

Major Extra and Intracellular Electrolytes

Electrolytes:

- ❑ Substance when dissolved in solution separates into ions & is able to carry an electrical current

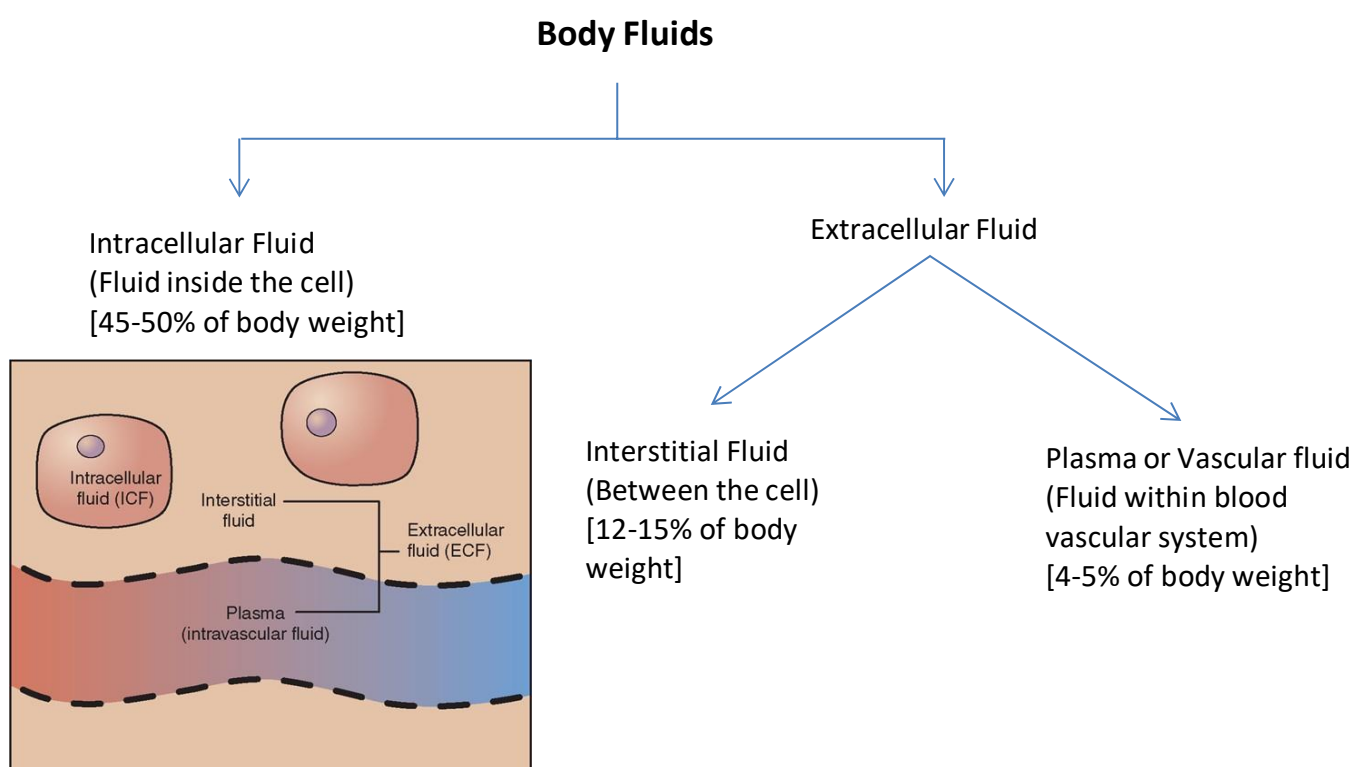
Cation - positively charged electrolyte e.g. Ca^{++}

Anion - negatively charged electrolyte e.g. Cl^-

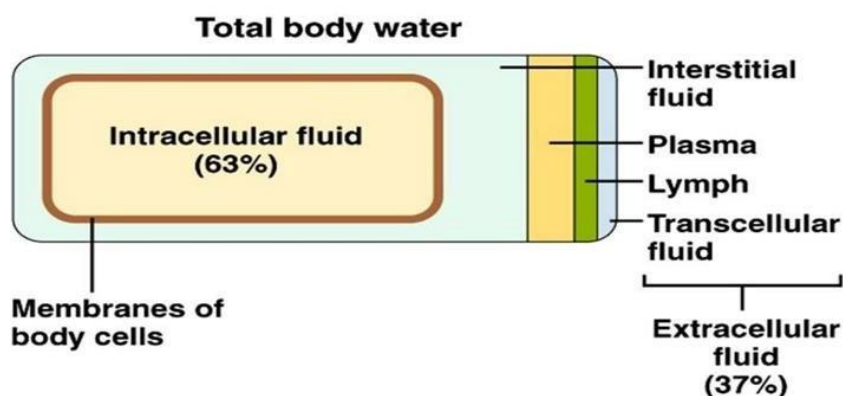
- ❑ But in our body, electrolytes are certain charged nutrients present in our body that have many important functions like:
 - Electrolytes regulate our nerve and muscles function, our body's hydration, blood pH, blood pressure, and rebuilding of damaged tissue.
 - The body cells require a perfect pH, osmotic balance and ionic balance. This balance is maintained by the body fluids which contains inorganic and organic solutes. These solutes can be electrolytes, acid, bases, blood products, carbohydrates, amino acids, proteins.

Electrolytic Fluid Compartments:

- ❑ Body contain 60-70% of water



- ❑ The term 'extracellular fluid' includes both interstitial and vascular fluids.
- ❑ These three compartments are separated from each other by membranes that are permeable to water and many organic and inorganic solutes.
- ❑ They are nearly impermeable to macromolecules such as proteins and are selectively permeable to certain ions such as Na^+ , K^+ , Mg^{2+}



Functions of Electrolytes:

- ❑ Maintain electrolytic balance, including acid-base balance and osmotic equilibrium in various body fluid.
- ❑ To facilitate specific metabolic functions by supplying the specific ion to the body fluids associated with the concerning cell or organ.
- ❑ To regulate the total amount of water in body fluids.
- ❑ Our heart, muscles and nerve cells use electrolytes to maintain voltage across their cell membranes and to carry electrical impulses to other cells.
- ❑ A muscle contraction needs calcium (Ca^{++}), sodium (Na^+), and potassium (K^+) to be present. Deficiency and excess of electrolyte level lead to either weak muscles, or muscles that contract too severely.

Electrolytic Imbalance and its causes:

- ❑ Body have capacity to adjust slight variation in concentration of electrolytes in fluid compartments. Mainly electrolytic level is kept constant by our kidneys and other hormones.
- ❑ Whenever there is a change in concentration of ions in any compartment, water will migrate across the cell membrane to re-establish osmotic equilibrium. If body is unable to adjust the concentration of fluid electrolytes then externally "electrolytic replacement therapy" is used.
- ❑ Body electrolytic levels tend to alter when water levels in the body changes- when our level of hydration goes up or down.

- ❑ Several other causes include:

Kidney disease	Vomiting or prolonged periods
Poor diet	severe dehydration
Diarrhea	Congestive heart failure
Edema (fluid gets accumulated in intestinal space between cells due to low osmotic pressure)	
Acid-Base imbalance	

Symptoms of electrolytic Imbalance:

- ❑ The symptoms will depend on which electrolyte is out of balance, and whether that level is too high or too low.
- ❑ An altered level of magnesium, sodium, potassium, or calcium may produce one or more of the following symptoms:

Irregular heart beat	Weakness
Bone disorder	Blood pressure change
Confusion	Seizures
Nervous system disorder	Convulsion
Muscle spasm	

Major Physiological Ions and their functions:

8 Major Physiological Ions	
Cations	Anions
Sodium (Na^+)	Chloride (Cl^-)
Calcium (Ca^{2+})	Bicarbonate (HCO_3^-)
Potassium (K^+)	Phosphate (HPO_4^-)
Magnesium (Mg^{2+})	Sulphate (SO_4^{2-})

A. MAJOR EXTRACELLULAR IONS

CHLORIDE (Cl^-)

Amount present in body: 50 mEq/Kg;

Recommended daily Requirement: 5-10 g as NaCl

Major Food Source: Common table salt, Animal food

Absorption from GIT and Fate in Body (Metabolism): Completely absorbed, eliminated from blood by glomerular filtration and possibly reabsorbed by the kidney tubules

Principle Physiological/ Metabolic Function: Maintenance of proper hydration, osmotic pressure, normal electrolyte balance, acid-base balance, Gastric HCl

Deficiency: *Hypochloemia* occur due to kidney disease, metabolic acidosis (due to diabetes or renal failure or prolong vomiting)

Excessive Presence: *Hyperchloemia* in dehydration, decreased renal blood flow associated with congestive heart failure (CHF), severe renal damage and excessive Cl^- intake.

SODIUM (Na^+),

Amount present in body: 1.8 g/Kg;

Recommended daily Requirement: Approx. 3-5 g.

Major Food Source: Table salt, baking soda, animal food and some vegetables.

Absorption From GIT and Fate in Body (Metabolism): Completely absorbed, excreted in sweat and urine, kidney regulates sodium contents of the body, hormone aldosterone increases reabsorption in renal tubules.

Principle Physiological/ Metabolic Function: Maintenance of normal hydration & osmotic pressure, acid-base balance, cell membrane permeability, muscle contraction, carbon dioxide transport, transmission of nerve impulses.

Deficiency: *Hyponatremia* may occur with excess loss of urine (diuresis) in diabetes insipidus, Addison's disease (with reduced secretion of anti-diuretic hormone, aldosterone) diarrhea & vomiting, renal damage.

Excessive Presence: *Hypernatremia* may occur in hyperadrenalism (Cushing's syndrome) with increased aldosterone production, severe dehydration, certain types of head injury, hypertension.

CALCIUM (Ca^{++})

Amount present in body: 22 g/Kg (99% in bones, rest mainly in extracellular fluid);

Recommended daily Requirement: About 1 g.

Major Food Source: Milk and milk products, eggs, green vegetables and some fishes.

Absorption From GIT and Fate in Body (Metabolism): Poorly absorbed (20-40%), variable absorption depend upon body requirements and affected by several factors c.f. *increased* in vit. D, lactose, acidity; *decrease* by fat, oxlate, low dietary phosphorous intake; excreted in faeces, parathyroid hormone controls blood Ca^{++} and phosphate level and mobilization in bones.

Principle Physiological/ Metabolic Function: Hardening of bones and teeth; coagulation of blood, muscle contraction, cell membrane permeability.

Deficiency: *Hypocalcemia* rickets in children's, poor growth, osteoporosis in adults, hyperexcitability, Cushing's syndrome (hyperactive adrenal cortex)

Excessive Presence: *Hypercalcemia* fatigue, muscle weakness, constipation, anorexia (loss of appetite), cardiac irregularities, renal failure [hypercalcemia is associated with hyperparathyroidism, hypervitaminosis D and some bone neoplastic (cancer) diseases.

BICARBONATE (HCO_3^-)

Amount present in body: 25-30 mEq/l in blood or plasma;

Major Food Source: Certain citrus fruits, milk etc. which *in vivo* converted into HCO_3^-

Absorption From GIT and Fate in Body (Metabolism): Bicarbonate salt (eg NaHCO_3) if taken orally neutralized by gastric acid in stomach. Organic acid radicals lactate, citrate etc. are converted into bicarbonate *in vivo*. Most CO_2 is exhaled by lungs but some as per body requirement converted into carbonic acid (H_2CO_3) and bicarbonate ion (HCO_3^-) constituting important physiological buffer.

Principle Physiological/ Metabolic Function: Maintenance of physiological acid-base balance, CO_2 transport, maintenance of proper hydration, gastric acid, electrolyte balance.

Deficiency: Metabolic acidosis especially in uncontrolled diabetes with ketosis, renal disease, poisoning by an acid salt, loss of intestinal fluid in vomiting, diarrhoea. Increased respiration (hyperpnea).

Excessive Presence: Metabolic Alkalosis due to ingestion of large quantities of alkalis in treatment of acidity, peptic ulcer, metabolic acidosis, high intestinal obstruction, prolong

vomiting or excessive removal of gastric secretion. In Cushing's disease and during corticotropin or cortisone administration, in hypokalemia.

B. MAJOR INTRACELLULAR IONS

PHOSPHATE (PO_4^{3-})

Amount present in body: 12 g/Kg;

Recommended daily Requirement: 800 mg

Major Food Source: Milk and milk products, oatmeal, whole grains, legumes, nuts, egg yolk, meat especially in liver and kidney.

Absorption From GIT and Fate in Body (Metabolism): Easily absorbed by intestine, excretion is mainly through urine via kidney (unlike calcium) only small amount are excreted in feces.

Principle Physiological/ Metabolic Function: like calcium, it is predominant constituent of bones and teeth; building block of several important substance including those used by the cell for energy (ATP), cell membranes, DNA & RNA, secondary messengers, modulation of enzyme activity, biological buffer etc.

Deficiency: Hypophosphatemia may be associated with vitamin D deficiency, hyperparathyroidism and prolong use of aluminium hydroxide gel antacids. It may leads to rare osteomalacia and cardiac arrhythmia.

Excessive Presence: Hyperphosphatemia may be associated with hypervitaminosis D, renal failure, hypoparathyroidism, it may lead to formation of kidney stone with possible kidney damage.

POTASSIUM (K^+)

Amount present in body: 2.6 g/Kg;

Recommended daily Requirement: Approx. 1.5-4.5 g.

Major Food Source: Milk and milk products, fruits, vegetables, legumes, whole grain, meat.

Absorption From GIT and Fate in Body (Metabolism): Rapidly absorbed, excess excreted by kidney. Presence in intracellular compartment is 23 times higher than extracellular and this ratio is maintained by active transport mechanism; through *sodium potassium pump*.

Principle Physiological/ Metabolic Function: Electrolyte, acid-base and water balance, buffer constituent, muscle contraction, membrane transport, carbon dioxide transport.

Deficiency: *Hypokalemia* (*hypopotassemia*) leading to depressed myocardial function, flaccid and feeble muscle and hypotension may occur from vomiting, diarrhoea, dehydration, burns, haemorrhages, intravenous infusion of potassium-lacking solution (dilution effect), excessive use of diuretics.

Excessive Presence: *Hyperkalemia* (*hyperpotassemia*) though less common, can occur with impaired renal functions (lack of excessive K^+ excretion) and potassium retention due to acidosis.

MAGNESIUM (Mg^{2+})

Amount present in body: 0.5 g/Kg;

Recommended daily Requirement: Approx. 350 mg.

Major Food Source: Green vegetables, legumes, whole grain, nuts, beans, meat, milk.

Absorption From GIT and Fate in Body (Metabolism): Not readily absorbed from GIT, absorption retarded by alkaline media, unabsorbed Mg^{2+} is excreted through urine, bile and intestinal secretion.

Principle Physiological/ Metabolic Function: Essential component of some enzyme involving phosphate metabolism, constituent of bones and teeth; essential for protein synthesis, smooth functioning of neuromuscular function.

Deficiency: *Hypomagnesemia* can occur due to malnutrition, dietary restriction, chronic alcoholism, malabsorption, GIT disorder, medication and parathyroid hormone imbalance. Personality changes confusion, choreiform movement, tremors, cardiac disorders including vasodilation.

Excessive Presence: *Hypermagnesemia* (increase in blood levels of magnesium) depress the nervous system and higher levels can induce anaesthesia and paralysis of skeletal muscle.