

Homeostasis

(1+2)

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- **At the end of this session, the students should be able to:**
 - **Understand the concept and importance of homeostasis.**
 - **Understand how the steady state is monitored.**
 - **Discuss the physiologic control mechanisms that enable maintenance of the normal steady state of the body.**
 - **Identify and describe the compensatory responses to any change in the steady state.**
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- **Homeostasis (2)**
 -
 - **Define a feedback mechanism and describe its components.**
 - **Differentiate between positive and negative feedback mechanisms and give examples for each in the body.**
 - **Apply the knowledge gained in feedback mechanisms to disturbances in the disturbances in ECF volume and osmolarity.**

Homeostasis

- 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**

Homeostatic Control Mechanisms

- The **variable** produces a **change in the body**
- The three interdependent components of control mechanisms are:
 - **Receptor** – monitors the environments 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

Regulation of body functions

1. Nervous system

- **sensory input.**
- **central nervous system.**
- **motor out put.**

Negative Feedback Control — Example

blood pressure rises

cancel

receptors
(in aortic and
carotid sinuses)

blood pressure falls

regulator
center in brain

arterial
walls relax

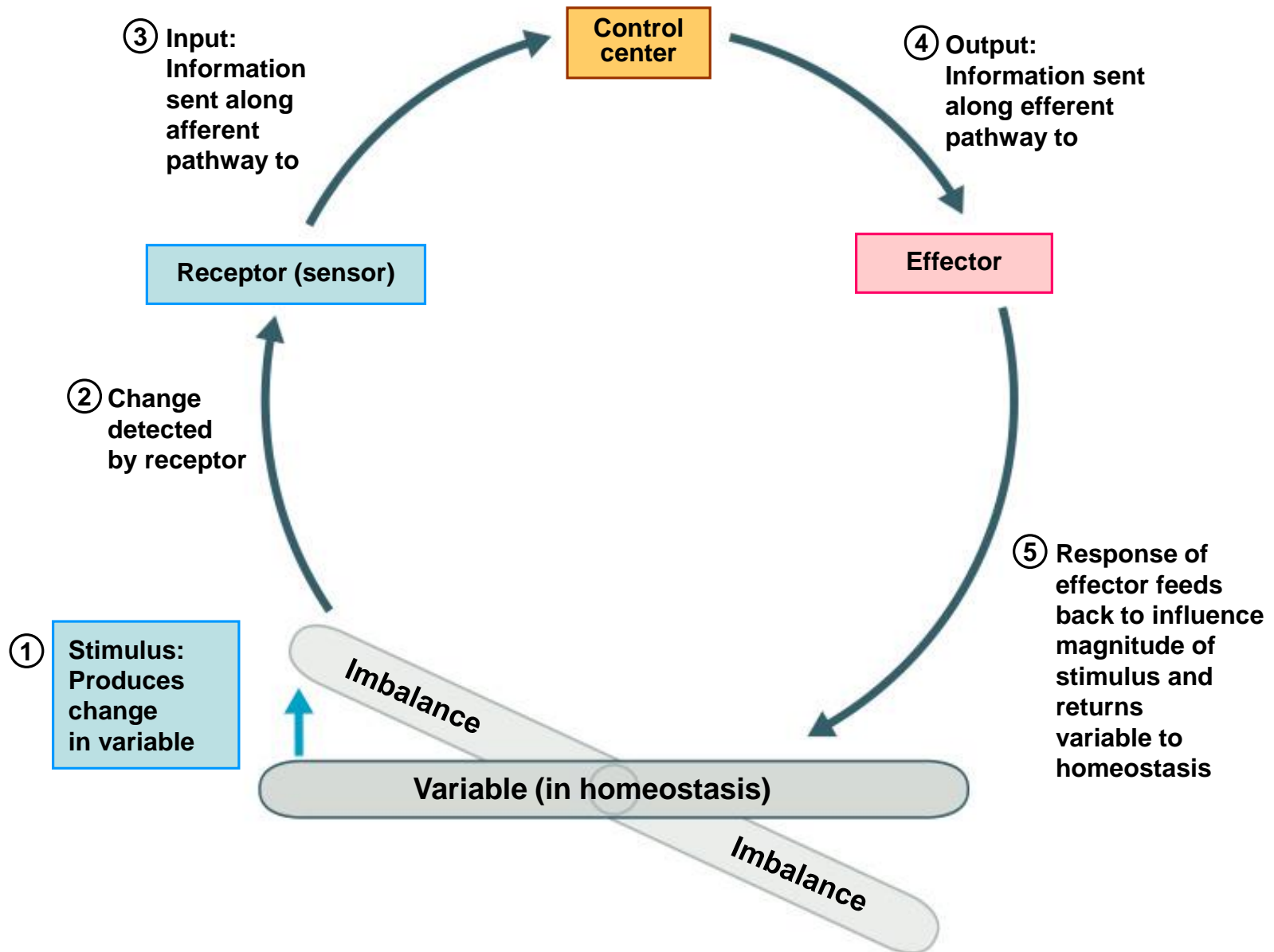
2. Hormonal system of regulation.

- Endocrine gland.

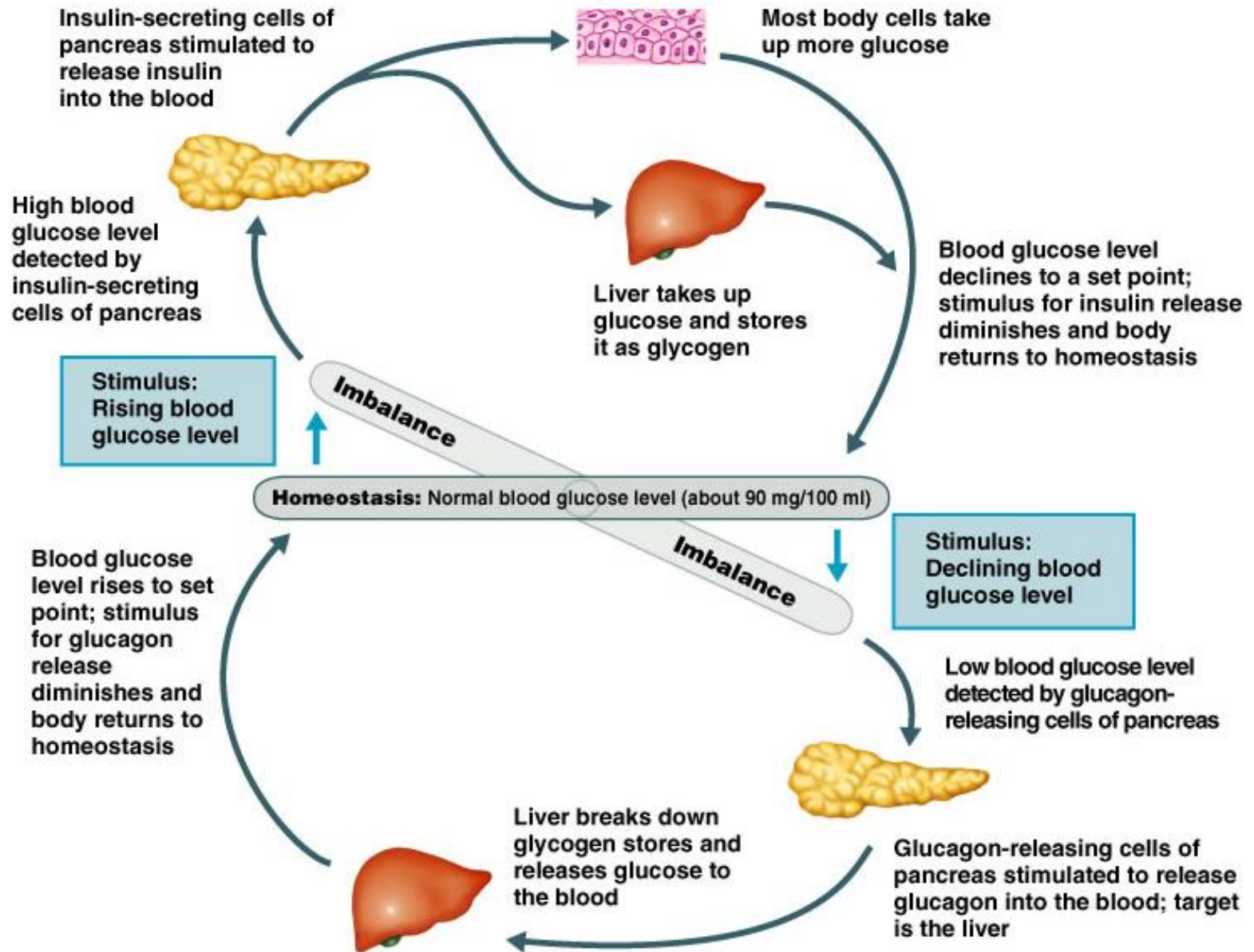
Pancreas, thyroid

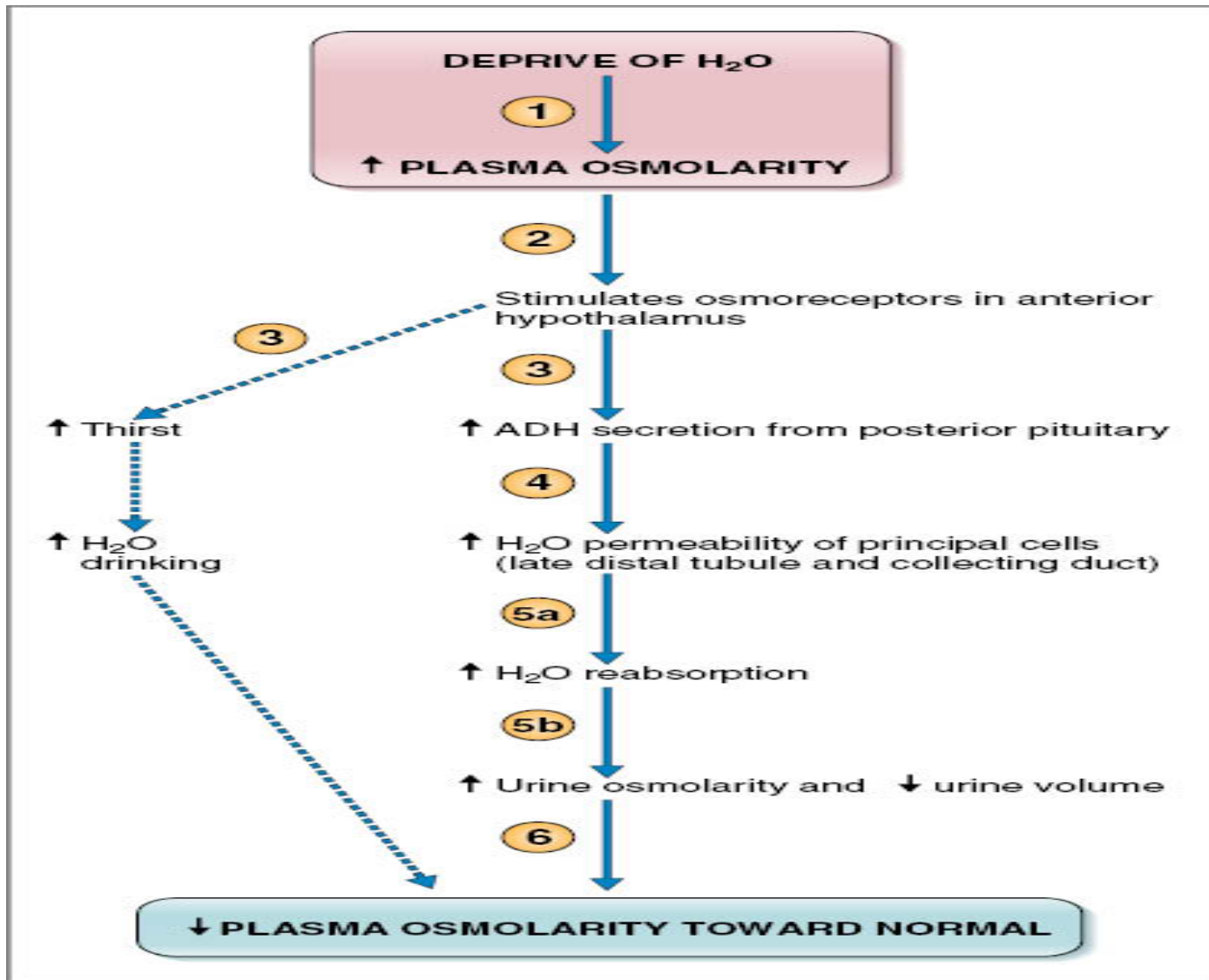
e.g. : insulin control glucose level.

Homeostatic Control Mechanisms



Feedback





DRINK H₂O
①
↓ PLASMA OSMOLARITY

②

Inhibits osmoreceptors in anterior hypothalamus

③

③

↓ ADH secretion from posterior pituitary

↓ Thirst

④

↓ H₂O permeability of principal cells (late distal tubule and collecting duct)

↓ H₂O drinking

⑤a

↓ H₂O reabsorption

⑤b

↓ Urine osmolarity and ↑ urine volume

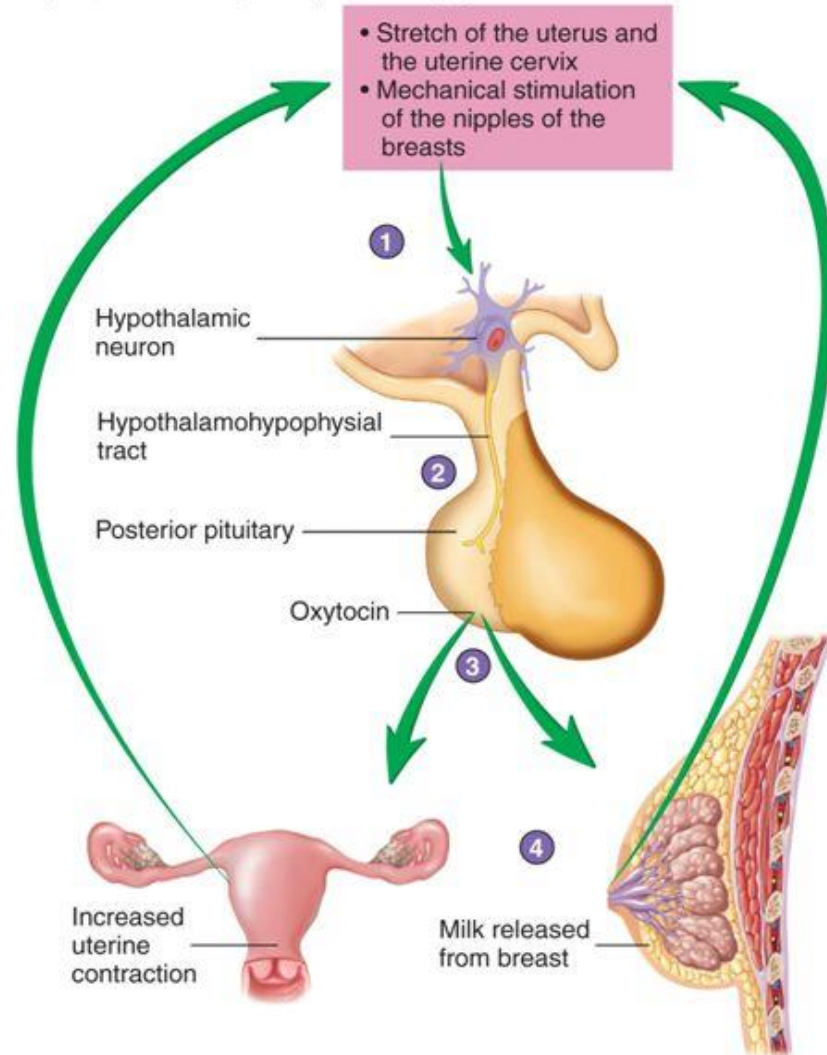
⑥

↑ PLASMA OSMOLARITY TOWARD NORMAL

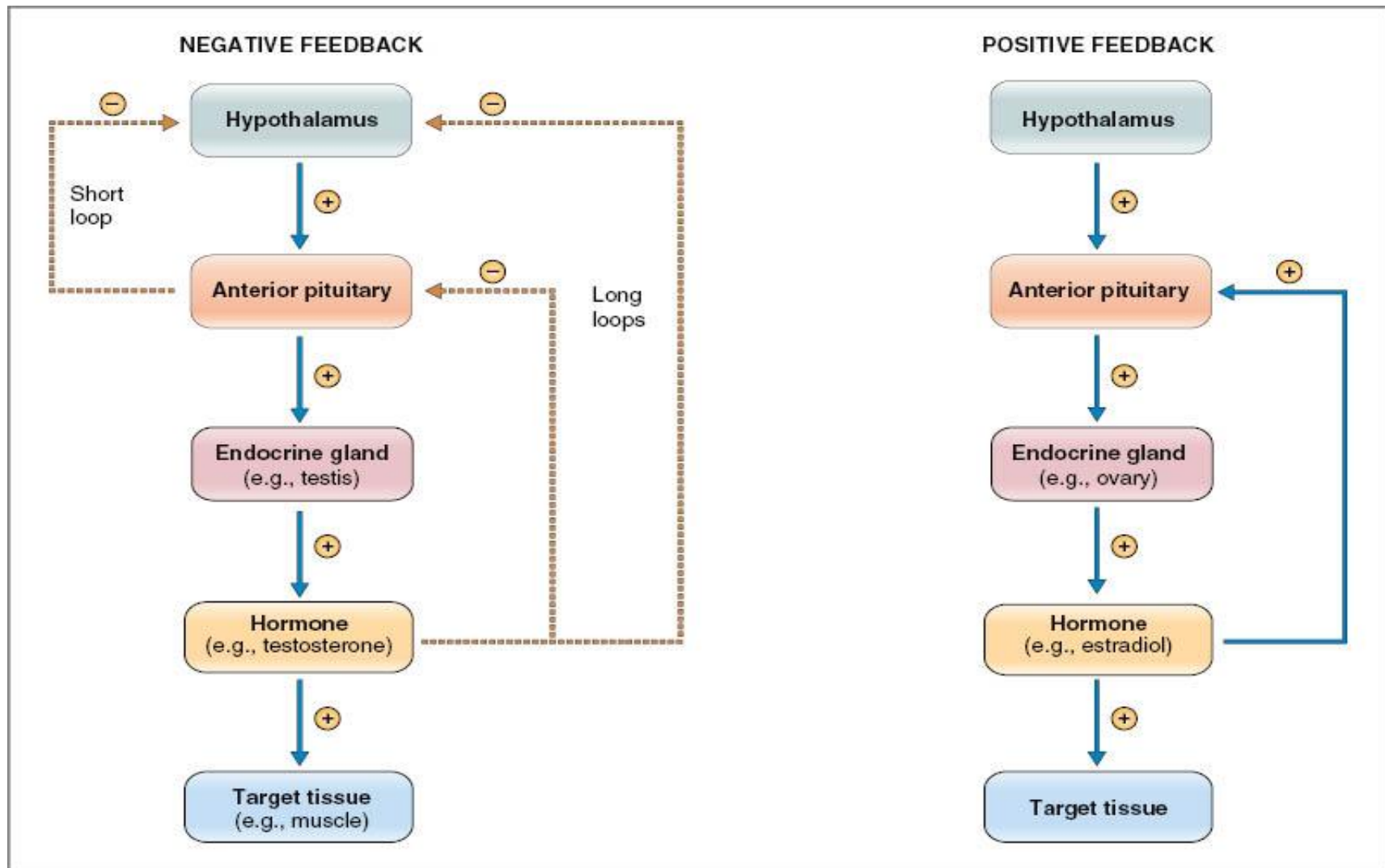
Control of Oxytocin Secretion

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- 1 Stretch of the uterus and the uterine cervix or stimulation of the breasts' nipples increases action potentials in axons of oxytocin-secreting neurons.
- 2 Action potentials are conducted by sensory neurons from the uterus and breast to the spinal cord and up ascending tracts to the hypothalamus.
- 3 Action potentials are conducted by axons of oxytocin-secreting neurons in the hypothalamohypophysial tract to the posterior pituitary, where they increase oxytocin secretion.
- 4 Oxytocin enters the circulation, increasing contractions of the uterus and milk ejection from the lactating breast.



FEEDBACK MECHANISM

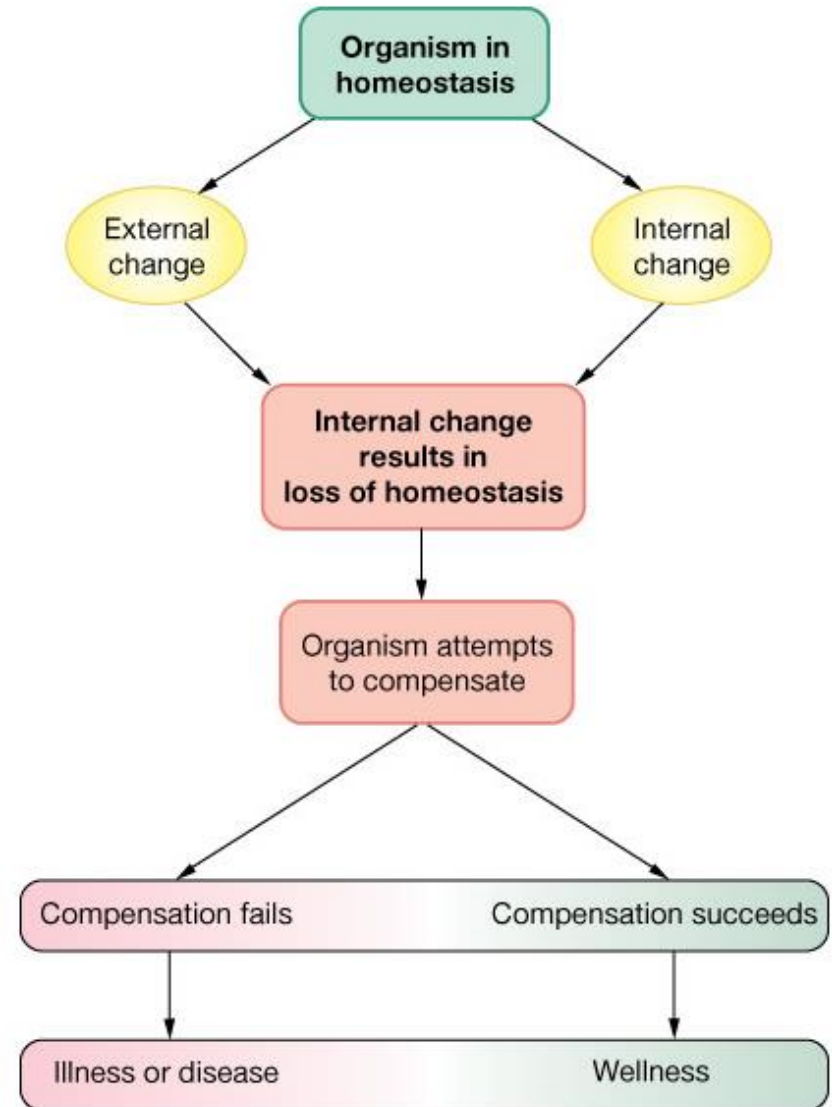


Homeostatic Imbalance

- **Disturbance** of homeostasis or the body's normal equilibrium

Homeostasis & Controls

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



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- **Apply the knowledge gained in feedback mechanisms to disturbances in the disturbances in ECF volume and osmolarity.**

Osmotic equilibrium is maintained between intracellular and extracellular fluids:

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

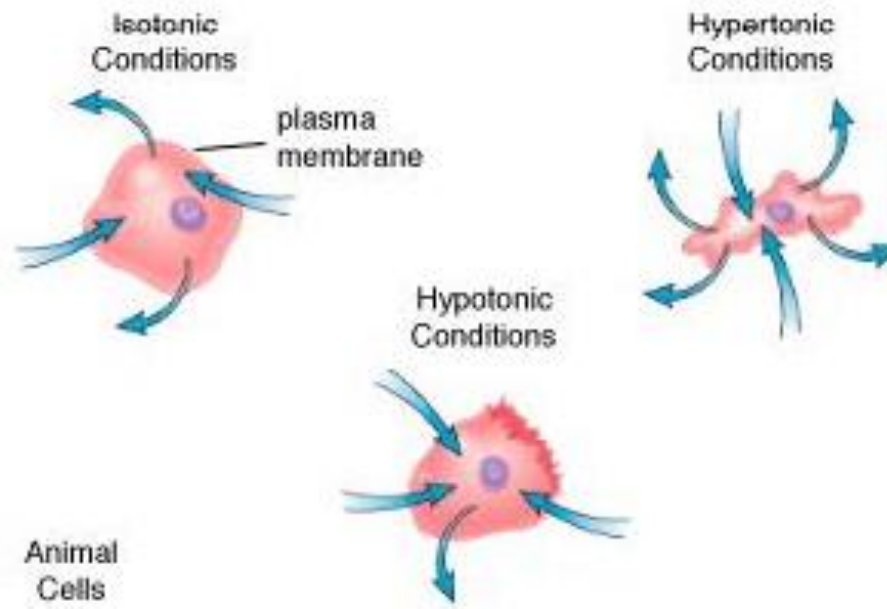
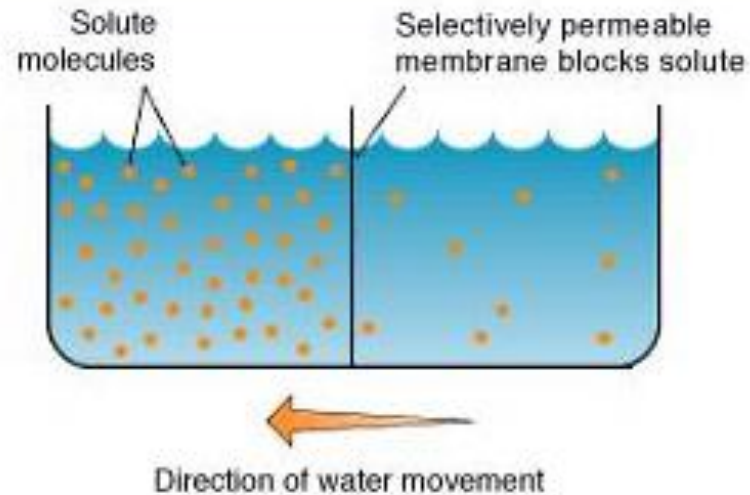
Mechanisms for Movement

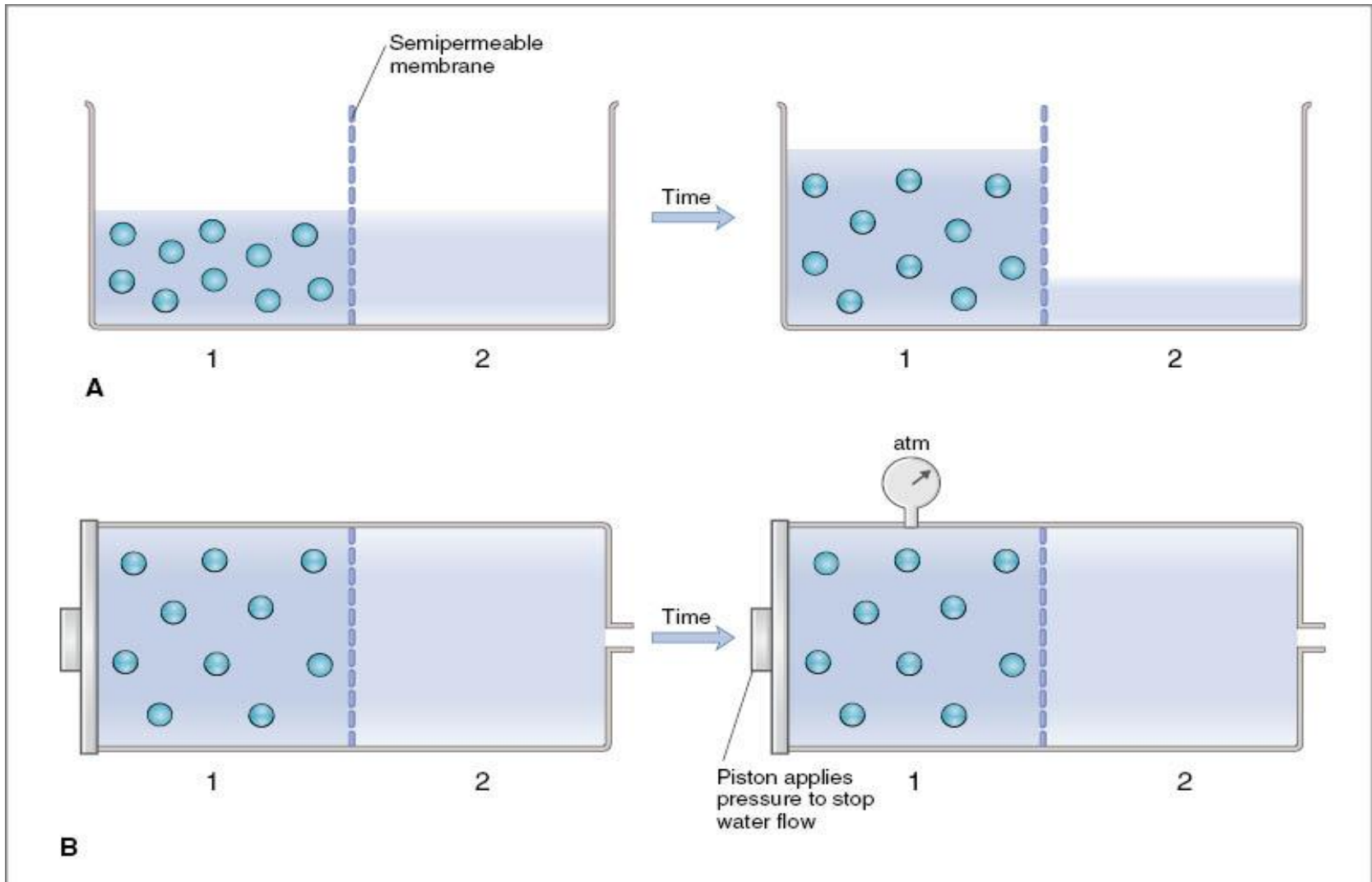
- **3 General mechanisms:**
 - 1. Simple diffusion (passive)**
 - 2. Facilitated transport (passive)**
 - 3. Active transport**

osmosis

- net diffusion of water from a region of **high water** concentration to region of **low water** concentration.

Osmosis

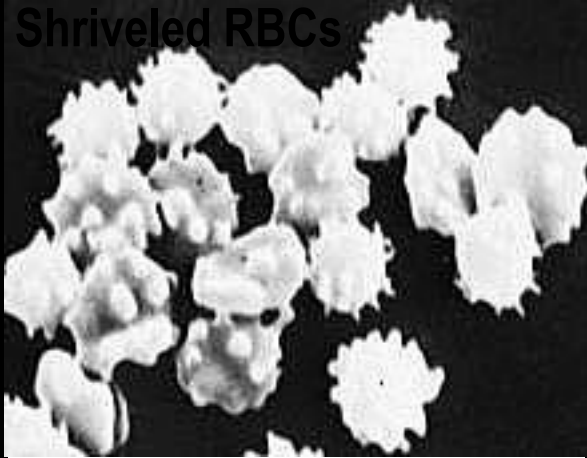




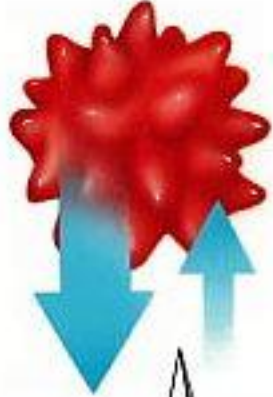
Tonicity:

- means effective osmolality in relation to plasma (=285 milliosmol/L). Therefore, isotonic solutions [e.g. 0.9% saline solution] **have almost equal tonicity** of the plasma, hypotonic solutions [e.g. 0.45% saline solution] **have < tonicity** than plasma, and hypertonic [e.g. 3% saline solution] solutions **have > tonicity** than plasma.

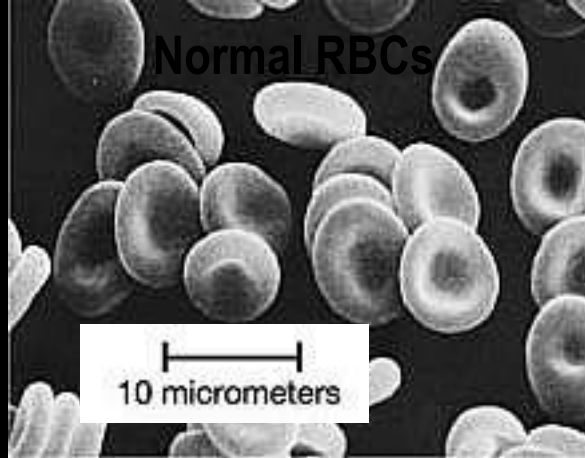
Osmosis



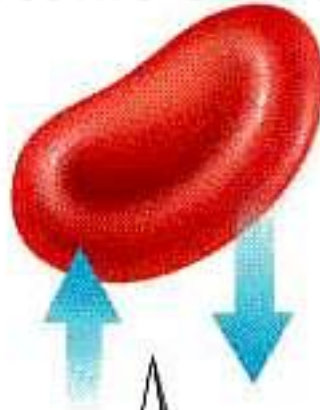
Hypertonic Solution



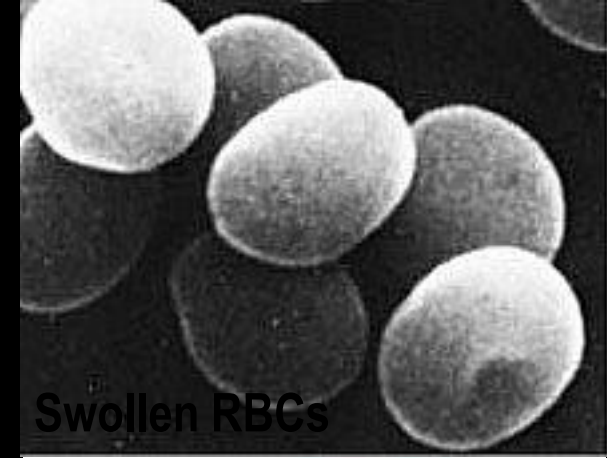
Net movement of water out of cells



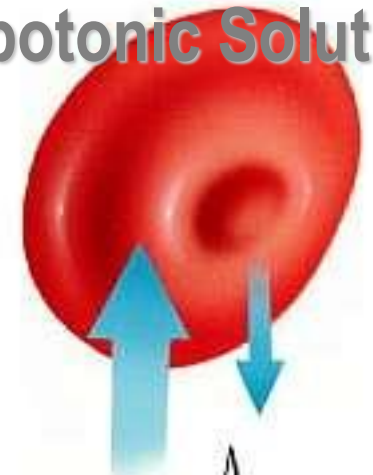
Isotonic Solution



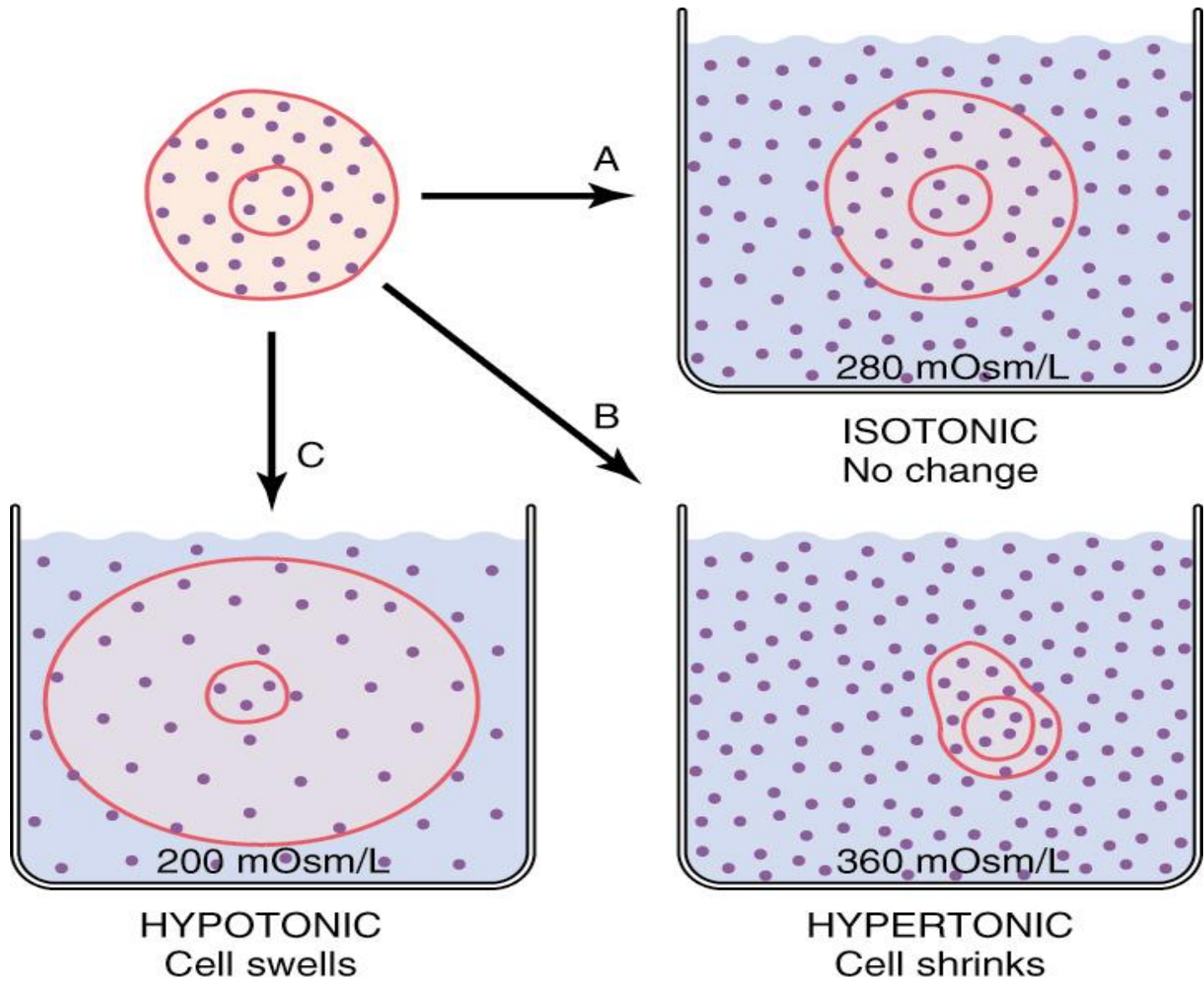
Equal movement of water into and out of cells



Hypotonic Solution



Net movement of water into cells



Osmosis

- **If environment is:**
 - **Hypertonic:**
 - **MORE SOLUTES** outside cell
 - **MORE WATER IN CELL**
 - **over time, cell loses water**
 - **Isotonic:**
 - **same**
 - **No change in cell volume**
 - **Hypotonic:**
 - **LESS SOLUTES** outside cell
 - **LESS WATER IN CELL, more solutes in cell.**
 - **over time, cell gains water**

❖ **Isotonic solution :**

- (no swells or shrink)
- **0.9% solution of sodium chloride .**
- **same in and out .**

❖ **Hypotonic solution :**

- (swelling)↓ **0.9%**
- **in is higher than out .**

❖ **Hypertonic solution :**

- (shrink) ↑ **0.9%**
- **out is higher than in**

Glucose and other solutions administered for nutritive purposes

- **People who can not take adequate amount of food.**
- **Slowly.**
- **Prepared in isotonic solution.**
- **Water is excreted.**

Volumes And Osmolarities Of ECF and ICF In Abnormal States.

- **Some factors can cause the change:**
 - **dehydration .**
 - **intravenous infusion.**
 - **abnormal sweating.**
 - **etc..**

- **Changes in volume :**

- 1. Volume expansion.**

- 2. Volume contraction.**

Volume contraction (decrease in the ECF volume) :



1. Diarrhea.

- osmolarity of fluid lost \approx osmolarity of ECF

(loss of isosmotic fluid).

- ↓ volume in ECF.**
- ↓ arterial pressure.**

2. Water deprivation :

- **Water and NaCl.**
- **Osmolarity and volume will change .**
- **Hyposmotic** fluid (small NaCl
large water)
-  **Osmolarity in both ECF and ICF.**
-  **Volume in both ECF and ICF.**

3. Adrenal insufficiency:

- Aldosterone deficiency.
- ↓ Na in the ECF.
- ↓ osmolarity in both .
- ↓ in ECF volume.
- ↑ in ICF volume.

Volume Expansion

1. - **Infusion of isotonic NaCl.**

-  **ECF volume.**

- **No change in osmolarity.**

- **Isosmotic expansion .**

2. High NaCl intake.

- ↑ eating salt.
- ↑ **osmolarity** in both.
- ↓ **volume of ICF** .
- ↑ **volume of ECF** .
- **hyperosmotic volume expansion.**

3- Syndrome of inappropriate antidiuretic hormone (SIADH):

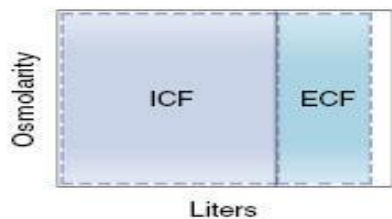
-  **volume**
-  **osmolarity**

NORMAL STATE

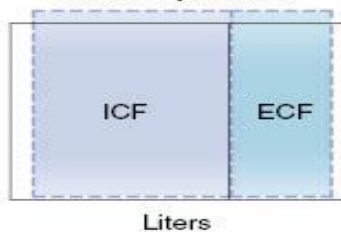


VOLUME CONTRACTION

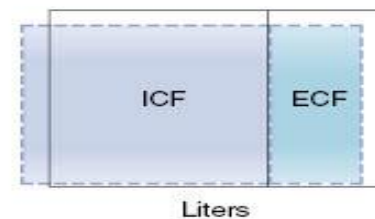
Diarrhea



Water deprivation

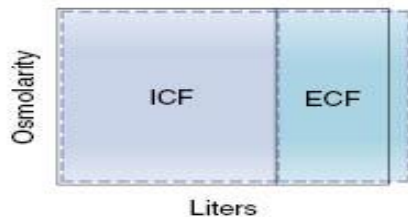


Adrenal insufficiency

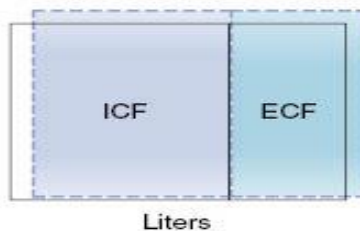


VOLUME EXPANSION

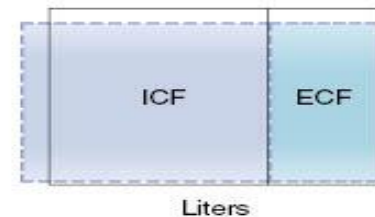
Infusion of isotonic NaCl



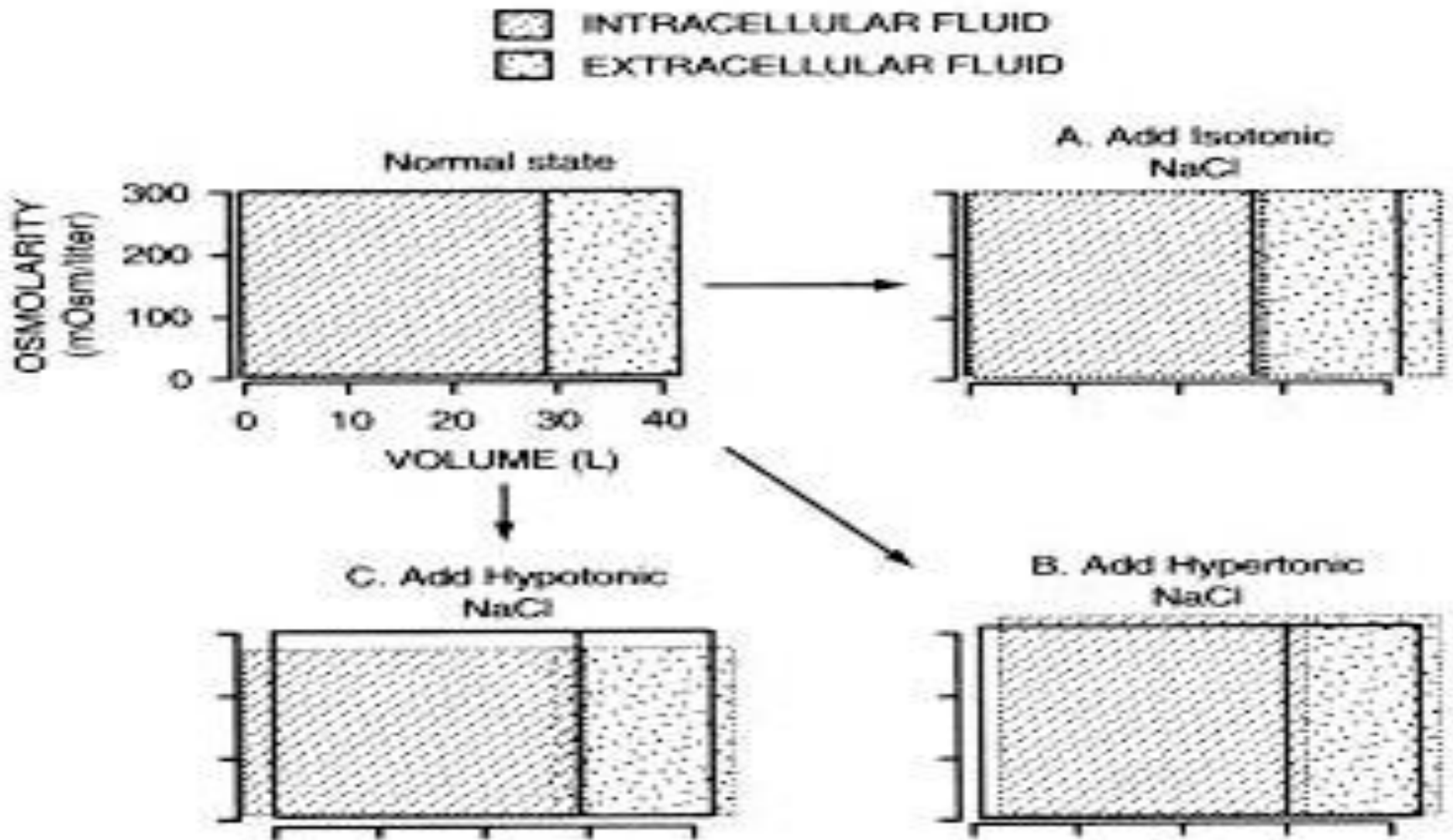
High NaCl intake



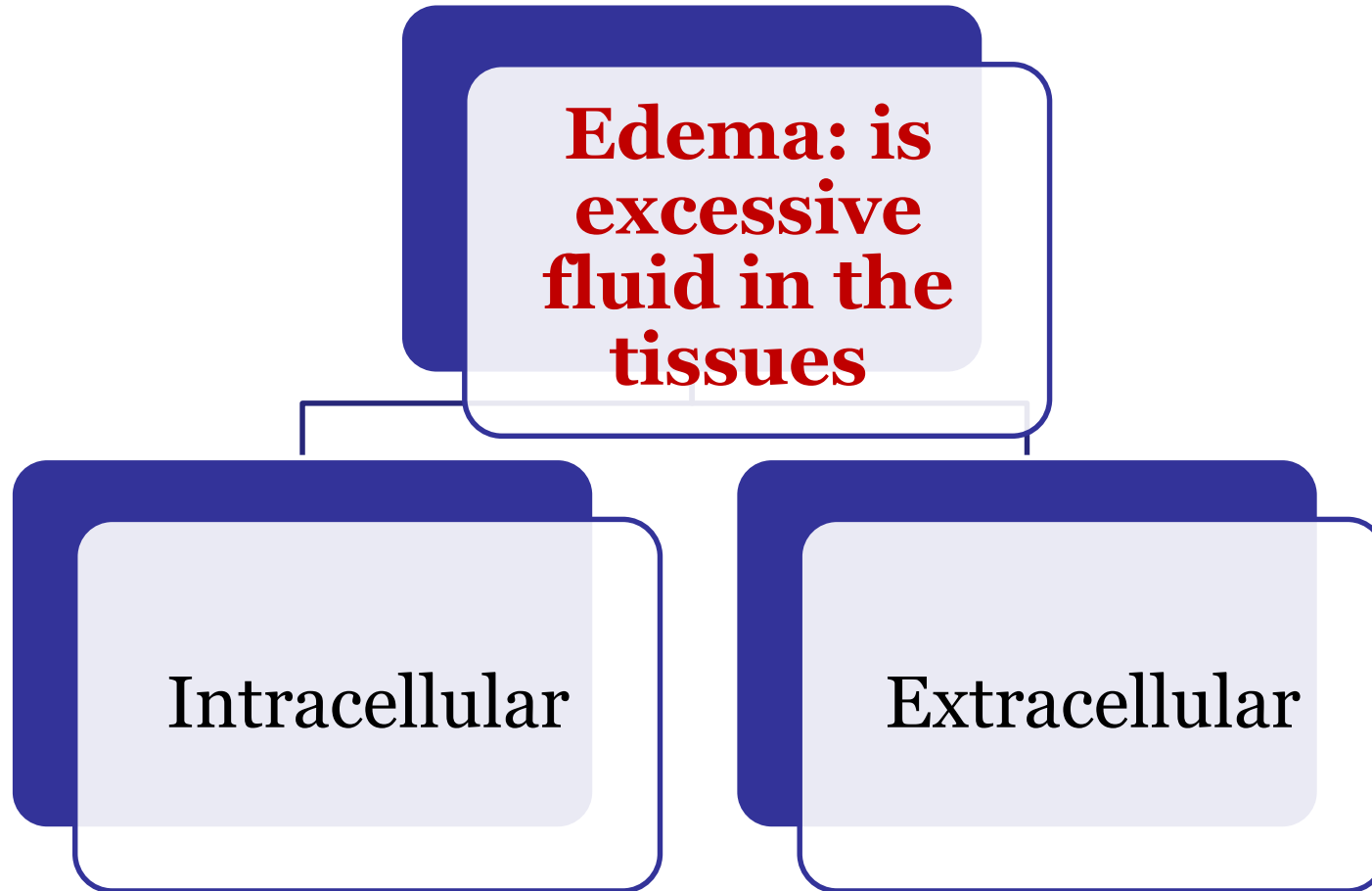
SIADH



Effect of adding saline solution to the ECF



Edema



Edema occurs mainly in the extracellular fluid compartment

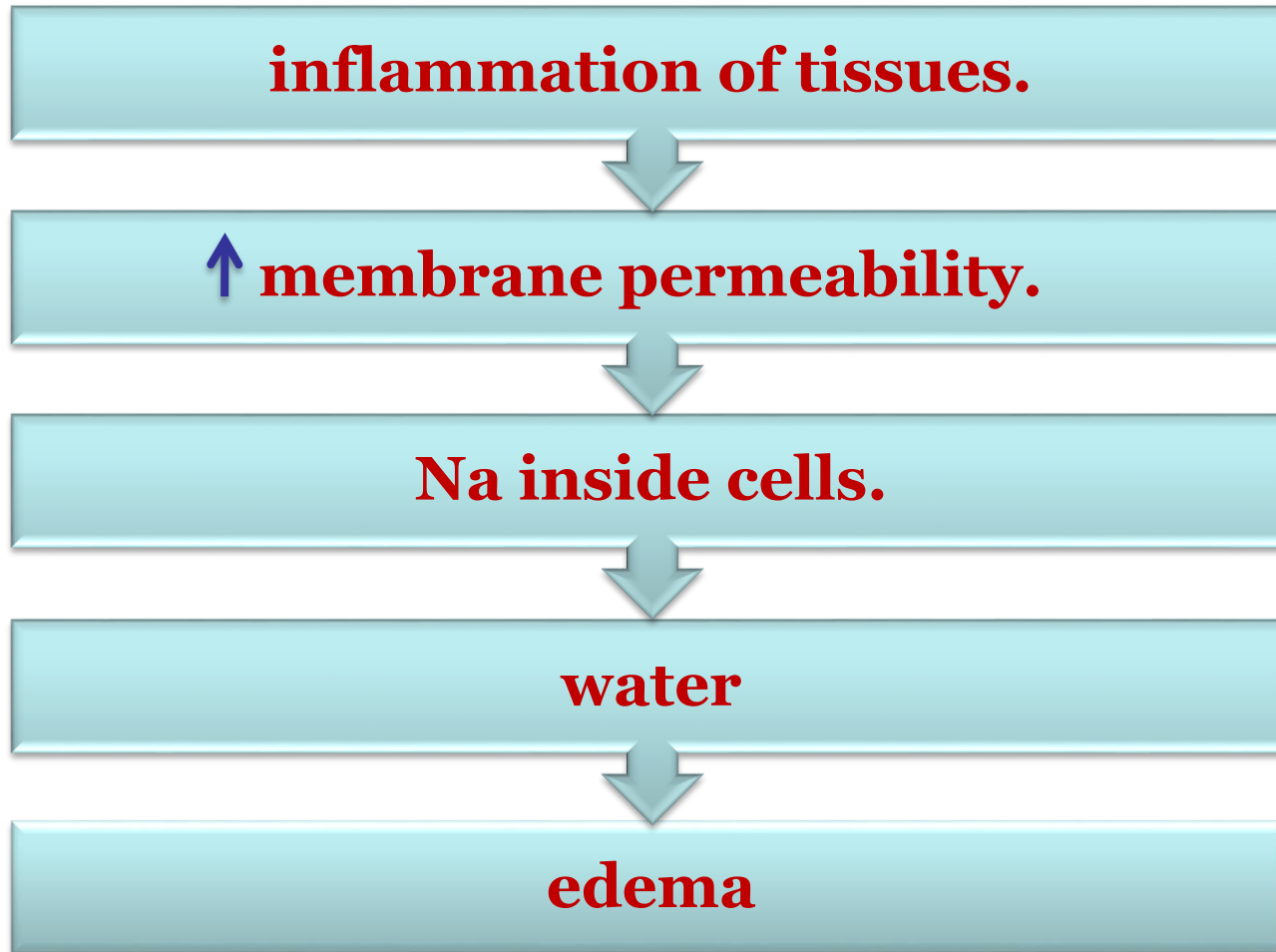


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Edema (swelling) of the ankles and foot

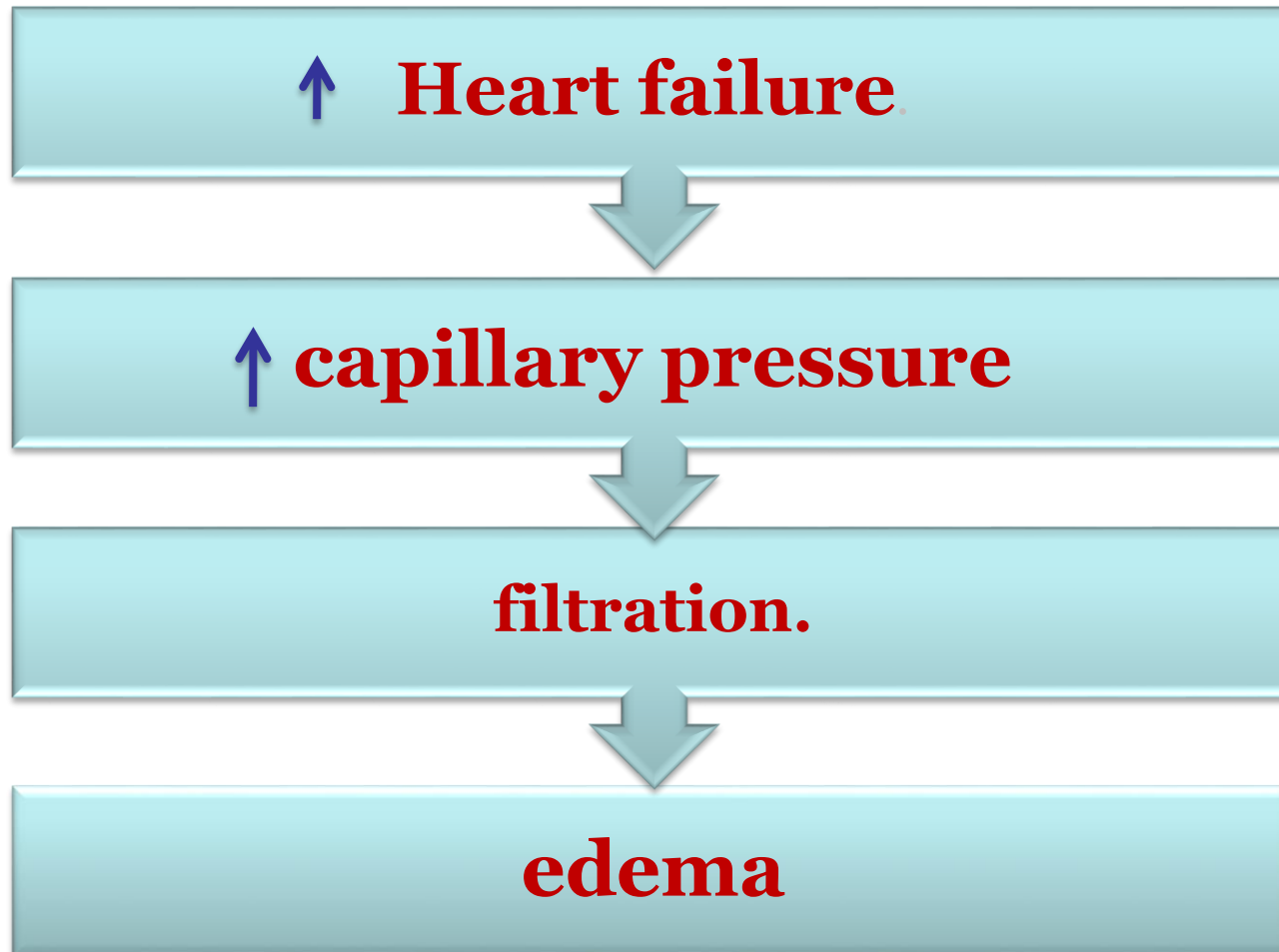


Intracellular Edema:

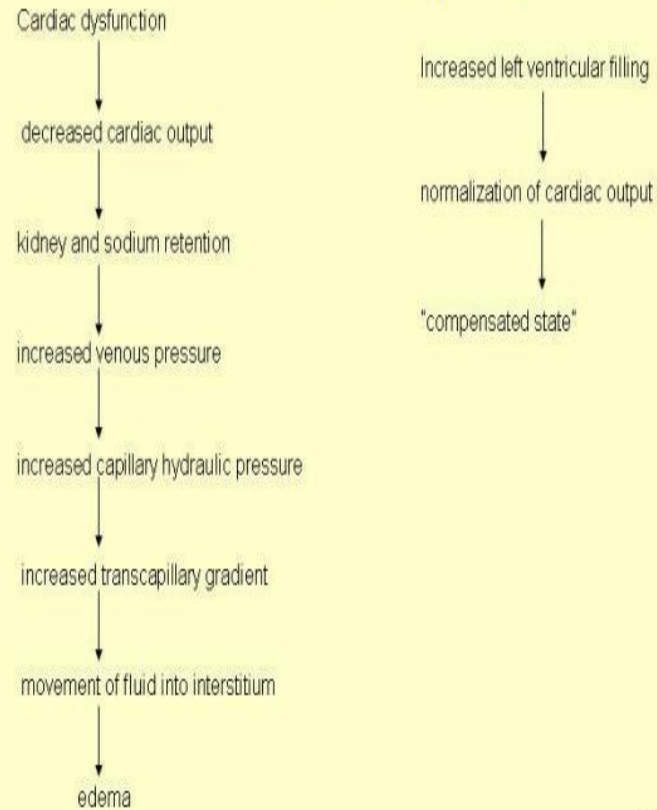


Extracellular Edema:

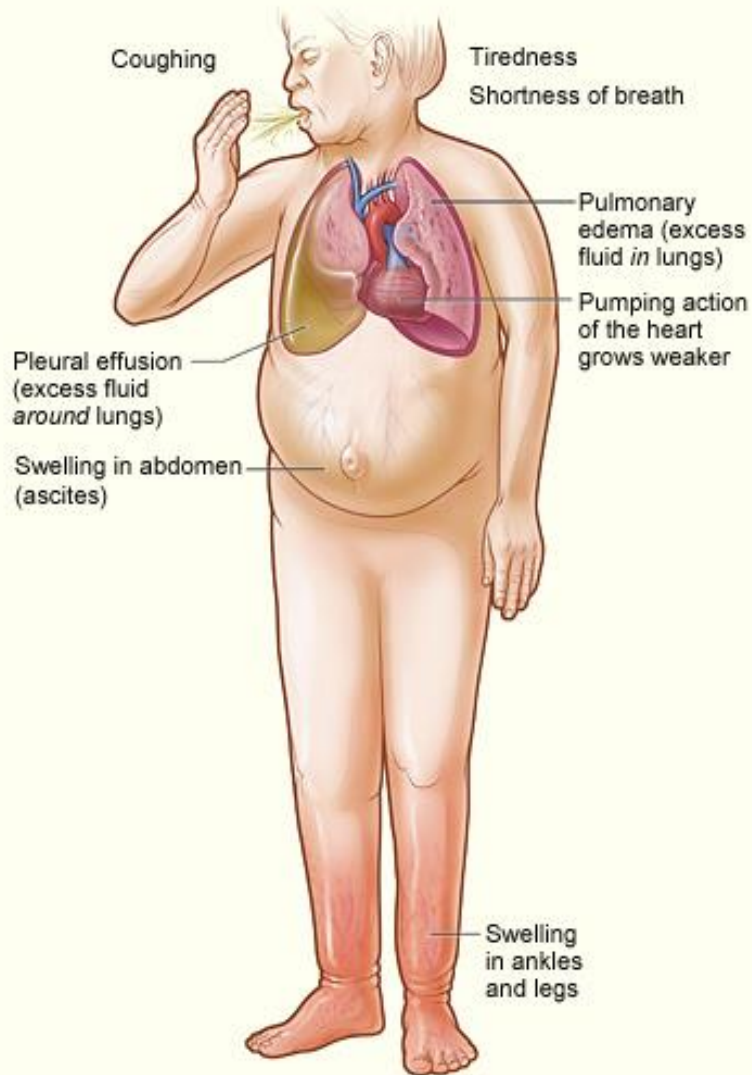
common clinical cause is excessive capillary fluid filtration.



Pathophysiology of edema in heart failure (HF)



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Decreased Cardiac Output

