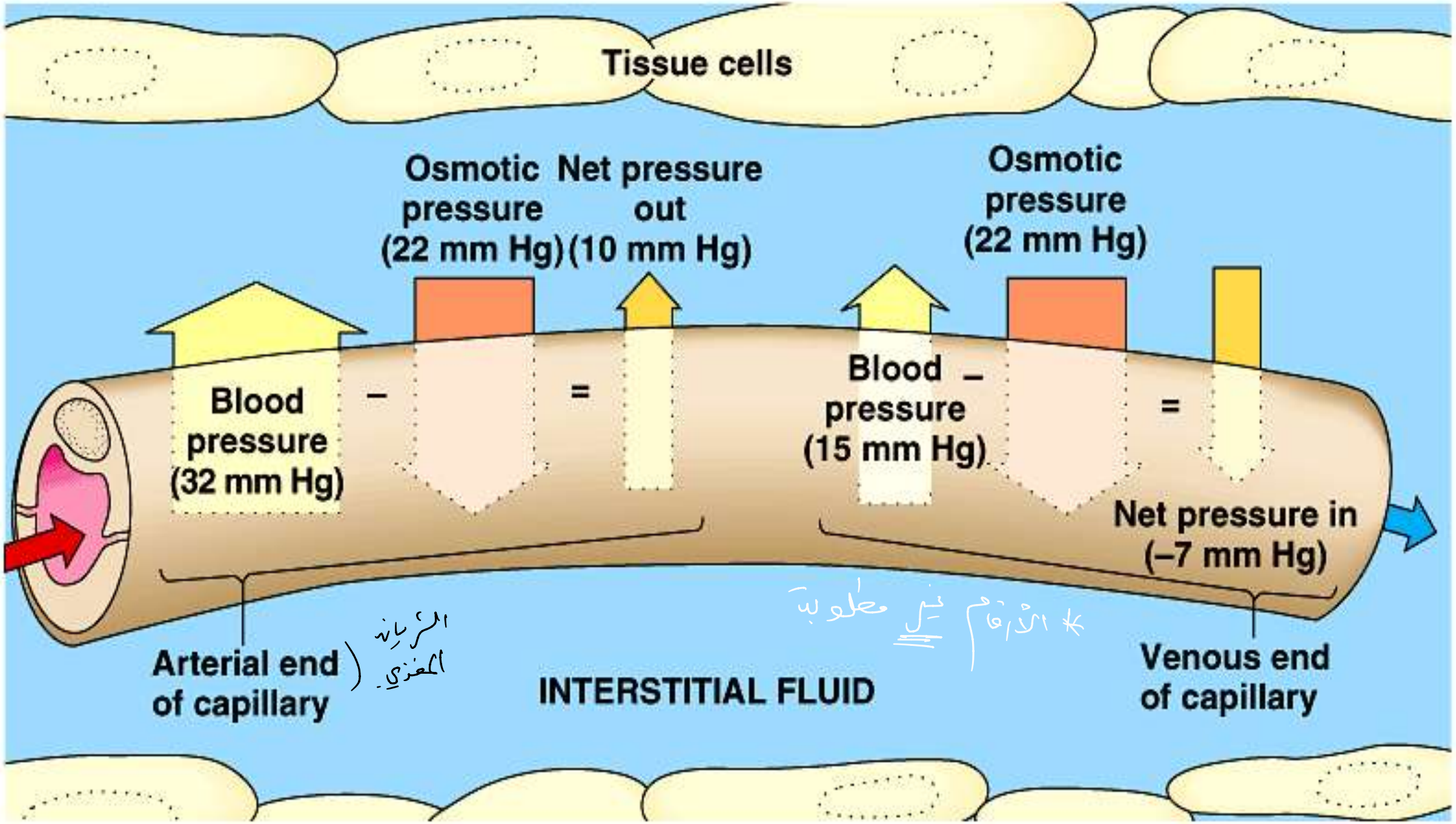
Four primary factors determine whether fluid move out of the blood into the interstitial fluid or in the opposite direction; these factors are.

the pressure of and venous end.

the Arterial end

Force ← 1- **The capillary hydrostatic pressure:**

- This is the force which tends to move fluid outward through the capillary membrane.
- It is 30 mmHg in the arterial end, 10 mmHg in the venous end.
- The functional mean capillary pressure is about 17.3 mmHg (i.e. it is the average effective pressure).


Tissue cells
Osmotic pressure (22 mm Hg)
Net pressure out (10 mm Hg)
Osmotic pressure (22 mm Hg)
Blood pressure (32 mm Hg)
–
=
Blood pressure (15 mm Hg)
–
=
Net pressure in (–7 mm Hg)
Arterial end of capillary
INTERSTITIAL FLUID
Venous end of capillary

Osmotic pressure of Plasma protein (albumen) // sodium cloried
موجودين بالدم يسحبو الي

عملية ال filtration مهمه لانو لولاها the cell will swell ،، و حجم الدم رح يقل

capillaries

Capillaries ل arterial end (الشريان المغذي) بتودي غذاء و اكسجين و اشياء كتيره
هاد الشريان بودي للانسجة الاشياء الي بدها اياها ، بتيجي الاوردة بتاخد العوادم الي بتنتج من اكسدة الغذاء بتتخلص منها عن طريق الجلد التعرق، البول و غيره

arterial end

Four primary factors determine whether fluid move out of the blood into the interstitial fluid or in the opposite direction; these factors are.

2. The interstitial fluid hydrostatic pressure:

- It is the **force which tend to move fluid inward through the capillary membrane** when it is positive, but **outward when it is negative.**
- It is about **-3 mmHg** and **is called negative interstitial fluid pressure.**

Four primary factors determine whether fluid move out of the blood into the interstitial fluid or in the opposite

3-The plasma colloid osmotic pressure:

- It is the force **which tends to cause osmosis of fluid inward** through **the capillary membrane** i.e. **it is the main absorbing force.**
- **The colloidal osmotic pressure or the oncotic pressure of normal** human plasma average about **28 mmHg (19 mmHg by plasma proteins and 9 by the accompanying** sodium ions due to **Donnan effect).**

Osmotic pressure: the pressure that cause osmosis

oncotic pressure: The osmotic pressure especilized for the large molecules.

Four primary factors determine whether fluid move out of the blood into the interstitial fluid or in the opposite

4-The interstitial fluid colloid osmotic pressure:

the osmotic pressure that is found in the interstitial fluid.

- It is the force which tends to cause osmosis of fluid outward through the capillary membrane.
- The average protein concentration of the interstitial fluid is about 3 gm/100 ml. resulting in average colloid osmotic pressure of about 8 mmHg.

Formation and drainage of the interstitial fluid

- About **20 liters of fluid are filtered every day at the arterial ends of capillaries**, 18 liters of them are reabsorbed back at the venous ends, **and the remaining 2 liters are drained by the lymphatic system.**

The forces concerned in the formation and drainage of interstitial fluid include:

1. The **capillary hydrostatic pressure.**
2. The interstitial fluid pressure.
3. **The plasma colloid osmotic pressure.**
4. The interstitial fluid colloid osmotic pressure.

The dynamic of the flow across the capillary membrane is as follows

The dynamic of the flow across the capillary membrane is as follows:

At the arterial end of the capillary:

A. Forces moving the fluid outward:

	mmHg
- **Capillary pressure**	30
- Negative interstitial fluid pressure	3
- **Interstitial fluid colloid osmotic pressure**	8
▶ **Total outward force**	41

The dynamic of the flow across the capillary membrane is as follows:

B. Forces moving the fluid inward

- **Plasma colloid osmotic pressure** 28

Summation of the forces:

Outward force 41

Inward force 28

Net outward force: 13

- Thus **13 mmHg filtration pressure occurs at the arterial ends of** the capillaries.

The dynamic of the flow across the capillary membrane is as follows

At the venous end of the capillary:

A. Forces tending to move fluid outward:	mmHg
- Capillary pressure	10
- Negative interstitial fluid pressure	3
- Interstitial fluid colloid osmotic pressure	8
Total outward force	21
B. Forces tending to move fluid inward:	
- Plasma colloid osmotic pressure	28
Summation of forces:	
Outward force	21
Inward force	28
Net inward force:	7

The dynamic of the flow across the capillary membrane is as follows

- Thus **7 mmHg is the reabsorbing pressure at the venous ends of the capillaries**.
- It is less than the filtration pressure, but the venous capillaries **are more numerous and more permeable so it reabsorbs** about 9/10 of the fluid, **the remainder flows into the lymph vessels.**

(تَوَرُّم) Edema

هاد التورم بصير بسبب ممكن يكون عندها فشل في الكبد ، فشل فيً الكلية

- **Edema means presence of excess fluid in the body tissues.**

- In most instances, edema occurs mainly **in the extracellular fluid compartment,** but it can involve the intracellular fluid as well, so it may be:

High hydrostatic >high filtration

Low oncotic pressure > no absorption

No working of lymphatics glands > extra water in the extracellular

1. **Intracellular "nonpitting" edema**

-Means edema due to increased intracellular fluid (i.e. intracellular swelling). It results from **disturbance of the membrane permeability e.g.:**

a. **Decreased metabolism of the tissues:** → inhibition of Na^+ - K^+ pump → increase Na^+ inside cells → osmosis of water into the cells.

b. **In inflamed tissues:** → increase cell membrane permeability (direct effect) → increase diffusion of Na^+ into cells → osmosis of H_2O into cells

Edema

Reasons of edema :
high filtration ,hydrostatic pressure is high
and the plasma protein is low and there .is no absorption

- **2. Extracellular "pitting" edema**
- **-** Occurs when there **is excess fluid accumulation in the extracellualr spaces i.e. increased** interstitial fluid. Generally it results from:
- **I. Increased filtering force (capillary blood pressure):**
- Filteration of fluid exceeds the reabsorption, producing edema which is caused by:
- ***1. Arteriolar dilatation*** as in:
-
-

Edema

- ***2. Increased venous pressure*** as in:

فشل في القلب.

- **a- Congestive heart failure (CHF)** – cardiac edema, which is due to:
- - Increased venous pressure and capillary Bl pressure
- **b- Pregnancy (pregnancy edema): the enlarged uterus presses on the iliac veins. → ↑ venous pressure in lower limbs → edema.**
- c- **Venous obstruction leads** to local edema in the area drained by the occluded vein.

* ضغط الوريد زاد

Edema

- **II. Decreased absorbing force:**
- Filtration of fluid exceeds the reabsorption producing edema. This is due to:
- ***1. Decreased plasma proteins level to 5 gm%*** **(normal level is** 7-7.5 gm%) as in:
- a) **Decreased protein intake** as in starvation (nutritional edema).
- b) Increased loss of protein in urine as in nephrotic syndrome (renal edema).
- c) **Decreased synthesis of albumin as in liver cirrhosis (ascites).**
- ***2. Increased the osmotically active substances in interstitial spaces*** **e.g.** ischemia of tissues and congestive heart failure (CHF).

Edema

- **III. Increased capillary permeability:**
- It leads to excessive fluid and protein filtration, edema develops as
- Excessive heat and excessive cold.
- **Bacterial toxins.**
- Inflammation – **(inflammatory edema)** due to histamine and bradykinin release.
- Allergy (allergic edema) due to histamine release.
- **Vitamin C deficiency.**
- Burns.

احد اسباب التورم

1- الاشياء الي بتفردها ال inflammation الي بتقوم ب زيادة ال permeability for the membrane , which accumulate the water

Decrease in the metabolism

Permeability ال for the membrane.

الحساسية تقوم بزيادة

Vitamin C is essential in the strength of the capillary.

Edema

- **IV. Lymphatic obstruction**
- Accumulation of tissue fluid and protein in tissue spaces produces edema as in:
- - **Infections (e.g. filaria)** produce edema called elephantiasis and it is non pitting.
- - Cancer produces cancer edema and it is non pitting.
- - **Surgical: due to interruption of lymphatic vessels.**
- - **Congenital absence of lymphatics**

Edema

- **V. Salt and water retention**
- Increases fluid retention in tissue spaces and edema develops as in:
- **- Congestive heart failure.** - Renal failure.
- **- Liver diseases (liver cirrhosis).**
- ***In these conditions the aldosterone secretion is increased*** *which causes salt and water retention.*

Edema

- **Edema safety factors**
- - Under normal conditions, the following three major factors operate to prevent edema formation:
- **1. Low compliance of the interstitium in the negative pressure range:**
- **-**The hydrostatic pressure of the interstitial fluid is negative (average -3 mmHg). It helps to hold tissues together → limits fluid accumulation in the loose subcutaneous tissues.
- - **This safety factor is estimated to be about 3 mmHg.**

Edema

- **2. Increased lymph flow:**
- - When fluid begins to accumulate in the tissues, its pressure rises→ opening of lymphatics → **↑lymph flow 10-50 folds** → ↑drainage of tissue fluid.
- - This safety factor is estimated to be about 7 mmHg.
- **3. "Wash-down" of the interstitial fluid protein:**
- - Excess filtration of fluid → ↑increase in lymph flow→ wash out larger amount of the proteins →↓ interstitial fluid colloid osmotic pressure → limits filteration.
- **- This safety factor is estimated to be about 7 mmHg.**
- **Therefore, the total capacity of these safety factors** against edema is about 17 mmHg (3 + 7 + 7). **This means that the capillary pressure in the peripheral tissues, could theoretically rise by 17 mmHg above its average value 17.3** before edema would occurs (approximately double the normal mean value).

Which is the most important means by which water and dissolved substances are transferred between the plasma and interstitial fluid?

a) Filtration
b) Active transport
c) Diffusion
d) Endocytosis
e) Pinocytosis

Enumerate **The forces concerned in the formation and drainage of interstitial fluid :**

Answer

1-The **capillary hydrostatic pressure.**

2. The interstitial fluid pressure.

3. **The plasma colloid osmotic pressure.**

4. The interstitial fluid colloid osmotic pressure.

Which is main the force **which tends to cause osmosis of fluid inward** through **the capillary membrane?**

a) Hydrostatic capillary pressure
b) Plasma protein oncotic pressure
c) Interstitial fluid osmotic pressure
d) Interstitial fluid hydrostatic pressure
e) Increased capillary permeability

Which is a cause of non pitting(cellular) edema ?

a) **Inflammation**
b) Congestive heart failure
c) Decreased protein intake
d) Salt and water retention
e) Increased capillary permeability

Which is a cause of pitting (extracellular) edema Due to increased Venous pressure ?

a) Loss of protein in urine
b) Vit C deficiency
c) Allergy
d) Pregnancy
e) Arteriolar dilatation

Enumerate and discuss edema safety factors

- Answer **1. Low compliance of the interstitium in the negative pressure range:**
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subcutaneous tissues.

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Thank

- you