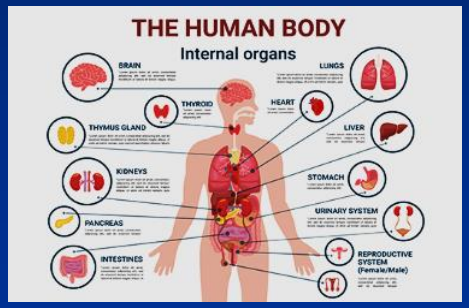
7. Body fluids & Fluid compartments.



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I- Body water content

i) Importance of body water:-

Water is the origin of life, all the chemical, physical or biological reactions in the body must be performed in an aqueous media.

Some other vital functions of water are:

1. It favors ionization of dissolved salts.
2. It regulates body temperature via both heat loss and heat gain balance.
3. It gives the blood its fluidity to reach all cells and to maintain BP.

-Water is the most abundant constituent in our bodies and it was found that the body of the young adult male consists of 18% proteins, 7% minerals, 15% fat while the remaining **60%** is water.

- In the newly born infant water constitutes as high as 75% of body weight while in old people it is slightly less than adult. Fat cells contain less water and thus females (being fattier than males) contain slightly less water.
- The water content of normal adult male weighing 70 kg = 42 liters.

ii)Total body water distribution:-

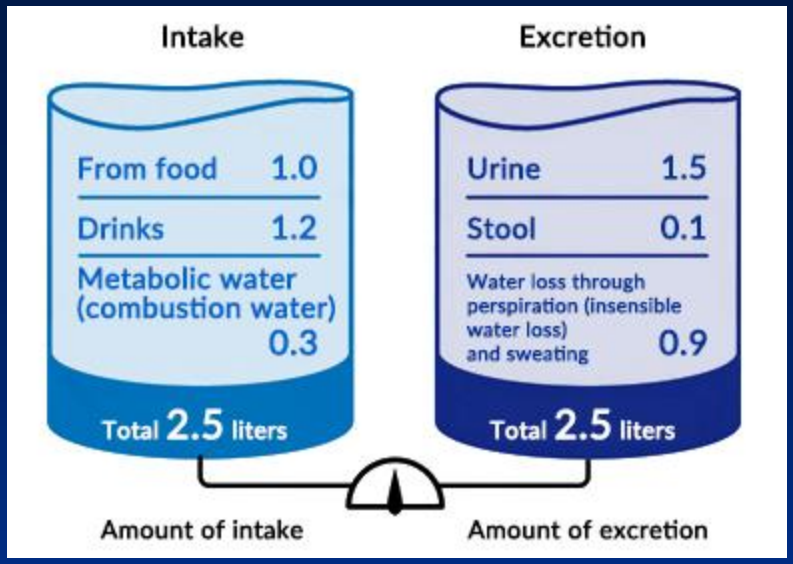
-About **28** liters intracellular fluid ICF.

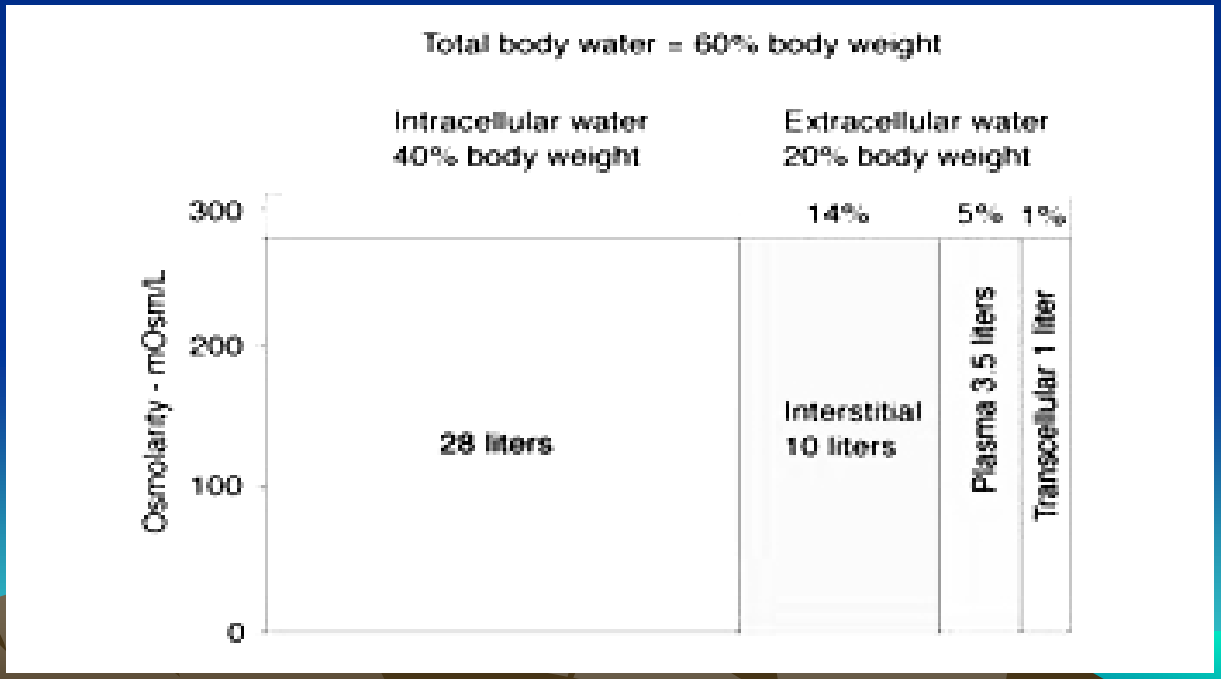
-About **14** liters extracellular fluid ECF distributed as follows:

-**3** Liters plasma

-**10** liters interstitial fluid ISF

- **one** liter represented as other fluids e.g. lymph, C.S.F, pericardial, pleural, and joints fluid.


Intake
Excretion
From food 1.0
Drinks 1.2
Metabolic water (combustion water) 0.3
Total 2.5 liters
Urine 1.5
Stool 0.1
Water loss through perspiration (insensible water loss) and sweating 0.9
Total 2.5 liters
Amount of intake
Amount of excretion


Total body water = 60% body weight
Intracellular water
40% body weight
Extracellular water
20% body weight
14%
5%
1%
300
200
100
0
Osmolarity - mOsm/L
28 liters
Interstitial
10 liters
Plasma 3.5 liters
Transcellular 1 liter

iii)Estimation of various types of body water.

It is done by the application of the **dilution principle**.

C1 x V1 = C2 x V2

1. Total body water is estimated by injection of heavy water or **"Deuterium"** which can disperse evenly through all water compartments (can cross cell membrane).

2. Extracellular fluid volume can be calculated by injection of **inulin** which can disperse only in extracellular fluid (cannot cross cell membrane).

3. Intracellular fluid volume is calculated by:

I.C.F = Total body water – Extracellular water.

4. Volume of plasma can be calculated by injection of **Evan's blue or radioactive plasma proteins**, which cannot cross capillary wall.

iv)Body Water Balance

It is the balance between water intake and water loss.

In comfortable zone of body temperature (22^{oC}) it was estimated that **water intake** by normal adult 70kg male= **2500 ml/day** which distributed as follow: 1500 ml is taken as pure water and beverages (tea for example), 800 ml from food as fruits and vegetables and 200ml from metabolic processes.

- **The water loss** normally = 2500ml/day which distributed as follow: 1500 ml excreted as urine, 900ml evaporated from the skin and lungs and 100 ml excreted in feces.

Water output each day	
Urines	1.5 litres
Feces	0.1 litre
Breathing and sweating	0.9 litre
TOTAL	2.5 litres

Water input each day	
Water contained in food	0.8 litre
Water produced by the cells	0.2 litre
Water you drink	1.5 litres
TOTAL	2.5 litres

Regulation of Water Intake (Thirst Sensation)

Stimuli of thirst sensations are:

1.Increased plasma osmolarity either due to pure water loss or excessive intake of salts. Both cause intracellular dehydration.

2.Diminished volume of extracellular fluid (following vomiting or diarrhea).

3.Hemorrhage and shock.

4.Dryness of mouth.

5.Increased angiotensin II secretion.

6.Psychological factors.

7.Potassium loss from body.

Routes of water loss from body

1.Insensible water loss: This is termed insensible water loss because we are not consciously aware of it, even though it occurs continually in all living humans.

A.The insensible water loss through the skin (insensible perspiration) occurs independently of sweating the average water loss by diffusion through the skin is about 300 to 400 ml/day.

B.Insensible water loss through the respiratory tract averages about 300 to 400 ml/day.

2.Sweat: The volume of sweat normally is about **100 ml/day**, but in very hot weather or during heavy exercise, water loss in sweat occasionally increases to **1 to 2 L/hour**.

3.In **stool** (**100 ml/day**) normally is lost in the feces.

4.In **urine** about **1500ml/day**.

Regulation of H+ ion concentration (Acid– base balance)

-The term pH is the negative logarithm of hydrogen ion concentration [H^+]. Or it is the log of the base of H^+ ion concentration.

pH = - log H^+ concentration or $= \text{Log} \frac{1}{H^+ \text{concentration}}$

Sources of H^+ in the body:

1-Oxidation of carbon in organic food substances $\rightarrow CO_2$ which dissolves in fluids$\rightarrow H_2CO_3\rightarrow$ H+ + HCO_3- (in normal adult 300 Lit. CO_2 & 13.000 mEq of H+ ion resulted per day).

2-Oxidation of sulphur & phosphorus in the proteins and lipids thus a high protein diet can produce acidosis in the body.

3- Ingestion of acids as lemon or acidifying salts as NH_4Cl.

4-Anerobic glycolysis in muscle which occurs in prolonged muscle contraction or starvation leads to lactic acid accumulation.

5-Hydrolysis of high-energy phosphate bond of ATP or CP.

Importance of H^+:

pH in arterial blood less than 7 or more than 7.8 causes death because:-

1-H^+ ions which carry a positive charge are bound to the negatively charged surface of enzymes and contractile molecules affecting their activities, so, any change in H^+ ions alter these activities.

2- Change in H^+ conc. $\rightarrow$ structural changes of protein.

3- H^+ ion concentration affects other ions level as K^+.

4-H^+ ion conc. affects many hormones as insulin and epinephrine & many drugs as digitalis.

5- Physiological Significance of Intracellular pH.

Body defensive mechanisms against pH disturbances

The body metabolism and muscle activities tend to add acids to the body fluids, hence we have an alkaline reserve in our body to oppose this tendency and maintenance of this pH depends on:

-Quick mechanisms: Chemical & Respiratory buffers.

-Slow mechanisms: Renal & Changes in cellular metabolism.

[A] Chemical Buffers: (very rapid–in fraction of a second)

By substances which minimize changes in pH of solution when acids or bases are added.

Most buffers consisted of weak acids + salt of its base (acid-base buffer pair) e.g. H_2Co_3-$NaHCO_3$. The relation between H+ conc. and the ratio of the buffer members is expressed by Handerson Hasselbach equation.

1- Bicarbonate – carbonic acid system

2- Phosphate system: (H2PO4 and HPO4)

3- Protein buffer system:

a-plasma protein **b-Hemoglobin** **c-Intracellular protein**

[B] Respiratory regulation of the pH. (1-12 minute)

Respiratory system controls pH of body fluids by controlling CO_2 tension in the arterial blood, which is the main source of H^+ ions.

- At pH 7.4 the ratio between HCO_3 to CO_2 = 20/1.

- If rate of removal of CO_2 from alveoli is less than rate of CO_2 production by cells (as occurs in hypoventilation) CO_2 content in blood will be increased leading to respiratory acidosis as occurs in cases of respiratory centre depression.

- If the reverse occurs e.g., in hyperventilation respiratory alkalosis occurs (e.g., in hysterical dyspnoea).

- While in **metabolic acidosis**, there will be hyperventilation resulting from stimulating effect of excess H- on respiratory center. This hyperventilation will cause more wash of CO2 from blood to correct this condition.

- The reverse occurs in **metabolic alkalosis**, where the decreased amount of H- will lead to hypoventilation that will help in increasing CO2 content of blood to correct the condition.

So the respiratory system acts as feed-back regulatory system for control of pH. as **two times powerful** than all chemical buffers.

Thank You