PHYSIOLOGY

النادي الطبي

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وَقُل رَّبِّ زِدْنِي عِلْمًا

Capillaries

السُّحيراتُ الدّمويةُ

← اللي رح تتعلمه هو كيف عملية التبادل بالموادعـن طريق الشعيرات الدموية ، و ماهي القوه التي تتحكم؟ وليش بيصير في تورّم في اكبسم .

▶ About **10 billion** capillaries with **total surface area of 500 to 700** square meters provide this function for the whole body.

Cardiovascular system includes heart, arteries, veins, capillaries

▶ The blood enters the capillaries through **an arteriole** and leaves by the way of **a venule.**

شريان أصغر

وريد صغير

▶ From **the arterioles** the blood passes into **metarterioles** → capillaries → venules → **veins.**

نحن من الكبير للصغير وبجديد من الصغير للكبير

طيب شو وظيفة capillaries ؟

الدم و وظيفته الأساسية، يلي هي انه بيغذي الانسجة، مثل carbohydrates, fats, proteins و هكذا، و بيوصل مواد regulatery مثل vitamins, enzymes, hormones و بيوصل الها الاكسجين و بياخد منها co2 ليتخلص منه، يعني لا بدّ انه يصير تبادل بين الدم و الانسجة، فـ الدم بيعطيها يلي بدها اياه و بياخد منها يلي ما بدها اياه مثل نتائج metabolism مثل uruea, uric acid و يتم التبادل عن طريق مين؟ يلي هي capillaries و هاد بفسّر سبب انها كثيرة جدًا و مساحة سطحها برضو كبيرة.

Precapillary sphincters
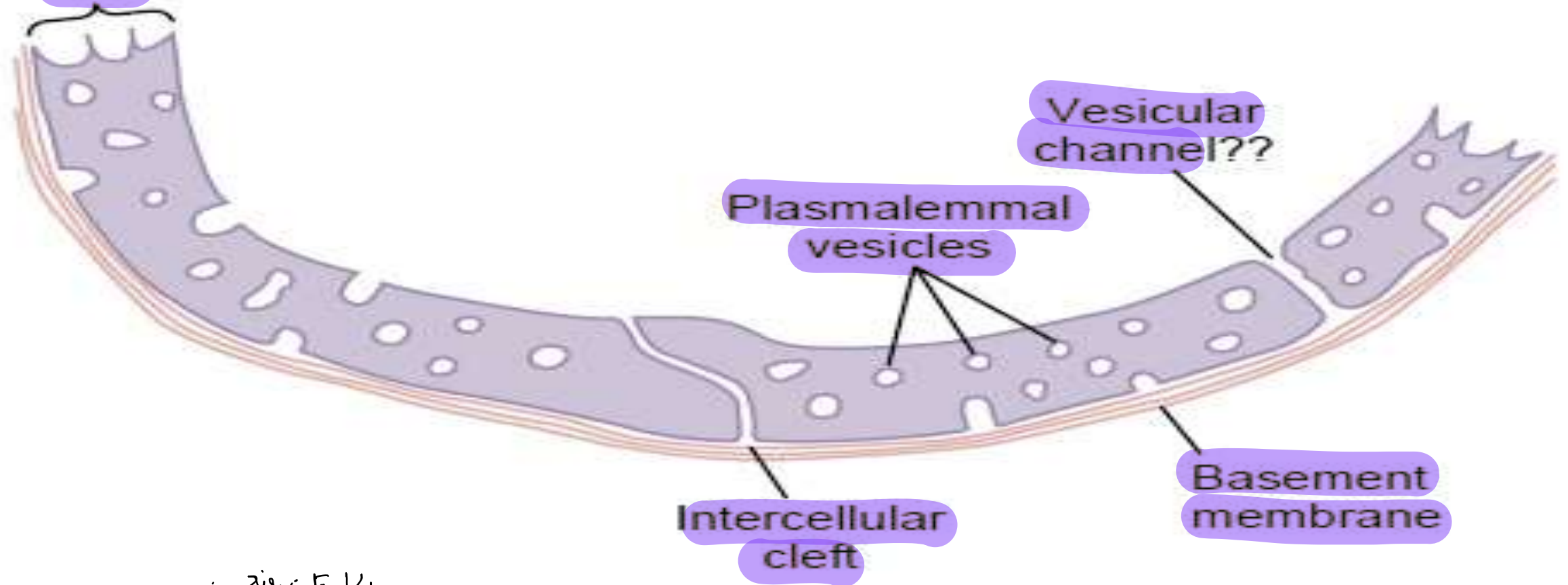
Metarteriole

Thoroughfare channel

True capillaries
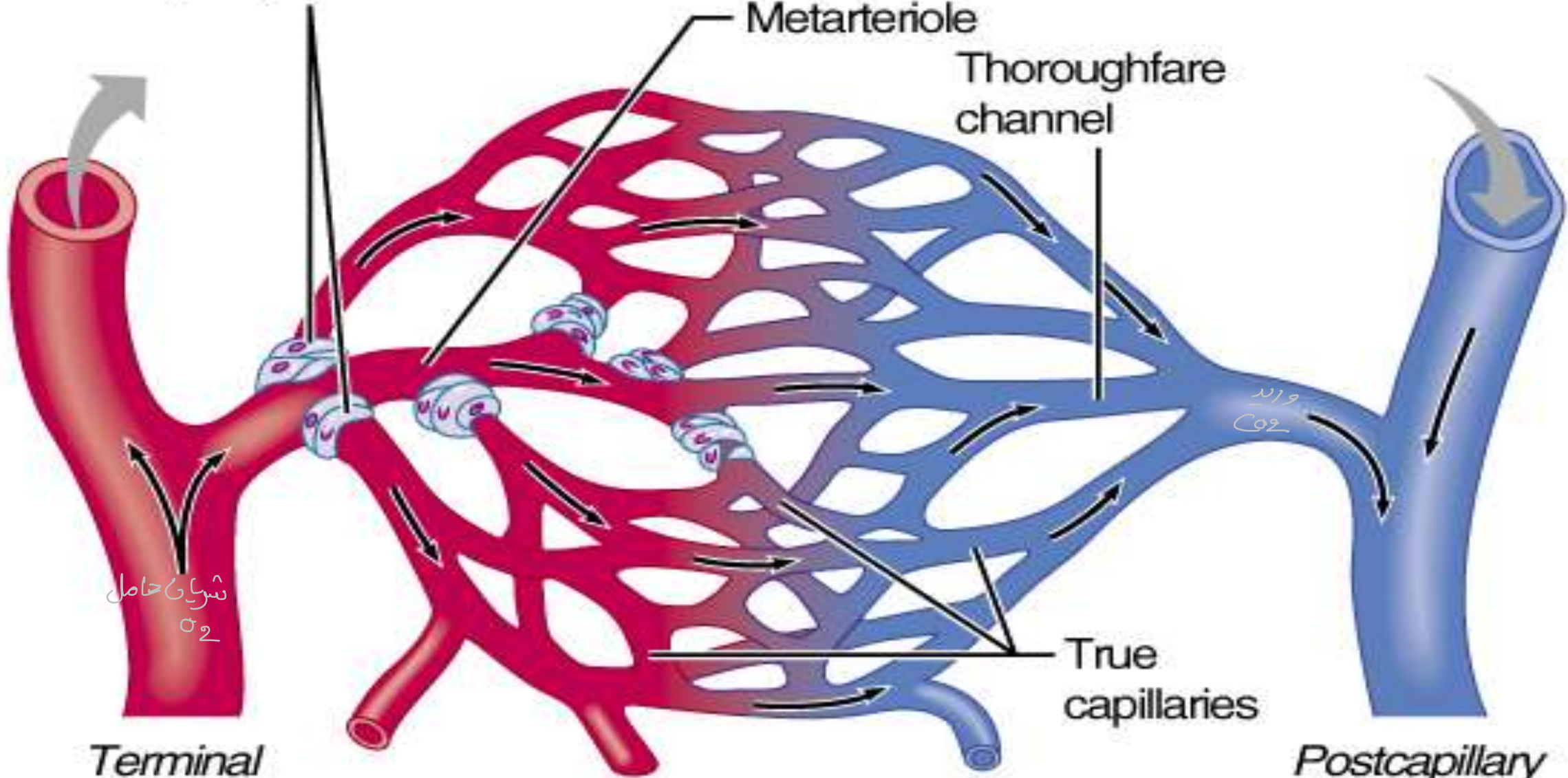
Terminal arteriole

Postcapillary venule

شریان حامل CO_2

وارد شوه

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

بـ طرق المبادل عن طريق الشعيرات الدموية .

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

التوشيح (للماء ومحها) والمواد الـ

high ← low
(passiv)

water (high→low)

← large molecules.

endocytosis + exocytocis عن طريق

يلي هي بشكل وبتخل حويصلة و من ثم تنتقل هذه الحويصلة

I. Diffusion:

▶ It is **the most important means** **by which water and dissolved substances are transferred** between the plasma and **in**terstitial fluid.

لأنها الأسط فـ هي لاتحتاج طاقة

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

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عوامل يعتمد عليها diffusion :-

1. Concentration gradient:

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

كل ما زادت التركيز زاد ، زاد الانتشار

2. Surfaces Area:

كل ما زادت المساحة زاد الانتشار

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

3. Capillary permeability:

كل ما كان اكبر، كلما كان، كل ما زاد الانتشار ، بالذات مع الرئة — نفاذية الجدار .

▶ The capillary wall **behaves as a semipermeable membrane through which diffusion** of different substances

occurs .

Filtration:

طيب ايش هو الفرق بين diffusion و filtration ؟

ببساطة الdiffusion هو انتقال المواد عن طريق الجدار ف المادة

بتنتقل لوحدها.

انما filtration هي ترشيح الماء يلي ذايب فيها املاح وغازات و غيرها

▶ **Filtration is the passage of a bulk flow of fluid** across the capillary membrane under the control of hydrostatic and osmotic pressure difference.

① ② 1+2 → forces

مثل H20 و كميتها

يلي بتسحب H20 ع الناحيتين

▶ **Starling 's principle states that**: " the rate & direction of fluid movement is proprtional 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.

الحوامل يلي بح تتحكم بانتقال السائل من الدم أك وكلاك أو العكس -:

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

1- **The capillary hydrostatic pressure:**

موجود عند arterial end أو venous end.

▶ **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.**

المتوسط

▶ **The functional mean capillary pressure is about 17.3 mmHg (i.e. it is the average effective pressure).**
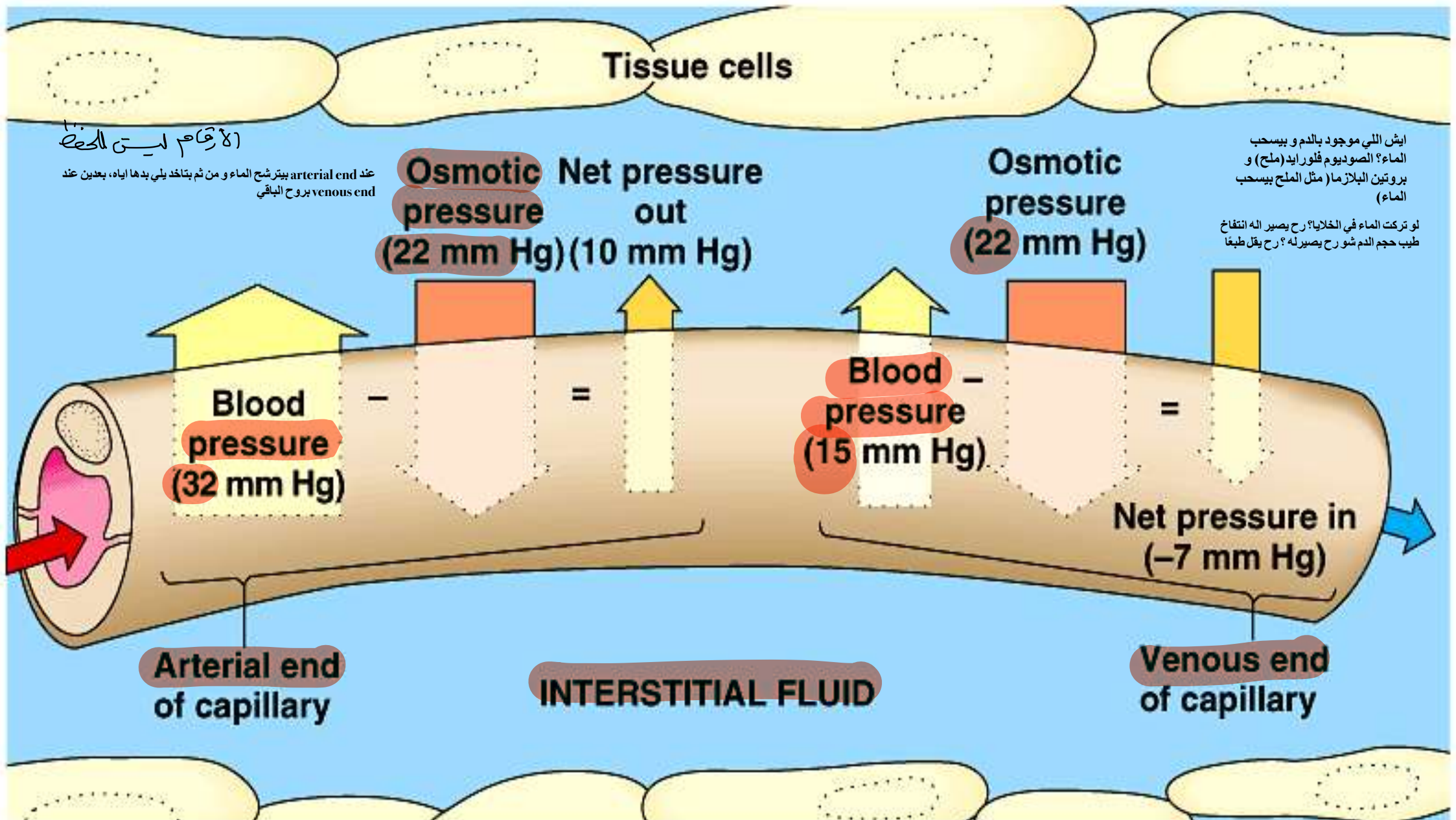
Tissue cells

(الأرقام ليست المهم)

عند arterial end بيترشح الماء و من ثم بتاخد يلي بدها اياه، بعدين عند venous end بروح الباقي

ايش اللي موجود بالدم و بيسحب الماء؟ الصوديوم فلورايد(ملح) و بروتين البلازما(مثل الملح بيسحب الماء)

لو تركت الماء في الخلايا؟ رح يصير اله انتفاخ طيب حجم الدم شو رح يصيرله ؟ رح يقل طبعاً

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

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

يلي بهمنا نعرف شو هو osmotic و encotic؟
Osmotic pressure هو يلي بيسحب الماء
osmotic هو نفس Encotic
بس الفرق انه مو للماء، هو لل large molecules
مثل proteins

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).**

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

بيسحب الماء برضو لل interstitial fluid بس

-4-**The interstitial fluid colloid osmotic pressure:**

▶ 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

ليرا

ليرا

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

B. Forces moving the fluid inward

بسحب
H2O كرا

- **Plasma colloid osmotic pressure**   28

Summation of the forces:

Outward force   41

Inward force   28

Net outward force: 13   →   قوة ترشّح H2O
عشان ن تروح
للأنسجة

▶ 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
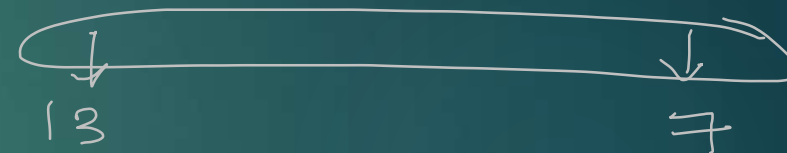
Inward force   28

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.**

أوعية لمفاوية

. يتم إعادة امتصاص 90%

ـ اللي يفضل و هو الفرق بين   in + out
عشان نقدّر يم الدم .

Edema

تورّم

- ▶ **- Edema means presence of excess fluid in the body tissues.** بين الكلايا
- ▶ - In most instances, edema occurs mainly in the extracellular fluid compartment, but it can involve the intracellular fluid as well, so it may be:

بينما لو هها خبّلت جوا الكلية مارح يحمير زي هيك

الكلايا

لمايكون عنا inflammation، فرح تطلع

- ▶ 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.:**

مافي طاقة

تشبيها

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

الأنسجة الملتهبة

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

Edema

لو hydrostatic pressure عالي، الترشيح اكثر
لو encotic pressure قليل ما رح يمتص الماء
لو الغدد اللمفاوية مو شغالة ، باقي الماء لن يُمتص

▶ **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: لها يتوسح ، جـ-كل د٣
أثو

Edema

▶ *2. Increased venous pressure* as in:

فشل في القلب ، يعني أجي أصيب في القلب ذطابيقل

▶ **a- Congestive heart failure (CHF)** – cardiac edema, which is due to:

في حاطلط

▶- Increased venous pressure and capillary Bl pressure

نقطرة لكل، بسبب انه الدم ضاغط ع الأوعية

▶ **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.

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.

اكساسية

▶- Allergy (allergic edema) due to histamine release.

▶- **Vitamin C deficiency.**   - Burns.   الحروف

- لأنه مهم جدًا لقوة جدار الشعيرات الدموية.

Edema

لحني داني عود لهفاوية

▶ **IV. Lymphatic obstruction**

▶ Accumulation of tissue fluid and protein in tissue spaces produces edema as in:

الحدى   داد العنل

▶- **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:**

▶ - **E**xcess 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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Thank

▶you