CHAPTER-XIII

ELECTROLYTES

Body water

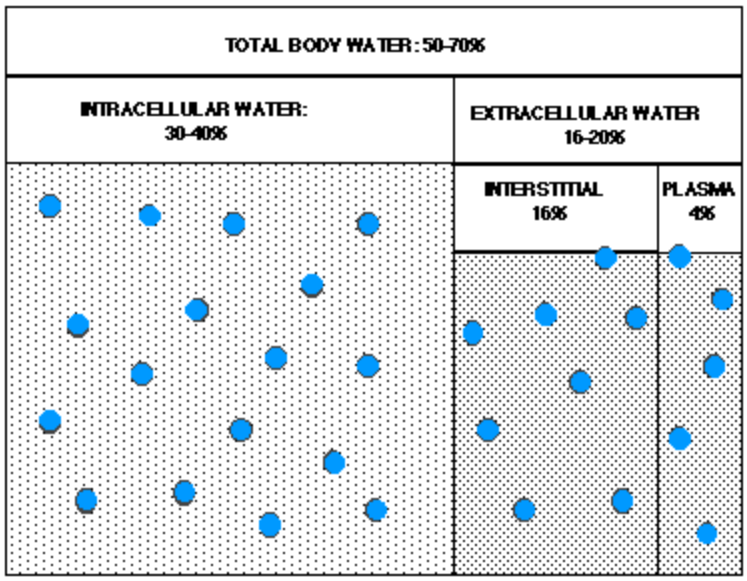
In physiology, body water is the water content of the human body. A significant fraction of the human body is water.

Arthur Guyton's *Textbook of Medical Physiology* states that "the total amount of water in a man of average weight (70 kilograms) is approximately 40 litres, averaging 57 percent of his total body weight. In a newborn infant, this may be as high as 79 percent of the body weight, but it progressively decreases from birth to old age, most of the decrease occurring during the first 10 years of life. Also, obesity decreases the percentage of water in the body, sometimes to as low as 45 percent". These figures are statistical averages, so are illustrative, and like all biostatistics, will vary with things like type of population, age and number of people sampled, and methodology. So there is not, and cannot be, a figure that is exactly the same for all people, for this or any other physiological measure. For example, Jackson's (1985) *Anatomy & Physiology for Nurses* gives a figure of 60% for the proportion of body-weight attributable to water, which approximates Guyton's 57%.

In diseased states where body water is affected, the compartment or compartments that have changed can give clues to the nature of the problem. Body water is regulated by hormones, including anti-diuretic hormone (ADH), aldosterone and atrial natriuretic peptide.

Per *Netter's Atlas of Human Physiology*, body water is broken down into the following *compartments:*

- Intracellular fluid (2/3 of body water). Per Guyton, in a body containing 40 litres of fluid, about 25 litres is intracellular,[5] which amounts to 62.5% (5/8), close enough to the 2/3 rule of thumb. Jackson's texts states 70% of body fluid is intracellular.
- Extracellular fluid (1/3 of body water). Per Guyton's illustration, for a 40 litre body, about 15 litres is extracellular, which amounts to 37.5% Again, this is close to the 1/3 rule of thumb cited here.
    - Plasma (1/5 of extracellular fluid). Per Guyton's illustration, of the 15 litres of extracellular fluid, plasma volume averages 3 litres.[5] This amounts to 20%, the same as per *Netter's Atlas*.
    - Interstitial fluid (4/5 of extracellular fluid)
    - Transcellular fluid (a.k.a. "third space," normally ignored in calculations)
        - Contained inside organs, such as the gastrointestinal, cerebrospinal, peritoneal, and ocular fluids.



Compartments of Body and Distribution of Water by Weight		
Plasma		5%
Interstitial 15%		
Intracellular		40%
Total 60 % Water		
Solids fat, minerals	-	40%

Fluid and Electrolyte Balance

The main fluid in the body is water. Total body water is 60% of body weight. The water is distributed in three main compartments separated from each other by cell membranes. The intracellular compartment is the area within the cell. The extracellular compartment consists of the interstitial area (between and around cells) and the inside of the blood vessels (plasma).

ELECTROLYTE DISTRIBUTION			
Electrolyte	Extracellular meq/liter	Intracellular meq/liter	Function
Sodium	142	10	fluid balance, osmotic pressure
Potassium	5	100	Neuromuscular excitability acid-base balance
Calcium	5	-	bones, blood clotting
Magnesium	2	123	enzymes
Total Positive ions	154	205	

Electrolyte Distribution			
Electrolyte	Extracellular meq/liter	Intracellular meq/liter	Function
Chloride	105	2	fluid balance, osmotic pressure
Bicarbonate	24	8	acid-base balance
Proteins	16	55	osmotic pressure
Phosphate	2	149	energy storage

Sulfate	1	-	protein metabolism
Total Negative ions	154	205	

Electrolytes are the chemicals dissolved in the body fluid. The distribution has important consequences for the ultimate balance of fluids.

Sodium chloride is found mostly in extracellular fluid, while potassium and phosphate are the main ions in the intracellular fluid.

Determination of Sodium, Potassium, Calcium, Chloride and bicarbonates in body fluids

Blood sodium testing is used to detect abnormal concentrations of sodium, termed hyponatremia (low sodium) and hypernatremia (high sodium). A doctor may order this test, along with other electrolytes, to identify an electrolyte imbalance. It may be ordered to determine if a disease or condition involving the brain, lungs, liver, heart, kidney, thyroid, or adrenal glands is causing or being exacerbated by a sodium deficiency or excess. In patients with a known electrolyte imbalance, a blood sodium test may be ordered at regular intervals to monitor the effectiveness of treatment. It may also be ordered to monitor patients taking medications that can affect sodium levels, such as diuretics.

Urine sodium levels are typically tested in patients who have abnormal blood sodium levels to help determine whether an imbalance is from, for example, taking in too much sodium or losing too much sodium. Urine sodium testing is also used to see if a person with high blood pressure is eating too much salt. It is often used in persons with abnormal kidney tests to help the doctor determine the cause of kidney damage, which can help guide treatment.

What does the test result mean?

A low level of blood sodium is usually due to loss of too much sodium, too much water intake or retention, or to excess fluid accumulation in the body (edema). If the sodium level falls quickly, the person may feel weak and fatigued; in severe cases, he may experience confusion or even fall into a coma. When the sodium level falls slowly, however, there may be no symptoms. That is why sodium levels are often checked even if someone has no symptoms.

Hyponatremia is rarely due to decreased sodium intake (deficient dietary intake or deficient sodium in IV fluids). Most commonly, it is due to sodium loss from conditions such as Addison's disease, diarrhea, diuretic administration, or kidney disease. In some cases, it may be due to excessive water consumption as might occur during exercise or excessive fluid accumulation as might occur in heart failure, cirrhosis, and kidney diseases that cause protein loss (nephrotic syndrome). In other cases (particularly diseases involving the brain and the lungs, many kinds of cancer, and in response to some drugs), the body makes too much anti-diuretic hormone (ADH), causing a person to keep too much water in their body.

A high blood sodium level is almost always due to inadequate water intake and dehydration. Symptoms include dry mucous membranes, thirst, agitation, restlessness, acting irrationally, and

coma or convulsions if the sodium level rises to extremely high concentrations. In rare cases, hypernatremia may be due to Cushing syndrome or a condition caused by too little ADH called diabetes insipidus.

Sodium urine concentrations must be evaluated in association with blood levels. The body normally excretes excess sodium, so the concentration in the urine may be elevated because it is elevated in the blood. It may also be elevated in the urine when the body is losing too much sodium; in this case, the blood level would be normal to low. If blood sodium levels are low due to insufficient intake, then urine concentrations will also be low.

- Decreased urinary sodium levels may indicate dehydration, congestive heart failure, liver disease, or nephrotic syndrome.
- Increased urinary sodium levels may indicate diuretic use or Addison's disease.

Sodium levels are often evaluated in relation to other electrolytes and can be used to calculate a quantity termed anion gap. The anion gap is useful in identifying the presence of unknown substances such as toxins in the blood.

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