

SHEET 10

Physiology

Hematolymphatic System



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Body fluids

In a 70-kilogram adult, the total body fluids are about 65% of the body weight (about 45 liters).

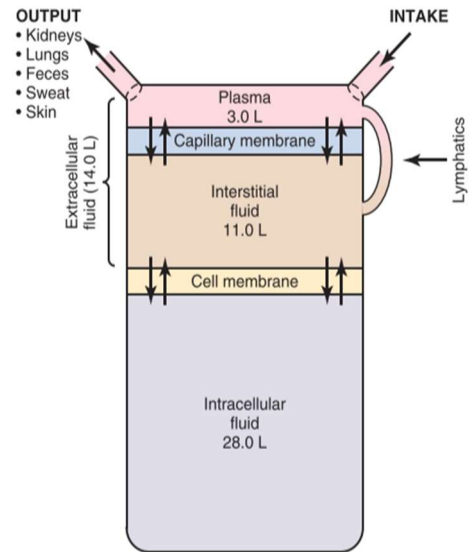
(Actually, the total body fluid is 42L (60% of the total body weight) but that is what the doctor said in 020 lecture)

The total body fluid is distributed mainly between two compartments:

- A. Extracellular fluid
- B. Intracellular fluid.

The extracellular fluid is divided into the interstitial fluid and the blood plasma.

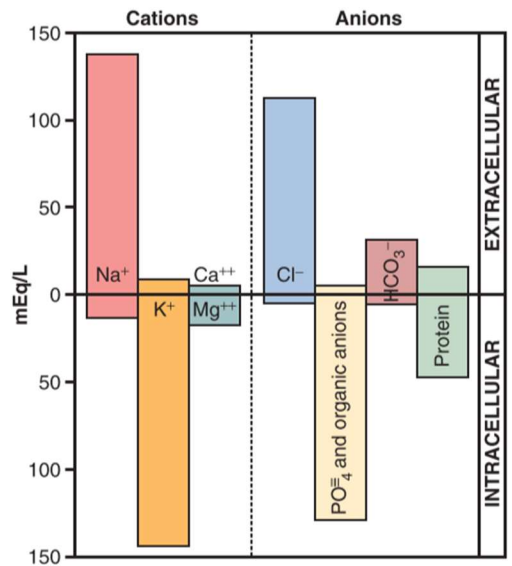
Memorize the numbers ➡



■ In the extracellular compartment, there is no significant difference between the plasma and the interstitial fluid concerning the concentrations of the constituents and the Ph **EXCEPT for the proteins**, and that's to provide colloidal osmotic pressure (ranges between 25-28 mmHg).

■ when we compare the extracellular fluid and intracellular fluid, we can see that the concentrations of potassium, sulfate, phosphate, and proteins are much higher inside the cells compared to their extracellular concentrations (interstitial fluid).

■ The concentration of sodium outside the cell is much higher than intracellularly. Whereas the concentration of potassium intracellularly is much higher than outside the cells. (Note: The Na⁺/K⁺ pump has a key role in maintaining this state)



CONSTITUENTS AND PROPERTIES	EXTRACELLULAR FLUID		INTRACELLULAR FLUID
	PLASMA	INTERSTITIAL FLUID	
Sodium	142	145	10
Potassium	4	4	160
Calcium	5	5	2
Magnesium	2	2	26
Chloride	101	114	3
Sulfate	1	1	20
Bicarbonate	27	31	10
Phosphate	2	2	100
Organic acids	6	7	—
Proteins	16	1	65
Glucose (av)	90 mg%	90 mg%	0-20 mg%
Lipids (av)	0.5 g%	—	—
pH	7.4	7.4	6.7

Total body water (TBW) in relation to age and sex:

Age	Male	Female
10-18	59%	57%
18-40	61%	51%
40-60	55%	47%
Over 60	52%	46%

* As a percentage of total body weight.

- Before the age of 18, there is no difference in TBW between males and females.
- Between the age of 18-40, there is a significant difference between males and females because of the effect of sex hormones, Females have a higher proportion of body fat; as a result, total body water is about 50% of their body weight, whereas about 60% of the body weight of an adult male is water.
- After the age of 60, the difference between males and females starts to decline gradually.

Distribution of water in various tissues and organs (not mentioned in 020 lecture)

■ Percent water: (% organ's content of water)

Blood has the highest percentage of water, followed by the kidneys and the Adipose tissues have the lowest percentage of water.

■ Percent to body weight (how much these organs constitute of the body weight)

Muscles (41.7 % about 42 %) Skin (18%) and skeleton (15.9%).

TISSUE/ORGAN	PERCENT WATER	PERCENT BODY WEIGHT	L. IN 70 KG MAN
Skin	72.0	18.0	9.07
Muscle	75.7	41.7	22.10
Skeleton	31.0	15.9	3.45
Brain	74.8	2.0	1.05
Liver	68.3	2.3	1.10
Heart	79.2	0.5	0.28
Lungs	79.0	0.7	0.39
Kidneys	82.7	0.4	0.23
Spleen	75.8	0.2	0.11
Blood	83.0	7.7	4.47
Intestine	74.5	1.8	0.94
Adipose	10.0	9.0	0.63
Total body	62.0	100.0	43.40

■ L. in 70-kg man (how many liters of water these organs contain)

Muscle (22.10 liters), Skin (9.07 liters), and blood (4.47 about 5 liters)

Water balance

■ Fluid intake should be equal to the fluid output

Fluid intake:

- Fluid ingested as liquid: 1.0 L
 - Fluid from ingested food: 1.2 L
 - Fluid from metabolism: 0.4 L
- } Total fluid intake = 2.6 L

Fluid output:

- Through urine: 1.5 L
 - Through expiration (through the lungs): 0.5 L
 - Through sweat glands (through the skin): 0.45 L
 - Through feces: 0.15 L
- Total fluid output = 2.6 L

Defense of body fluid volume

There are defense mechanisms against abnormalities in body fluids (hypovolemia and hypervolemia)

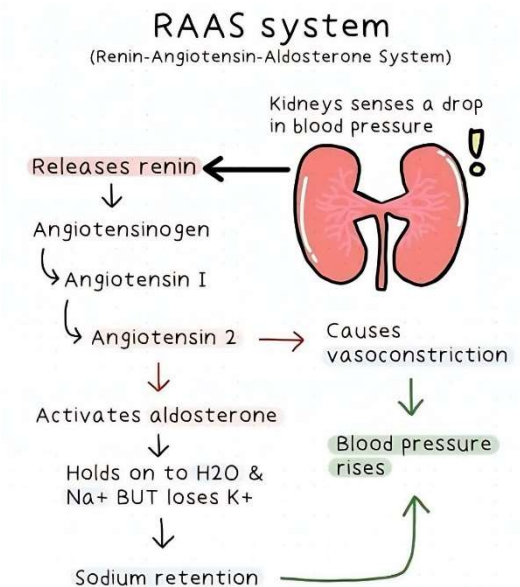
Hypervolemia

- Hypervolemia is due to an excess of total body sodium and water, which leads to the expansion of the ECF compartment.
- Increased Na⁺ intake causes retention of water which increases blood volume.
- The defense mechanism in hypervolemia:
 1. A hormone called “Atrial Natriuretic Peptide (ANP)” is released from the atria of the heart. This hormone increases sodium excretion.
 2. ADH released from the posterior pituitary is inhibited; consequently, sodium and water excretion are stimulated.
 3. Normal body fluid volume is restored.

Hypovolemia

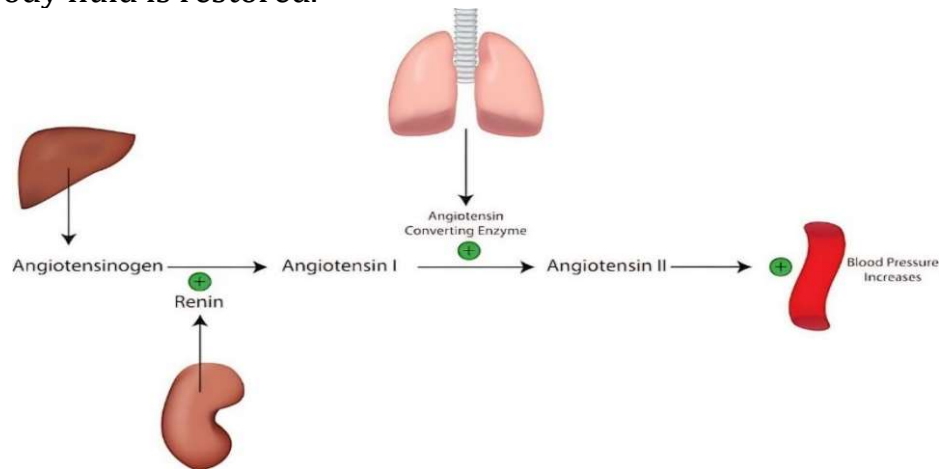
- Hypovolemia is a condition that occurs when your body loses fluid, like blood or water.
- Decreased sodium intake causes the excretion of water which decreases blood volume and blood pressure.
- The defense mechanism in hypovolemia:

1. Low pressure detected by afferent arteriole in the kidney
2. Renin hormone is secreted from the kidneys, this hormone will convert angiotensinogen into angiotensin I which will be converted into angiotensin II by a converting enzyme in the lungs.
3. Angiotensin II causes:
 - a. Thirst
 - b. Constriction of blood vessels.
 - c. Stimulation of the release of ADH.



d. Stimulation of the release of aldosterone from the adrenal cortex will lead to increased reabsorption of Na^+ and water.

4. Normal body fluid is restored.



Dehydration

■ If the hemodynamics mechanisms fail to operate properly, loss of fluid, electrolytes (ions) or both occur.

■ Dehydration may be a consequence of:

- * Failure of water absorption from the GI.
- * Excessive loss from sweating, diarrhea, vomiting or excessive diuretics.
- * Diabetic patients are usually dehydrated due to excessive urination.
- * Drainage from wounds and burns.

■ Depending on the relative losses of fluid and electrolyte there are 3 types of dehydration:

Isotonic dehydration

- * Equal loss of fluid and electrolyte.
- * There is a proportionate loss of fluid and electrolyte so that the total volume of ECF changes, but its osmotic pressure remains within normal limits.

Hypertonic dehydration

- * Excessive fluid loss as compared to electrolyte
- * More fluid than electrolytes are lost. As a result, the ECF becomes more concentrated. Water thus tends to be drawn from cells.

Hypotonic dehydration

- * Excessive electrolyte loss as compared to fluid
- * More solute than fluid is lost, therefore, the ECF becomes diluted. Water thus tends to enter cells.

Characteristics that result from dehydration (not mentioned in 020 lecture)

- A shrunken appearance of the face & the body
- The skin loses its elasticity and becomes hard and leathery
- There's a rapid loss of body weight
- when the deficiency reaches a degree that the water is no longer sufficient for the removal of heat of metabolism, high fevers may occur.
- As the condition worsens, circulatory failure develops
- Anuria results (because there's no fluid)
- Acids products are retained leading to acidosis
- Cerebral disturbances, excitement, delirium and coma terminate the episode

Hydration (water intoxication)

- Hydration is a term referring to the results of:

- 1) Excessive water intake.
- 2) Decreased loss of water.
- 3) Increased reabsorption of water from the kidney because of ADH administration.

Note: excessive water is evenly distributed between extracellular and intracellular, this increased water volume causes the **dilution** of the substances within the extracellular and intracellular.

- Excessive water intake may produce the syndrome of water intoxication in which:

- 1- Cellular function is disturbed by the dilution of cellular electrolytes.
- 2- Disorientation, convulsions and coma.
- 3- Gastrointestinal dysfunction, muscular weakness, and abnormal cardiac rhythms.

Past papers

Q1. Which one of the following substances is found exactly in the same percentage in both plasma and interstitial fluid?

- a. Glucose
- b. Proteins
- c. Lipids
- d. Bicarbonate
- e. Chloride

Answer: A

Q2. About ADULT males and females fluid distribution, which of the following is correct:

- a. both have the same fluid and fat distribution
- b. Males have more fluid and fat distribution
- c. Females have more water and fat distribution
- d. females have more fat and less water distribution

Answer: D

Q3. We regulate extracellular fluid because?

- a. to maintain blood pressure
- b. to increase the release of ADH
- c. to prevent cells from shrinkage and swelling

Answer: C

Q4. A fall in sodium plasma concentration

- a. decreases the freezing point of plasma
- b. increases intracellular fluid volume
- c. is not associated with thirst
- d. can't be caused by excessive (uncontrolled) secretion of ADH (anti- diuretic hormone)
- e. causes edema

Answer: B

Q5. Chose the wrong statement

- a. In hypertonic dehydration, water tends to be drawn from cells
- b. hormones and amino acids are responsible for a significant portion of blood osmolality

Answer: B

Q6. Which of the following electrolytes has the most effect on osmolality:

- a. K⁺
- b. Na⁺
- c. Cl

Answer: B