

(Foundation Block)

Body Fluids and Electrolytes

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Learning Objectives:

- Identify and describe daily intake and output of water and maintenance of water balance.
- List and describe of body fluid compartments as intra-cellular fluid (ICF), Extra-cellular fluid (ECF), interstitial fluid, trans-cellular fluid, and total body water (TBW).
- Describe the composition of each fluid compartment, in terms of volume and ions and represent them in graphic forms.
- Describe the physiological and pathological factors influencing the body fluid.

Composition of the human body:

A. Body Water:

The human body made mainly of water, which consistutes about 60% of body weight in the adult, however the amount of water varies with age.

	Male (%)	Female (%)
At birth	82	82
Children and adolescents	70	70
18-20 years	59	57
20-40 years	61	51
40-60 years	55	47
Over 60 years	52	46



Composition of the human body:

B. Protein:

Is the second largest component in the human body, largest amount found in skeletal muscle.

C. Fat:

The third largest component in lean individual. It is found in adipose tissue



Composition of the human body:

D. Minerals:

Minerals, present in the human body in relatively small quantities with the exception of calcium. (Found in bones)

Minerals and electrolytes are found in the body fluids in minute concentrations, which are closely regulated to maintain the composition of the internal environment



The body fluids:

- Total body water (TBW):
constitutes 55-60% of the body weight in young men
and 45-50% in young women.

Why the percentage is lower in women?

- The TBW is distributed as follows:
Muscle (50%)
Skin (20%)
Other organs (20%)
Blood (10%)



The body fluids:

- **Infants** have **low body fat, low bone mass**, and are 73% or more water.
- Total water content declines throughout life.
- Healthy **males** are about **60% water**; healthy **females** are around **50%**
 - This difference reflects females':
 - Higher body fat
 - Smaller amount of skeletal muscle
- In **old age**, only about **45%** of body weight is water.



The body fluids:

- The water content of the body is divided into two compartments.

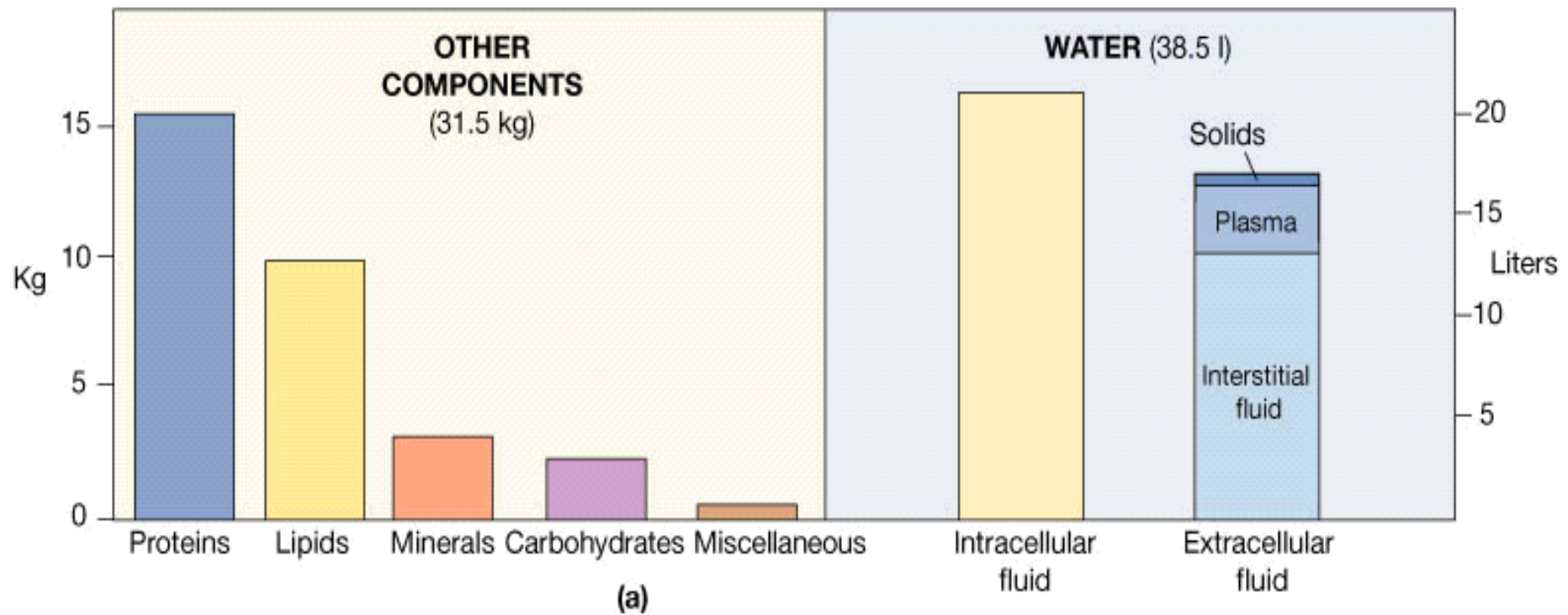
1) **Intracellular compartment:**

Contained within the cell, represent approximately 67% of the total body water, 40% of total body weight.

2) **Extracellular Compartment:**

Contained within the vessels of the cardiovascular system, is the remaining 33% of the total body water, about 20 % of total body weight,

The Composition of the Human Body:





Extracellular fluid (ECF)

The ECF compartments has several subcompartments:

1. **Plasma**, the fluid portion of the blood, represents approximately 25% of the ECF.

Blood volume, approximately 80 ml/kg of body weight (8%).



Extracellular fluid (ECF)

2. **Interstitial fluid (ISF)**, is contained in a gel-like extracellular matrix.

ISF surrounds all cells except blood cells and includes Lymph (2-3%) of total body weight

The ISF represent approximately 15% of the total body weight and 75% of the ECF.



Extracellular fluid (ECF)

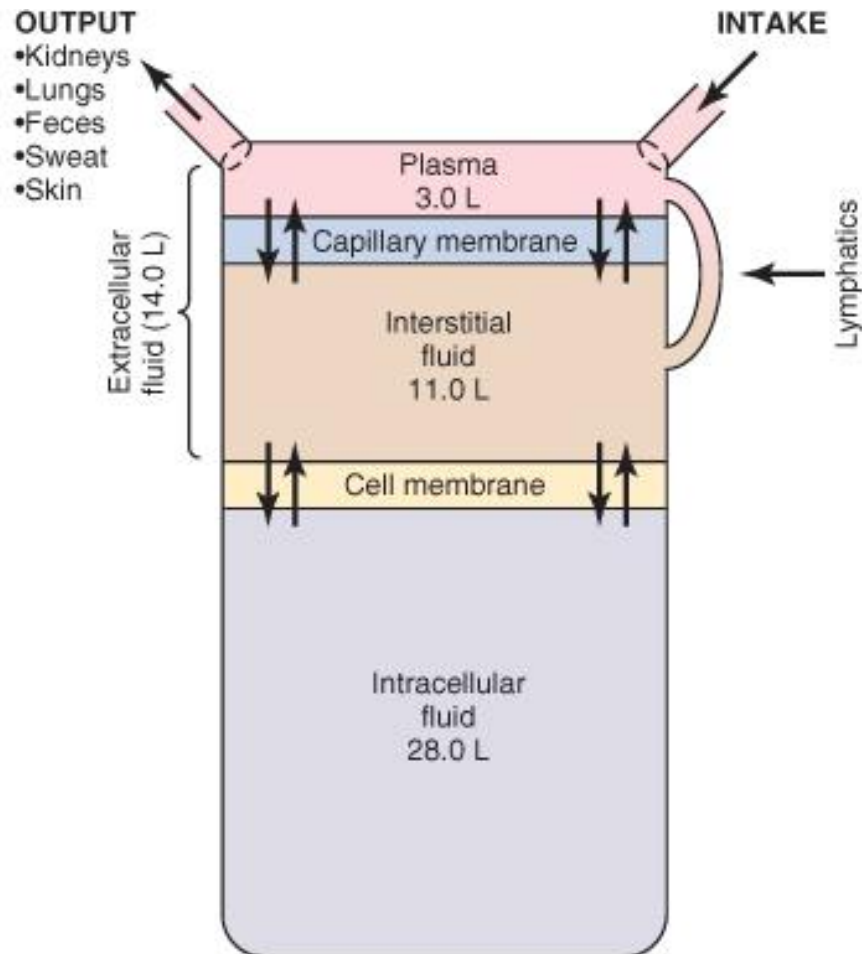
3. Transcellular fluid volume, is about 1 L, occupies approximately 15 ml/kg of body weight (1.5%).

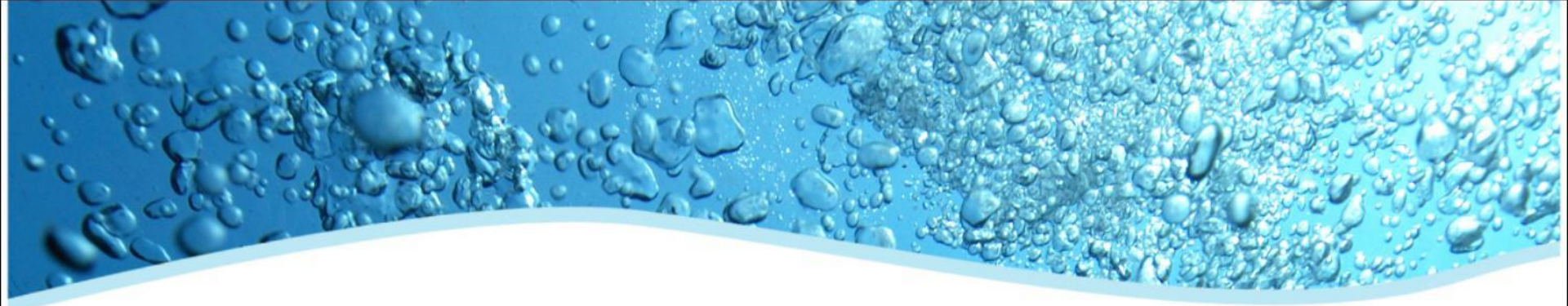
* Represents fluid in the lumen of structures lined by epithelium and includes digestive secretions, sweat, CSF, pleural, peritoneal, synovial, intraocular, pericardial fluids, bile, thyroid, and cochlea.

Constitutes of extracellular and intracellular fluids:

	Plasma (mOsm/L H ₂ O)	Interstitial (mOsm/L H ₂ O)	Intracellular (mOsm/L H ₂ O)
Na ⁺	142	139	14
K ⁺	4.2	4.0	140
Ca ⁺⁺	1.3	1.2	0
Mg ⁺	0.8	0.7	20
Cl ⁻	108	108	4
HCO ₃ ⁻	24	28.3	10
HPO ₄ ⁻ , H ₂ PO ₄ ⁻	2	2	11
SO ₄ ⁻	0.5	0.5	1
Phosphocreatine			45
Carnosine			14
Amino acids	2	2	8
Creatine	0.2	0.2	9
Lactate	1.2	1.2	1.5
Adenosine triphosphate			5
Hexose monophosphate			3.7
Glucose	5.6	5.6	
Protein	1.2	0.2	4
Urea	4	4	4
Others	4.8	3.9	10
Total mOsm/L	301.8	300.8	301.2
Corrected osmolar activity (mOsm/L)	282.0	281.0	281.0
Total osmotic pressure at 37°C (mm Hg)	5443	5423	5423

The major body fluid compartment and membranes separate them

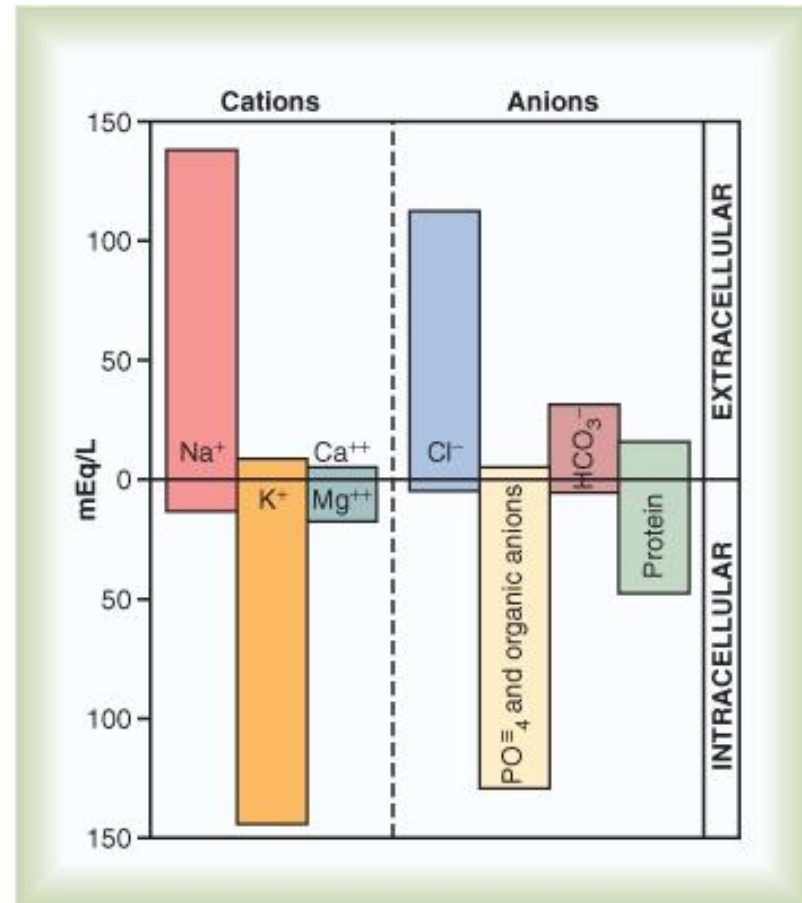




- The plasma and interstitial fluid are separated only by highly permeable capillary membranes, their ionic composition is similar but protein is higher in the plasma.
- the intracellular fluid is separated from extracellular fluid by a cell membrane that is highly permeable to water but not to most of the electrolytes in the body.

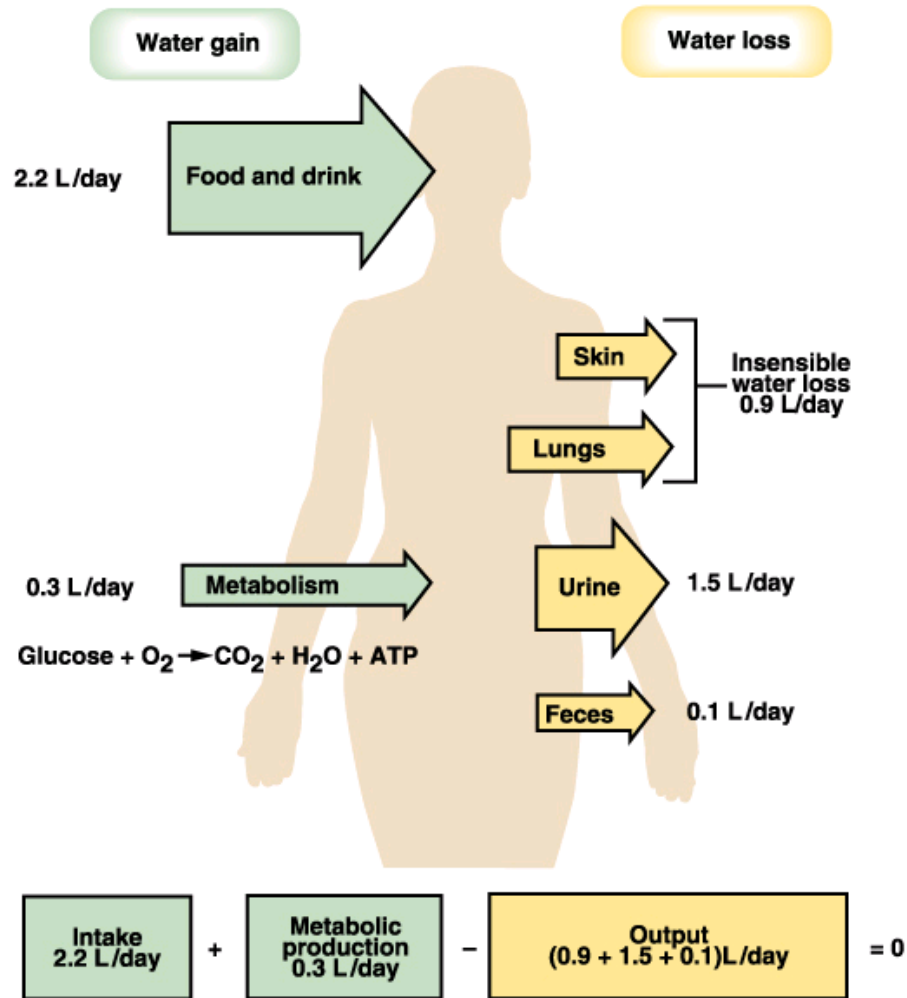
Solute Overview: Intracellular vs. Extracellular

- Ionic composition very different
- Total ionic concentration very similar
- Total osmotic concentrations virtually identical



Water Steady State:

- Amount ingested = amount eliminated.
- Pathological losses:
Vascular bleeding.
Vomiting.
Diarrhea.



Factors That Affect TBW:

Physiological factors:

- Age
- Sex
- Body fat
- Climate
- Physical activity

Pathological factors:

- Vomiting
- Diarrhea
- Diseases with excessive loss of water (DM, excessive sweating,....)
- Blood loss



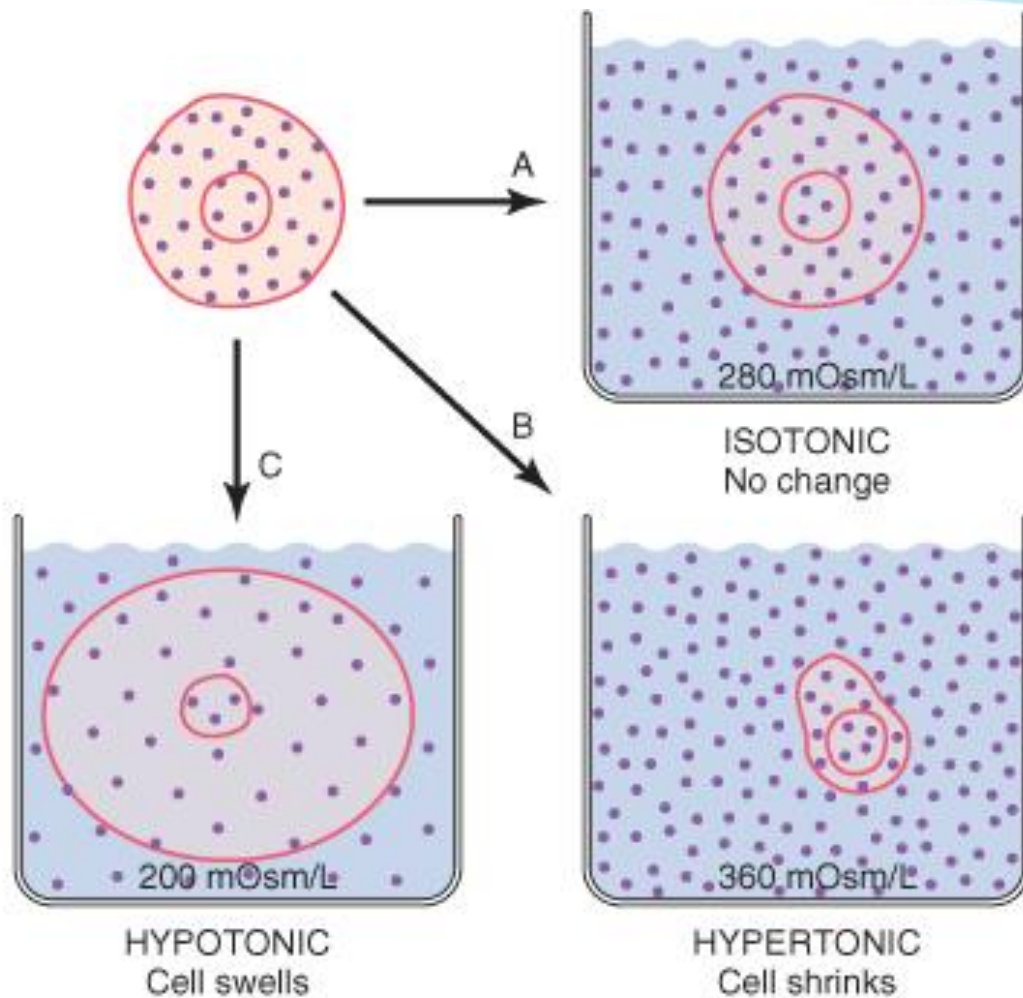
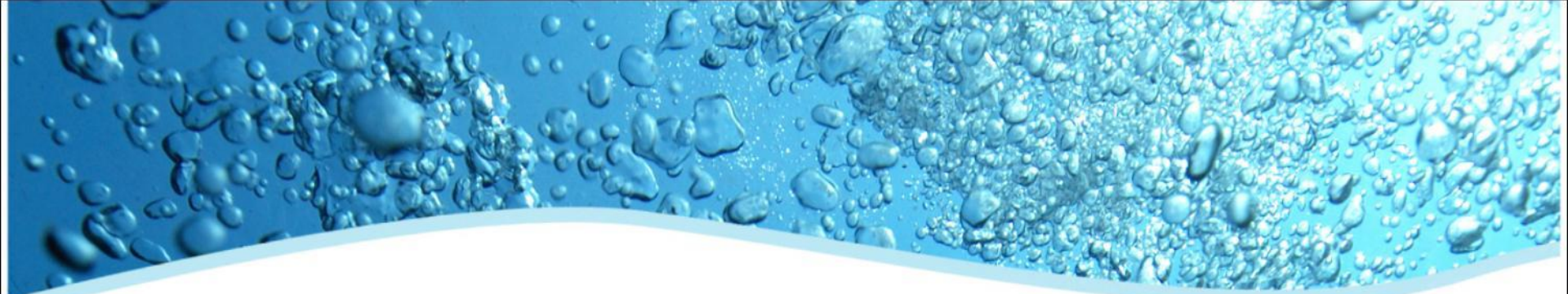
Definitions:

- **Volume:** the general clinical terms for volume abnormalities are dehydration and overhydration. Both conditions are associated with a change in ECF volume.
- **Concentration:** Osmolarity refers to the number of solute particles per liter of solution, and Osmolality refers to the number of solute particles per kilogram of water.
- **Tonicity:** The effect of a solution on the osmotic movement of H₂O.



Tonicity

- Isotonic:
 - Equal tension to plasma.
 - RBCs will not gain or lose H₂O.
- Hypotonic:
 - Osmotically active solutes in a lower osmolality and osmotic pressure than plasma.
 - RBC will hemolyse.
- Hypertonic:
 - Osmotically active solutes in a higher osmolality and osmotic pressure than plasma.
 - RBC will crenate.





Regulation of fluids and electrolytes:

- Homeostatic mechanisms respond to changes in ECF
- No receptors directly monitor fluid or electrolyte balance
 - Respond to changes in plasma volume or osmotic concentrations.
 - All water moves passively in response to osmotic gradients.
 - Body content of water or electrolytes rises if intake exceeds outflow.

Primary regulatory hormones:

- Antidiuretic hormone (ADH)
 - Stimulates water conservation and the thirst center
 - Regulates the concentration of body fluid
- Aldosterone
 - Controls Na^+ absorption and K^+ loss along the DCT
 - Regulates the volume of body fluid compartment
- Natriuretic peptides
 - Reduce thirst and block the release of ADH and aldosterone



Sodium balance:

- Rate of sodium uptake across digestive tract directly proportional to dietary intake
 - Sodium losses occur through urine and perspiration
- Shifts in sodium balance result in expansion or contraction of ECF
 - Large variations corrected by homeostatic mechanisms
 - Too low, ADH / aldosterone secreted
 - Too high, ANP secreted



Potassium balance:

- Potassium ion concentrations in ECF are low
 - Not as closely regulated as sodium
 - Potassium ion excretion increases as
 - ECF concentrations rise
 - Aldosterone secreted
 - pH rises
 - Potassium retention occurs when pH falls