WATER AND THE MAJOR IONS

Water

The living cell is made up of approximately 70% of water. It is an irregular tetrahedron molecule with oxygen at its center. It is essential for life and solubilizes and modifies the properties of biomolecules. H_2O is its chemical formula.

PROPERTIES

- It is dipolar(It has unequally distributed electrical charge)
- The elements of this compound are joined by weak hydrogen bonds which accounts for its liquidity at room temperature
- It is highly viscous
- It has a high surface tension.
- good solvent: water dissolves more compounds than any other liquid
- high heat capacity
- high melting and boiling point

Sources; water as such by drinking, water in the feed supply and metabolic water obtained from the oxidation of carbohydrates, fat and protein in the body.

FUNCTIONS

1. It's a vital constituent of cells and provides medium for chemical reactions
2. It provides fluidity to blood and other body fluids e.g. saliva, cerebrospinal fluid, gastric juices etc hence serves as a lubricant in the transport of feed to tissues
3. It acts as a medium of heat dissipation in the body.
4. An aid in excretion
5. A buffering agent to regulate pH (acidity or alkalinity) of body fluids 70% of the body is composed of water which is distributed in two major compartments in the body.
6. Water can act as both hydrogen donor and hydrogen acceptor i.e. acid and base, the basis of which it acts as a solvent to compounds which can also accept or donate protons themselves for H-binding with Water.

A number of factors affect the amount of water consumed by an animal including physiologic states, environmental temperature, and type of diet and so on. Dissolved within the body water are solutes composed chiefly of three categories of substances:

1. Organic compounds of large molecular e.g. proteins and these aid in distribution of water between the compartments of the by its effect on osmotic pressure.
2. Organic compounds of small molecular size e.g. glucose, urea etc exert little or no osmotic pressure but when in large quantities aid in retention of water.
3. Inorganic electrolytes or ions, these are found in large quantities within the fluids hence play a vital role in retention and distribution of body water.

MAJOR IONS: H^+, NA^+, K^+, CL^- AND HCO_3^-

Electrolytes are elements or compounds that dissociate in solution for example NaCl , KCl to give the constituent ions Na^+, K^+ and Cl^-, ions that are completely surrounded by water molecules. Positive ions are called cations while negative ions are called anions. These elements are involved in the maintenance of homeostasis (water, osmotic and PH status).the law of electrical neutrality states that the total number of +ve ions always equals the total number of –ve ions.

Hydrogen ion (proton) - H^+

H^+ ions are present in all body compartments and the maintenance of appropriate concentrations is essential for normal cellular functions. It has the largest concentration amongst cations in the plasma. It has negligible osmotic activity

The gradient of H^+ concentration between inner and outer mitochondrial membranes acts as a driving force for oxidative phosphorylation. In addition H^+ concentration in a fluid medium determines the ionization of weak acids and hence their functions within the body. Also H^+ Levels affect the surface charge and physical properties of proteins that make up the body. PH level is a measure of the H^+ concentration, hence H^+ concentration determines the PH of blood and determines optimum environment for body chemical reactions.

H^+ is excreted in urine as $H_2PO_4^{2-}$.

Sodium ion (Na^+)

It is the major cation of the ECF and helps to regulate the volume of the ECF. Total body sodium is about 4000mEq, 50% is found in bones, 40% in ECF and 10% in soft tissues. Na^+ as well as other cations constitutes osmotically active particles. Sodium pump operates in all cells to keep the levels of Na^+ in the ECF always higher than that in the ICF, its activity is usually accompanied by opposite movement of K^+. Normal plasma concentration of Na^+ is about 136-145mEq/l while in the ICF its 12mEq/l.

NaCl (common salt) is the major source of Na^+ to the body, although it is also widely distributed in food materials mainly of animal sources.

Na^+ is readily absorbed from the intestines by sodium pump located in the Basal and lateral plasma membrane enterocytes and renal cells and Na-pump actively transports Na into the ECF.

FUNCTIONS

1. It maintains the crystalloid osmotic pressure of ECF, helping to retain water in the ECF.
2. It's involved in neuromuscular excitability/irritability.
3. It maintains viscosity by the sodium salt and along with K^+ helps to maintain the degree of hydration of plasma proteins.
4. It plays an active role in resting membrane potential, by keeping the Na conc. Far in the ECF than in the ICF (known as the resting membrane potential) causing a polarization creating a potential difference of up -70 to -90mV across the membranes.
5. In the same vein, the sudden increased permeability of the membrane to Na causing a rapid influx of Na into the cell occurs in the generation of action potential.

99% of Na^+ is filtered along in the glomerular filtrate and reabsorbed majorly in the proximal convoluted tubules. At the distal tubules , rennin (secreted from the juxtaglomerular cells) is produced due to decreased arterial pressure (decreased Na^+) and this stimulates the secretion of Aldosterone that causes reabsorbtion of Na^+, K^+ and to a lesser extent H^+ is lost in its place. Water subsequently moves in the direction of Na^+.

Potassium ion (K^+)

It is the major cation of the ICF and helps to maintain the intracellular osmotic pressure. Total body K^+ is about 3500mEq/l.

This ion is easily obtained from many foods such as fruits and vegetables etc.

K^+ is easily absorbed into the blood.

FUNCTIONS

1. EC K^+ is an important factor in skeletal and cardiac muscle contraction.
2. It is also involved in acid –base balance in the body
3. It is also actively involved in nerve impulse transmission and neuromuscular irritability.
4. Certain enzymes such as pyruvate kinase require K^+ as cofactor.

Plasma levels are about 3.5-5mEq/l while IC levels reach up to 150mEq/l.

It is obligatorily lost during Na^+ reabsorbtion from the tubules. It is also excreted in gastrointestinal tract, saliva, gastric juices, bile, pancreatic and intestinal juices.

Chloride ion (Cl^-)

It is the major anion of the ECF and forms inorganic anion of greatest quantity in the body .it also forms part of the osmotically active particles in plasma.

Cl^- is obtained from NaCl, and many other food substances. It is readily absorbed.

FUNCTIONS

1. It is involved in water distribution
2. Osmotic pressure maintenance and
3. Anion-Cation balance in ECF
4. It is important in the formation of gastric juices and hydrochloric acid.

Intake, output and metabolism of Na^+ and Cl^- run in parallel; it is filtered in renal tubules and passively reabsorbed in the proximal tubules. Cl^- is also excreted in sweat.

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