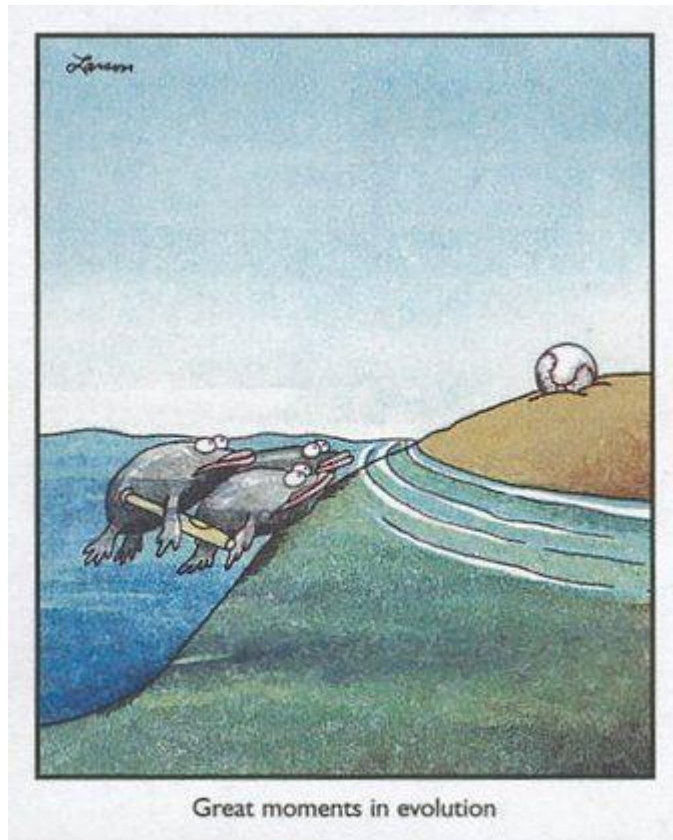


Water-electrolyte (im)balance

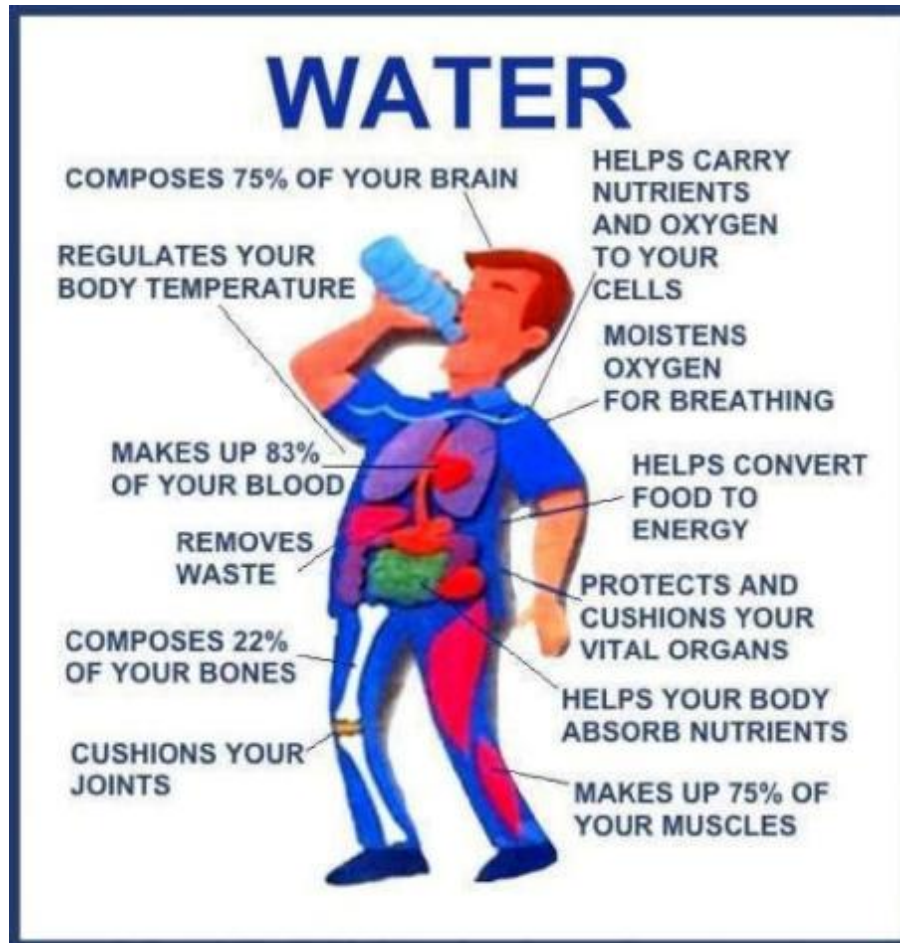
Kiril Terziski, MD, PhD
Pathophysiology Dept.
Medical University of Plovdiv

Crawling out of ... water



Evolution
Belief is optional. Participation is not!

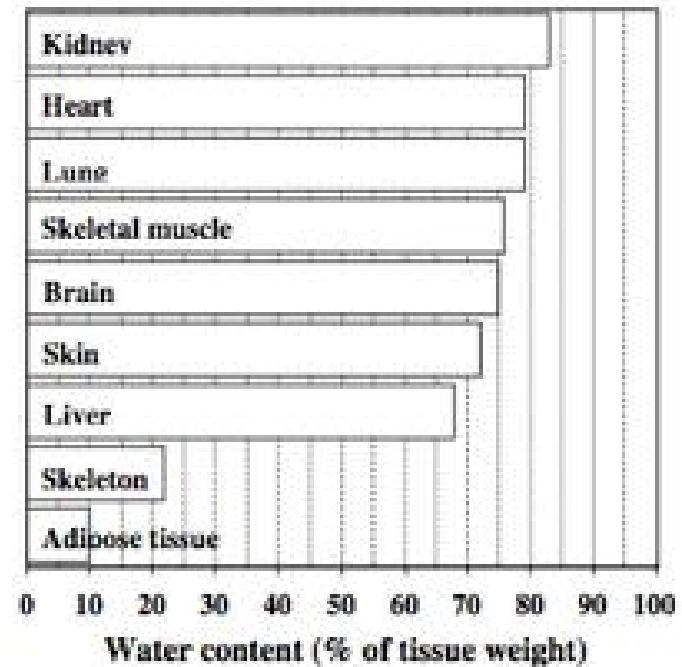
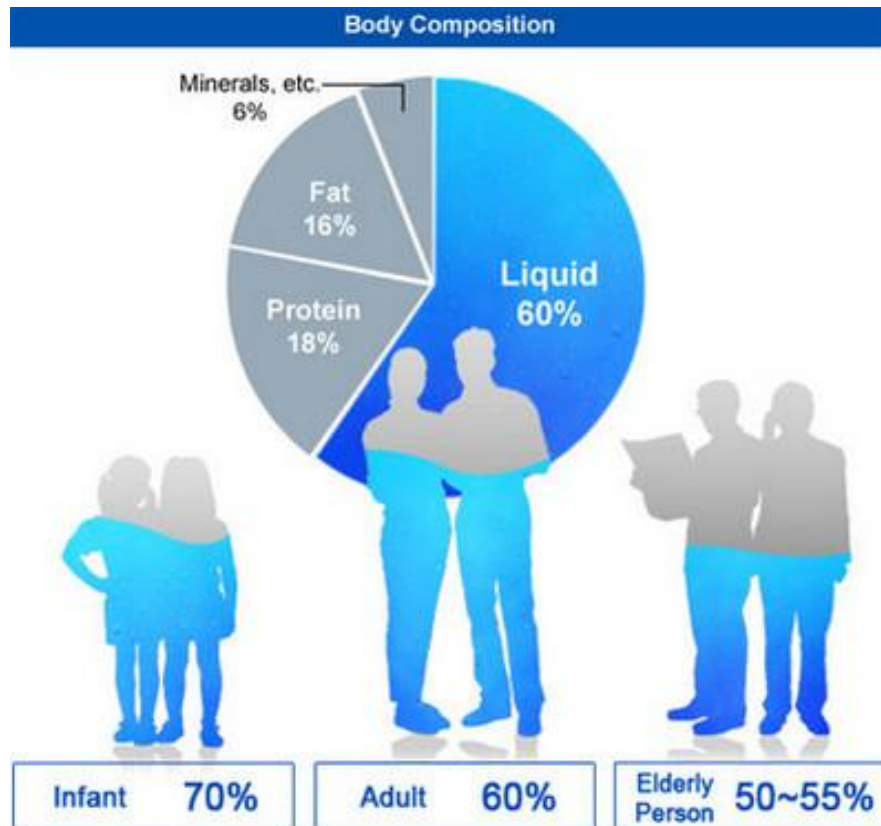
Water is life



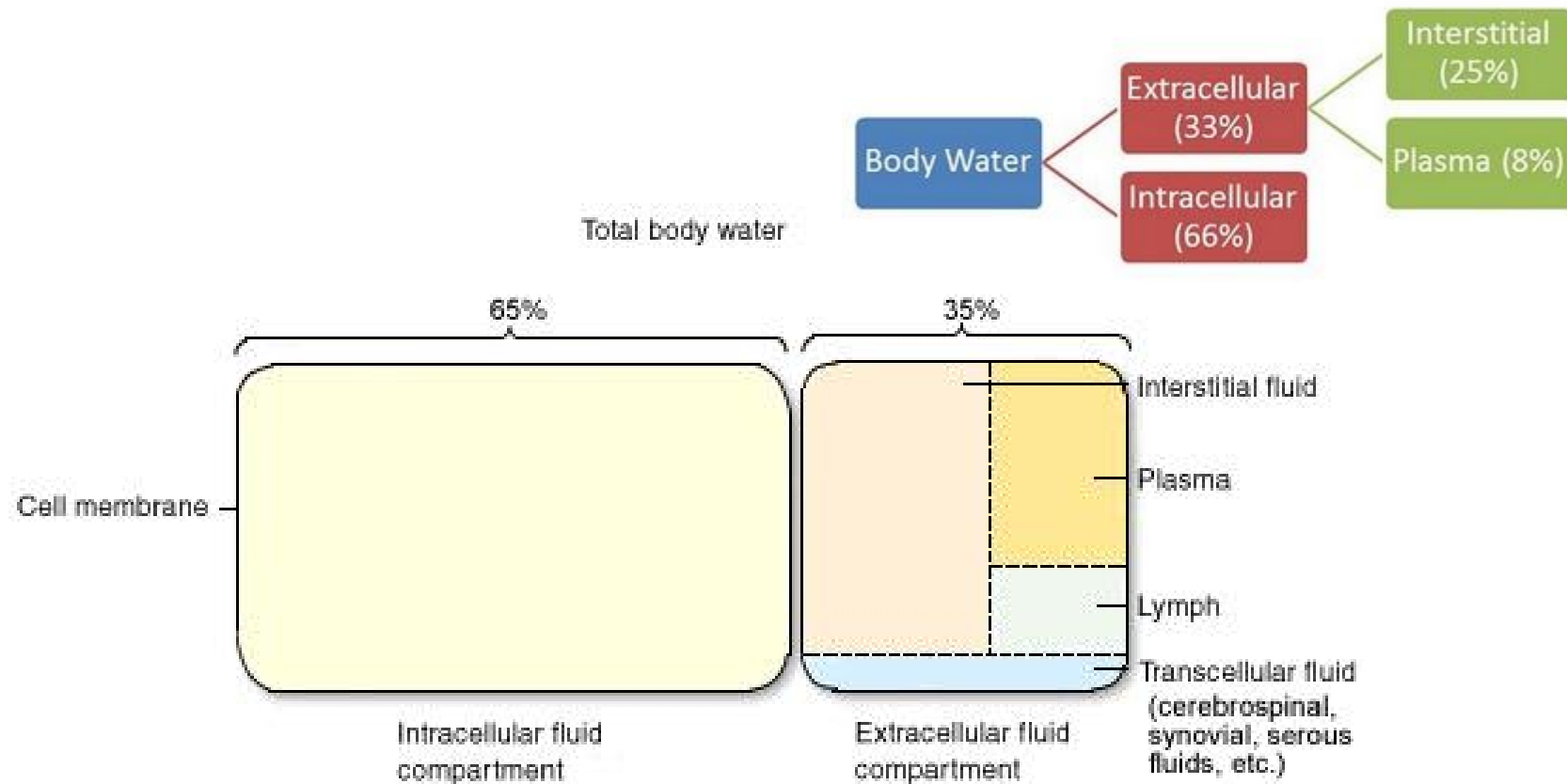
Medium for metabolism
Solvent for secretions
Absorption
Transport
Thermoregulation

...

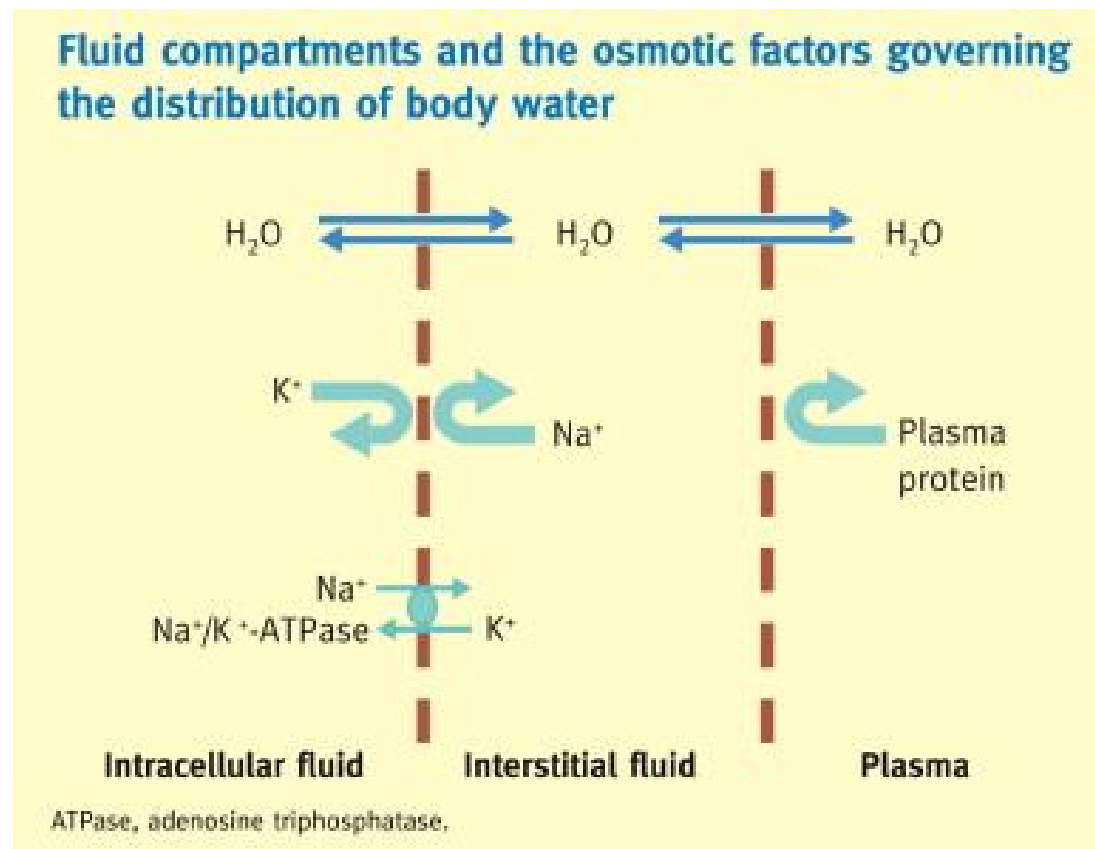
Getting solid with age



Water distribution



Water flows



Osmotic pressure
Oncotic pressure

Donnan's Law

...the behavior of charged particles near a semi-permeable membrane that sometimes fail to distribute evenly across the two sides of the membrane



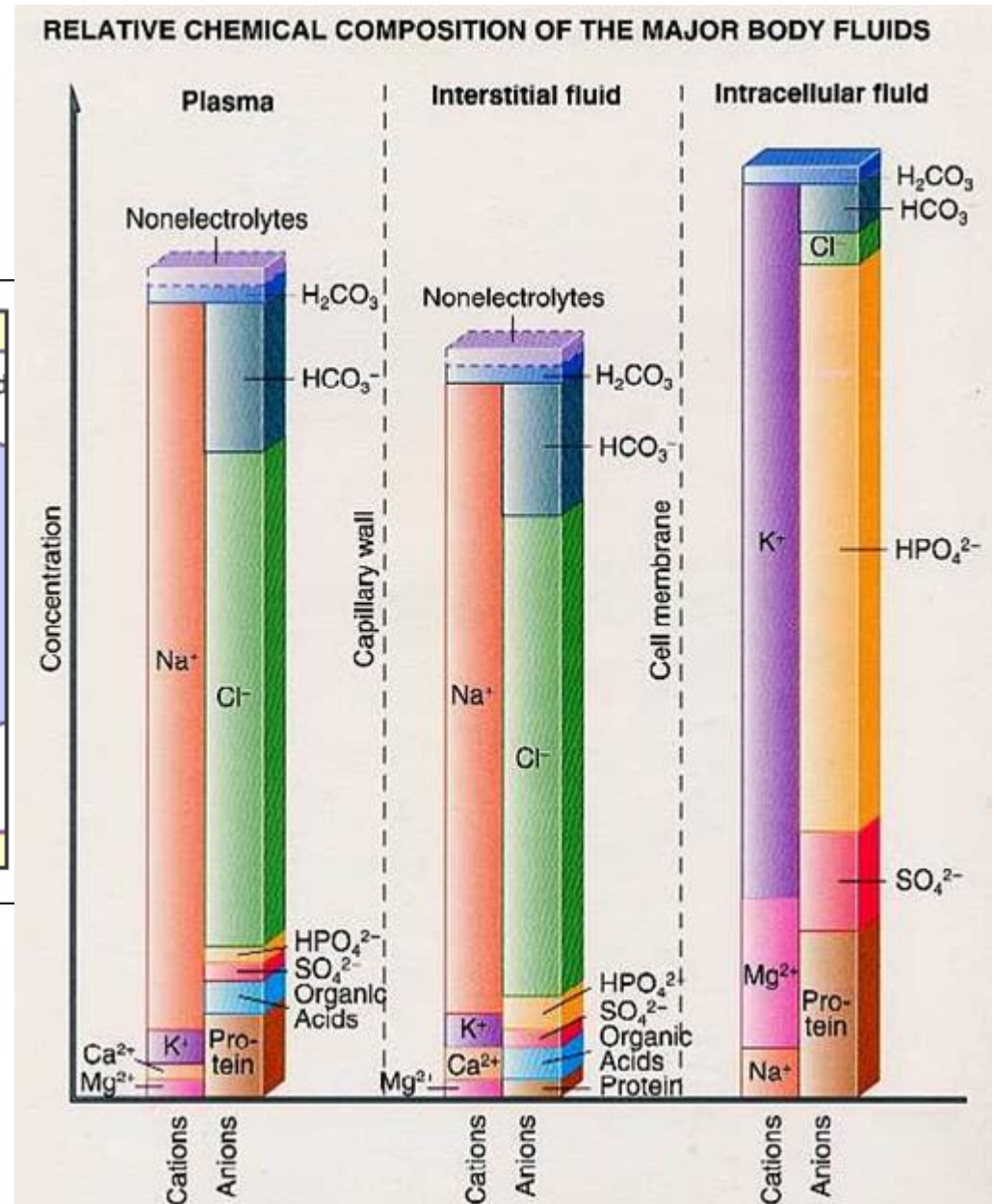
Extracellular Fluid		Intracellular Fluid
Na^+	142 mEq/L	10 mEq/L
K^+	4 mEq/L	140 mEq/L
Ca^{++}	5 mEq/L	<1 mEq/L
Mg^{++}	3 mEq/L	58 mEq/L
Cl^-	103 mEq/L	4 mEq/L
HCO_3^-	28 mEq/L	10 mEq/L
Phosphates	4 mEq/L	75 mEq/L
SO_4^{--}	1 mEq/L	2 mEq/L
Osmolality	281 mOsm/L	281 mOsm/L

Na^+ - 135-145 mmol.L⁻¹

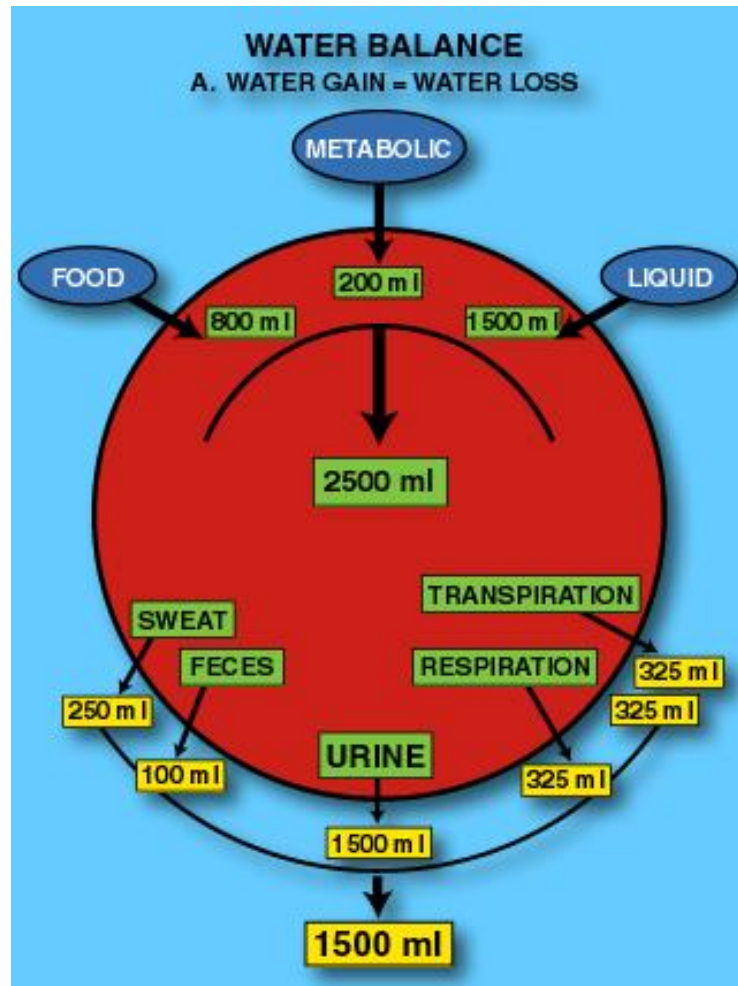
K^+ - 3.5-5.5 mmol.L⁻¹

Cl^- - 95-105 mmol.L⁻¹

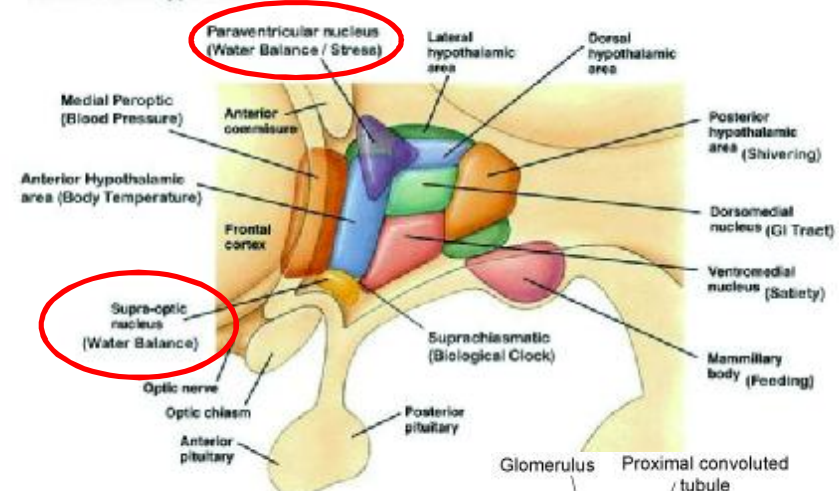
Ca^{2+} - 2.12-2.62 mmol.L⁻¹



Give what you get

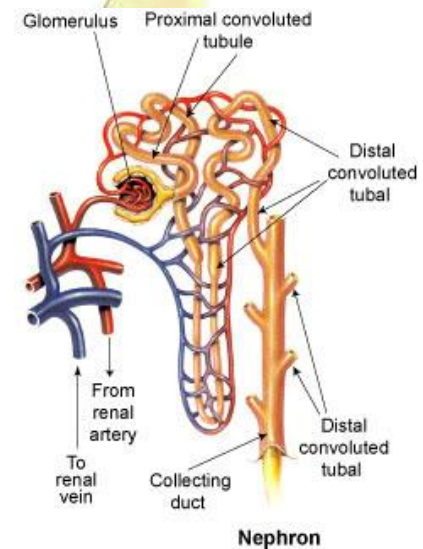


► Nuclei of the Hypothalamus

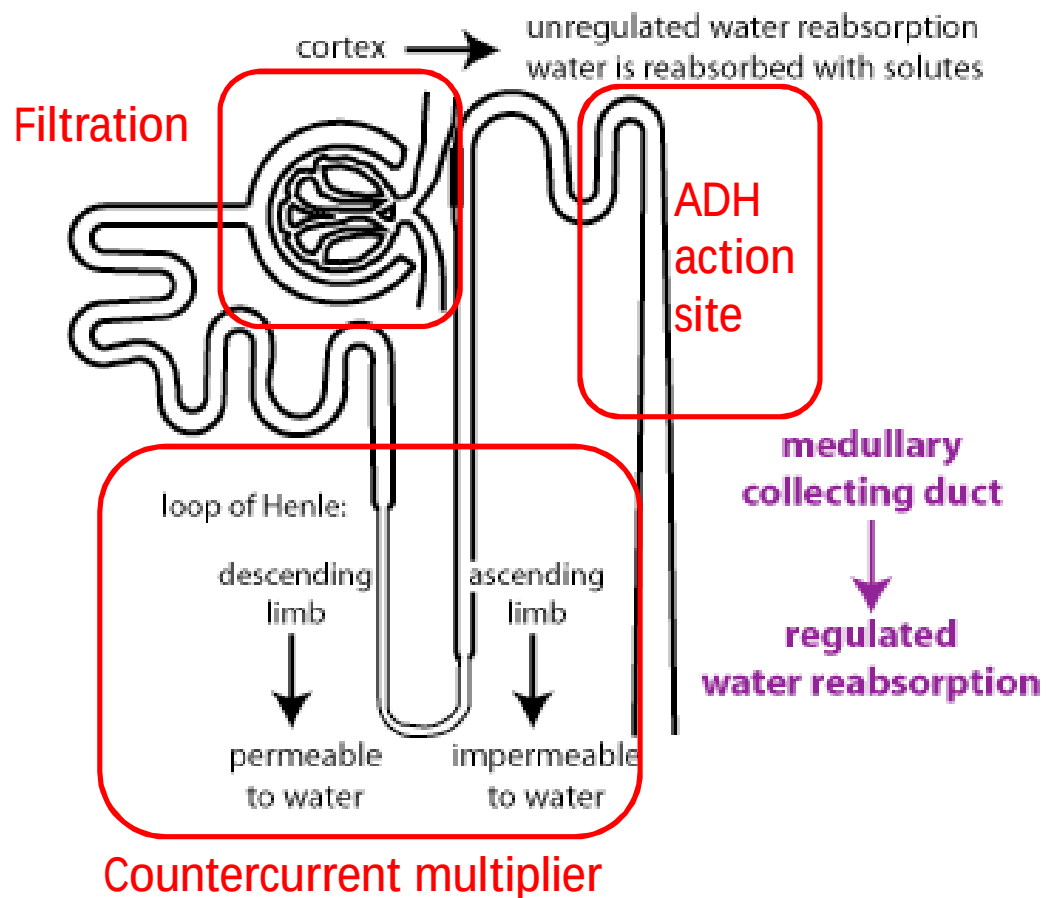


Thirst (water intake)

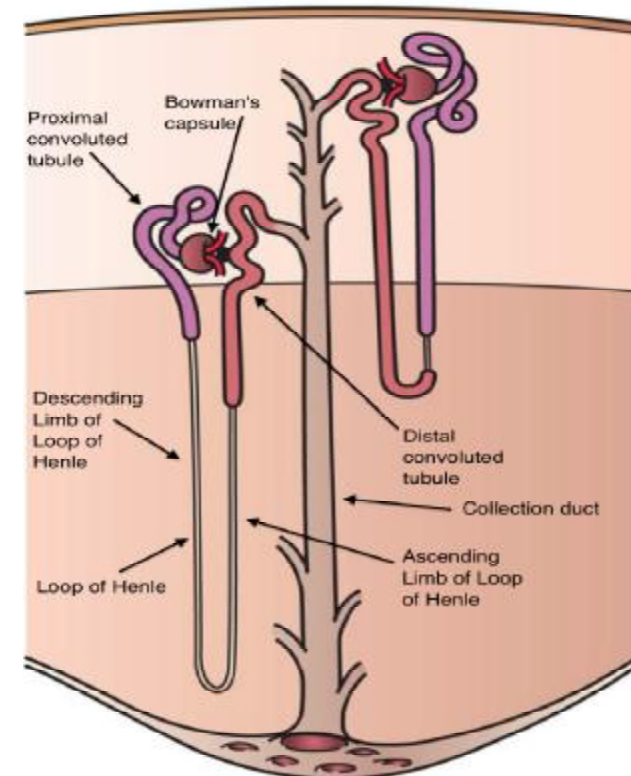
Urine production (water loss)



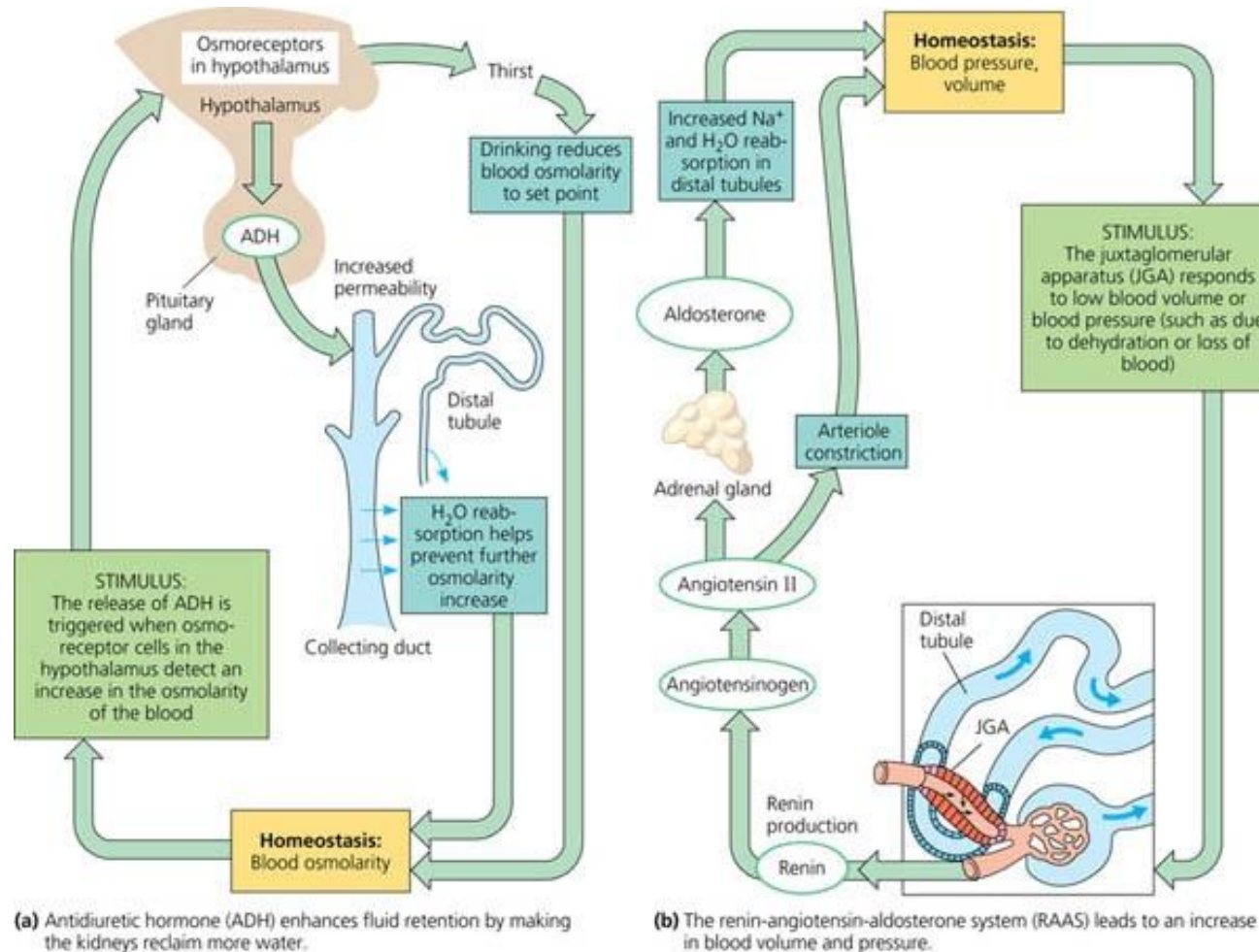
The role of the kidneys



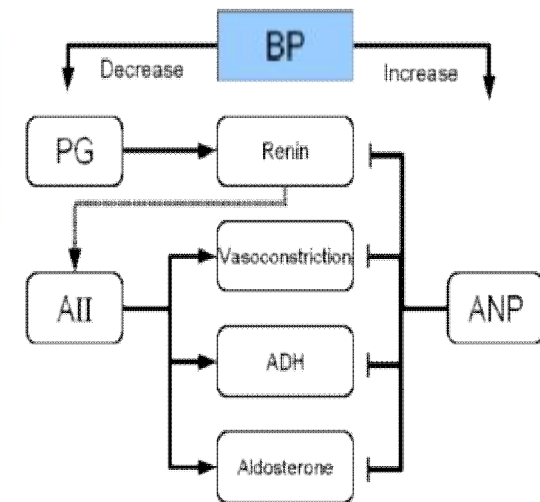
Juxtamedullary and cortical nephrones



RAAS, ADH and thirst

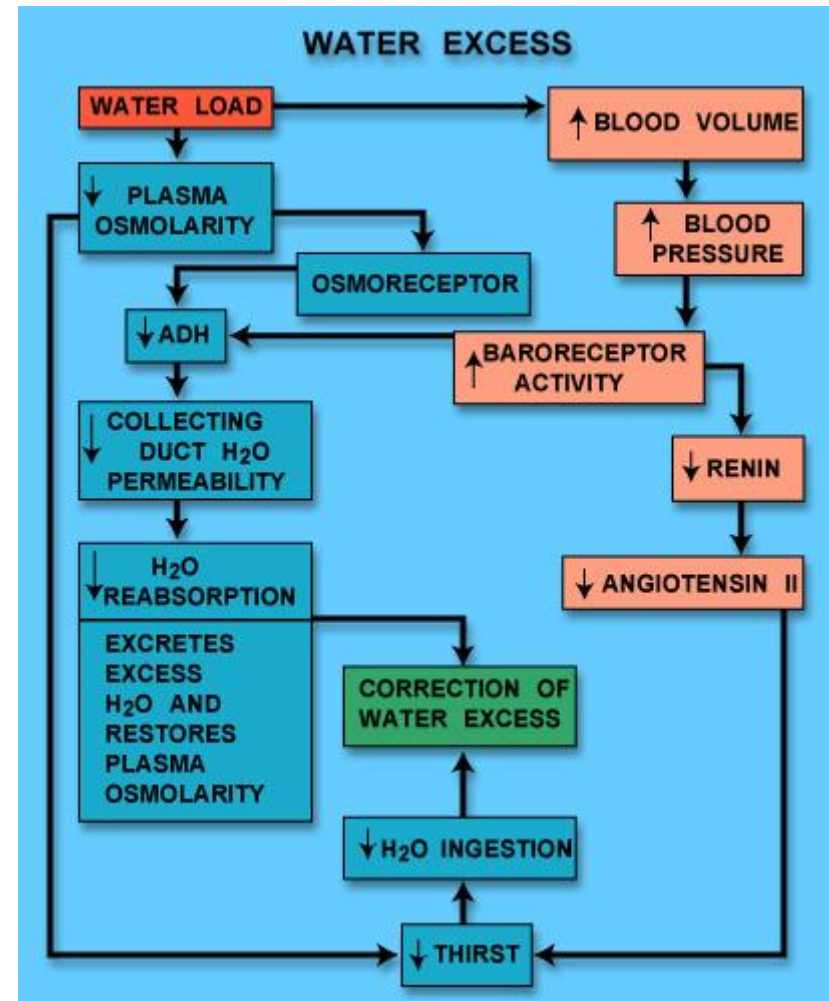
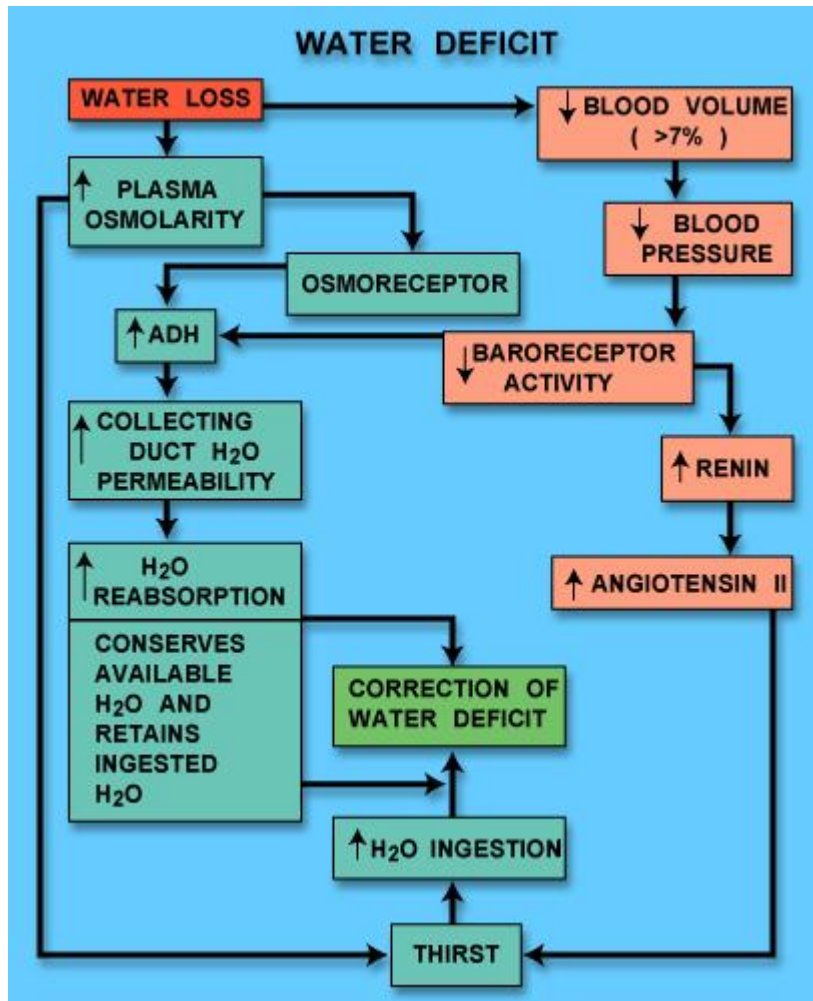


Atrial Natriuretic Peptide
Brain Natriuretic Peptide



Prostaglandines (renal)

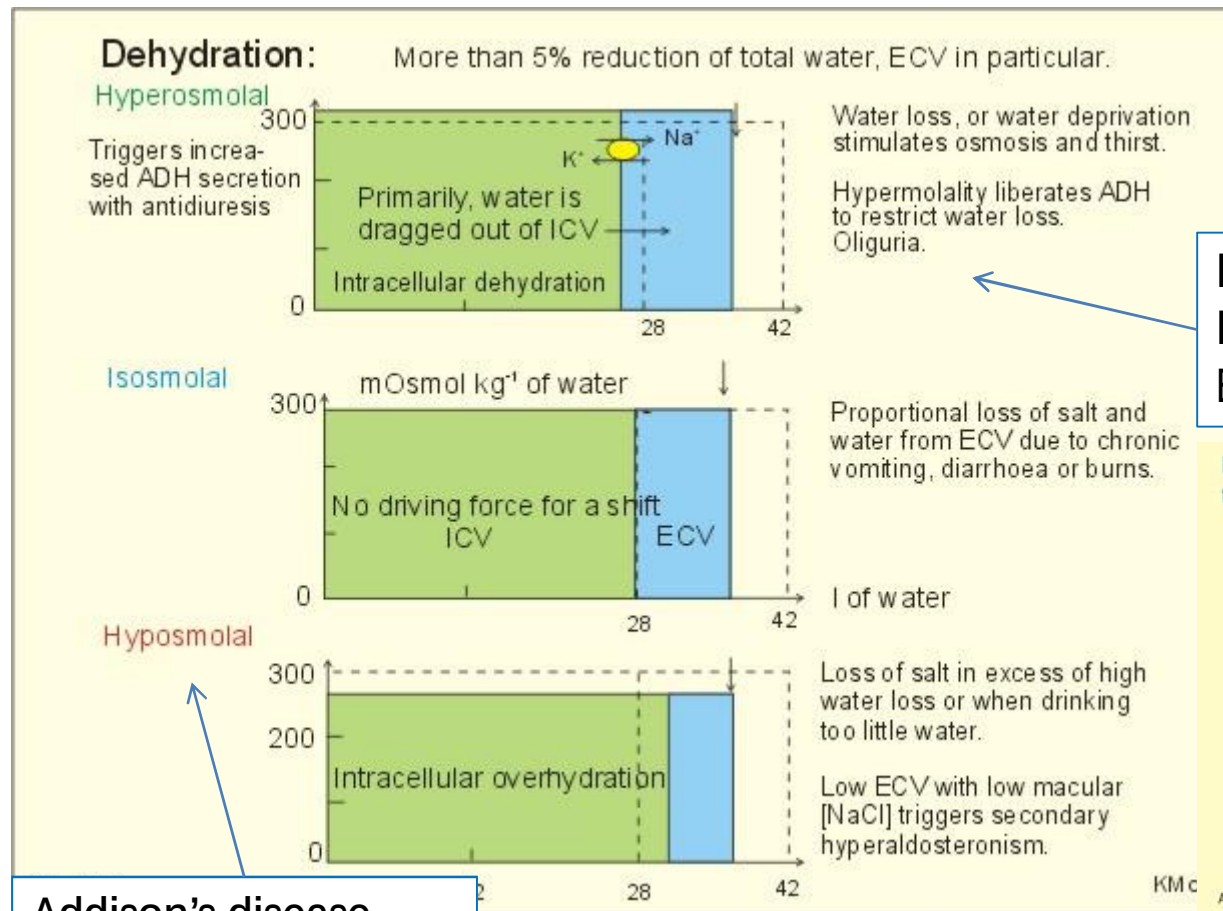
The regulation in action



Disturbances in water-electrolyte balance - classification

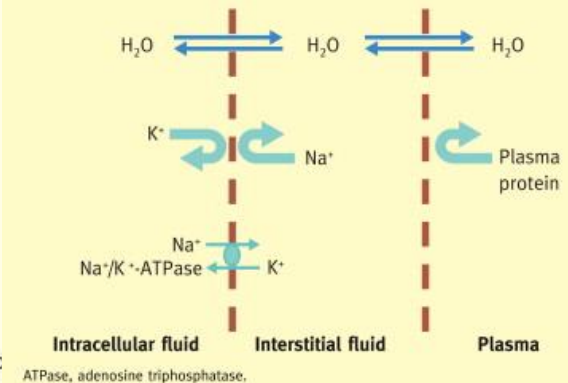
- Dehydration
 - Isotonic (Isoosmolal)
 - Hypotonic (Hypoosmolal)
 - Hypertonic (Hyperosmolal)
- Hyperhydration
 - Isotonic (Isoosmolal)
 - Hypotonic (Hypoosmolal)
 - Hypertonic (Hyperosmolal)

Dehydration



Diabetes insipidus
Diabetes mellitus
Extreme sweating

Fluid compartments and the osmotic factors governing the distribution of body water



Addison's disease
Brain tumors

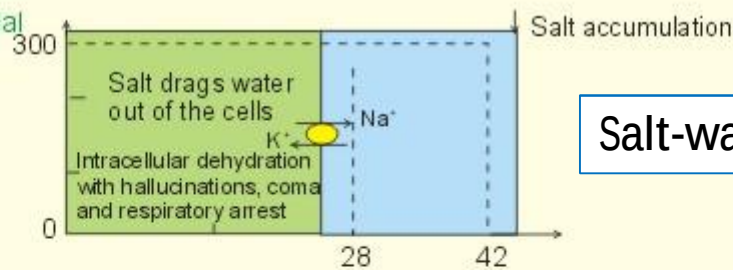
No thirst!

Hyperhydration



Overhydration: Abnormal increase in total water, ECV in particular.

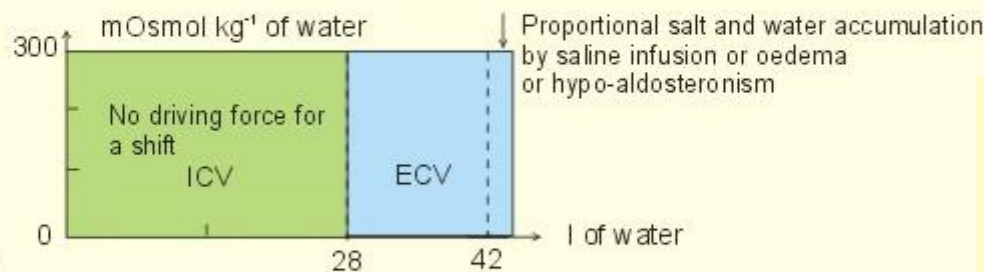
Hyperosmolar



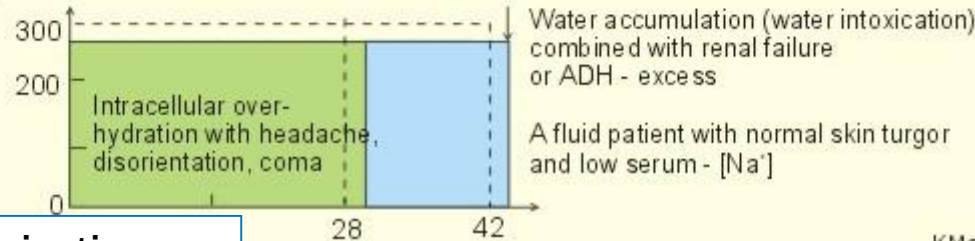
Salt-water drinking

Extreme thirst!

Isosmolar

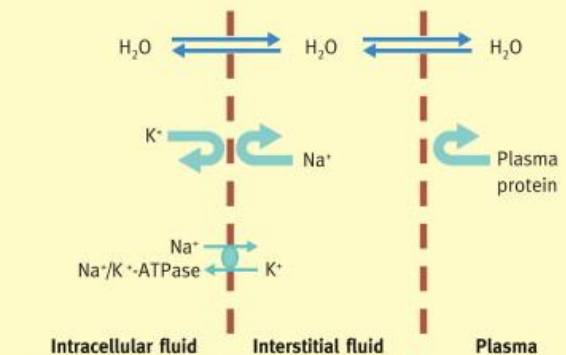


Hyposmolar



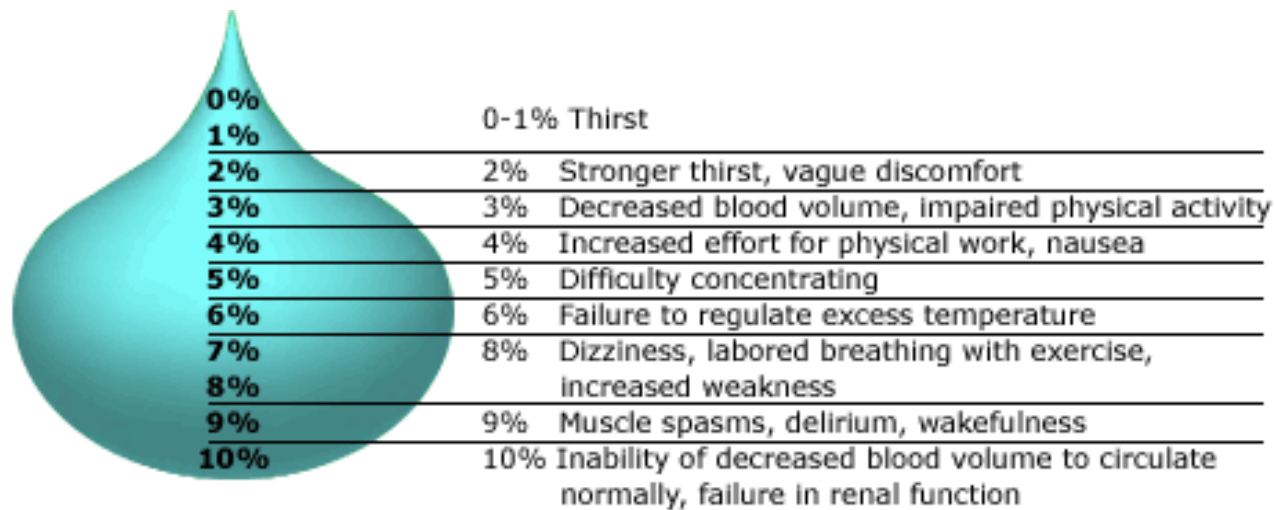
Water intoxication

Fluid compartments and the osmotic factors governing the distribution of body water



ATPase, adenosine triphosphatase.

Signs of dehydration



Tachycardia

Arterial hypotension

No micturition

Hypovolemic shock

Vulnerable populations



Body surface area/ Body mass
Net ammount of water
(Im)maturity of homeostasis
Concentration ability of kidneys
Dependence on caregivers
Inability to speak
Frequent pathology



Net ammount of water
Imperfect homeostasis
Concentration ability of kidneys
Dependence on caregivers
Dementia
Frequent pathology

Vulnerable populations



Signs of dehydration

STATUS	No Dehydration	Some Dehydration	Severe Dehydration
CONDITION	Well, alert	Restless, Irritable*	Lethargic or unconscious; floppy*
EYES (Tears)	Normal (present)	Sunken (not present)	Very sunken and dry (not present)
MOUTH & TONGUE	Moist	Dry	Very dry
THIRST	Drinks normally, not thirsty	Thirsty, drinks eagerly*	Drinks poorly or not able to drink*
SKIN PINCH	Goes back quickly	Goes back slowly*	Goes back very slowly*
DECIDE	The child has no signs of dehydration	If the child has 2 or more signs, including at least 1 major sign, there is some dehydration	If the child has 2 or more signs, including at least 1 major sign, there is severe dehydration

* = A major sign

Information provided by the Centers for Disease Control and Prevention (CDC), located in Atlanta, Georgia, USA. CDC is an agency of the United States Department of Health and Human Services.

ig.

Oedemas

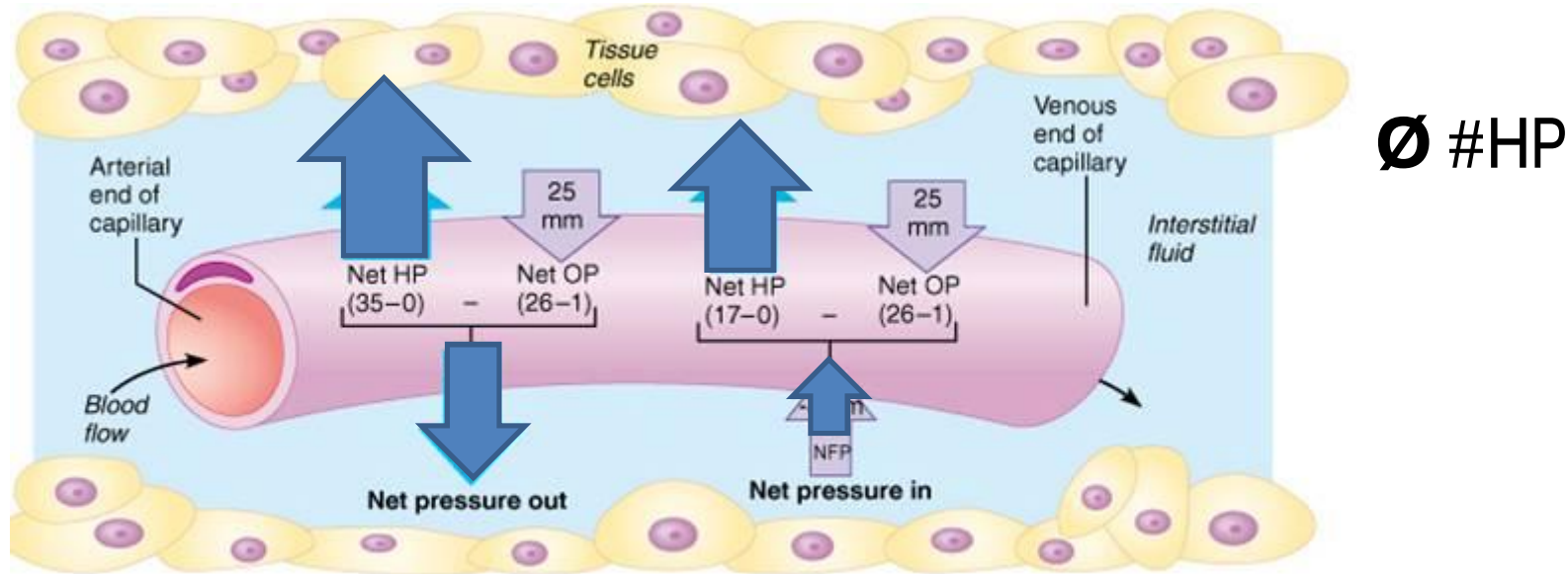


Common mechanisms

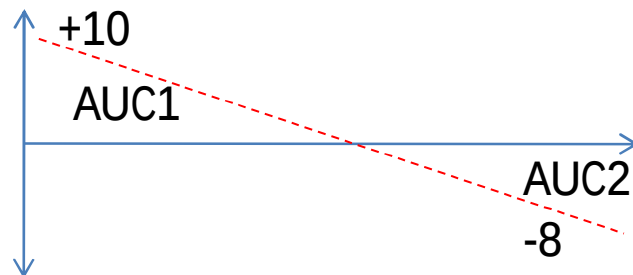
Factors, influencing water exchange in the tissues:

- Hydrodynamic pressure (HP)
 - Oncotic pressure (OP)
 - Capillary permeability
 - Lymph drainage
-
- $HP - OP = \text{Filtration pressure (force)}$
 - $OP - HP = \text{Absorption (force)}$

Simplified example



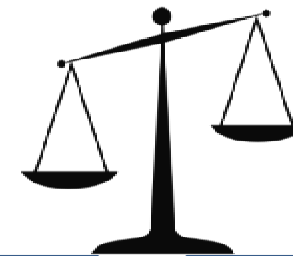
Filtration pressure alongside the capillary



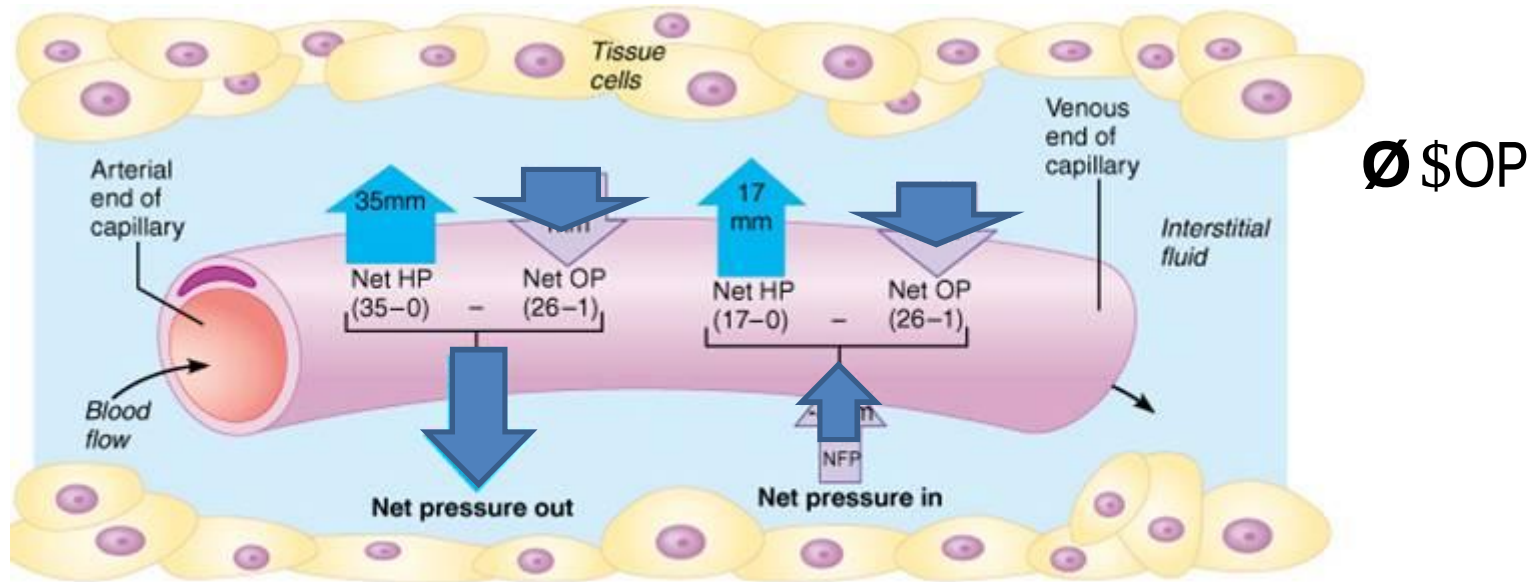
$$AUC2 < AUC1$$

Positive water balance in the interstitium

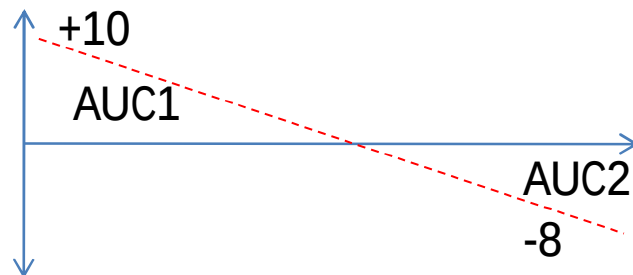
Lymph drainage



Simplified example



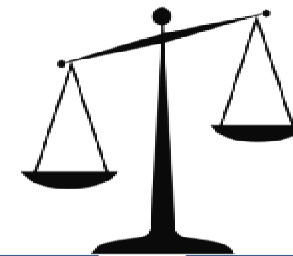
Filtration pressure alongside the capillary



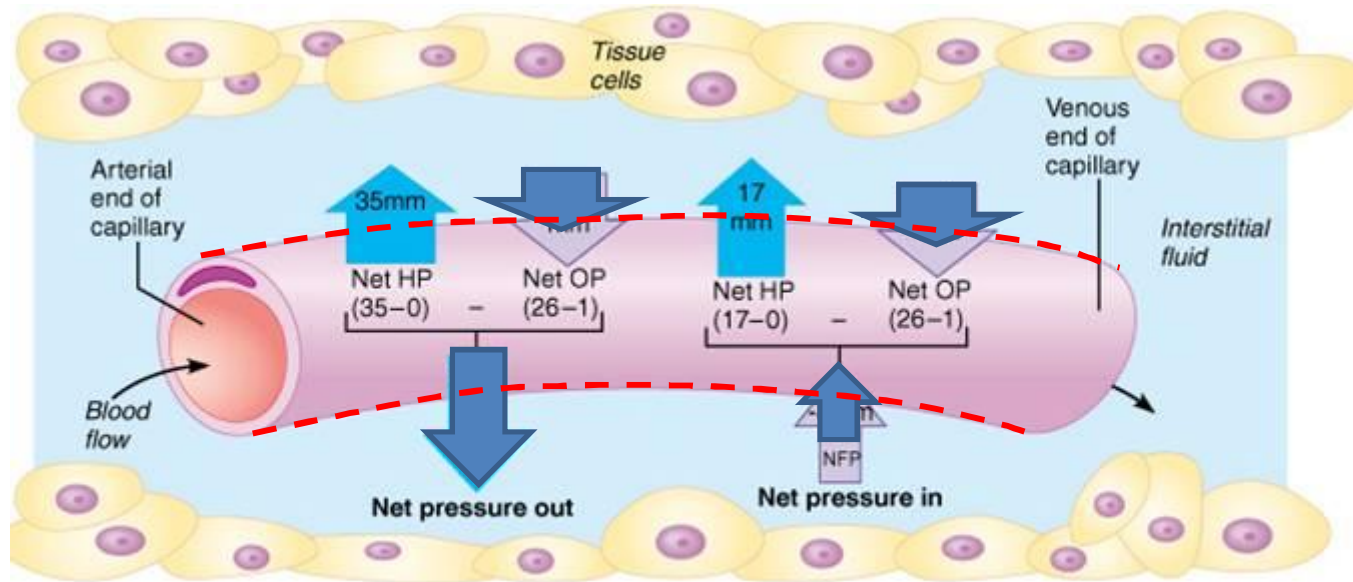
$$AUC2 < AUC1$$

Positive water balance in the interstitium

Lymph drainage

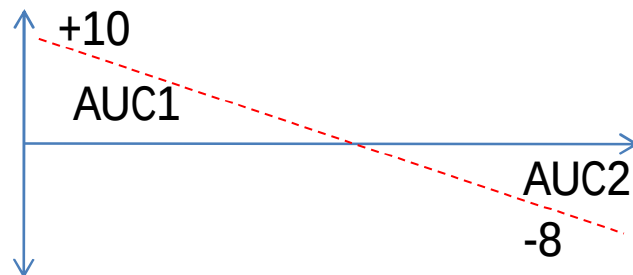


Simplified example



Ø #Permeability

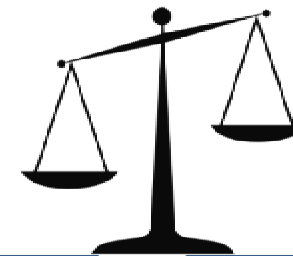
Filtration pressure alongside the capillary



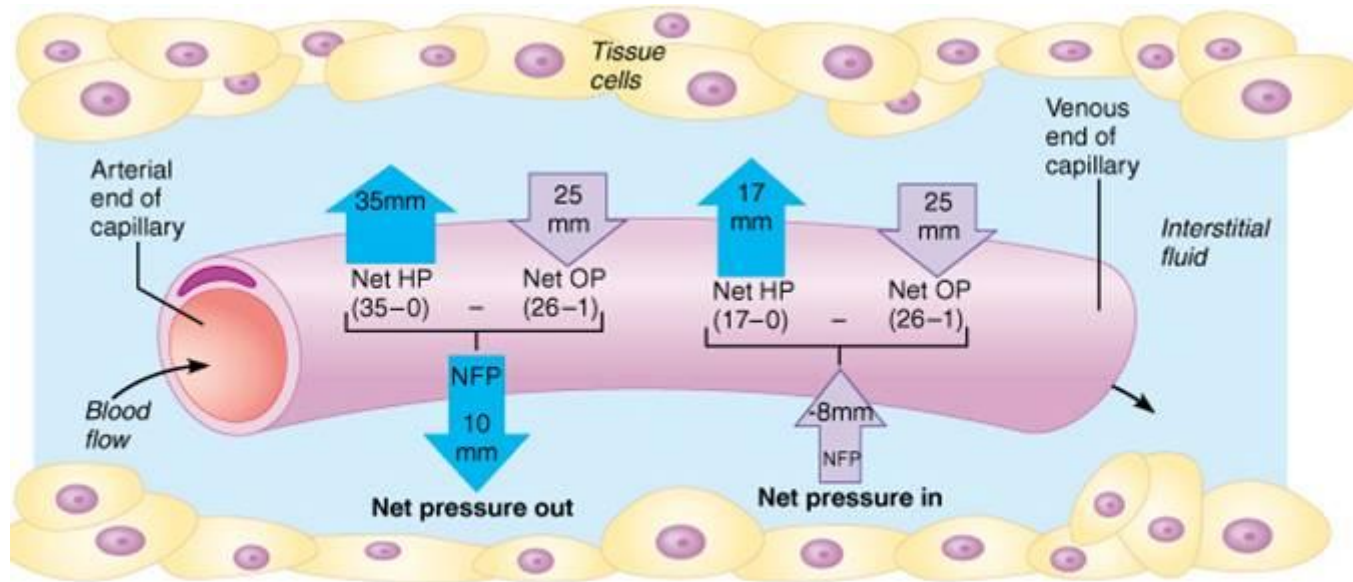
AUC2<AUC1

Positive water balance in the interstitium

Lymph drainage

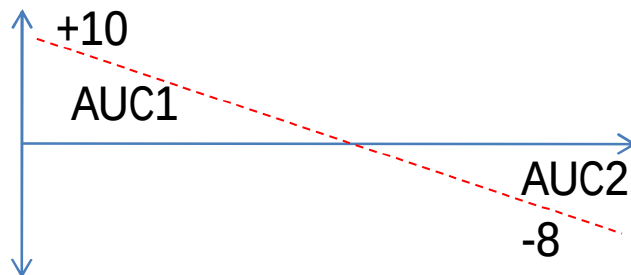


Simplified example



Ø \$Lymph drainage

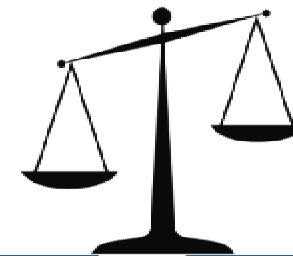
Filtration pressure alongside the capillary



$$AUC2 < AUC1$$

Positive water balance in the interstitium

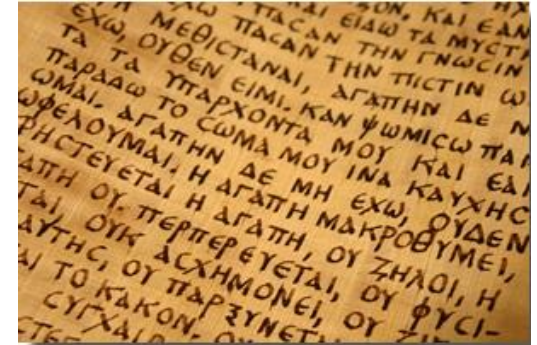
Lymph drainage



Different diseases, different mechanisms

- #HP
 - Chronic heart failure
 - Varices
 - Inflammation*
- \$OP
 - Nephrotic syndrome
 - Hypoproteinemia
 - Inflammation*
- #Permeability
 - Allergy
 - Inflammation*
- \$Lymph drainage
 - Parasites
 - Surgery

A little bit of Greek



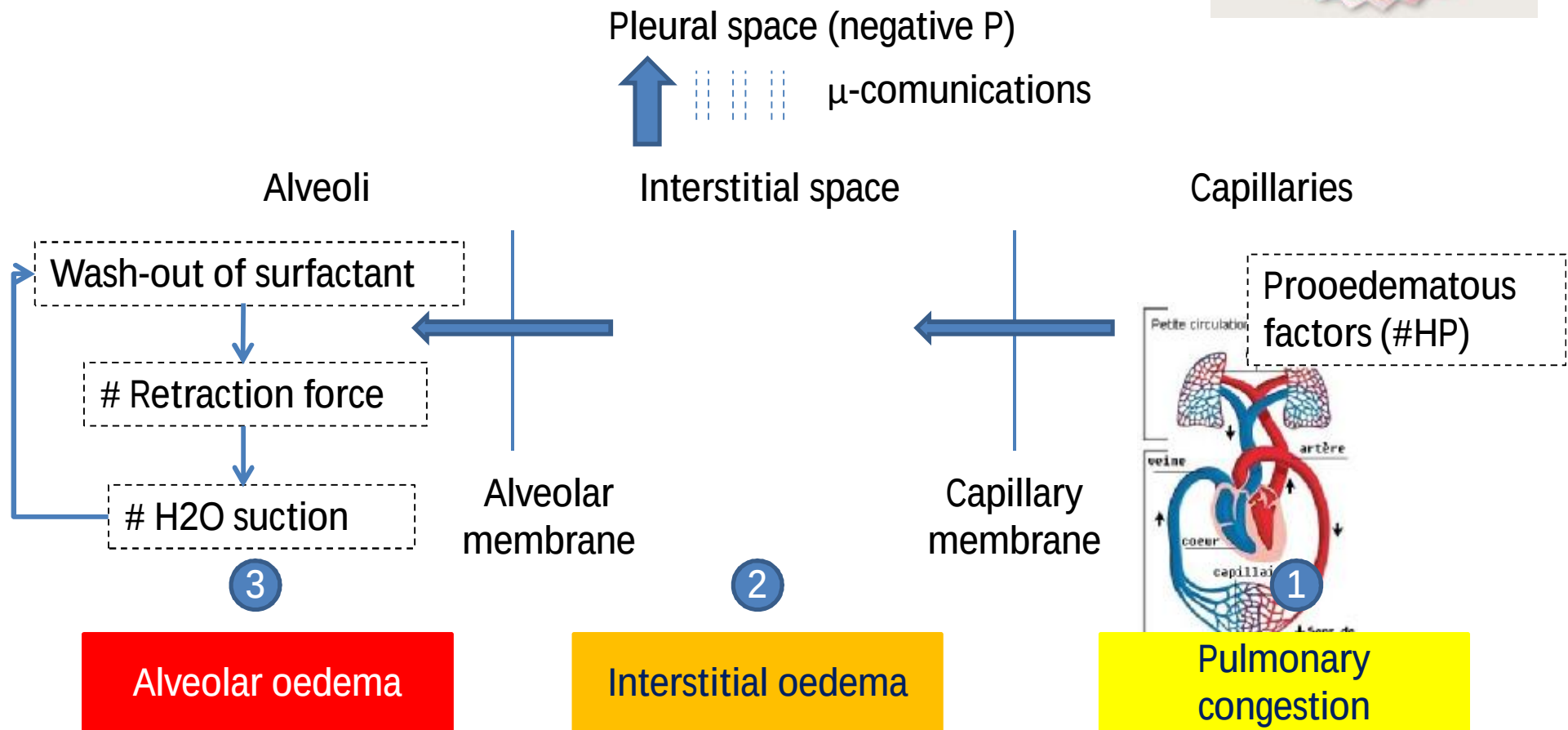
- Anasarca - extreme generalized oedema
- Ascites - accumulation of fluid in the peritoneal cavity
- Hydrothorax - effusion in the pleural cavity
- Hydropericardium - effusion in the pericardial cavity
- Hydrocephalus - abnormal accumulation of fluid in the cerebral ventricles
- Hydrocele - effusion in the scrotal pouch
- Synovial hydrops - abnormal accumulation of fluid in the joints

Pulmonary oedema

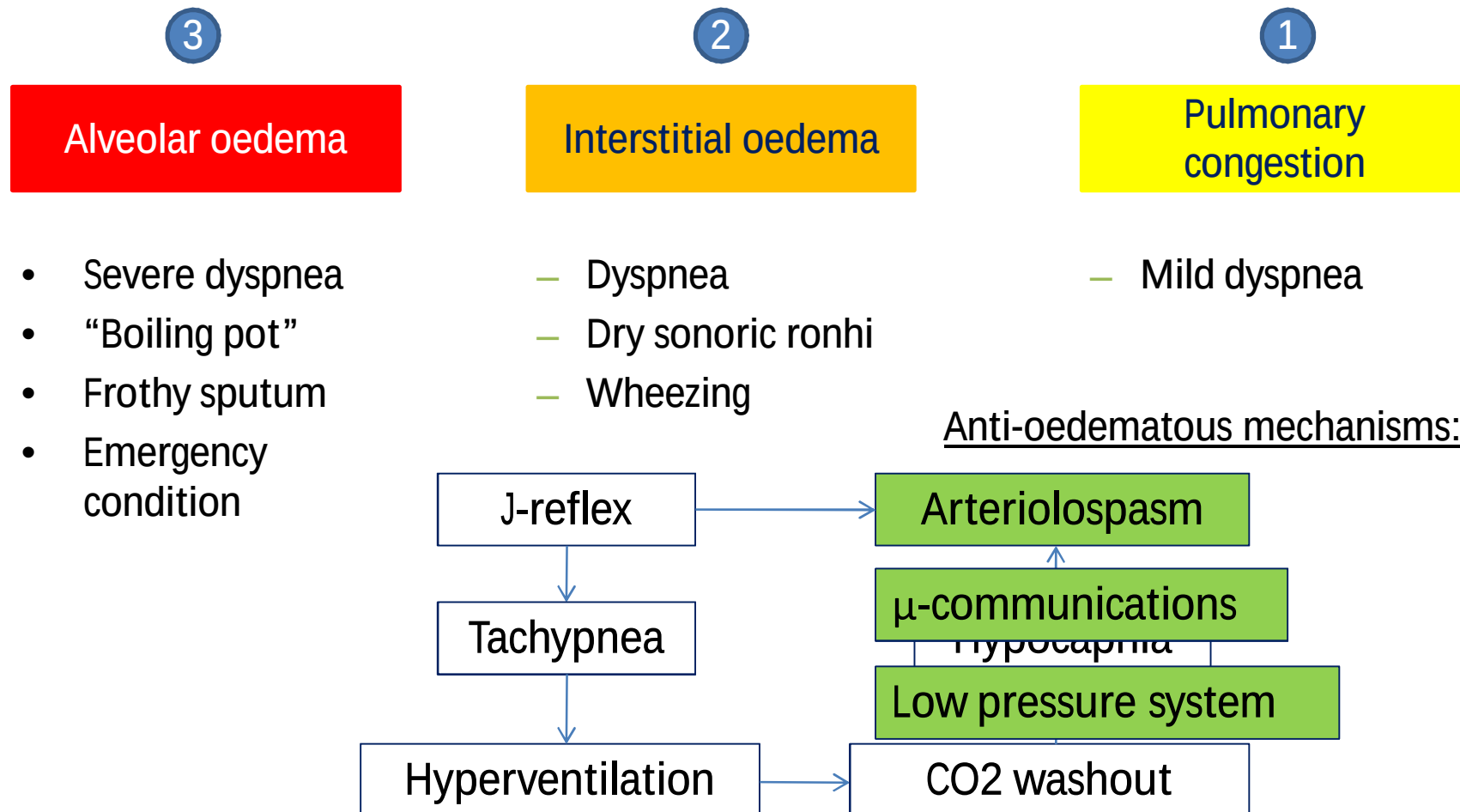


- Exogenous (toxins, hyperoxia)
- Endogenous
 - Cardiogenic (LV-CHF)
 - Non-cardiogenic (Shock)

Pulmonary oedema



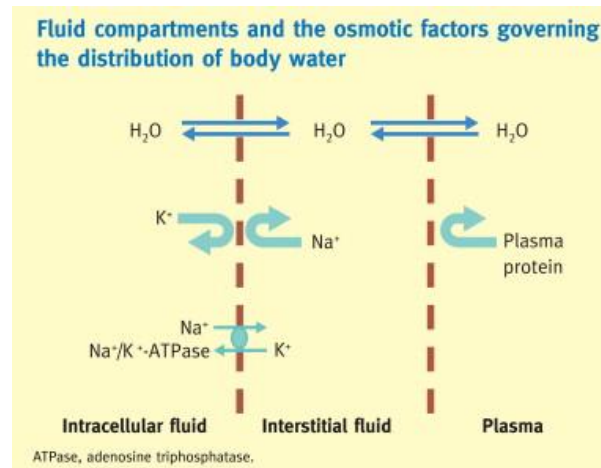
Pulmonary oedema – from Pathophysiology to symptoms



Brain oedema



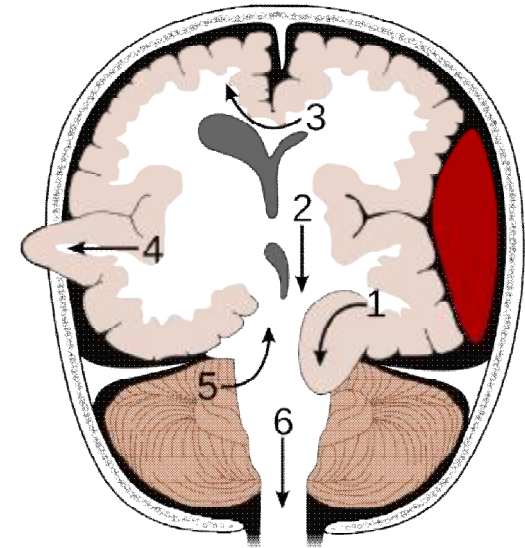
- Peculiarities
 - Intracellular oedema
 - Confined in the skull



- Etiology
 - Head trauma
 - Hyponatremia
 - High altitude
 - Brain tumors
 - Hydrocephalus
- Symptoms
 - Headaches
 - Confusion
 - Unconsciousness/ Coma



Size does matter!



Brain herniation in foramen magnum causes compression of the vital centers in the forelying brainstem



**KEEP
CALM
AND
DRINK
WATER**