Electrolytes:

is defined as substance that develops on electrical charge when dissolved in water.

Na^+ ; K^+, Ca^{++} ; Cl^- ; HCO_3^- ; phosphates ....

Those that develop a positive charge in water are called Cations for example: Na^+, K^+, Ca^{++}

electrolytes that develop negative charges when dissolved in water are called Anions for example: Cl^- ; HCO_3^- ; sulfates ; phosphates ;

in all body fluids; Anion and Cations are always present in equal amount, because +ve and -ve charges must be equal.

Table: ..

major electrolyte content in ECF and ICF.

Plsma electrolytes: Cations = Anions (total)

ICf electrolytes : Cations = Anions (total)

The major electrolytes in the

ECf → Na^+ ; Cl^-

ICf → K^+ ; Phosphate.

BODY FLUID

1 Lecture

About 60% of the adult human body is fluid. Some of this fluid is inside the cell and is called the intracellular fluid (ICF). The fluid in the spaces outside the cell is called the extracellular fluid (ECF).

In animals with closed vascular systems, the ECF is divided into 2 components: The Interstitial Fluid and the Circulating Blood Plasma. The plasma and cellular elements of the blood, principally red blood cells, fill the vascular system, and together they constitute the total blood volume. About a third of the total body water (TBW) is extracellular; the remaining two-thirds is intracellular fluid.

Size of the Fluid Compartments:-

In the average young adult male, 18% of the body weight is protein and related substances, 7% is mineral, and 15% is fat. The remaining 60% is water. The distribution of this water is: The intracellular component of the body water accounts for about 40% of the body weight and the extracellular component about 20%. Approximately 25% of the extracellular component is in the vascular system (Plasma = 5% of the body weight) and 75% outside the blood vessels (interstitial fluid = 15% of the body weight). The total blood volume is about 8% of body weight.

Differences between Extracellular Fluid and Intracellular Fluid:-

Both of these fluids contain reasonable amounts of the usual nutrients required by the cells for metabolism, including such substances as glucose, amino acids, lipids, cholesterol, phospholipid, and neutral fat. Also, both fluids contain oxygen and CO_2 and H^+ concentration (is only slightly different between the ECF and intracellular fluid).

	ECF	ICF
	Nat greater outside	k+ greater inside
Na^+	142 mEq/1	10 mEq/1
K^+	5 mEq/1	141 mEq/1
Ca^{++}	5 mEq/1	< 1 mEq/1
Mg^{++}	3 mEq/1	58 mEq/1
Cl^-	103 mEq/1	4 mEq/1
HCO_3^-	28 mEq/1	10 mEq/1
Phosphates	4 mEq/1	75 mEq/1
SO_4^{--}	1 mEq/1	2 mEq/1
Glucose	90 mgm %	0-30 mgm %
Aminoacids	30 mgm %	200 mgm %
Cholesterol) Phospholipids) Neutral fat)	0.5 gm %	2-95 gm %
PO_2	35 mm.Hg	20 mm.Hg
PCO_2	46 mm.Hg	50 mm.Hg
PH	7.4	7.0

There are two major reasons for the different concentrations between ECF and ICF:

1. Some substances that enter the cells are utilized so rapidly that their concentrations become reduced inside the cell in comparison with the outside. For instance;- The concentrations of both glucose and O_2 are lower inside than outside because both are continually being used in the metabolic reactions of the cell. These metabolic reactions inside the cell also create new substances, thereby causing the concentrations of these to be greater inside than outside. For instance, large quantities of CO_2 are formed in the cells, which means that the CO_2 concentration is normally somewhat higher inside than outside. Likewise,

other end-products of cellular metabolism, such as urea, creatinine, sulfates, and so forth, are all present in the ICF in considerably higher concentration than in ECF.

2. The second reason is selectivity of transport of substances through the cell membrane. The cell membrane is highly permeable to some substances and very poorly permeable to others.

The Fluid Transport System:-

ECF is transported to all parts of the body in two different stages:

- The first stage entails movement of blood around the circulatory System.
- The second, movement of fluid between the blood capillaris and the cells.

All the blood in the circulation traverses the entire circuit of the circulation on average of once each minute, when a person is at rest and as many as six times each minute, when he becomes extremely active. As blood passes through the capillaries, continual exchange occurs between the plasma portion of the blood and the interstitial fluid in the spaces surrounding the capillaries.

The capillaries are porous so that large amounts of fluid can diffuse back and forth between the blood and the tissue spaces. This process of diffusion is caused by kinetic motion of the molecules in both the plasma and ECF. That is, all fluid and dissolved molecules are continually moving and bouncing in all directions through the pores, through the tissue spaces and so forth. Almost no cell is located more than 25 to 50 microns from a capillary which ensures diffusion of almost any substance from the capillary to the cell within a few seconds. Thus the ECF throughout the body is

TABLE 1-2. Plasma Electrolytes

Electrolytes	mEq/L
Cations	
Sodium (Na^+)	142
Potassium (K^+)	5
Calcium (Ca^{++})	5
Magnesium (Mg^{++})	2
Total cations	154
Anions	
Chloride (Cl^-)	103
Bicarbonate (HCO_3^-)	26
Phosphate (HPO_4^{--})	2
Sulfate (SO_4^{--})	1
Organic acids	5
Proteinate	17
Total anions	154

☆ # cations ~~cats~~ in plasma = # of anions in plasma = 154

☆ # cations in ICF = # of anions in ICF = 200

TABLE 1-3. Approximation of Major Electrolyte Content in Intracellular Fluid

Electrolytes	mEq/L
Cations	
Potassium (K^+)	150
Magnesium (Mg^{++})	40
Sodium (Na^+)	10
Total cations	200
Anions	
Phosphates, Sulfates	150
Bicarbonate (HCO_3^-)	10
Proteinate	40
Total anions	200

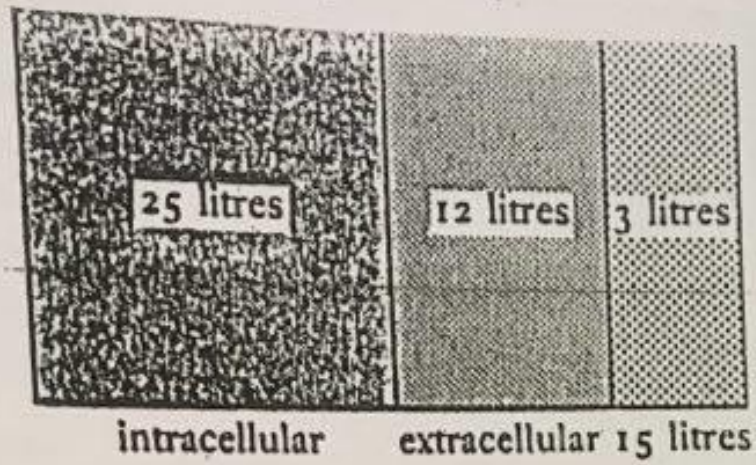


Figure 2.6. Fluid compartments.

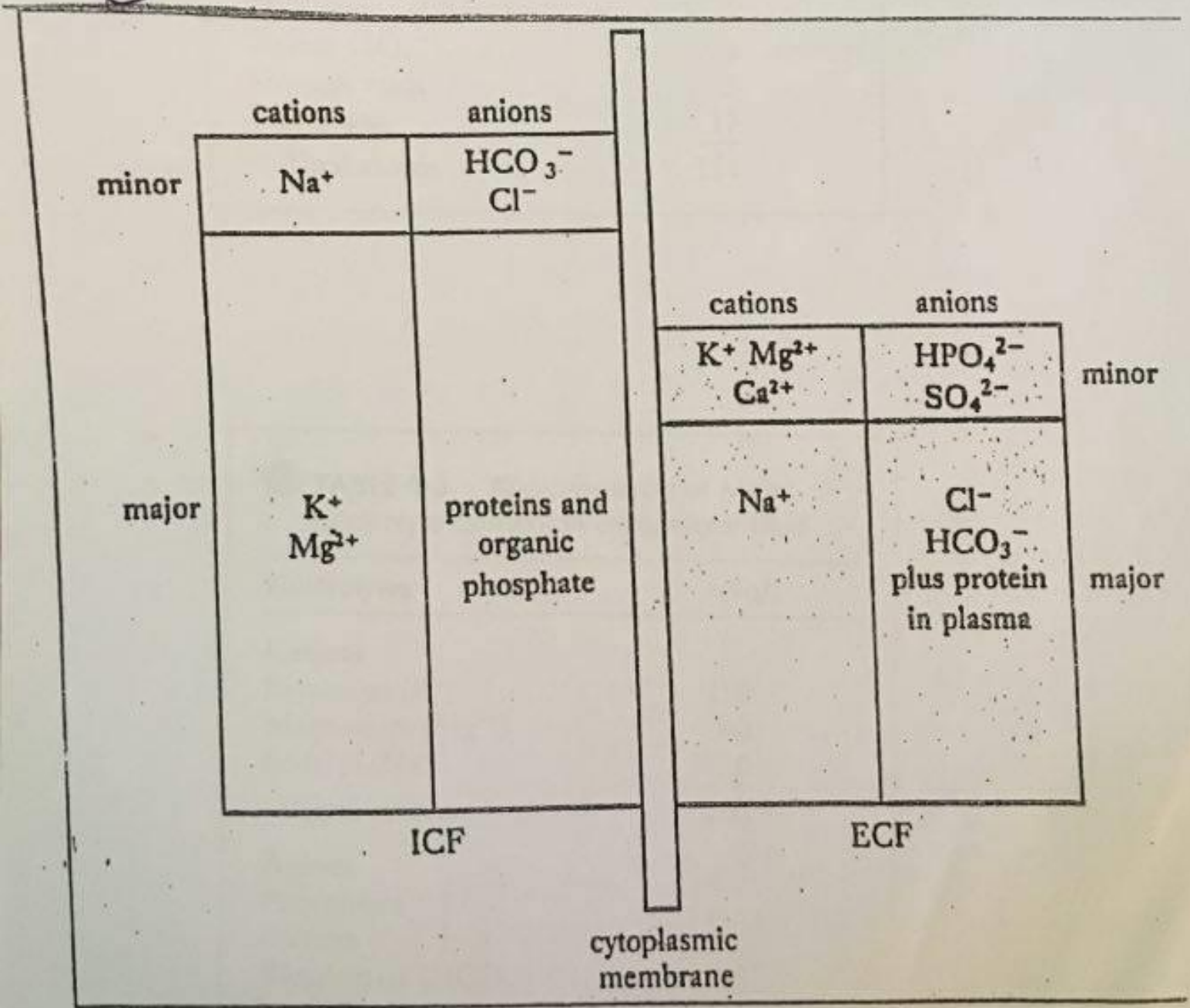


Figure 2.7. Comparision of the electrolyte composition of intracellular fluic and extracellular fluid (ECF).

continually mixed and thereby maintains almost complete homogeneity.

Measurement of body fluid volumes:-

It is theoretically possible to measure the size of each of the body fluid compartments by injecting substances that will stay in only one compartment and then calculating the volume of fluid in which the test substance is distributed (the volume of distribution of the injected material). The volume of distribution is equal to the amount injected (minus any that has been removed from the body by metabolism or excretion during the time allowed for mixing), divided by the concentration of the substances in the sample.

(not very important)

Example:-

150 mg of sucrose are injected into 70 Kg man. The plasma sucrose level after mixing is 0.01 mg/ml, and 10 mg have been excreted or metabolized during the mixing period. The volume of distribution of the sucrose is

$$\frac{150 \text{ mg} - 10 \text{ mg}}{0.01 \text{ mg/ml}} = 14.000 \text{ ml.}$$ (Dilution Principle)

14.000 ml is the space in which the sucrose was distributed, it is also called the sucrose space. The material injected must be non toxic, must mix evenly throughout the compartment being measured, must have no effect of its own on the distribution of water or other substances in the body, and must be unchanged by the body during the mixing period. It also should be relatively easy to measure.

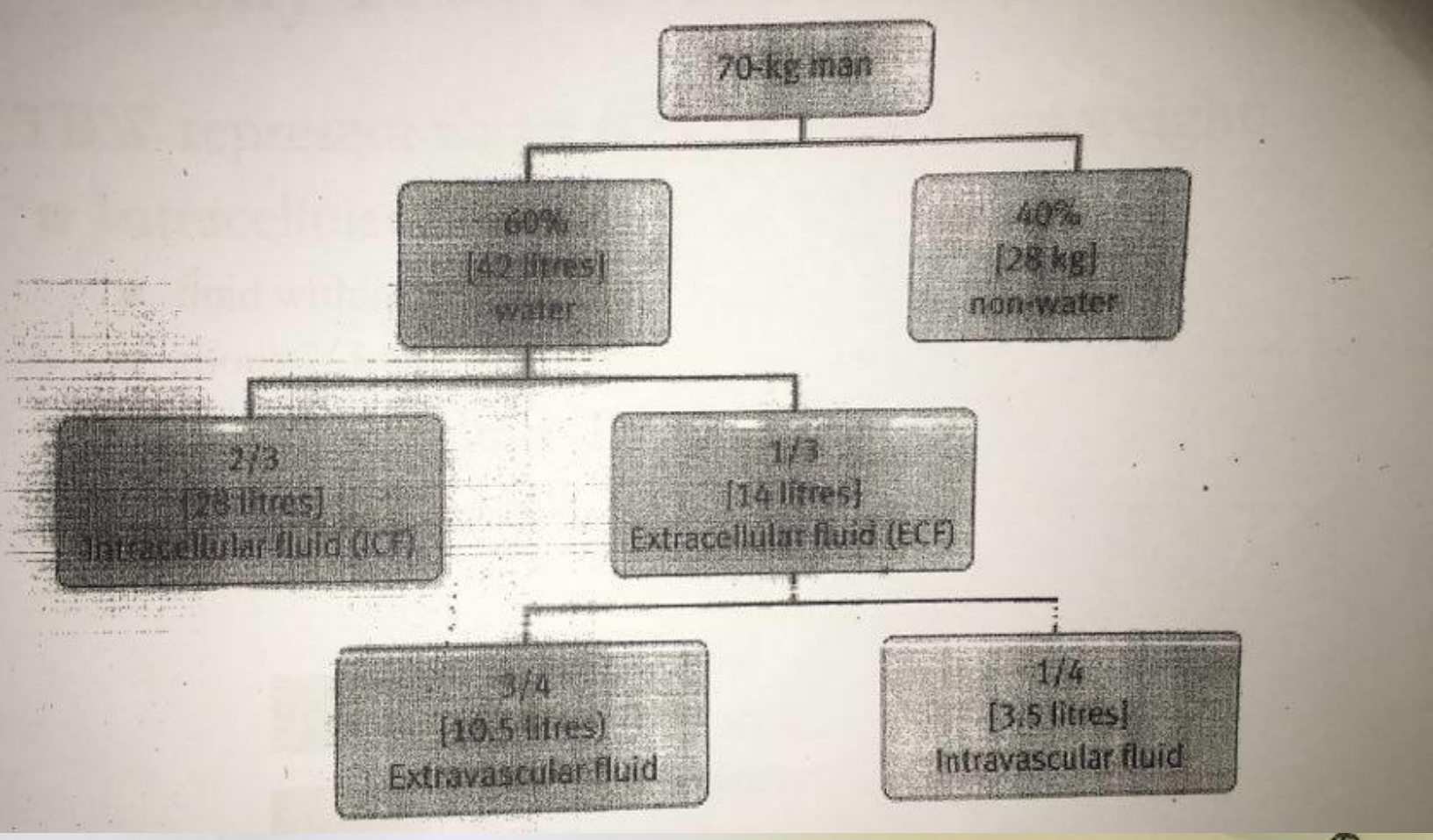
Plasma Volume:-

The plasma volume is measured by injecting some substance that will stay in the plasma compartment of the circulating blood. Such a substance frequently used is a dye called Evans blue (T-1824), which, upon intravenous injection, combines almost immediately with plasma proteins - plasma volume can also be measured by injecting serum albumin labeled with radioactive iodine.

Body fluid

- Variation in water content:
  - Variation due to age: total body water (TBW) ↓ with increasing age, by age of 60 years it becomes **50 %**
  - Variation between tissues:
    - Most tissues are water-rich and contain 70-80% water
    - Plasma contains >90% water
    - Fat is the driest tissue of all, having only 10% water content
  - Variation between individuals:
    - TBW in a standard male is **60%** of his body weight, while in female, its **55%**, due to higher fat content
    - Obese adults have lower percentage

- **Plasma :**
  - Liquid part of the blood
  - Inside the blood vessel (intra vascular)
  - ¼ of ECF
- **Interstitial fluid:**
  - baths all the cells in the body and is the link between ICF and intravascular compartment
  - ¾ of ECF
- **Transcellular fluid:**
  - Small fluid volumes secreted by specific cells into a cavity, to perform a specialized function
  - It includes CSF, GIT fluids, aqueous humor and joint fluid
- **Lymph:**
  - The fluid being returned from the interstitial fluid to the Plasma by lymphatic vessels



Body Fluid Compartments

- TBW represent about 60% of total body weight:
  - Intracellular fluid (ICF):
    - fluid within the cells
    - about 2/3 of TBW (40%)
  - Extracellular fluid (ECF):
    - fluid outside the cells
    - About 1/3 of TBW (20%)