

PHYSIOLOGY

Team
433

Lecture 3 & 4: Homeostasis

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Blue = Main Topic

Violet = sup topic

Red = important

Orange = Explanation

White & Black = Addition

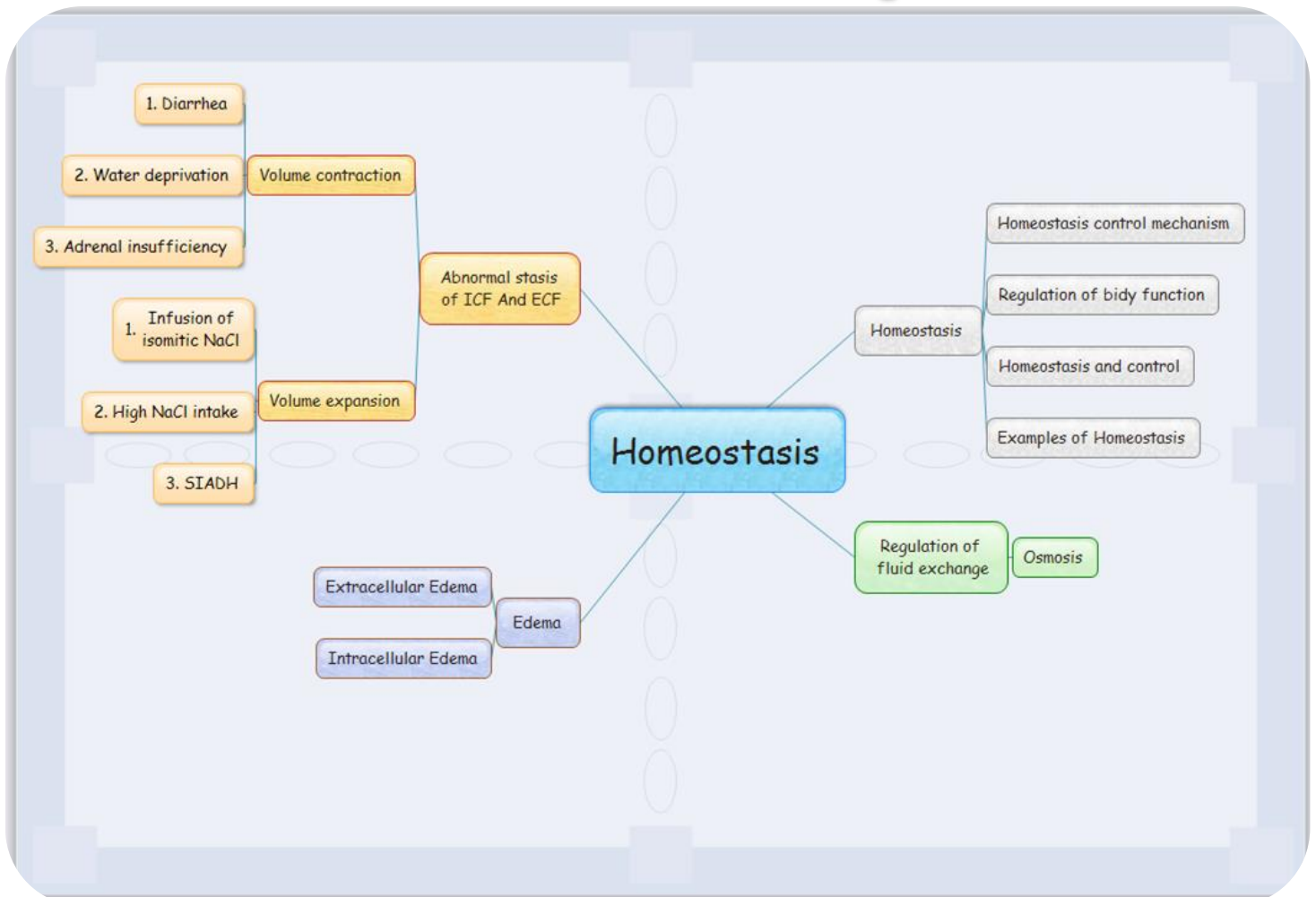
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Objectives

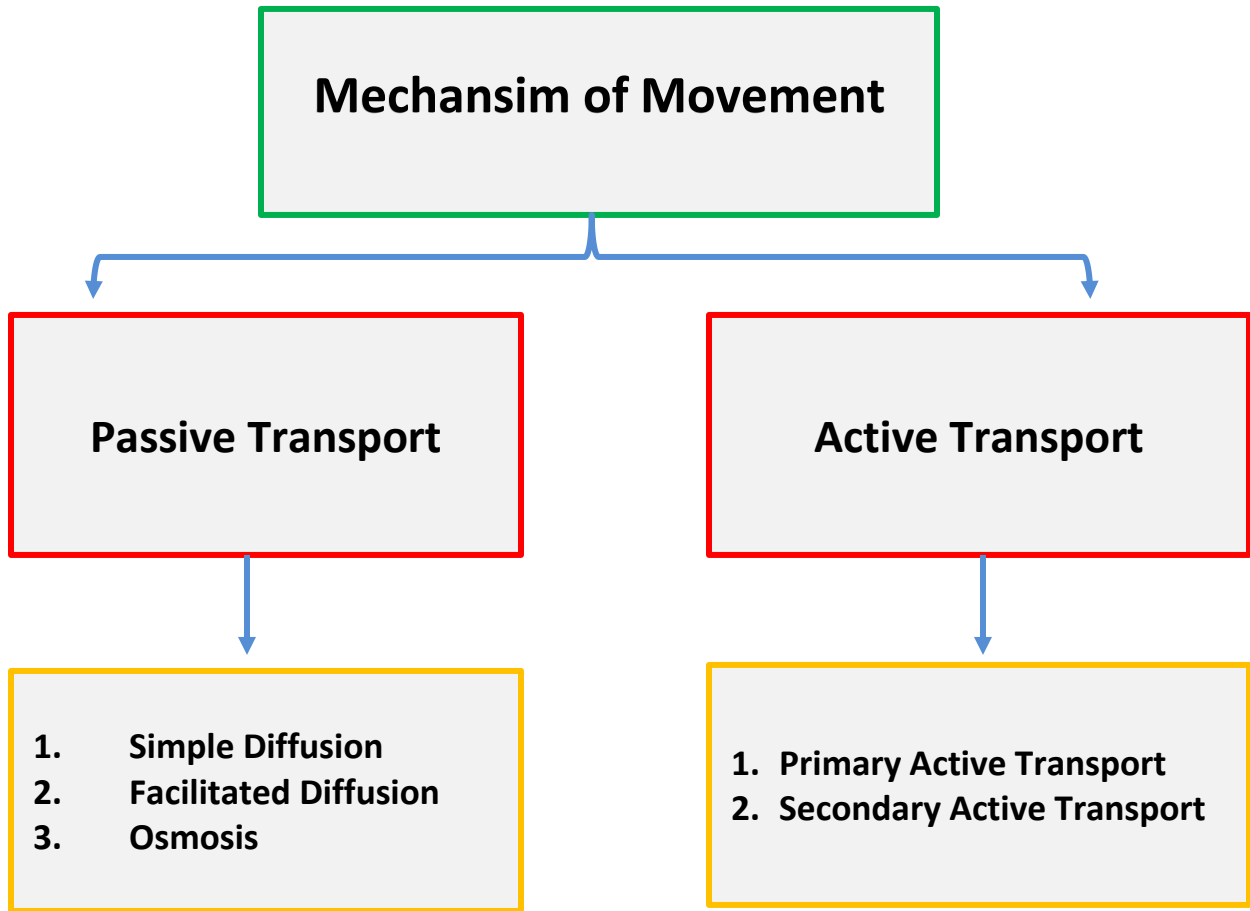
At the end of this session, the students should be able to:

- ✓ Understand the concept and importance of homeostasis.
- ✓ Review how body fluids are compartmentalized.
- ✓ Understand how the steady state is monitored.
- ✓ Review the compensatory responses to any change in the steady state.
- ✓ Review the disturbances of volumes of ECF and ICF.

Mind Map



Regulation of fluid exchange (عملية تنظيم تبادل السوائل في الجسم)



توضيح : سيتم شرح الأسموزية في هذا الدرس فقط ،
وفي الدروس القادمة سيتم شرح الأنواع الأخرى

Extracellular and intracellular fluids

- Ion fluxes are restricted and move selectively by **active transport**.
- Nutrients, respiratory gases, and wastes move Unidirectionally.
- Plasma is the only fluid that circulates throughout the body and **links** external and internal Environments.
- Osmolalities of all body fluids are **equal**; changes in solute concentrations are quickly followed by **osmotic changes**.

Osmotic concentration, formerly known as osmolarity, is the measure of solute concentration defined the number of osmosis per liter.

Osmosis (الخاصية الأسموزية)

Net diffusion of water from region of **high water** concentration to region of **low water** concentration

OR

Net diffusion of water from region of **low solutes** concentration to region of **high solutes** concentration

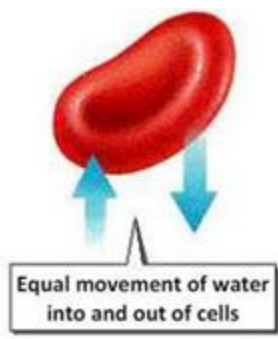
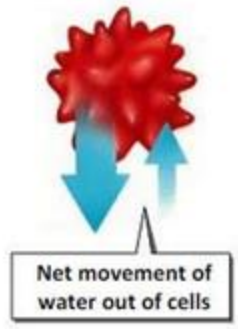
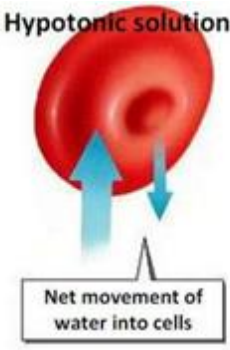
Net diffusion = **Transport in two directions (outside and inside the cell)**

You have to know that:

- The cell membrane is **Selectively Permeable**
 - The cell **highly permeable to water** because it is very small molecule
 - The cell **impermeable to ions** so they need to carrier protein to move through
- The cell membrane

Cell membrane is permeable of fat soluble because it is composed of lipids. **BUT** there is an exception for **WATER** because it is too small molecule and across through membrane by Osmosis. Other molecules like ions cannot across through membrane because they are large.

- Small changes in **concentration** of solutes in the extracellular fluid can cause tremendous change in cell **volume**
- Intracellular **osmolarity** = extracellular **osmolarity** $\approx 300 \text{ mosm/L}$

Environment	Water	Solutes	The effect on the cell
Isotonic	No change in water Volume	The same outside and inside the cell 0.9% of sodium chloride Or 5% glucose	No swells or shrinks 
Hypertonic	Less Water Outside	More Solutes Outside Higher than 0.9% of sodium chloride	Shrink 
Hypotonic	More Water Outside	Less Solutes Outside Lower than 0.9% of sodium chloride	Swelling Hypotonic solution 

Homeostasis

Homeostatic control mechanism

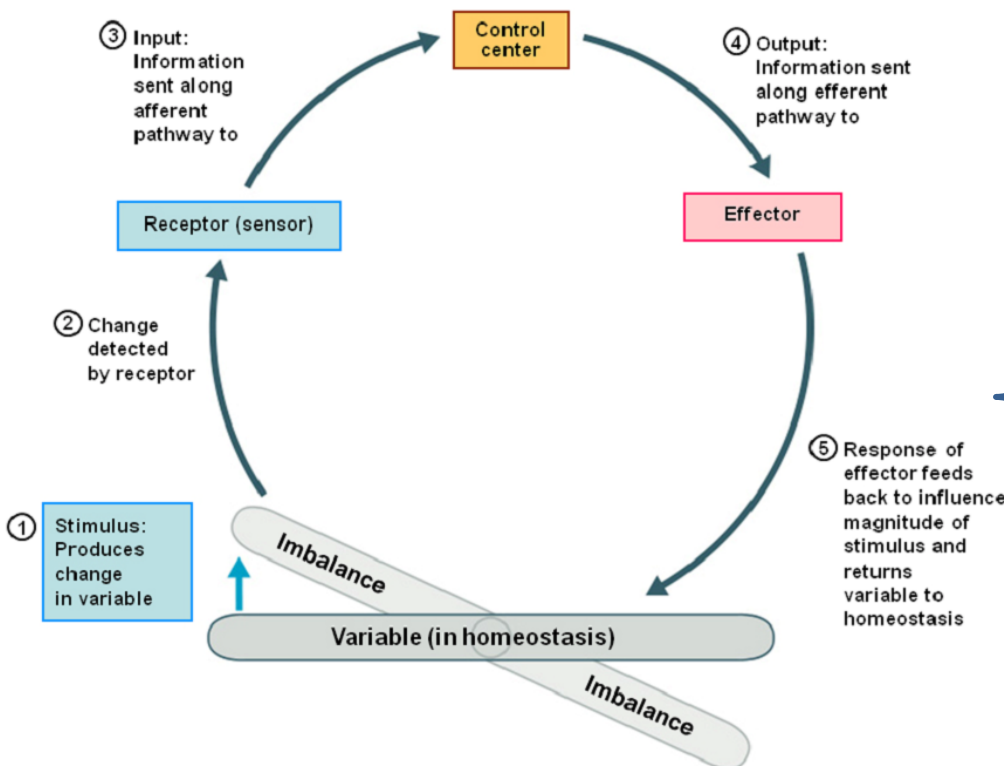
Homeostasis starts its mechanism when there is a variable produces a change in the body

Components of Control mechanisms

Receptor
 Monitors the environment and responds to changes (Stimuli)

Control center
 Determines the set point at which the variable is maintained

Effector
 Provides the means to respond to the stimulus



١- يتم الكشف عن التغير بواسطة المستقبلات
Receptors = Sensors

٢- يتم تحديد القيم التي يعود بها الجسم لحالته الطبيعية
Control Center = Nervous system

٣- تستجيب المؤثرات لهذه القيم وتبدأ بالعمل على تطبيقها للعودة للحالة الطبيعية
Effectors = Muscles and glands



Regulation of body functions

Nervous system.

- Sensory input.
- Central nervous system.
- Motor output.

Endocrine (Hormonal) system.

- Endocrine gland.
 - Pancreas, thyroid
- e.g. : insulin control glucose level



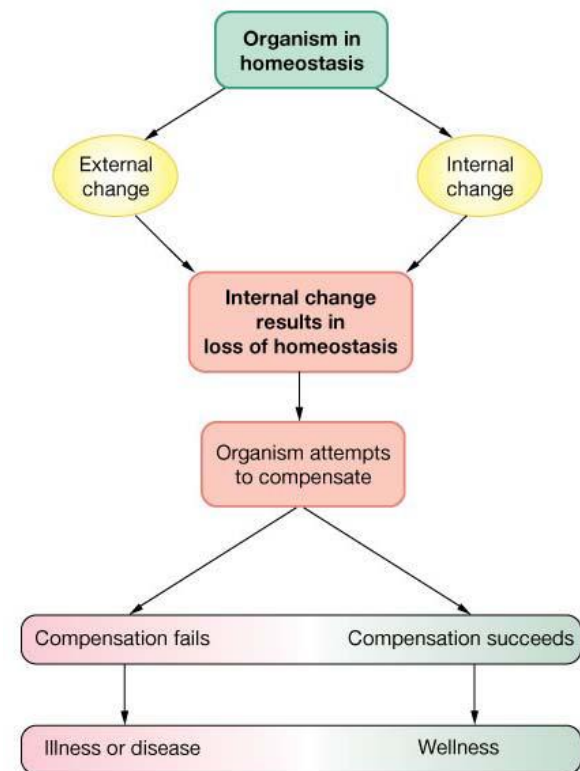
Homeostatic imbalance

- Disturbance of homeostasis or the body's normal equilibrium

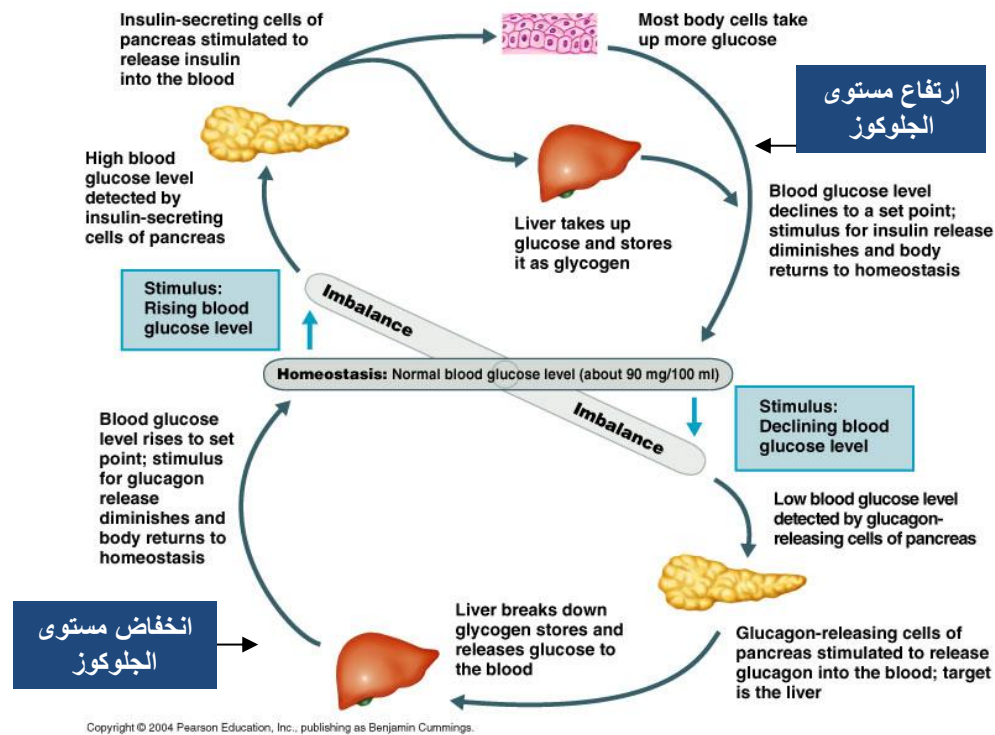
Homeostasis and control

- ❖ **Successful compensation.**
 - Homeostasis reestablished.
- ❖ **Failure to compensate.**
 - Pathophysiology.
 - Illness.
 - Death.

إذا حدث اضطراب للـ Homeostasis يحاول الجسم أن يصلح هذا الاضطراب وإذا لم يستطع فإن هذا يؤدي إلى مرض أو وفاة. **مثال** : مريض السكر يعاني من ارتفاع في نسبة الجلوكوز في الدم والبنكرياس لا يفرز الانسولين الذي يحتاجه الجسم إلى خفض نسبة الجلوكوز في الدم.



Examples of Homeostasis



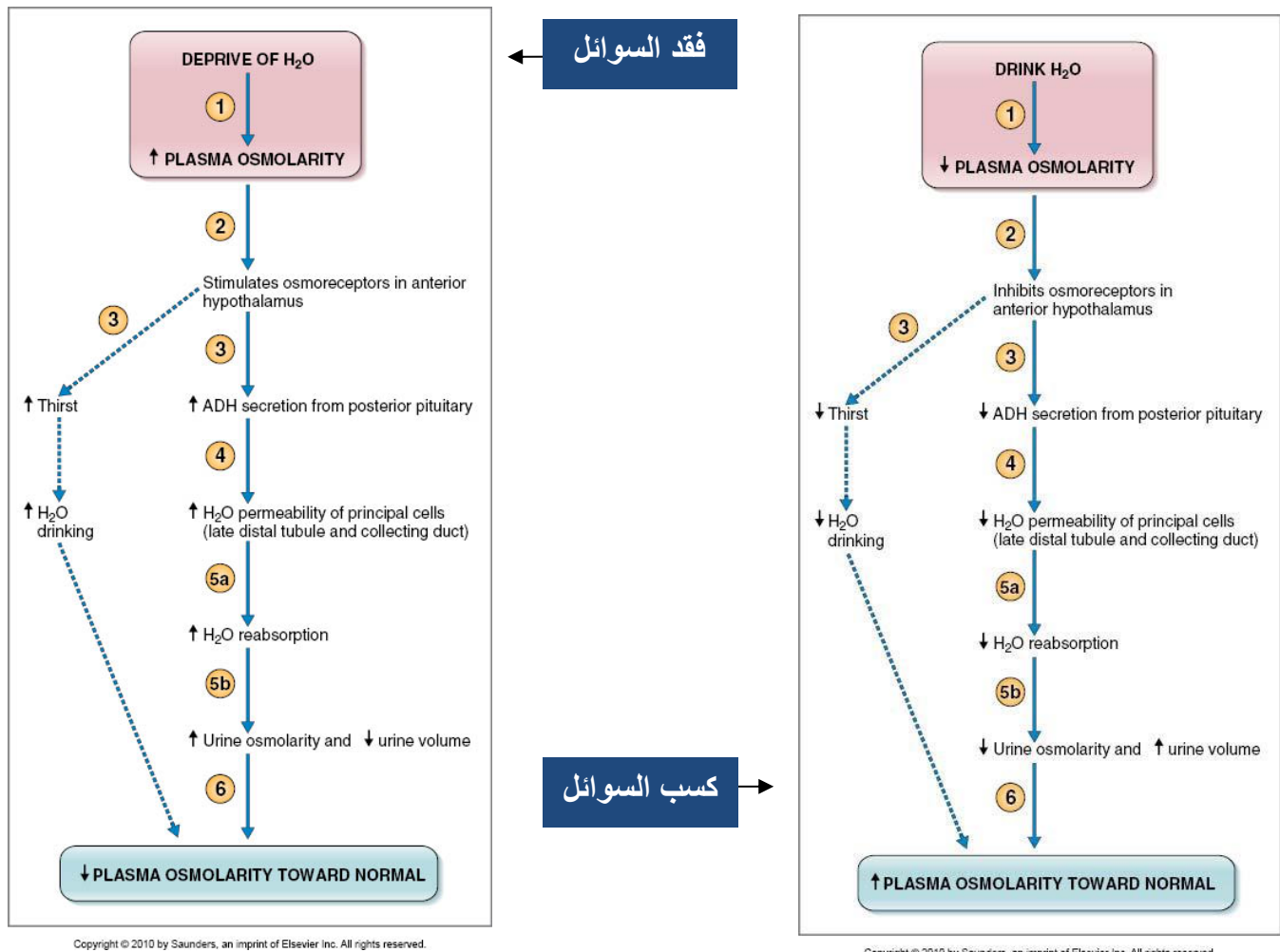
إذا ارتفع مستوى الجلوكوز في الدم سيتم فرز الانسولين من خلايا البنكرياس لإعادة مستوى الجلوكوز بالدم لحالته الطبيعية (Homeostasis)

If high blood glucose level was detected by the insulin-secreting cells of pancreas the cells will stimulate the release of insulin into the blood to get the blood to (Homeostasis)

إذا كان مستوى الجلوكوز في الدم منخفض سيتم تحويل الجلايكوجين إلى جلوكوز بواسطة هرمون الجلوكاجون لإعادة مستوى الجلوكوز بالدم لحالته الطبيعية (Homeostasis)

If low blood glucose level was detected by the glucagon-releasing cells of pancreas, the cells will stimulate breaking of stored glycogen from the liver to release glucose into the blood to get the blood to (Homeostasis)

HOMEOSTASIS



عندما يفقد الجسم سوائل ولم يتم تعويضها بشرب الماء يفرز الجسم هرمون الـ ADH (Antidiuretic Hormone) الذي يعمل على تقليل ادرار البول ويأمر بإعادة الامتصاص.

When the body loses fluids, and there was no water drinking. The body will activate ADH that works on decreasing the volume of urine and orders to reabsorb the water.

عندما يكتسب الجسم سوائل يُقَلَّل من افراز هرمون الـ ADH (Antidiuretic Hormone) اذ يخرج البول بكمية كبيرة.

When the body gains fluid. The body will disable the work of ADH, because of that the volume of urine will increase.

Volumes and Osmolarities of ECF and ICF In Abnormal States

Volume contraction (decrease in the ECF volume):

Why does osmolarity decrease even the water moved from ICF to ECF?

- 1- For example, if we have Na osmolarity of 300 in ECF
- 2- Then Adrenal insufficiency occurs. The Na osmolarity changed to 100 in ECF.
- 3- After the movement of water from ECF to ICF osmolarity become 200

So, $300 > 200$

1. Diarrhea :

- Osmolarity of fluid lost \approx osmolarity of ECF (**Loss of isosmotic fluid**).
- **No** change in osmolarity.
- \downarrow volume in **ECF** and **no changes** in ICF.
- \downarrow arterial pressure.

- Decreasing in osmolarity will be equal. So, the osmolarity will be the same but the volume will change.
- The arterial pressure will decrease because the decreasing in volume of ECF.

2. Water deprivation :

- Lose **High concentration of Water** and **small concentration NaCl (Hyposmotic fluid)**.
- \uparrow Osmolarity in both ECF and ICF.
- \downarrow Volume in both ECF and ICF.

Decreasing in osmolarity because the osmolarity of ECF increased due to lose high amount of water and small amount of NaCl (**for example by excessive sweating**). So, that leads to water movement from ICF to ECF.

3. Adrenal insufficiency :

- **Aldosterone** deficiency.
- \downarrow Na in the **ECF**.
- \downarrow Osmolarity in both **ECF** and **ICF**.
- \downarrow volume of **ECF** and \uparrow volume of **ICF**.

Adrenal is a gland that secretes Aldosterone and it reabsorbs Na to bring it back to ECF. When insufficiency happened in adrenal gland. The amount of Aldosterone will decrease and leads to a low amount of Na in ECF. According that water is moved from ECF to ICF.

Volume expansion (increase in the ECF volume):

1. Infusion of isotonic NaCl.

- **Isosmotic expansion.**
- **No change in osmolarity.**
- **↑ Volume in ECF and no changes in ICF.**

Happened only if adding an osmotic NaCl fluid that does not effect on the osmolarity of ECF. The volume will increase and ICF will remain the same.

2. High NaCl intake.

- **↑ eating salt.**
- **Hypersomotic expansion.**
- **↑ Osmolarity in both ECF and ICF.**
- **↑ volume of ECF ↓ volume of ICF.**

Increasing in osmolarity of ECF due to the High amount of NaCl. So, net movement of water will occur from ICF to ECF.

(راجع الملاحظة في بداية هذا العنوان لمعرفة لماذا لم تعود الأسمولية لطبيعتها)

3. Syndrome of inappropriate antidiuretic hormone (SIADH):

- **↓ Osmolarity in both ECF and ICF.**
- **↑ Volume in both ECF and ICF.**

SIADH function is water reabsorption. If there is an excessive secretion of this hormone the water will go back to ECF. So, That will result in increasing of ECF volume and decreasing of osmolarity And ICF volume increase and osmolarity will decrease too.

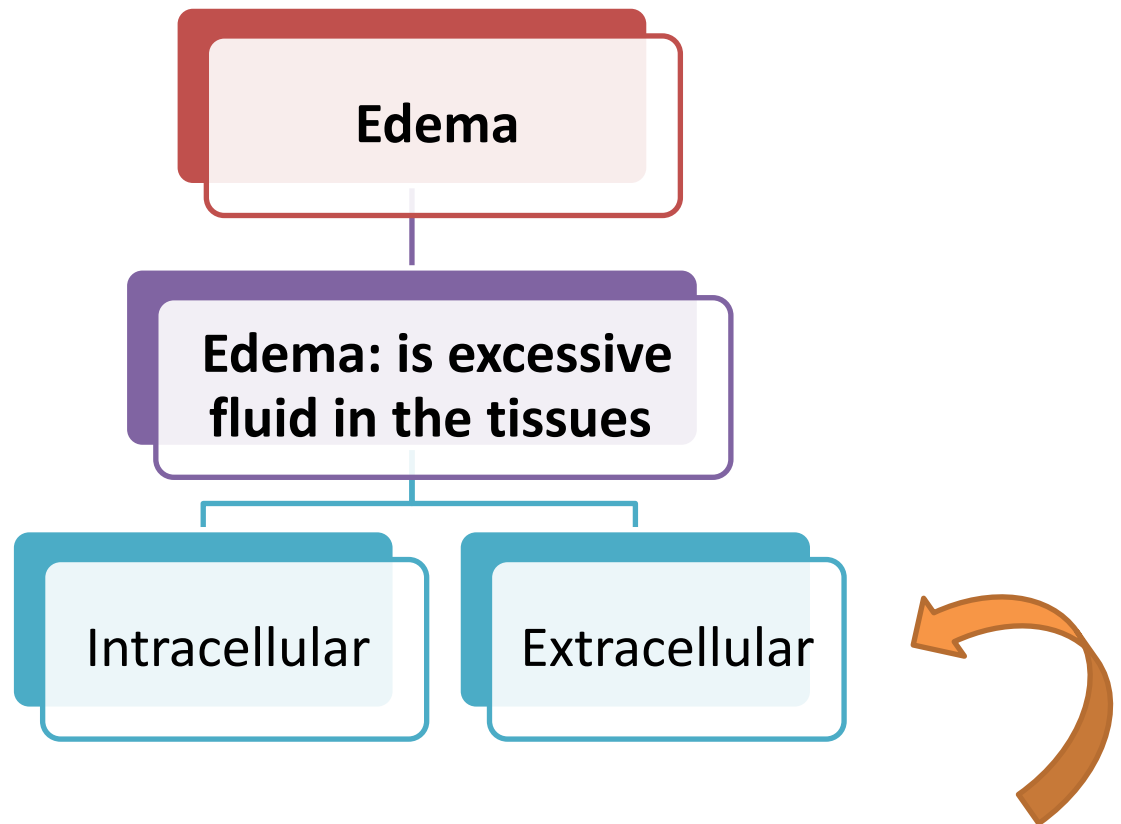
Summary of Volumes and Osmolarities of ECF and ICF In Abnormal States

Volume Contraction

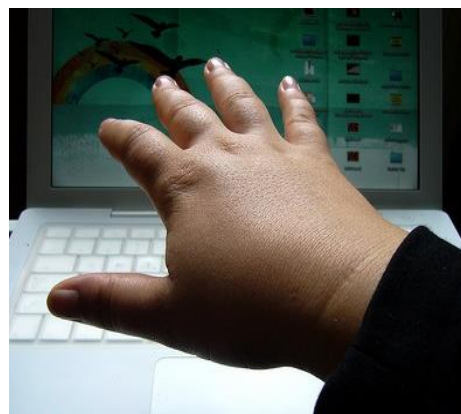
	ECF		ICF	
	volume	osmolarity	volume	osmolarity
Diarrhea	↓	-	-	-
Water deprivation	↓	↑	↓	↑
Adrenal insufficiency	↓	↓	↑	↓

Volume Expansion

Infusion of isotonic NaCl	↑	-	-	-
High NaCl intake	↑	↑	↓	↑
SIADH	↑	↓	↑	↓

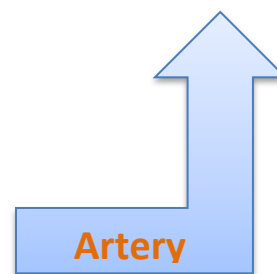
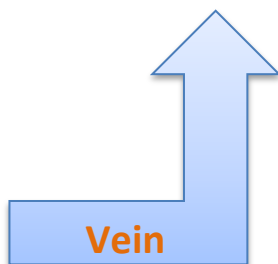
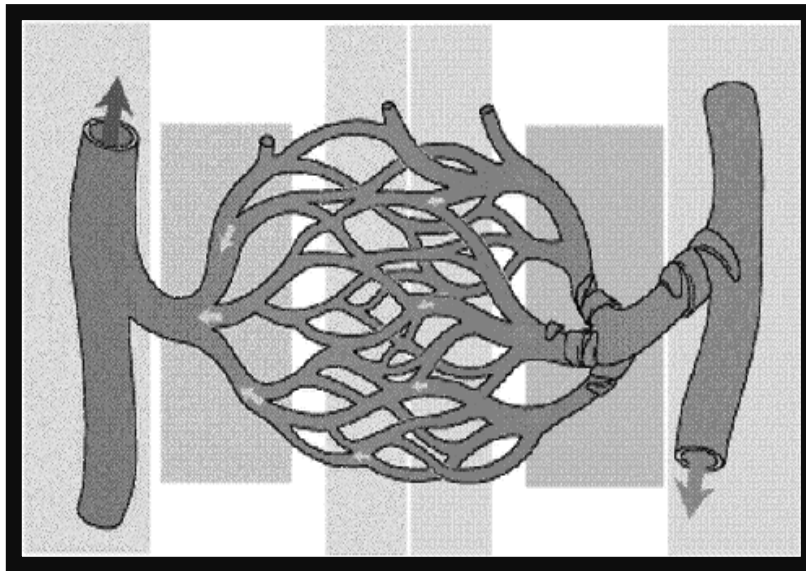


- **Edema occurs mainly in the ECF compartment.**



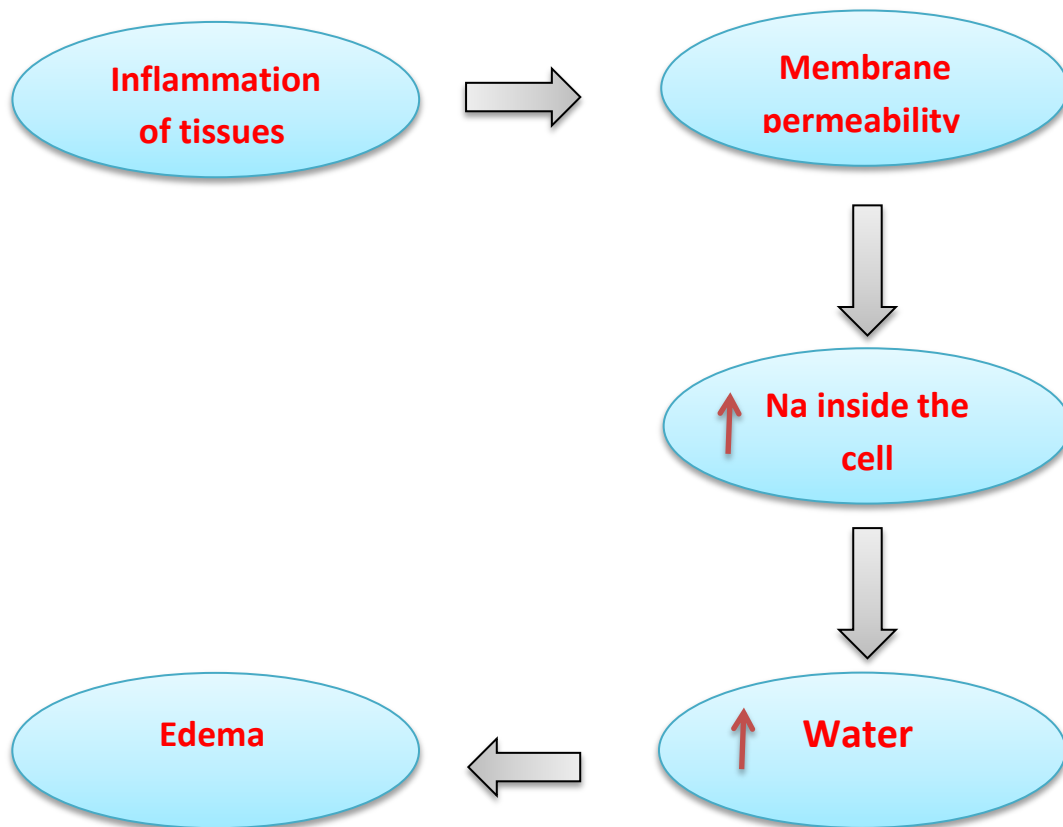
Extracellular edema

Common clinical cause is excessive capillary fluid filtration e.g. heart failure.



For example: if there is a problem in the heart then Pressure of the capillaries increase then the fluid filter and inter the tissue e.g. heart failure.

Intracellular edema



Inflammation of tissues caused imbalance in cell membrane. So, when Na molecules enter the cell. Water molecules will cross too.

Summary

- Homeostasis is the ability to maintain a relatively stable internal environment in an ever-changing outside world.
- The internal environment of the body (ECF) is in a dynamic state of equilibrium.
- All different body systems operate in harmony to provide homeostasis.
- Some factors like dehydration can cause changing in the volume and osmolarity of ECF AND ICF.
- Edema is excessive fluid in the tissues and it can be ECF or ICF edema.

Related videos:

Homeostasis 1, Physiological Principles

https://www.youtube.com/watch?feature=related&v=5HS66q_OA8g&app=desktop

Homeostasis

<https://www.youtube.com/watch?v=0kxsviCkS40&desktop=&app=desktop>



Multiple Choice Questions

Q1: which of the following determine the set point of maintain the body?

- A- Stimulus
- B- Control Center
- C- Effector
- D- Receptor

Answer is : B

Q2: Decrease in the ECF volume takes place in?

- A- Volume expansion
- B- Edema
- C- Volume contraction
- D- SIADH

Answer is : C

Q3: Which of these is an example of volume expansion ?

- A- Adrenal insufficiency
- B- Diarrhea
- C- SIADH
- D- Water deprivation

Answer is : C

Q4: Which of the following statement is true?

- A- Edema occurs mainly in ECF compartments
- B- Edema occurs mainly in ICF compartments
- C- Hyperosmotic fluid contains small NaCl
- D- Hyperosmotic fluid contains large Water

Answer is : A

Q5: Infusion of isotonic NaCl causes?

- A- Increase in ICF osmolarity
- B- Increase in ECF osmolarity
- C- Increase in ICF volume
- D- Increase in ECF volume

Answer is : D