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Lecture Title: Body Fluids

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(Body fluids):-

-In the average young adult male , 18% of the body weight is protein & related substances , 7% is mineral & 15% is fat .

-The remaining 60% is water .

-Total body water is comprised **of extracellular &intracellular fluid**.

-The extracellular fluid can be subdivided **into two main** sub-compartments :-

1-**The plasma** , Which makes up almost one – fourth of the extracellular fluid .

2-**And the interstitial fluid** which lies between the tissue cells & amounts to more than three – fourths of the extracellular fluid .

- -**The extracellular fluid** , Which is about 20% of total body weight

-Approximately 25% of the extracellular fluid is in the vascular system (plasma = 5% of body weight) & 75% outside the blood vessels.

- **interstitial fluid** = 15% of body weight) .

- -Whereas , the **intracellular fluid** accounts for about 40% of body weight .

-The percentage of total body water is greater in newborns & lean persons,& is lower in adult females, elderly persons, or adults with a large amount of adipose tissue.

-Because the plasma & interstitial fluids are separated only by highly permeable capillary membranes , their ionic compositions are similar & they are often considered together as one large compartment of homogeneous fluid .

- ✓ -The most important difference between plasma & interstitial fluid is the higher concentration of protein in the plasma , which exists because the capillaries have allow permeability to the plasma proteins .

-Both extracellular & intracellular fluid contain nutrients that are needed by the cells , including glucose , amino acids, oxygen & other nutrients.

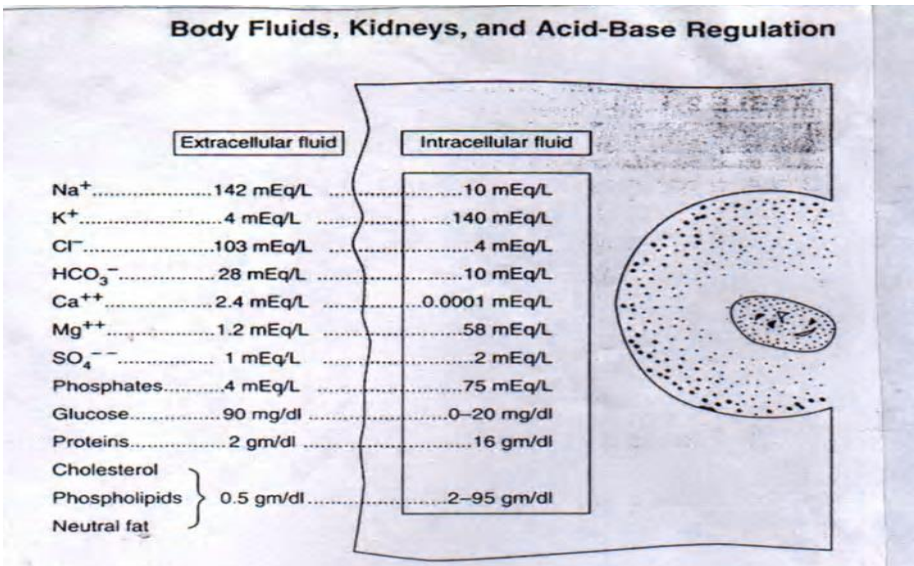

Figure 2-2.
Approximate chemical compositions of extracellular and intracellular fluids.

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-Substances used for major fluid compartments:-

-Total body water (TBW) :-

-Is measured using substances that disperse throughout the body fluids ,such as a radioactive water ($3H_2O$) or heavy water (deuterium,$2H_2o$).

-Extracellular fluid (ECF) :-

-Is measured using several substances that disperse in the plasma & interstitial fluid but do not permeate the cell membrane , such as radioactive sodium , inulin , & thiosulfate .

-Intracellular volume (ICF):-

-Cannot be measured directly , but can be calculated as the difference between total body water & extracellular volume (TBW-ECF volume) .

-Plasma volume :-

-Is measured by injecting substances, such as radioactive albumin (RISA) , that do not penetrate capillary membranes & therefore remain in the vascular system .

-Interstitial fluid volume (TCF) :-

-Cannot be measured directly but can be calculated as the difference between extracellular fluid volume & plasma volume (ECF volume – plasma volume).

Measurement of Body Fluid Volumes

Volume	Indicators
Total body water	$^{3}H_2O$, $^{2}H_2O$, antipyrine
Extracellular fluid	^{22}Na, ^{125}I-iothalamate, thiosulfate, inulin
Intracellular fluid	(Calculated as total body water – extracellular fluid volume)
Plasma volume	^{125}I-albumin, Evans blue dye (T-1824)
Blood volume	^{51}Cr-labeled red blood cells, or calculated as Blood volume = Plasma volume/1 – hematocrit
Interstitial fluid	(Calculated as extracellular fluid volume – plasma volume)

-Transport across cell membranes :-

1 -Simple diffusion :-

which is the net movement of molecules through the cell membrane along chemical or electrical gradients.

-Molecules migrate from a region of high concentration to one lower concentration.

-This form of transport is not carrier mediated.

-Not require metabolic energy , therefore is passive .

-Example of simple diffusion., **water, oxygen and carbon dioxide molecules can pass directly through the cell membrane without requiring any energy**

- -The rate of diffusion across the cell membrane is directly related to :-

-(1):-The electrical potential &chemical concentration differences across the membrane

-(2):-The surface area of the membrane .

-(3):- The permeability of the membrane for the solute .

-The permeability of membrane for solute is inversely related to the size of the solute & the membrane thickness.

2-Carrier –mediated transport:-

-Apply to facilitated diffusion & primary & secondary active transports .

1-Facilitated diffusion: -

- The word diffusion derives from the Latin word, diffundere, which means "to spread out.

-**The process of movement of a substance (solid, liquid, or gas) from the region of higher concentration to the region of lower concentration so as to spread uniformly**

-Dose not require metabolic energy & therefore is passive.

-Is more rapid than simple diffusion.

-Is carrier – mediated.

-Ex. Glucose transport in muscle & adipose cells.

2-Primary active transport:-

- active transport, is the **process** molecules move from an area of low concentration to an area of high concentration

- molecules across a cellular membrane through the use of cellular energy

-Requires direct input of metabolic energy in form of ATP & is active.

-Is carrier – mediated?

-Examples of primary active transport:-

-(a):- Na^+, K^+- ATPase (or Na^+- K^+pump) in the cell membrane transports Na^+ from intracellular to extracellular fluid & K^+ from extracellular to intracellular fluid ; It maintains low intracellular Na^+& high intracellular K^+.

-Energy is provided from ATP.

-(b):- Ca^{+2}- ATPase (or Ca^{+2} pump) in the sarcoplasmic reticulum (SR) or cell membranes transports Ca^{+2}against electrochemical gradient.

-(c):- H^+, K^+ – ATPase (or proton pump) in gastric parietal cells transports H^+ into lumen of the stomach against its electrochemical gradient .

3-Secondary active transport: -

-In this transport ; transport of two or more solutes is coupled ..

- is the transport of two different molecules across a transport membrane using energy in other forms than ATP

-Metabolic energy is not provided directly .

-If the solutes move in the same direction across the cell membrane , it is called cotransport or symport .

cotransport or symport .: Proteins that move two molecules in the same direction across the membrane

-Example … are Na^+- glucose cotransport in the small intestine .

-If the solutes move in opposite directions across the cell membranes , it is called countertransport , exchang or antiport .

-Example … Na^+ – Ca^+ exchange or Na^+ – H^+ exchange .

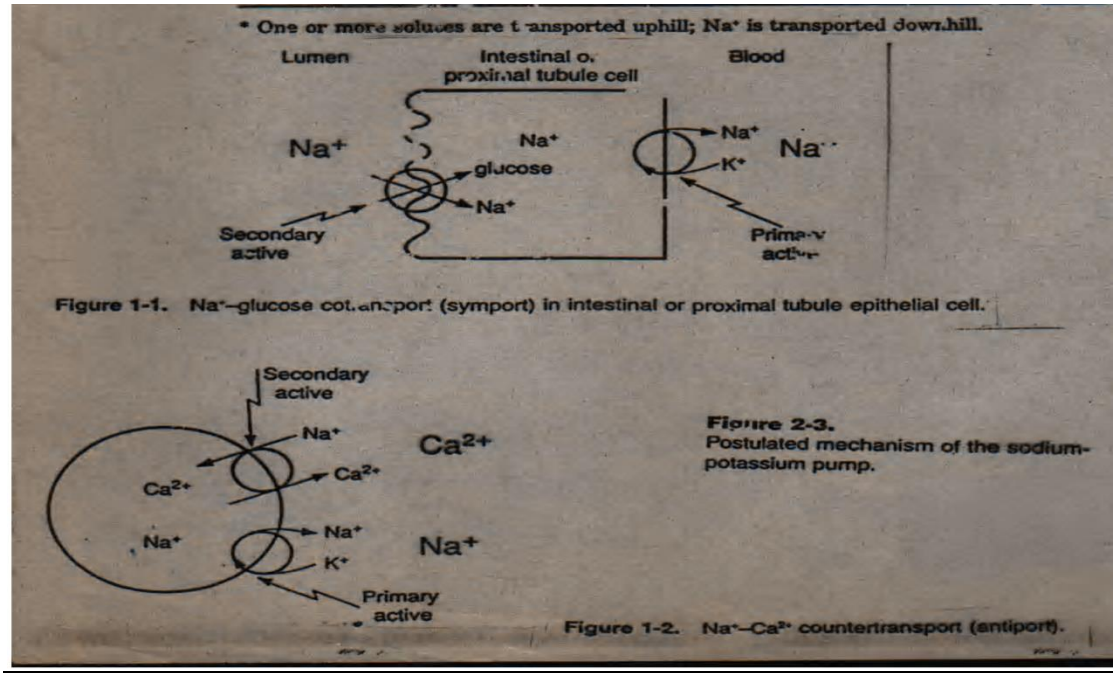

Figure 1-1. Na^+–glucose cotransport (symport) in intestinal or proximal tubule epithelial cell.

Figure 2-3. Postulated mechanism of the sodium-potassium pump.

Figure 1-2. Na^+–Ca^{2+} countertransport (antiport).

Figure 1-3. Osmosis of H_2O across a semipermeable membrane.

Table 1-1. Characteristics of Different Types of Transport

Type	Electrochemical Gradient	Carrier-mediated	Metabolic Energy	Na^+ Gradient	Inhibition of Na^+–K^+ Pump
Simple diffusion	Downhill	No	No	No	—
Facilitated diffusion	Downhill	Yes	No	No	—
Primary active transport	Uphill	Yes	Yes	—	Inhibits (if Na^+–K^+ pump)
Cotransport	Uphill*	Yes	Indirect	Yes, same direction	Inhibits
Countertransport	Uphill*	Yes	Indirect	Yes, opposite direction	Inhibits