Homeostasis
(1+2)

- **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.**

- **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

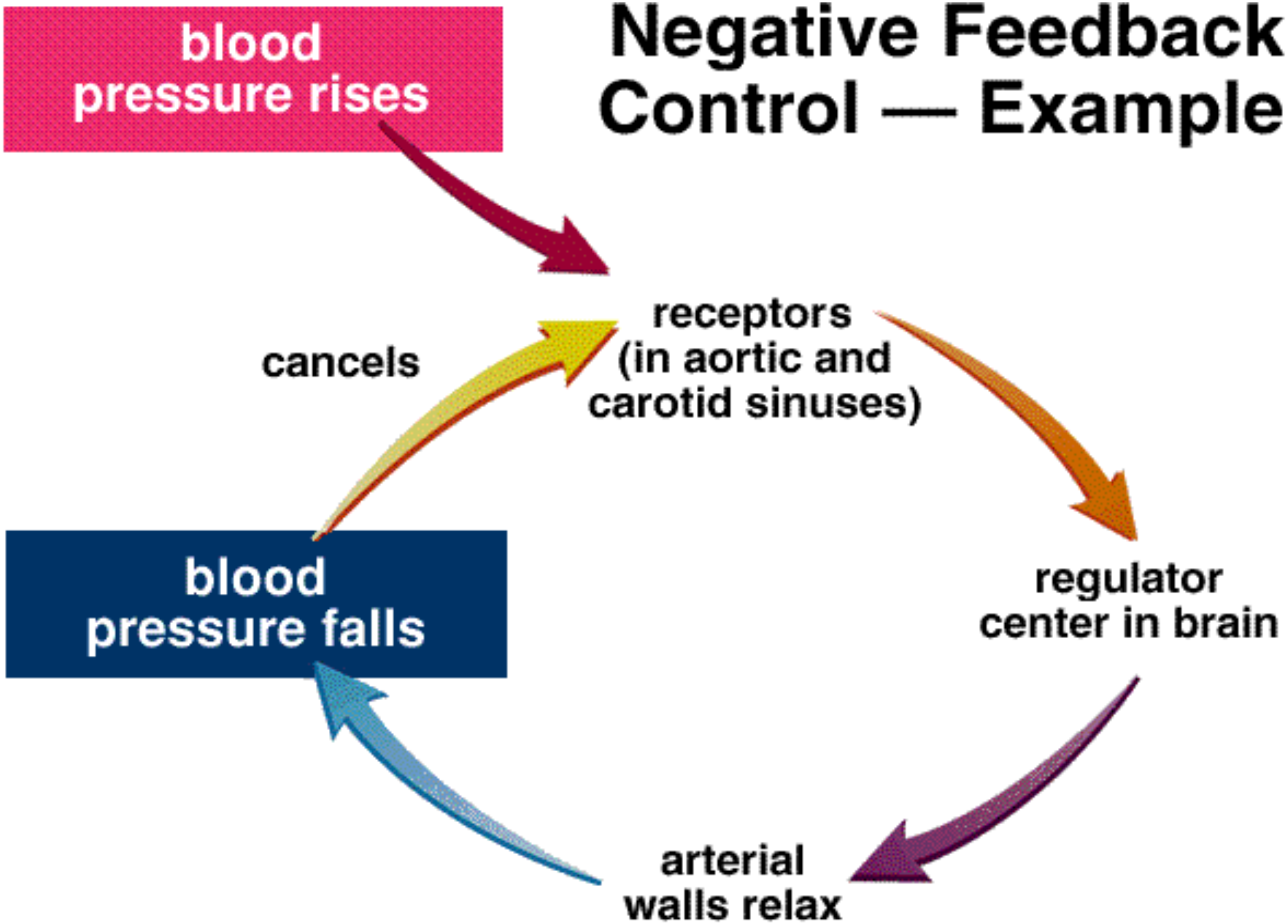
- The variable produces a change in the body
- The three interdependent components of control mechanisms are:
  - Receptor – monitors the environments and responds to changes (stimuli)
  - Control center – determines the set point at which the variable is maintained
  - Effector – provides the means to respond to the stimulus

Regulation of body functions

1. **Nervous system**

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

Negative Feedback Control — Example



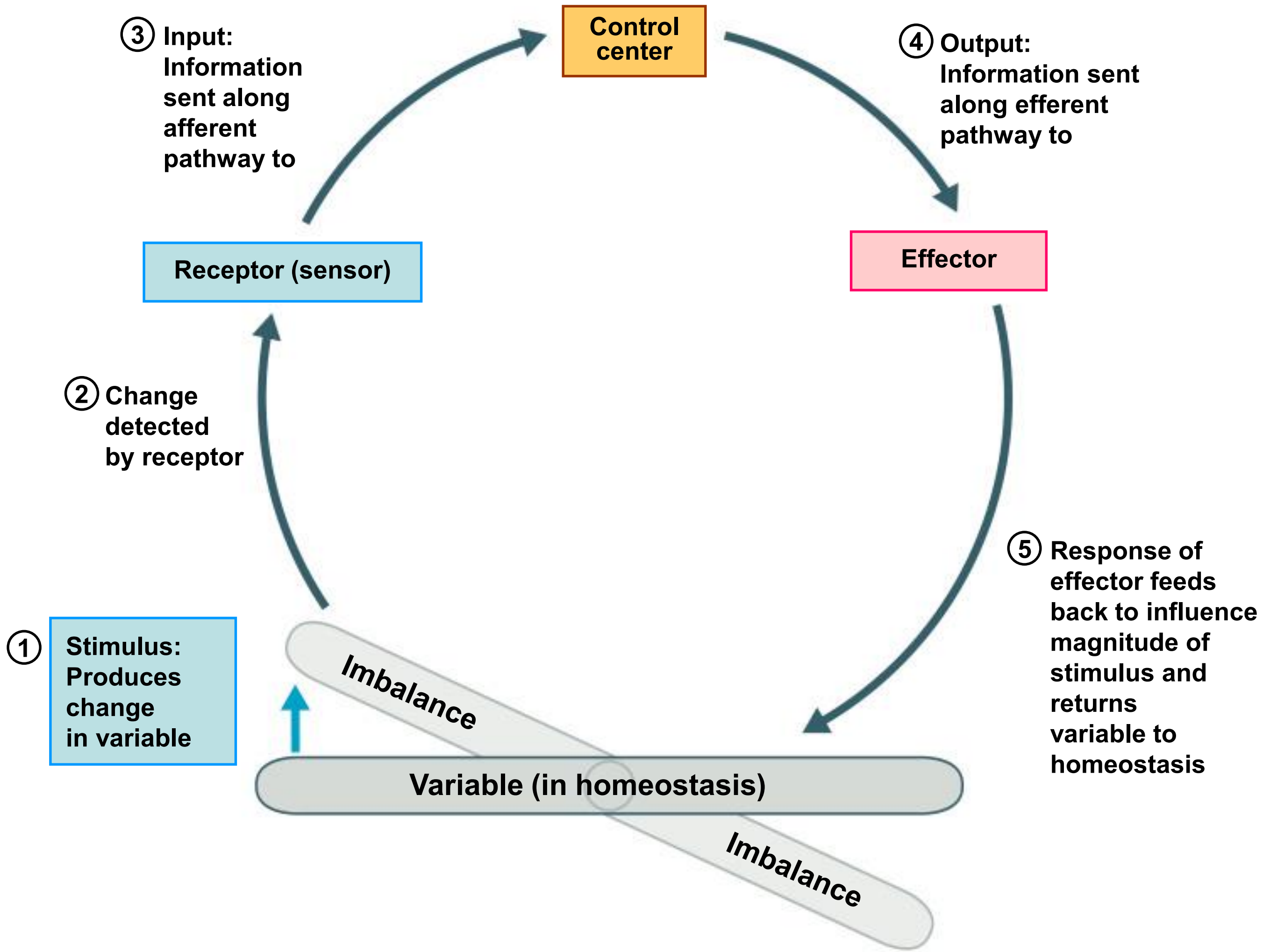
2. Hormonal system of regulation.

- Endocrine gland.

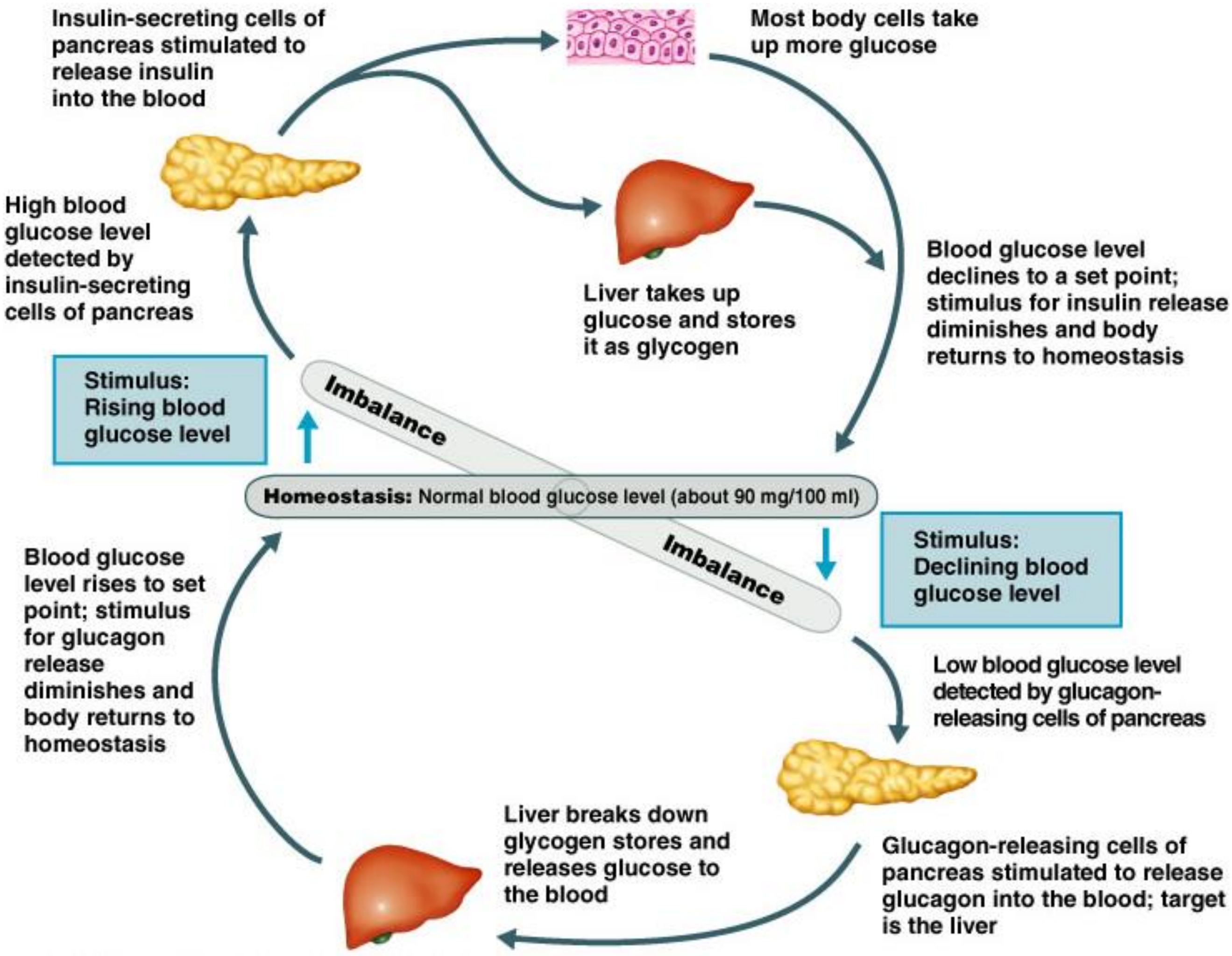
  Pancreas, thyroid

e.g. : insulin control glucose level.

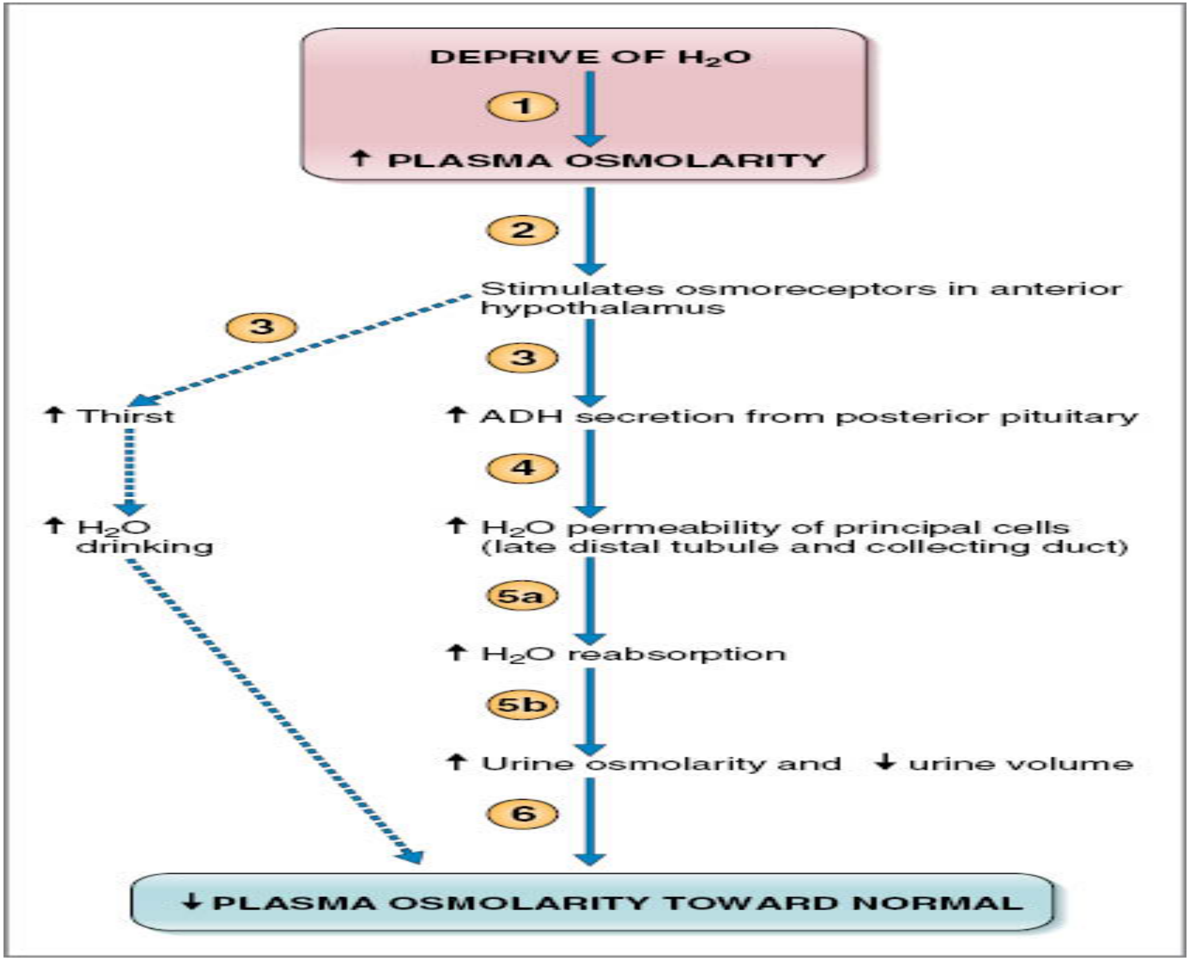
Homeostatic Control Mechanisms

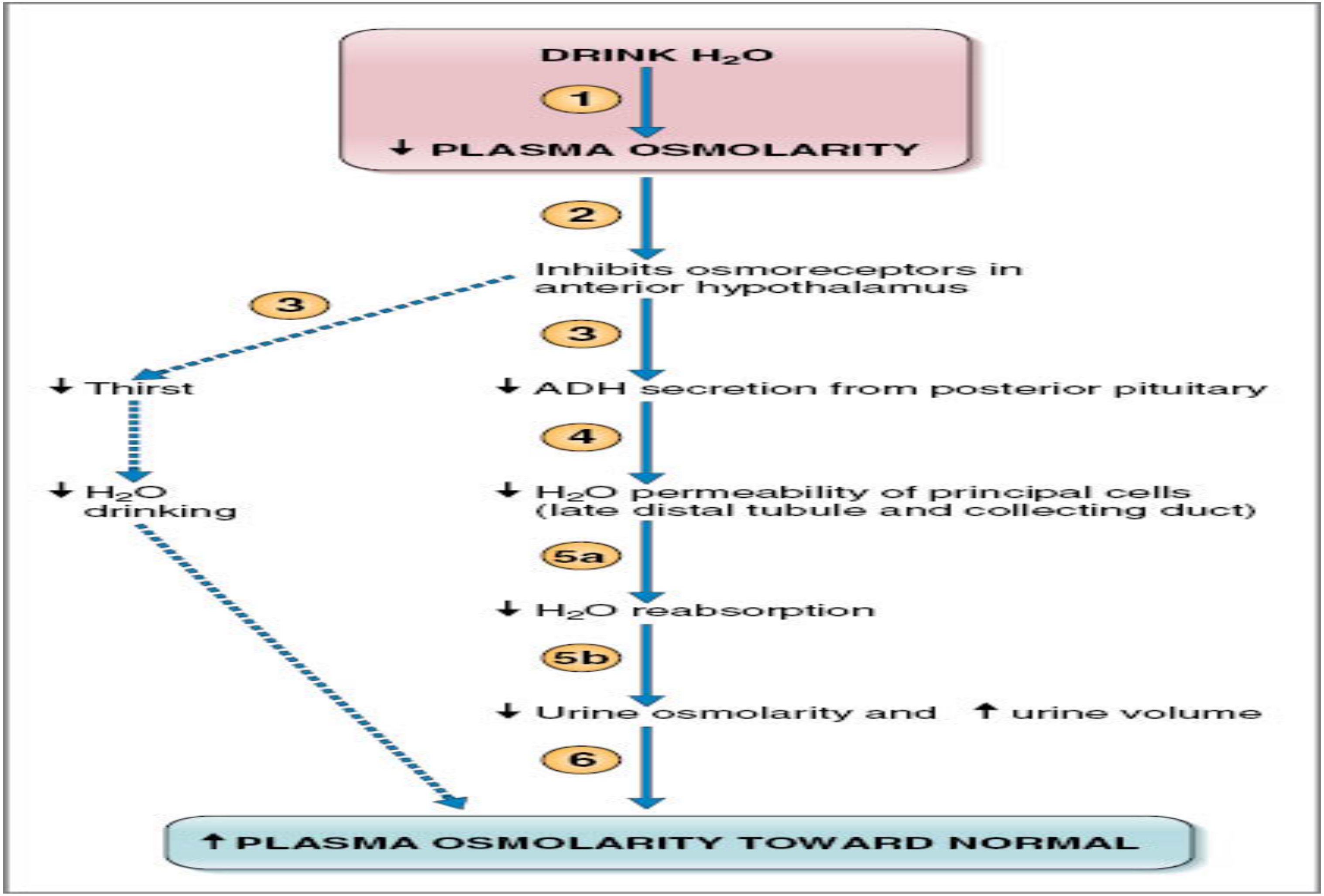


Feedback



Insulin-secreting cells of pancreas stimulated to release insulin into the blood
Most body cells take up more glucose
High blood glucose level detected by insulin-secreting cells of pancreas
Liver takes up glucose and stores it as glycogen
Blood glucose level declines to a set point; stimulus for insulin release diminishes and body returns to homeostasis
Stimulus: Rising blood glucose level
Imbalance
Homeostasis: Normal blood glucose level (about 90 mg/100 ml)
Imbalance
Stimulus: Declining blood glucose level
Blood glucose level rises to set point; stimulus for glucagon release diminishes and body returns to homeostasis
Low blood glucose level detected by glucagon-releasing cells of pancreas
Liver breaks down glycogen stores and releases glucose to the blood
Glucagon-releasing cells of pancreas stimulated to release glucagon into the blood; target is the liver

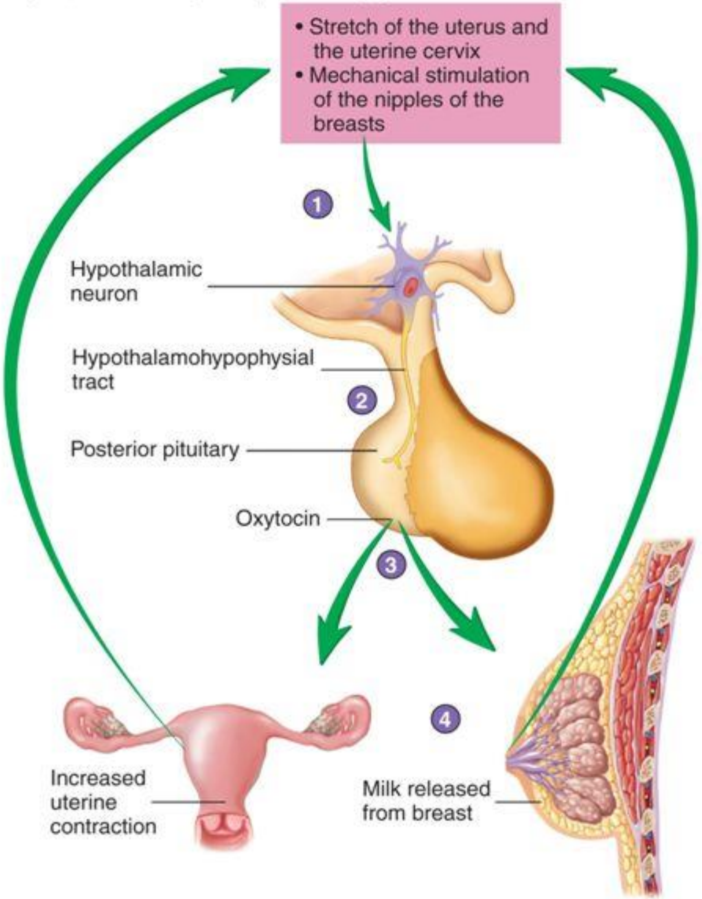

DEPRIVE OF H_2O
1
↑ PLASMA OSMOLARITY
2
Stimulates osmoreceptors in anterior hypothalamus
3
3
↑ Thirst
↑ ADH secretion from posterior pituitary
4
↑ H_2O drinking
↑ H_2O permeability of principal cells (late distal tubule and collecting duct)
5a
↑ H_2O reabsorption
5b
↑ Urine osmolarity and ↓ urine volume
6
↓ PLASMA OSMOLARITY TOWARD NORMAL



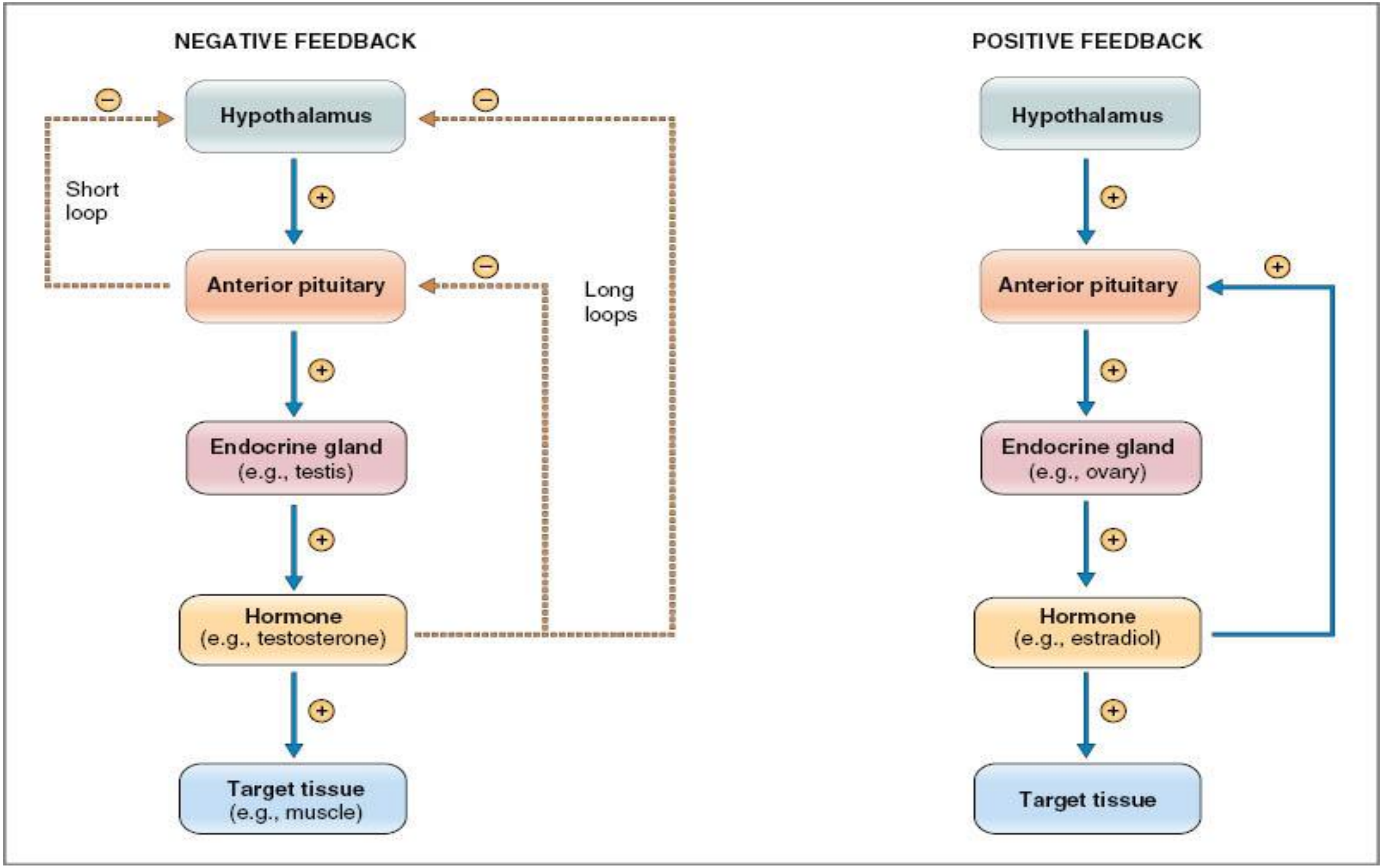
DRINK H_2O
1
↓ PLASMA OSMOLARITY
2
Inhibits osmoreceptors in anterior hypothalamus
3
3
↓ Thirst
↓ H_2O drinking
↓ ADH secretion from posterior pituitary
4
↓ H_2O permeability of principal cells (late distal tubule and collecting duct)
5a
↓ H_2O reabsorption
5b
↓ Urine osmolarity and ↑ urine volume
6
↑ PLASMA OSMOLARITY TOWARD NORMAL

Control of Oxytocin Secretion

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

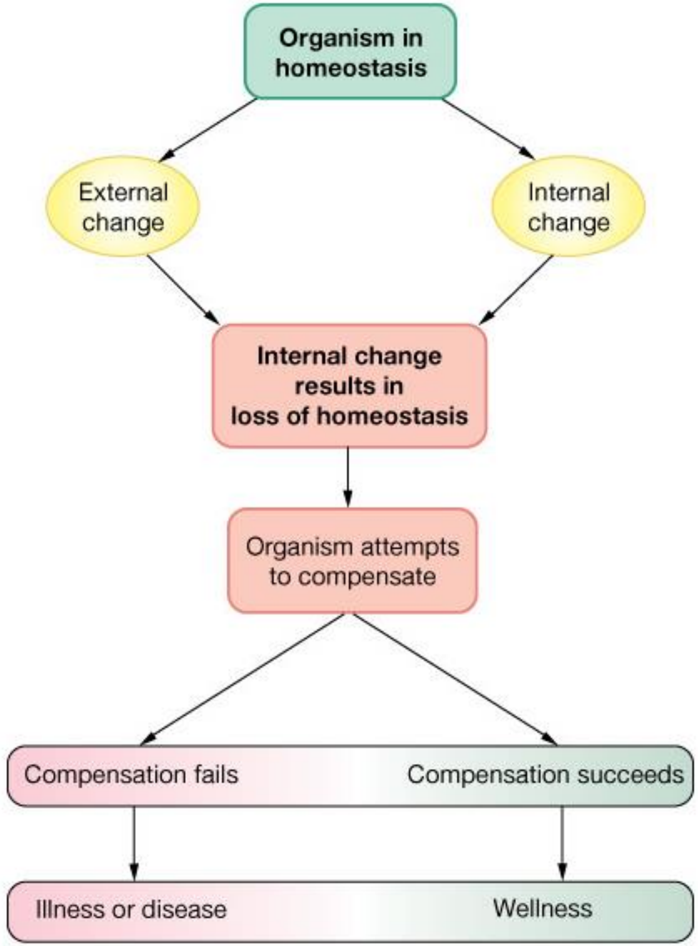


Homeostatic Imbalance

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

Homeostasis & Controls

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



- **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**
  -
- **≈ 300 mosm/L**

Mechanisms for Movement

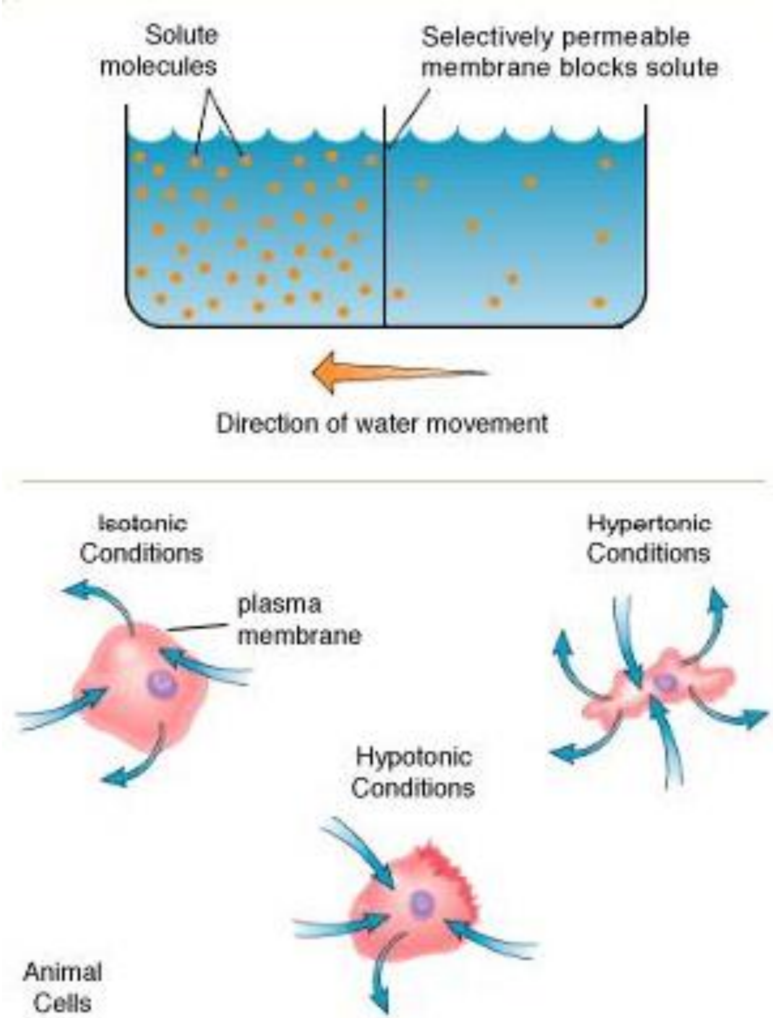
- 3 General mechanisms:

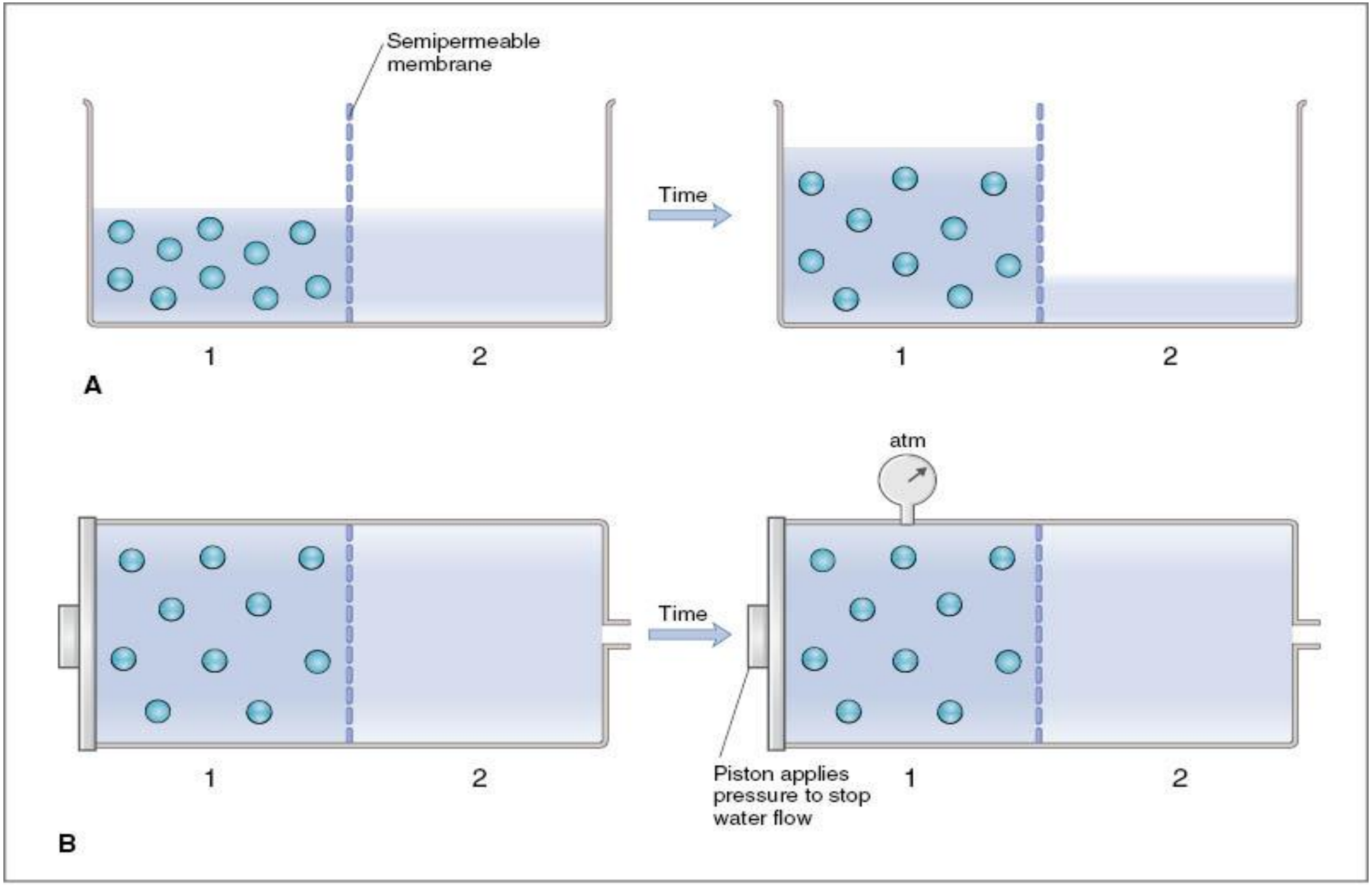
1. Simple diffusion (passive)
2. Facilitated transport (passive)
3. Active transport

osmosis

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

Osmosis

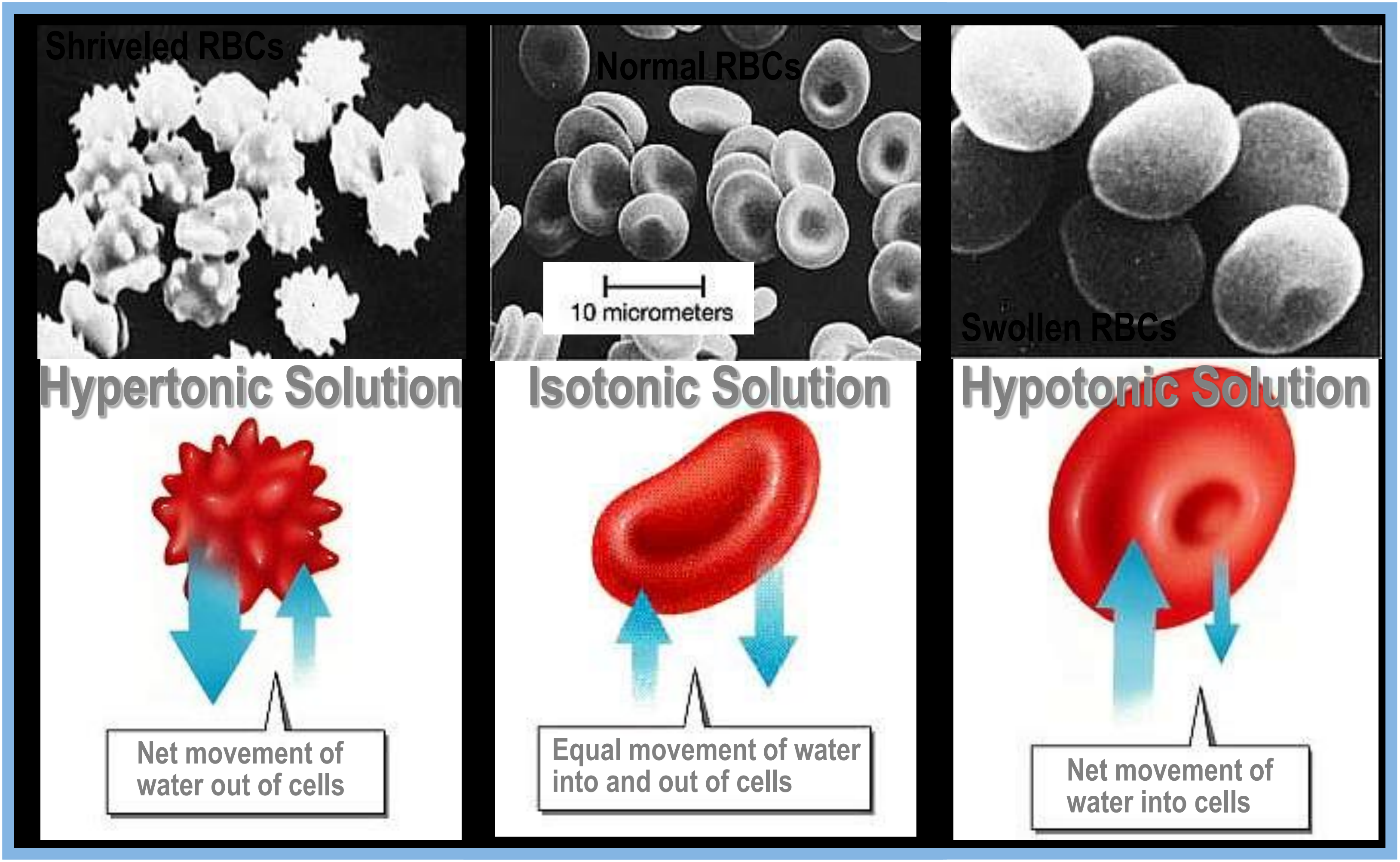

Solute molecules
Selectively permeable membrane blocks solute
Direction of water movement
Isotonic Conditions
plasma membrane
Hypertonic Conditions
Hypotonic Conditions
Animal Cells

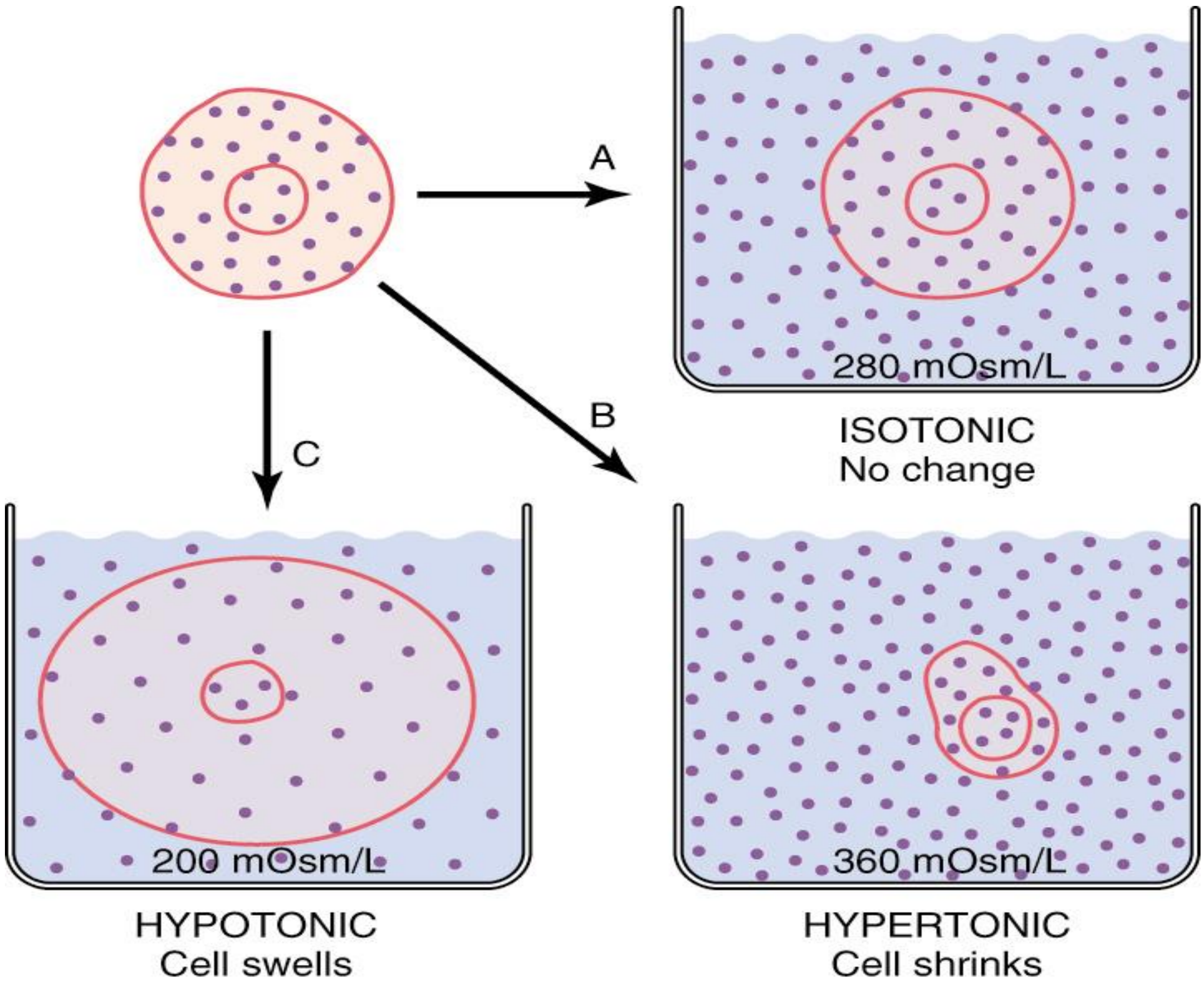

Semipermeable
membrane
Time
1
2
1
2
A
atm
Time
1
2
Piston applies
pressure to stop
water flow
1
2
B

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


Shriveled RBCs
Normal RBCs
10 micrometers
Swollen RBCs
Hypertonic Solution
Isotonic Solution
Hypotonic Solution
Net movement of water out of cells
Equal movement of water into and out of cells
Net movement of water into cells



A
B
C
280 mOsm/L
ISOTONIC
No change
200 mOsm/L
HYPOTONIC
Cell swells
360 mOsm/L
HYPERTONIC
Cell shrinks

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 .

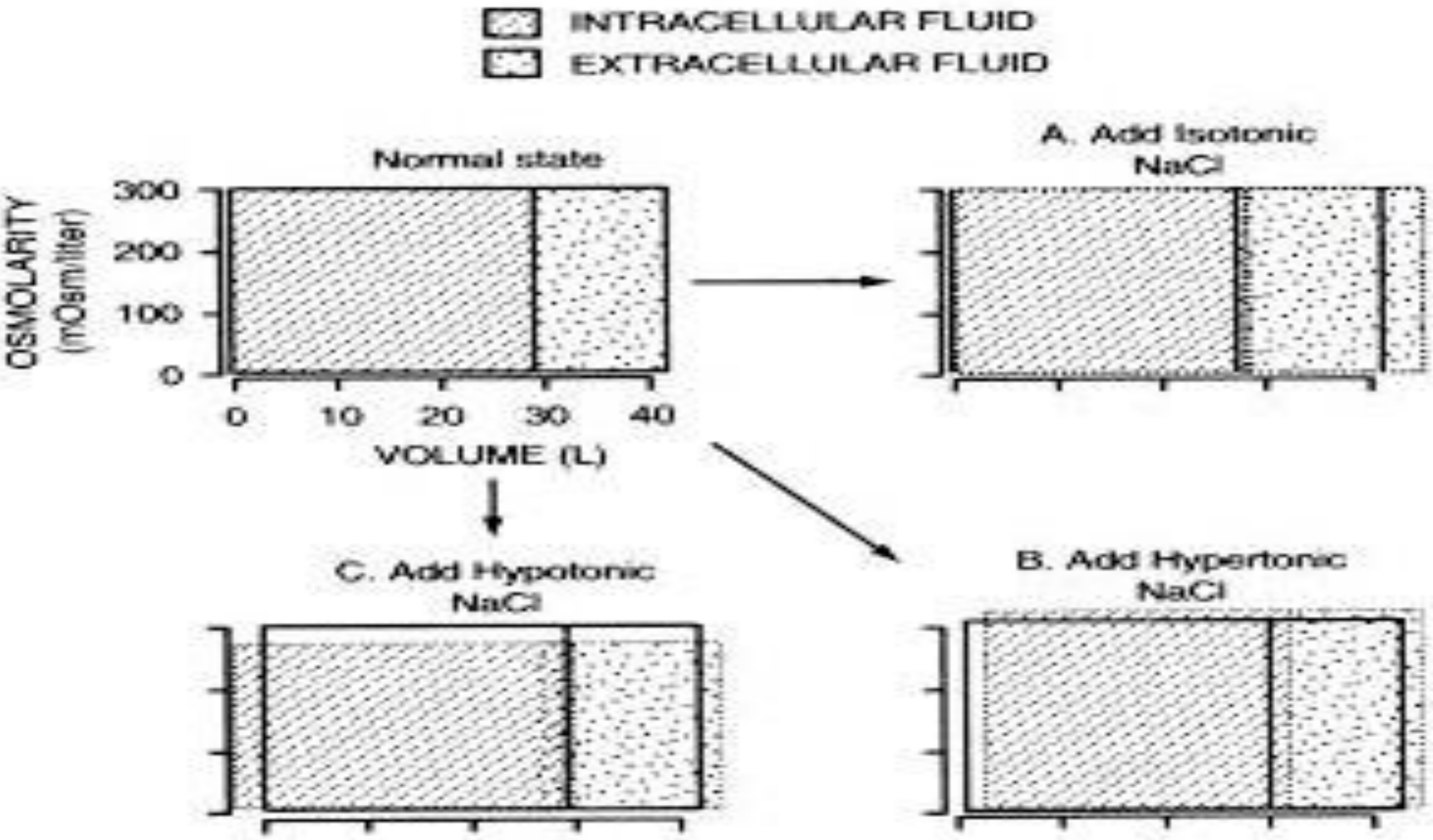
❖ Hypotonic solution :

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

❖ Hypertonic solution :

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

Effect of adding saline solution to the ECF



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 ≈ 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.

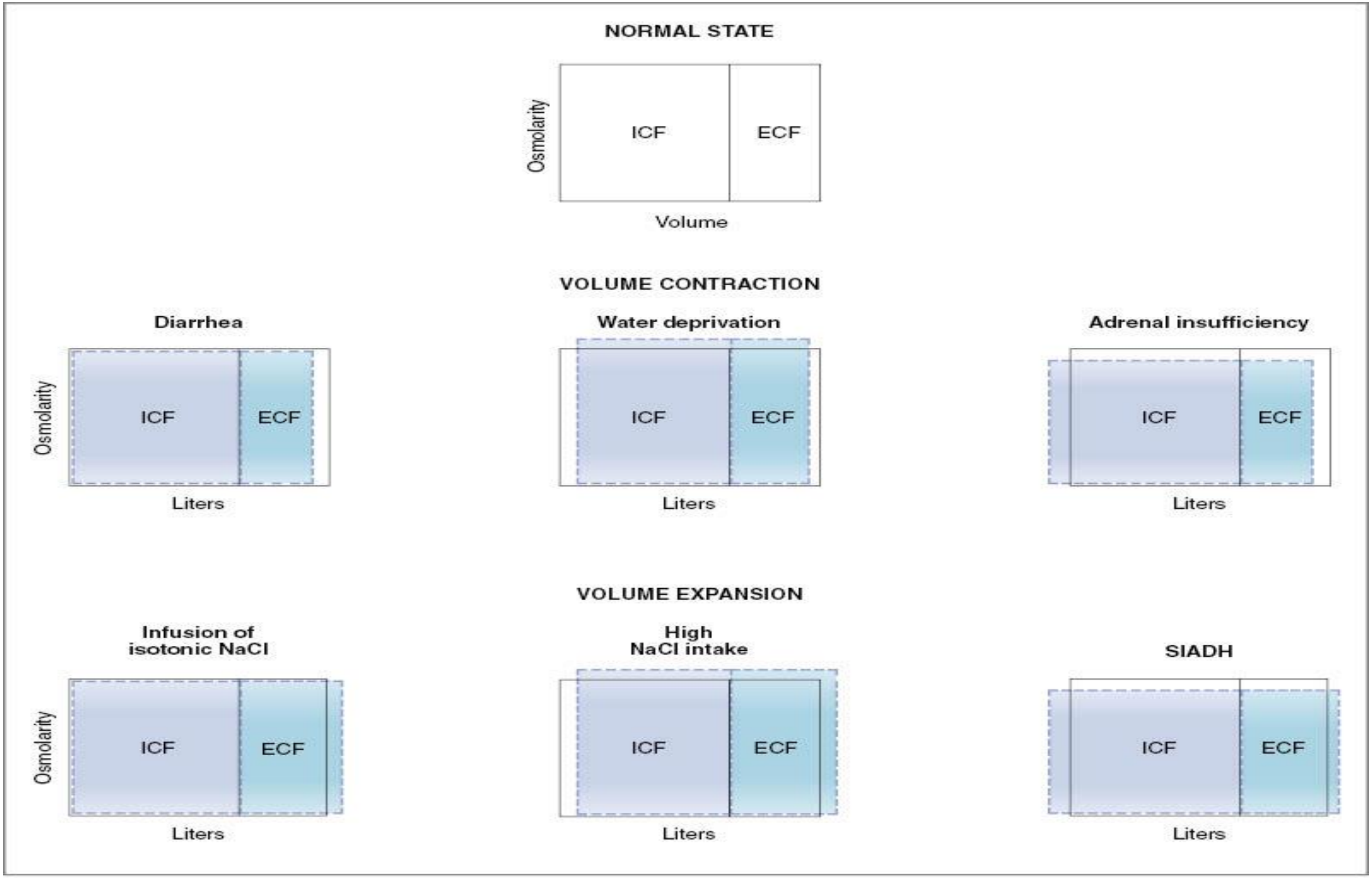
   - ↑ ECF volume.
   - No change in osmolarity.
   - Isomotic expansion .

2. High NaCl intake.

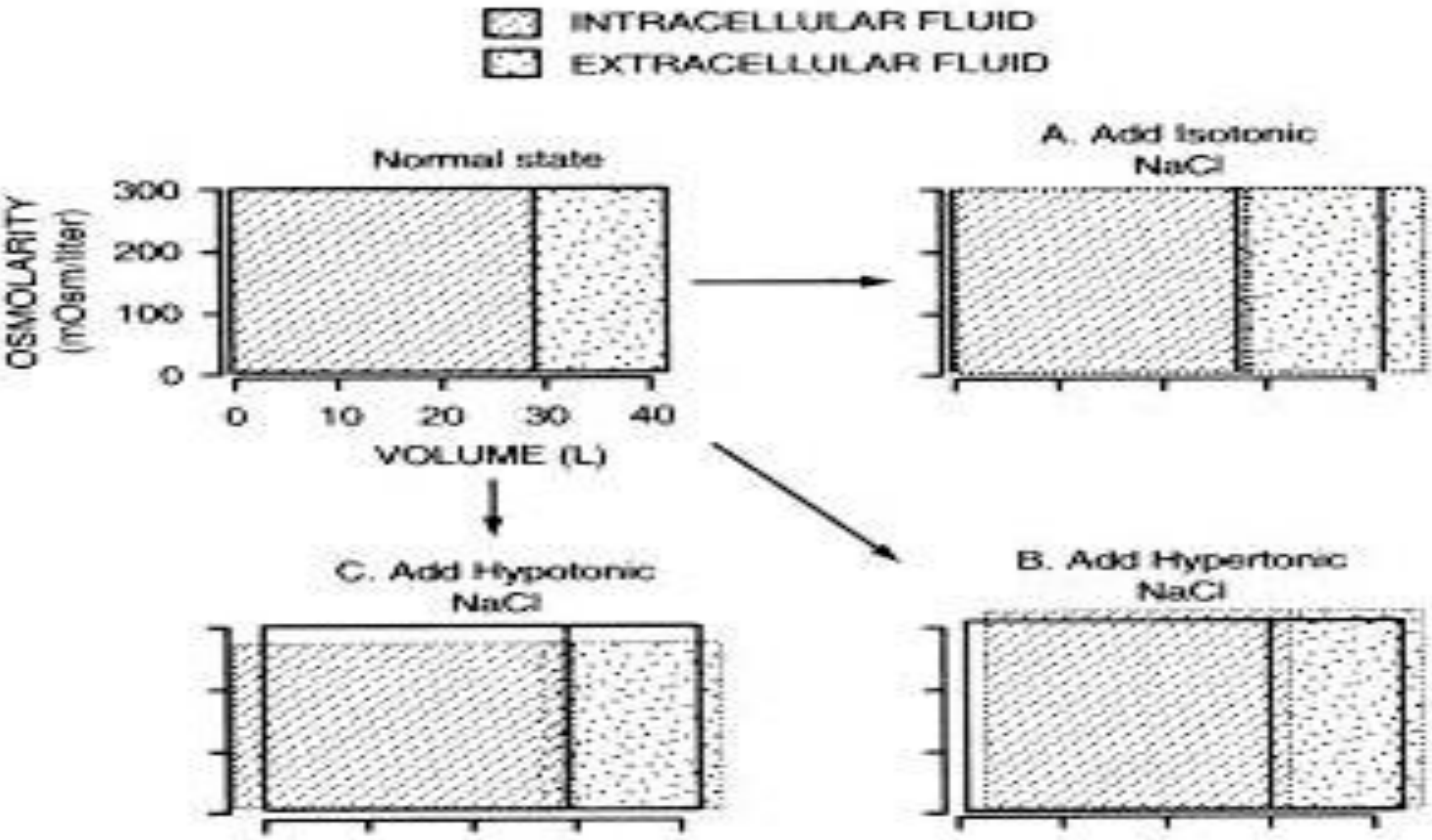
- ↑ eating salt.
- ↑ osmolarity in both.
- ↓ volume of ICF .
- ↑ volume of ECF .
- hyperosmotic volume expansion.

3- Syndrome of inappropriate antidiurtic hormone (SIADH):

- ↑ volume
- ↓ osmolarity


NORMAL STATE
Osmolarity
ICF
ECF
Volume
VOLUME CONTRACTION
Diarrhea
Osmolarity
ICF
ECF
Liters
Water deprivation
ICF
ECF
Liters
Adrenal insufficiency
ICF
ECF
Liters
VOLUME EXPANSION
Infusion of
isotonic NaCl
Osmolarity
ICF
ECF
Liters
High
NaCl intake
ICF
ECF
Liters
SIADH
ICF
ECF
Liters

Effect of adding saline solution to the ECF



Edema

Edema: is excessive fluid in the tissues

- Intracellular
- Extracellular

Edema occurs mainly in the extracellular fluid compartment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Edema (swelling) of
the ankles and feet

Intracellular Edema:

inflammation of tissues.

↓

↑ membrane permeability.

↓

Na inside cells.

↓

water

↓

edema

Extracellular Edema:

common clinical cause is excessive capillary fluid filtration.

↑ Heart failure

↓

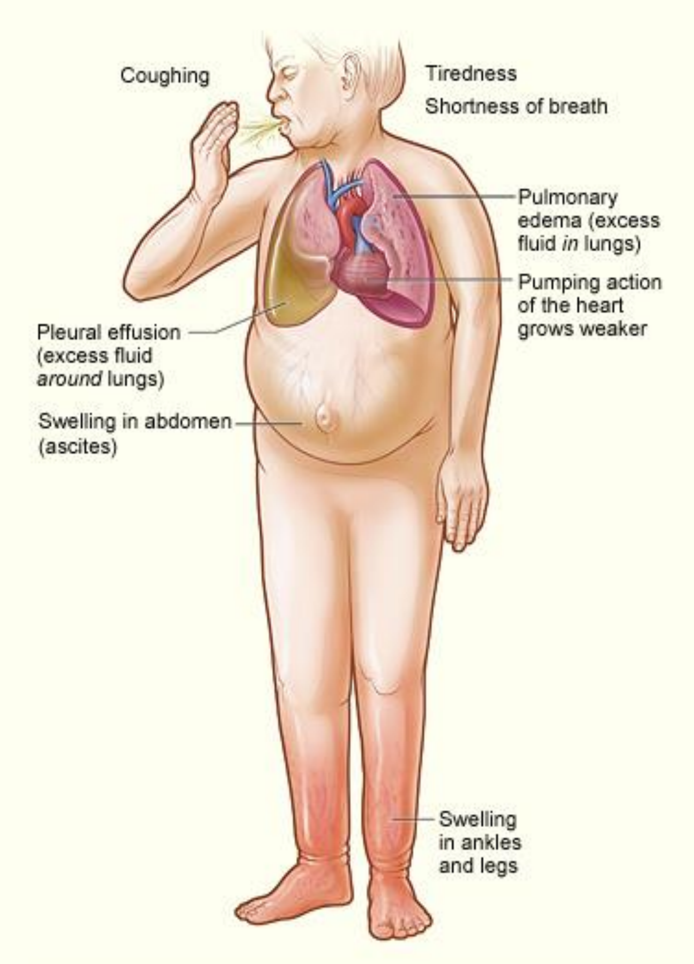
↑ capillary pressure

↓

filtration.

↓

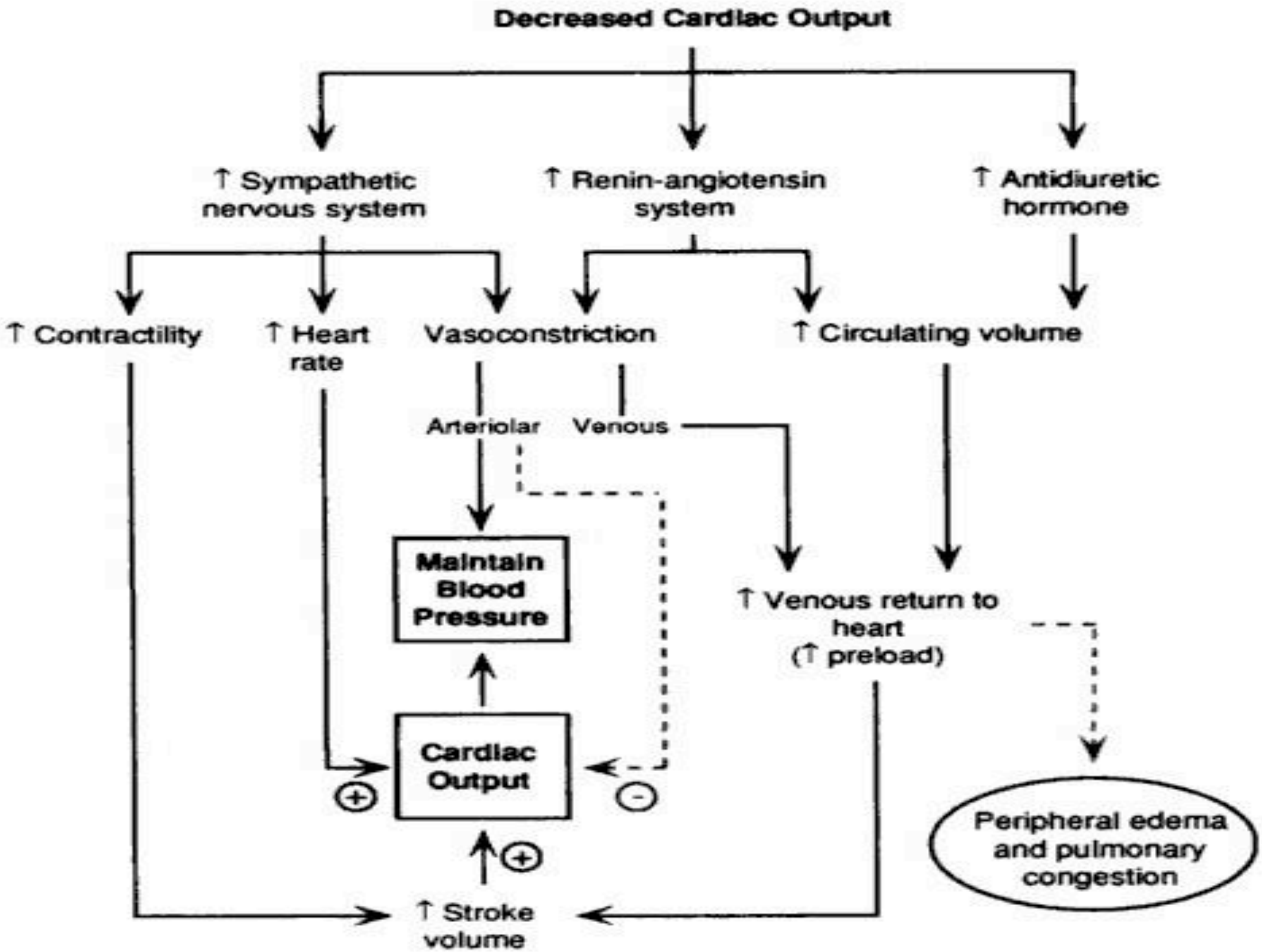
edema



Pathophysiology of edema in heart failure (HF)

Cardiac dysfunction
↓
decreased cardiac output
↓
kidney and sodium retention
↓
increased venous pressure
↓
increased capillary hydraulic pressure
↓
increased transcapillary gradient
↓
movement of fluid into interstitium
↓
edema

Increased left ventricular filling
↓
normalization of cardiac output
↓
"compensated state"


Decreased Cardiac Output
↑ Sympathetic nervous system
↑ Renin-angiotensin system
↑ Antidiuretic hormone
↑ Contractility
↑ Heart rate
Vasoconstriction
↑ Circulating volume
Arteriolar
Venous
Maintain Blood Pressure
↑ Venous return to heart (↑ preload)
Cardiac Output
+
-
Peripheral edema and pulmonary congestion
+
↑ Stroke volume