UNIT II

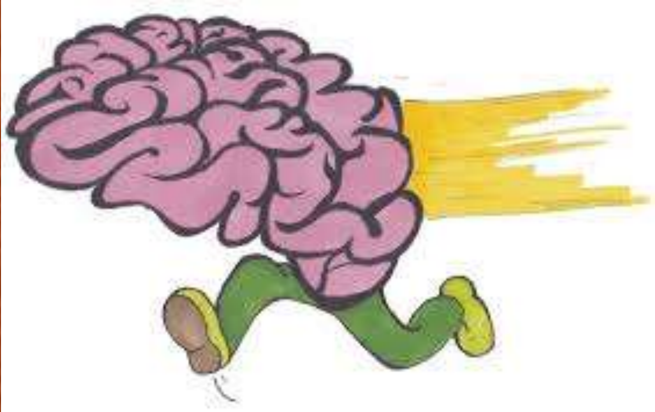
MAJOR EXTRA & INTRACELLULAR ELECTROLYTES

Syllabus Contents:

a) Functions of major physiological ions

b) Electrolytes used in the replacement therapy

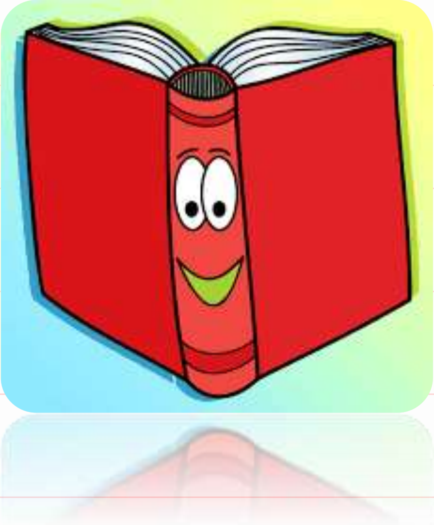
- ❑ Sodium chloride
- ❑ Potassium Chloride
- ❑ Calcium gluconate
- ❑ Oral Rehydration Salt (ORS)



a) Introduction

b) Role of major physiological cations and anions

- ❖ Sodium
- ❖ Potassium
- ❖ Calcium
- ❖ Magnesium
- ❖ Chloride
- ❖ Phosphate
- ❖ Bicarbonate

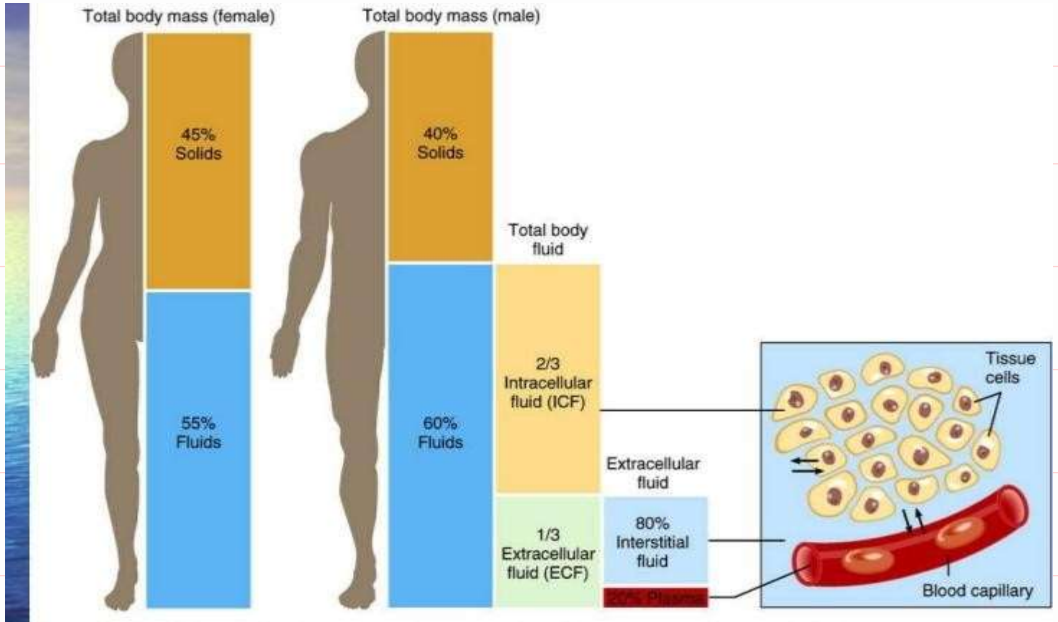


c) Electrolytes used in the replacement therapy

d) Electrolytes Combination Theory

e) Physical acid base balance

The Composition of the Human Body



(a) Distribution of body solids and fluids in an average lean, adult female and male

(b) Exchange of water among body fluid compartments

Figure 27.01 Tortora - PAP 12/e

Mineral salts (inorganic compounds) are necessary within the body for all body process.

- They are usually required in small quantities.
- Main elements: Calcium & Phosphorus: bone & teeth Iron: haemoglobin - convey oxygen & CO2. Na & K: Transmission of nerve impulses & contraction of muscles

- Chemical substance dissolved in body fluid can be categorized into:

A. Non-electrolytes: Organic molecules, Do not generate ions in solution form. e.g., Glucose, Urea, Creatine etc

B. Electrolytes: Mostly inorganic substances, Dissociates into ions (+ve/-ve) in the body fluid.

e.g., Acids, Bases, Salts, few organic molecules like Citric acid, Lactic acid, Oxaloacetic acid etc

Body: "Both are necessary to perform physiological functions"!

Salt & water balance:

- Oral intake of fluid & electrolytes
- Evaporation of solute – free water across the skin and lungs.
- Excretion of water & electrolytes through the kidneys : ⇅ output – antidiuretic hormone (ADH) & aldosterone.

INTRODUCTION

Body consists of 70% water

◦ Intracellular water (fluid inside cells) ICF

◦ Extracellular water (fluid is outside the cells i.e. within interstitial tissues surrounding cells, blood plasma, and lymph) ECF

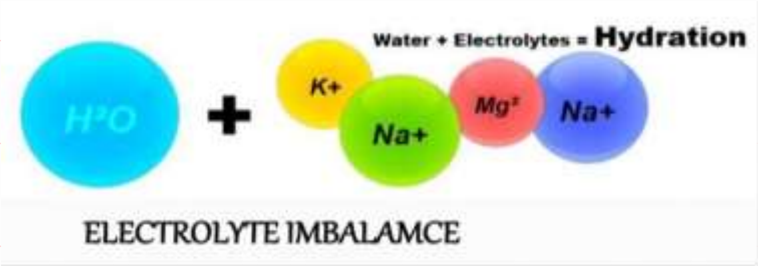
◦ 2/3 of body weight is H2O

◦ 1/3 of H2O is within cells 1/3 of H2O is extracellular in tissues surrounding cells

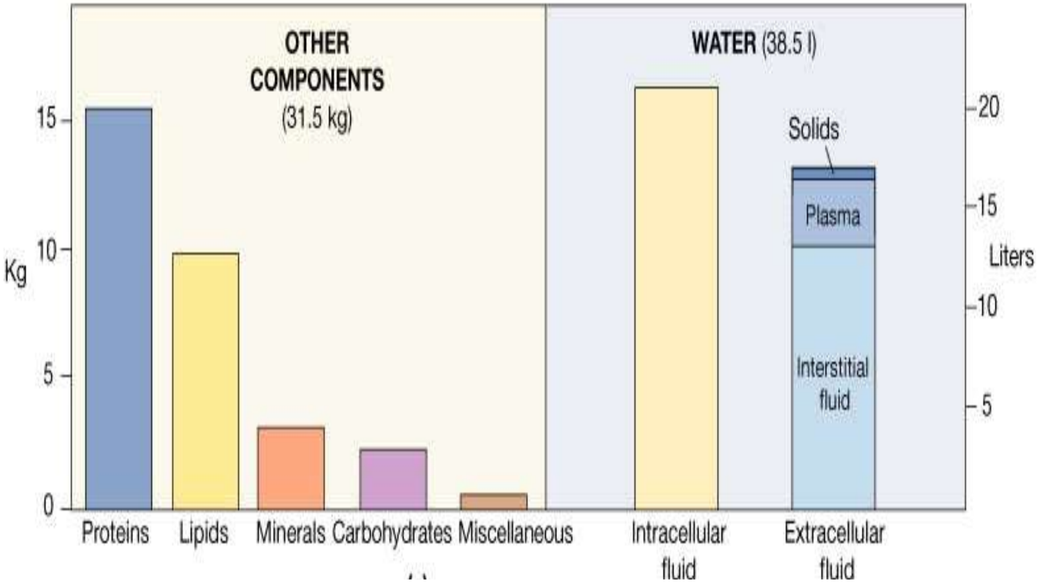
◦ 25 % interstitial fluid (ISF)

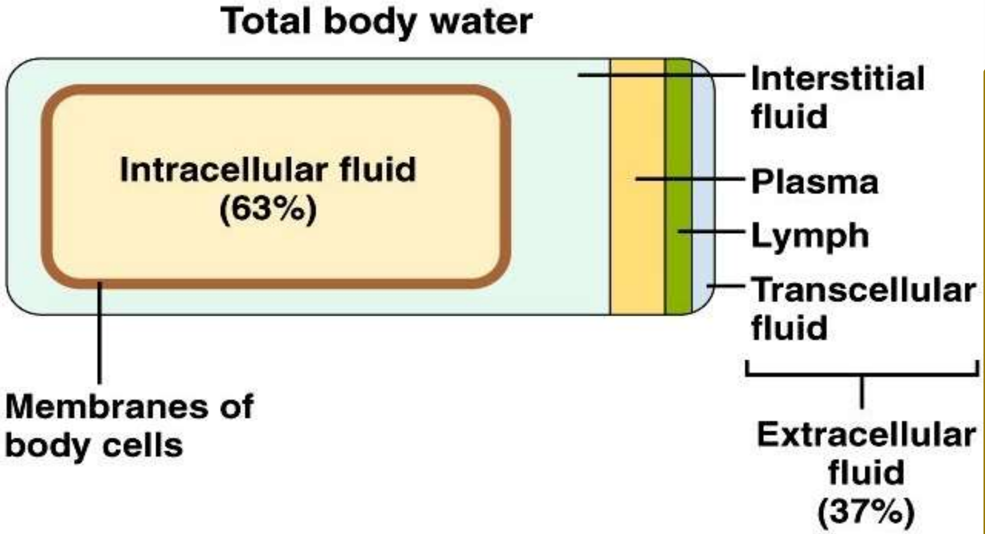
◦ 5- 8 % in plasma (IVF intravascular fluid)

◦ 1- 2 % in transcellular fluids – CSF, intraocular fluids, serous membranes, GIT, respiratory and urinary tracts



The Composition of the Human Body





MAJOR COMPARTMENTS FOR FLUIDS

INTRACELLULAR FLUID (ICF):

Inside cell Most of body fluid here - 63% weight

Decreased in elderly

EXTRACELLULAR FLUID (ECF):

Outside cell

a. Intravascular fluid - within blood vessels (5%)

b. Interstitial fluid - between cells & blood vessels (15%)

c. Transcellular fluid - cerebrospinal, pericardial and synovial fluid.

The Solution In Each Compartment Is Ionically Balanced

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Electrolytes (dissolved ions): chemicals dissociates into cations (+vely charged) and anions when they dissolve in the body fluids. E.g. acids, bases, NaCl

What are intra and extra cellular Electrolytes?

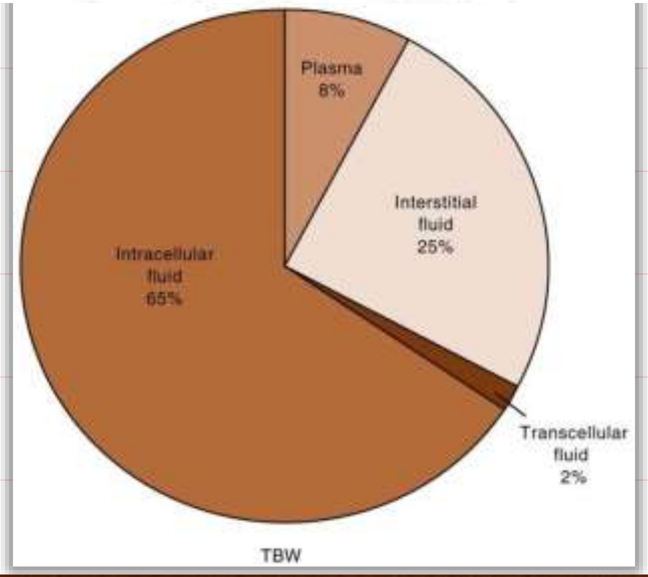
[sum15, sum13, win14]

Intracellular Electrolytes : present in the cell
e.g. Potassium and phosphate ions

Extracellular Electrolytes : interstitial & vascular compartment (present out of cell)
e.g. Sodium and chloride ions

Role in the Body:

- pH control, osmotic balance, perform physiological function and many more



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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-

- No of Cations must equal to no of Anions for homeostasis to exist in each fluid compartment

ELECTROLYTES IN BODY FLUID COMPARTMENTS:

Intracellular: K, Mg, P

Extracellular: Na, Cl, HCO3-

- Various organic and inorganic compounds are present in body fluids and concentration of them is maintained in such a way that body cell and tissue have same environment (homeostasis)

- To maintain this internal homeostasis, there are regulatory mechanisms that control pH, ionic balances, osmotic balances etc.

- There are a large number of products under the general heading of replacement therapy which can be used by the physician when the body itself is unable to correct an electrolyte imbalance due to a change in the composition of its fluids.

- These products include electrolytes, acids and bases, blood products, carbohydrates, amino acids and proteins.

Inorganic Ions Present In Body Fluid

ANIONIC	CATIONIC
HCO3-	Sodium
Cl-	Potassium
SO4-	Calcium
HPO4-	Magnesium

- **The electrolyte concentration will vary with a particular fluid compartment.**

The three compartments are :

1. intracellular fluid (45-50% of body weight)
2. interstitial fluid (12- 15% of body weight)
3. plasma or vascular fluid (4-5% of body weight)

- 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+, Mg2+

ELECTROLYTES

Na^+: most abundant electrolyte in the body, chem. and osmotic gradient, osmosis, heart function and cell memb etc.

K^+**:** essential for normal **membrane excitability** for nerve impulse

Cl^-**:** regulates **osmotic pressure** and assists in regulating acid- base balance

Ca^{2+}**:** usually combined with Pto form the mineral salts of **bones** and **teeth**, promotes **nerve impulse** and **muscle** contraction/relaxation.

Mg^{2+}**:** plays role in **carbohydrate** and **protein metabolism**, **storage** and use of **intracellular energy** and **neural transmission.** Important in the functioning of the **heart, nerves,** and **muscles.**

- Electrolytes are express in terms of mEq/L i.e. Miliequivalent per Litre rather than weight/volume (w/v).
- Equivalent weight is obtained by dividing the atomic or molecular weight by the valence.

  - $\text{mEq/L} = \frac{\text{mg of substance /litre}}{\text{Equivalent weight}}$

  - $\text{Equivalent weight} = \frac{\text{Molecular weight}}{\text{Valency}}$

Important Functions:

- Control of osmosis of water between body compartments.
- Maintain the acid-base balance required for normal cellular activates.
- Help to generate action potentials & graded potentials.
- Help to control secretion of some hormones (e.g., Aldosterone, Thyroid hormones) and neurotransmitters.

MAJOR CATION PRESENT IN BODY

SODIUM

- Location: extracellular compartment as salt Na^+
- Normal level: 136-142 mEq / L
- Functions:
  - absorbed and excreted by cells (maintain charge balance btwn the body fluids)
  - Along with Cl^- , maintains osmotic balance of all body fluids
  - In kidney, maintains blood-urine volume level

Hyponatremia

ന൭> Low level of sodium (Na^+) in body

[win11]

- Reasons: extreme urine loss (in diabetic insipidus), kidney damage, diarrhea, vomiting, excessive sweating, diarrhea

Condition	Hyponatremia	Hypernatremia
	Low level of Na+	High level of Na+
Reason	Extreme urine loss, diarrhea, kidney damage, vomiting, excessive sweating	Dehydration. High sodium intact
Symptoms	Muscular weakness, headache, respiratory depression.	Intense thirst, fatigue
Treatment	Electrolyte replacement	Low sodium diet, diuretics.

Functions of Sodium

- Transmission and conduction of **nerve impulses**
- Responsible for **osmolarity** of vascular fluids
- Regulation of **body fluid levels**
- Na shifts into cells and K shifts out of the cells (**sodium pump**)
- Assists with regulation of **acid-base balance** by combining with Cl or HCO_3 to regulate the balance

Hyponatremia

- Excessive sodium loss or H_2O gain
- CAUSES
  - Prolonged diuretic therapy
  - Excessive diaphoresis
  - Insufficient Na intake
  - GI losses - laxatives, vomiting
  - Administration of hypotonic fluids
  - Compulsive water drinking
  - Labor induction with oxytocin
  - Cystic fibrosis
  - Alcoholism

Treatment

- Restrict fluids
- Monitor serum Na levels
- IV normal saline or Lactated Ringers
- If Na is below 115, mEq/L hypertonic saline is administered
- May given a diuretic to increase H_2O loss
- Encourage a balanced diet
- Safety for weakness or confusion
- Assist with ambulation if low B.P.

Hyponatremia

- Monitor sign & symptoms in patients at risk
  - Muscle weakness
  - Tachycardia
  - Fatigue
  - Apathy
  - Dry skin, pale mucus membranes
  - Confusion
  - Headache
  - Nausea/Vomiting, Abdominal cramps
  - Orthostatic hypotension

Symptoms

- Headache
- Faintness
- Confusion
- Muscle cramping/twitching
- Increased weight
- Convulsions

Hypernatremia

Occurs with excess loss of H_2O or excessive retention of Na

- Can lead to death if not treated
- Causes
  - Vomiting/diarrhea
  - Diaphoresis
  - Inadequate ADH
  - Some drugs
  - Hypertonic fluids
  - Major burns
- Sign/Symptoms
  - Thirst
  - Flushed skin
  - Dry mucus membranes
  - Low urinary output
  - Tachycardia
  - Seizures
  - Hyperactive deep tendon reflexes

Treatment of Hypernatremia

- Low Na diet
- Encourage H_2O drinking
- Monitor fluid intake on patients with heart or renal disease
- Observe changes in B.P. and HR if hypovolemic
- Monitor serum Na levels
- Weigh monitoring

SODIUM/CHLORIDE IMBALANCE

- Regulated by the **kidneys**
- Influenced by the hormone **aldosterone**
- **Na** is responsible for **water retention** and serum **osmolarity** level
- Chloride ion frequently appears with the sodium ion
- Normal Na = 135-145 mEq/L
- Chloride 95-108 mEq/L
- Na and Cl are concentrated in ECF

POTASSIUM

- Location- intracelluler fluid.
- Normal level- 3.0-5.0 mEq/L
- Functions- 1. contraction of muscles. (Cardiac)
- 2. along with chloride maintain osmotic balance of all fluid.
- 3. nerve impulse transmission.

Condition	Hypokalemia
Decrease K+ level in body	
Reasons	Lower absorption, urine loss, Heart disease Kidney damage, cardiac disease, CNS depression
Symptoms	Mental confusion. Muscle weakness.

Potassium Imbalances

- K is the most abundant cation in the body cells
- 97% is found in the ICF, plentiful in the GIT
- Normal extracellular K^+ is 3.5-5.3
- Serum K^+ level below **2.5** or above **7.0** can cause **cardiac arrest**
- 80-90% is excreted through the kidneys
- **Functions**
  - Promotes conduction and transmission of **nerve** impulses
  - Contraction of **muscle**
  - Promotes **enzyme** action
  - Assist in the maintenance of **acid-base** balance

Food sources - veggies, fruits, nuts and meat

Hypokalemia

Low potassium level: Causes

- Prolonged diuretic therapy
- Inadequate intake
- Severe diaphoresis
- Use of laxative, vomiting
- Excess insulin
- Excess stress
- Hepatic disease
- Acute alcoholism

Signs and Symptoms of Hypocalemia

- Anorexia
- Nausea, vomiting
- Drowsiness, lethargy, confusion
- Leg cramps
- Muscle weakness
- Hyperreflexia (overactive or overresponsive reflexes).
- Hypotension
- Cardiac dysrhythmias
- Polyuria

Hyperkalemia

- Higher than normal levels of K
- Decreased pH(**acidosis)**
- Results form impaired renal function
- Metabolic acidosis
- Acts as myocardial depressant; decreased heart rate, cardiac output
- Muscle weakness
- GI hyperactivity

Etiology

- Increased dietary intake
- Excessive administration of K^+
- Excessive use of salt substitutes
- Widespread cell damage, burns, trauma
- Administration of larger quantities of blood that is old
- Renal failure

Signs and Symptoms

- Apathy
- Confusion
- Numbness/ paresthesia of extremities
- Abdominal cramps
- Nausea
- Flaccid muscles
- Diarrhea
- Oliguria
- Bradycardia
- Cardiac arrest

CALCIUM

- Location: 1% in extracellular and 99% in bones and teeth
- Functions:

[win11] [sum13]

  - blood cloating,
  - muscle contraction
  - release of ACh from neurons
  - Bones and teeth

Hypocalcemia

[win11] [sum13]

ПЭ> Decreased Ca^{++} level in body
- Reasons: lower absorption, Vit. D deficiency, bone cancer
- Symptoms: titanic spasms, convulsions

Hypercalcemia

[win11] [sum13]

ПЭ> Increased level of Ca^{++} in body
- Reasons: hypervitaminosis D, bone neoplastic disease
- Symptoms: muscle weakness, constipation, cardiac irregularities

Regulated by the parathyroid gland

Parathyroid hormone

- Helps with calcium retention and phosphate excretion through the kidneys
- Promotes calcium absorption in the intestines
- Helps mobilize calcium from the bone

- About 99% of body Ca is found in **bones** and the remaining is present in **ECF.**
- It is important for blood **clotting** and contraction of various **smooth muscles**.
- In cardiovascular system (CVS) Ca is essential for **contraction** coupling in cardiac muscles as well as for the conduction of **electric impulse** in certain regions of heart.
- It plays role in maintaining **the integrity of mucosal membrane,** cell **adhesion** and **function** of the individual cell membrane as well.

Physiological role of Calcium

Calcium is found mainly in the ECF whilst P is found mostly in the ICF.

Both are important in the maintenance of healthy bone and teeth.

Ca is also important in the transmission of nerve impulses across synapses, the clotting of blood and the contraction of muscles. If the levels of **Ca fall** below normal level both muscles and **nerves become more excitable.**

Condition	Hypochloremia	Hyperchloremia
	Decrease calcium level in body	Increase calcium level in body
Reason	1. Metabolic acidosis 2. Vomiting 3. Lack of reabsorption	Excess loss of bicarbonate ions and dehydration
Symptoms	Alkalosis and muscle spasm	

Hypercalcemia

- When the level of Calcium **rises** **a**bove normal, (Hypercalcemia) Increased serum levels of Ca^{++}
- the nervous system is depressed, and the reflux action of CNS can become sluggish.
- It also **decreases** the **QT** interval of the heart which can lead to cardiac arrhythmia.
- It causes constipation and lack of appetite and depresses contractility of the muscle walls of the GIT.

- The depressive effect begins to appear when blood Calcium level rises above 12mg/dl and beyond 17 mg/dl $CaPO_4$crystals are likely to ppt throughout the body.
- This situation occurs due to
  - ✓ hypoparathyroidism,
  - ✓ vit D deficiency,
  - ✓ Osteoblastic metastasis,
  - ✓ steatorrhea (fatty stools),
  - ✓ Cushing syndrome (hyper active adrenal cortex),
  - ✓ acute pancreatitis and acute hypophosphatemia.

Signs and Symptoms

1. Muscle weakness
2. Personality changes
3. Nausea and vomiting
4. Extreme thirst
5. Anorexia
6. Constipation
7. Polyuria
8. Pathological fractures
9. Calcifications in the skin and cornea
10. Cardiac arrest

Hypocalcemia:

- Change in blood pH can influence the degree of calcium binding to plasma proteins. With acidosis less calcium is bound to plasma proteins.
- When calcium ion concentration falls below normal, the excitability of the nerve and muscle cells increases markedly.

MAGNESIUM

- Location: It is majorly found in intracellular fluid, abt 54% in bones and abt 45 % in ICF
- Functions:
  - To activate enzymes which are involved in CH and protein metabolism
  - Neuronal transmission
  - Myocardial function
  - For the function of Na^+ / K^+ ATPase pump.

Hypomagnesemia

⇒ Decreased Mg^{++} ion level in body

- Reasons: lower absorption, malnutrition, diarrhoea, chronic alcoholism
- Symptoms: muscle weakness, confusion, nausea, cardiac arrhythmia

Hypermagnesemia

⇒ Increased Mg^{++} ion level in body

- Reasons: Addison's disease, acute diabetic acidosis, renal failure
- Symptoms: hypotension, cardiac arrest

CHLORIDE

- <u>Location</u>: It is majorly found in all body fluid
  Nearly 66% of ion content in plasma is chloride ion
- <u>Normal level</u>: abt 50 mEq / Kg
- <u>Functions</u>:
  - absorbed and excreted by cells (maintain charge balance btwn the body fluids)
  - Along with Na^+ , maintains osmotic balance of all body fluids
  - Takes part in formation of gastric acid

Hypochloremia

⇒ Decreased Cl^- level in body

- Reasons: …

- Chloride major <u>extracellular anion</u> is principally responsible for maintaining proper hydration, osmotic pressure, and normal cation anion balance in vascular and interstitial compartment.
- The concentration of chloride is 103mEq/l in extracellular fluid, and 4 mEq/l in intracellular fluid.

- metabolic acidosis seen in diabetes mellitus and renal failure
- Lack of reabsorption from kidney
- Therapy of diuretics
- Excessive vomiting – loss as gastric acid (HCl)

Symptoms: alkalosis, respiratory depression, muscle spasm

Hyperchloremia

⇒ Increased Cl^- level in body

- Reasons: excess loss of bicarbonate ions, dehydration, CHF

- <u>Hyperchloremia:</u>

(Increased concentration of chloride): may be due to

- dehydration,
- decreased renal blood flow found with congestive heart failure (CHF) or
- excessive chloride intake.

- <u>Hypochloremia:</u>

(Decreased chloride concentration):

- It can be the result of
  - salt losing nephritis, leading to lack of tubular reabsorbtion of chloride,
  - metabolic acidosis such as found in diabetes mellitus,
  - in renal failure and
  - prolonged vomiting.

PHOSPHATE

Phosphate is a crucial electrolyte (charged mineral) in the body, vital for bone health, energy (ATP), nerve/ muscle function, and pH balance, found in foods and mainly stored in bones.
In biological systems, it's an important intracellular anion, while in batteries, phosphate compounds enhance safety and efficiency.

Phosphate as a Biological Electrolyte (Body)

Definition : Phosphate is a mineral (phosphorus + oxygen) that carries an electric charge in fluids, acting as an electrolyte.

Functions : Builds bones /teeth, essential for ATP (energy currency), cell membranes , DNA, and helps buffer acid-base balance.

Location : Mostly in bones (85%), inside cells, and a small amount in extracellular fluid.

Regulation : Kidneys , intestines , and hormones (like PTH, FGF23, calcitriol) control levels.

PHOSPHATE

It is principal anion of ICF compartment.

-Inorganic phosphate in the plasma is mainly in two forms

i)HPO_4^- and ii) H_2PO_4

The concentration of HPO_4^- is 1.05 mmole/L and the concentration of H_2PO_4 0.26 mmole/L.

When the total quantity of the phosphate in ECF rises so does the concentration of each of these ions.

When pH of the ECF becomes more acidic there is relative increase in H_2PO_4 and decrease in HPO_4

- P is essential for proper metabolism of calcium, normal bone and tooth development. HPO_4 and H_2PO_4 makes an important buffer system of body.

BICARBONATE

- It is the second most prevalent anion in ECF. Along with carbonic acid it acts as body's most important buffer system.
- Each day kidney filters about 4320 milliequivalents of bicarbonate and under normal conditions all of this is reabsorbed from the tubules, thereby conserving the primary buffer system of the extracellular fluid.
- When there is reduction in the ECF hydrogen ion concentration (alkalosis) the kidneys fail to reabsorb all the filtered bicarbonate thereby increasing the excretion of bicarbonate.
- Because bicarbonate ions normally buffer hydrogen in the extracellular fluid, this loss of bicarbonate is as good as adding a hydrogen ion to the extracellular fluid.
- Therefore, in alkalosis, the removal of bicarbonate ions raises the ECF hydrogen ion concentration back towards normal.
- In acidosis the kidneys reabsorb all the filtered bicarbonate and produces new bicarbonate which is added back to the ECF. This reduces the ECF H^+ concentration back towards normal. i.e. reverse of acidosis since HCO_3 is alkaline

Electrolytes used in the Replacement Therapy

- In a healthy person, at least 70 liters of fluids are exchanged (secreted and reabsorbed) across the walls of the intestines per day.
- The brain, heart, kidney, and virtually every other vital organ depend on these fluids to function.
- As the body takes in the water and salts it needs, it loses or excretes those it does not need through urine, stools, and sweat.
- Thus, the secretion and absorption rates are kept in balance.
- In various condition like prolonged fever, sever vomiting or diarrhea creates a tremendous outpouring of water (heavy loss of water) & electrolytes (body salts) state of dehydration and impairs the capacity to reabsorb the fluid & electrolytes in our system.
- To compensate this loss, Electrolyte Replacement Therapy / Oral Rehydration Therapy is required.

The fluid in each compartment is ionically balanced.

- Body has the capacity to adjust slight variations in electrolytic concentration of the fluid compartments.
- If concentration of electrolytes changes – water will migrate across the cell membrane to reestablish Osmotic equilibrium.

Replacement Therapy

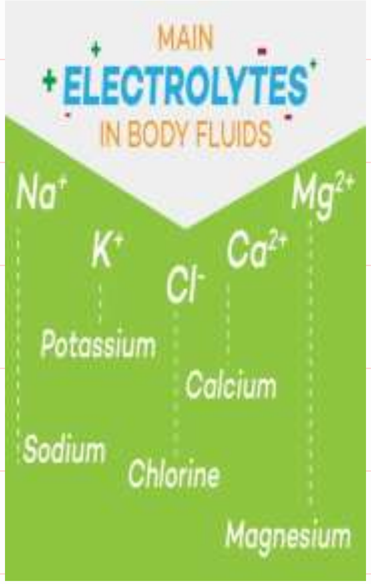
- When body itself fails to correct an electrolyte imbalance. Products:
- Electrolytes • Acids & Bases • Blood Products • Carbohydrates • Amino acids • Proteins

ELECTROLYTE REPLACEMENT THERAPY

- When body itself fails to correct an electrolyte imbalance.

Products:

- Electrolytes
- Acids & Bases
- Blood Products
- Carbohydrates
- Amino acids
- Proteins



Important Functions:

- Control of osmosis of water between body compartments.
- Maintain the acid-base balance required for normal cellular activates.
- Help to generate action potentials & graded potentials.
- Help to control secretion of some hormones (e.g., Aldosterone, Thyroid hormones) and neurotransmitters.

Synonym: Electrolyte replenisher

Due to serious symptoms of the loss of e-lytes, it is essential to maintain the normal level by external supply of e-lytes . This therapy is called as e-lyte replacement therapy.

2 type of supply:

a. Rapid initial replacement: solution contains e-lytes with concentration resemble with the e-lyte concentrations found in extracellular fluids.

b. Subsequent replacements: lower concentration of e-lytes in solution

Compounds:

(1) For Sodium replacement

NaCl
Sodium acetate

(2) For Potassium replacement

Potassium chloride
Potassium acetate
Potassium bicarbonate

(3) For Calcium replacement

Calcium chloride
Calcium lactate
Calcium levulinate
Calcium phosphate
Calcium gluconate

(4) For Magnesium replacement

$MgSO_4$ – Epsom salt *(covered in GI agents)*

$MgCl_2$

(1) SODIUM CHLORIDE

Physical properties:

- White or colorless powder, saline taste
- Soluble in water, insoluble in alcohol

Chemical properties:

- Oxidized to give chlorine gas

$$2Cl^- + MnO_2 + 2H_2SO_4 \longrightarrow Mn^{+2} + 2SO_4^{-2} + 2H_2O + Cl_2\uparrow$$

- It react with silver nitrate and gives white ppt of silver chloride

$$NaCl + AgNO_3 \longrightarrow AgCl\downarrow + NaNO_3$$

Preparation:

a. From sea water

a. In lab. It is prepared from common salts (impure) in water by passing HCl gas. Crystals of NaCl are ppted out

Assay:

- about 0.1 g and dissolve in 50 ml of water
- Add 50.0 ml of 0.1 M silver nitrate, 5 ml of 2 M nitric acid and 2 ml of dibutyl phthalate
- Titrant: 0.1 M ammonium thiocyanate
- Indicator: ferric ammonium sulphate solution
- End point: colour becomes reddish yellow

1 ml of 0.1 M silver nitrate is equivalent to 0.005844 g of NaCl

Storage: tightly closed container, in dry place

Use:

- Source of sodium and chloride ions (Sodium replacement)
- Making other pharmaceutical formulations like Ringer's injection, ORS.

ELECTROLYTE USED IN REPLACEMENT THERAPY

- Sodium chloride and its preparations
- Potassium chloride and its preparations

SODIUM CHLORIDE

- Moleculer formula- NaCl
- Molecular weight- 58.44

PHYSICAL PROPERTIES

- It is white, anhydrous crystalline solid.
- Odourless but having salty taste.
- It is soluble in water but insoluble in alcohol.
- Its 0.9% Solution is Isotonic (That means having same Osmotic pressure) to blood.

METHOD OF PREPARATION

- Sodium Chloride (NaCl) can be obtained from natural source as well as it can also be prepared in laboratory.
- Naturally It can be obtained from Rock salt strata & Sea water. But from these sources it can be obtained in impure form. The pure form of salt can be obtained by the filtration process & finally the dried form can be collected by evaporation process.
- It can also be prepared in laboratory in small scale by the acid- base reaction. In which strong acid (HCl) reacts with strong base (NaOH) & finally it gives Sodium Chloride.

CHEMICAL PROPERTIES

- When react with permanganate it liberate chorine gas.
- It reacts with Silver nitrate and forms white precipitates of Silver chloride.

$$NaCl + AgNO_3 \longrightarrow AgCl + NaNO_2$$

USES

- It is used as electrolyte replenisher.
- Its 0.9% solution is isotonic (having same osmotic pressure) as blood.
- It is also used as taste enhancer in the preparation of dishes.
- It is also used in Wet dressings & irrigation of body cavities.

OFFICIAL PREPARATION OF SODIUM CHLORIDE

1. Sodium chloride injection I.P
2. Sodium chloride hypertonic injection I.P
3. Sodium chloride eye lotion B.P
4. Sodium chloride solution B.P
5. Sodium chloride & Dextrose injection I.P
6. Sodium chloride & Mannitol injection I.P
7. Sodium chloride tablets U.S.P

SODIUM CHLORIDE INJECTION I.P

- It is sterile isotonic solution of NaCl in water for injection.
- I.P.- 0.85-0.95% w/v (150 milimoles of Sodium chloride ions per litre)
- B.P.- 95-105% w/v
- When it is required as diluent for other pharmacopoeial injctions, 0.9% w/v solution of NaCl is used.

SODIUM CHLORIDE HYPERTONIC INJECTION I.P

- It is sterile isotonic solution of NaCl in water for injection contain not less than 1. 52% and not more than 1.68% w/v of sodium chloride.
- (270 milimoles of sodium chloride ions per litre)
- no antimicrobial ions are present.

- **Sodium chloride eye lotion B.P** 0.85-0.95% w/v of NaCl
- **Sodium chloride solution B.P** 0.9% w/v solution

Normal saline solution

If sterile- it is completely free from micro organisms.

SODIUM CHLORIDE & DEXTROSE INJECTION I.P

Sterile solution of sodium chloride and dextrose.

Concentration of Dextrose	Concentration of Sodium chloride
5 % w/v	0.11, 0.18, 0.20, 0.225, 0.30, 0.33 %
2.5, 5, 10%	0.45%
2.5, 5, 10 , 25 % w/v	0.9%

(1) COMPOUND SODIUM INJECTION

Synonym: Ringer's injection (Ringer's solution)

Composition:

- Each 100ml of soln is having-
  - NLT 0.82g and NMT 0.90g of NaCl
  - NLT 0.0285g and NMT 0.0315g of KCl
  - NLT 0.030g and NMT 0.036g of $CaCl_2 . 6H_2O$
- It should be free from microorganism

Preparation:

- Ingredients with appropriate quantity are dissolved in WFI
- Solution is filtered and filtrate is sterilized by heating in an autoclave.

Sodium Chloride	8.6g
Potassium Chloride......	0.3g
Calcium Chloride.........	0.33g
WFI q.s.	1000 ml

Assay:

- The three salts present in preparation may be assayed individually.

Use: electrolyte replenishes

(2) COMPOUND SOD. LACTATE INJ.

Synonym: Ringer Lactate Injection

Composition:

- Each 100ml of soln is having-
  - NLT 0.27g and NMT 0.32g of Na
  - NLT 0.019g and NMT 0.022g of K
  - NLT 0.37g and NMT 0.42g of total chloride
  - NLT 0.025g and NMT 0.029g of $CaCl_2 . 2H_2O$
  - NLT 0.23g and NMT 0.28g of lactate
- It should be free from microorganism

Physical properties:

- Clear, colourless solution
- Acidic in nature

Preparation:

- NaOH is first dissolved in 200ml WFI
- Add Lactic acid
- Heat in an autoclave at 115 °C for 1 hr
- After cooling soln is neutralised wit HCl
- Other ingredients are dissolved in 700ml water and prepared soln is mixed with previous soln
- Make up total volume of 100ml with WFI
- Soln is filtered and sterilized.

Lactic acid.......................... 2.4ml
Sodium hydroxide.................. 1.15g
Dil. HCl............................. q.s.
Sodium Chloride 6.0g
Potassium Chloride................ 0.4g
Calcium Chloride, hydrated......... 0.4g
WFI q.s. .... 1000 ml

Assay:

- The three salts present in preparation may be assayed individually.

Use: electrolyte replenishes

Storage: in single dose container of glass or plastic

(3) ORS

Oral Rehydration Salt

ID→ Oral Rehydration Salts are dry, homogeneously mixed powders containing Dextrose, Sodium Chloride, Potassium Chloride and either Sodium Bicarbonate or Sodium Citrate for use in oral rehydration therapy after being dissolved in the requisite amount of water.

- is a combination of oral electrolytes.

Composition:

- Contains essential electrolytes those are important to maintain the normal functions of the body.
- Also contains sufficient amount of water.

- The concentration of electrolytes may be varying depending on the level of loss of particular electrolyte.

Use:

- In heavy loss of water (dehydration) and loss of electrolytes
- Conditions like severe vomiting, diarrhea and prolonged fever.

- The therapy is done with butter milk, rice, light tea, coconut water etc.

Formulations

WHO Drug Information Vol. 16, No. 2, 2002
(2002; 91 pages)

The total substance concentration (including that contributed by glucose) should be within the range of **200-310 mmol/l**.

Glucose	should at least equal that of sodium but **should not exceed 111 mmol/l**
Sodium	should be within the range of **60-90 mEq/l**
Potassium	should be within the range of **15-25 mEq/l**
Citrate	should be within the range of **8-12 mmol/l**
Chloride	should be within the range of **50-80 mEq/l**

Electrolytes Combination Theory

SODIUM CHLORIDE & MANNITOL INJECTION U.S.P

- Sterile solution of sodium chloride and mannitol.

Concentration of Mannitol	Concentration of NaCl
5-10%	0.3%
15-20%	0.45%

SODIUM CHLORIDE TABLETS I.P

- 95-105% w/v of stated amount
- Strength available- 180,300,500mg

POTASSIUM CHLORIDE

- Molecular formula- KCl
- Molecular weight- 74.55
- Synonym- potassium muriate, potash muriate

METHOD OF PREPARATION

- It can be commonly obtained by mining its
- minerals, followed by extraction.
- It is also extracted from brine (salt water).
- It can also be prepared in the laboratory in small scales by reacting potassium hydroxide (KOH) with hydrochloric acid (HCl).

$$KOH + HCl \rightarrow KCl + H2O$$

PROPERTIES

- **Physical properties-**
- It is white crystalline powder, odourless & strong saline taste.
- Like Sodium Chloride it is freely soluble in Water, & insoluble in alcohols.
- **Chemical properties-**
- Another important reaction of KCl is used to produce metallic potassium, by reducing KCl with metallic sodium at 850 °C.

$$KCl + Na \rightarrow NaCl + K$$

USES

- It is used as electrolytes replenisher.
- pH buffers
- Preparation of fertilizers, explosives, potassium metal and potassium hydroxide.
- In treatment of hypokalemia (potassium deficiency disorder)

  Used in treatment of digitalis poisoning

  Used in treatment of myasthenia gravis

OFFICIAL PREPARATION OF POTASSIUM CHLORIDE

- Potassium chloride and glucose IV infusion B.P. injection I.P
- Potassium chloride & Sodium chloride I.VInfusion I.P/ Injection
- Potassium chloride & Dextrose(Glucose) I.V infusion I.P

(2) POTASSIUM CHLORIDE

Physical properties:

- White or colorless powder, saline taste
- Soluble in water, insoluble in alcohol

Preparation:

a. Lab scale

- Reaction of HCl with K_2CO_3 *or* $KHCO_3$

$$K_2CO_3 + 2HCl \longrightarrow 2\,KCl + CO_2\uparrow + H_2O$$

$$KHCO_3 + HCl \longrightarrow KCl + CO_2\uparrow + H_2O$$

b. Industry scale

- From mineral carnallite KCl. $MgCl_2$. $6H_2O$
- Carnallite is dissolved by treating with hot water.
- Less soluble KCl will crystallizes out on cooling the solution

Assay:

- Principle: Mohr's method (Argentometric titration)
- about 0.15 g and dissolve in 50 ml of water
- Titrant: 0.1 M silver nitrate
- Indicator: potassium chromate solution

1 ml of 0.1 M silver nitrate is equivalent to 0.007455 g of KCl

Use

- Source of potassium ions (potassium replacement)
- Making other pharmaceutical formulations like Ringer's injection, ORS
- As diuretic
- In ' Myasthehenia gravis'

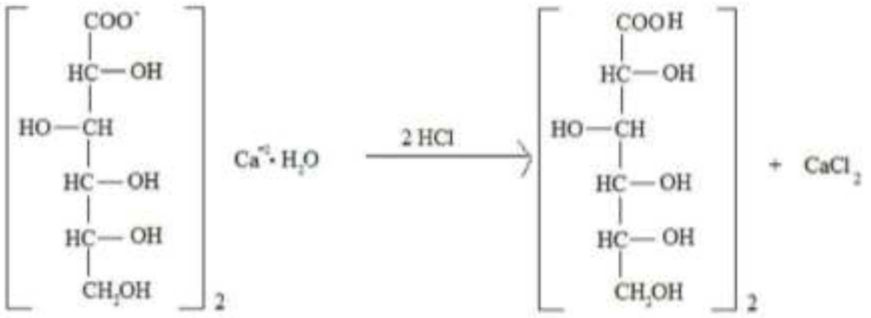
(3) CALCIUM GLUCONATE

Physical properties:

- white crystals, granules or powder,
- stable in air, does not lose its ($C_{12}H_{22}O_{14}Ca$. H_2O) water of crystallization on drying
- Neutral to litmus paper

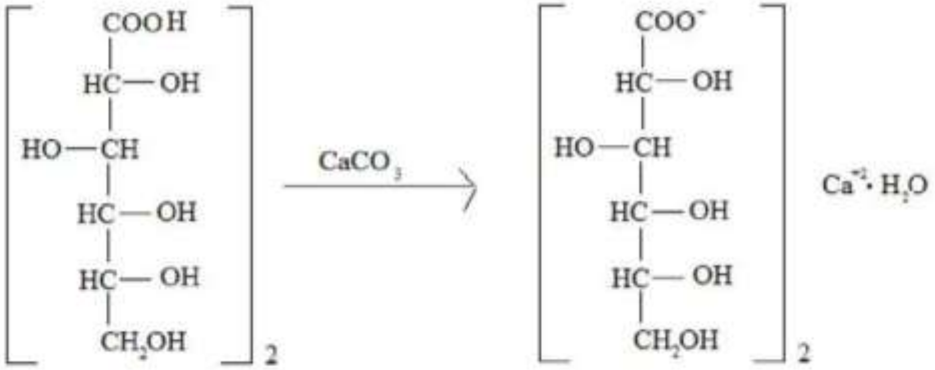
Chemical properties:

- When treated with dil. HCl, It is decomposed into gluconic acid and calcium chloride.



Preparation:

- It is prepared by boiling a solution of gluconic acid with Ca. carbonate
- Pdct is filtered and ♯ed out from solution.



Assay:

- Principle: Complexometric titration
- 0.5g sample is dissolved in warm water, cool and add 5.0 ml of 0.05 M $MgSO_4$ and 10 ml of strong ammonia solution
- Titrant: 0.05 M disod. edetate
- Indicator: mordant black II mixture
- End Point: until deep blue color develops.
- From the volume of 0.05 M disod. edetate required, subtract the volume of the $MgSO_4$ solution added for actual reading.
- Factor: 1 ml 0.05 M disod. EDTA ≡ 0.02242g of Ca. gluconate

⇒ Combination of electrolytes are prepared and given to the patient according to its requirements.

Conditions like,

- During surgery
- when the patient unable to take normal diet
- Malnutrition

Formulations:

Ringer lactate solution

ORS

PHYSIOLOGICAL ACID-BASE BALANCE

- Electrolytes also play an important role in regulating body's acid-base balance
- Body fluids contain balanced quantities of acids & bases.

- Acidity of the solution: fluid/solution - ECF Sources: $[H^+]$ No of $[H^+]$ present in Glucose, Fatty acids, & food products
- Cellular metabolism Amino acids etc
- Reabsorption

Body Fluid	pH value
Urine	4.5 – 08
Blood	7.4 – 7.5
Gastric juice	1.5 – 3.5
Saliva	5.4 – 7.5
Bile	6.0 8.5

- Biochemical reactions: Very sensitive to change in pH (acidity/alkalinity)

e.g., enzyme Pepsin in the stomach–helps in digestion of dietary proteins at low pH. Enzyme Ptyalin in saliva helps in digests carbohydrates at pH between 5.4 - 7.5.

Protein Buffer System

Acids-bases are continually taken into & formed by the body, the pH of fluids inside & outside cells remain fairly constant because of the presence of 'BUFFER SYSTEMS'.
•Consists of a weak acid & the salt of that acid Functions:

- to convert strong acids or bases into weak acids or bases.
- to prevent drastic change in pH of the blood.

Note: However, it will be effective only if excess acid/alkali excreted out by lungs and/or kidneys.

Phosphate Buffer

- The phosphate buffer system ($HPO_4^{2-}/H_2PO_4^-$) plays a role in plasma and erythrocytes.
- $H_2PO_4^- + H_2O \leftrightarrow H_3O^+ + HPO_4^{2-}$
- Any acid reacts with monohydrogen phosphate to form dihydrogen phosphate

dihydrogen phosphate monohydrogen phosphate

- $H_2PO_4^- + H_2O \leftarrow HPO_4^{2-} + H_3O^+$
- The base is neutralized by dihydrogen phosphate

dihydrogen phosphate monohydrogen phosphate

- $H_2PO_4^- + OH^- \rightarrow HPO_4^{2-} + H_3O^+$

Types of Buffer systems:

- Carbonic Acid ($H2CO3$) – Bicarbonate ($HCO3^-$) Buffer System
- Phosphate ($H2PO4^-$,$HPO4^{2-}$,$PO4^{3-}$) Buffer System
- Protein (Hemoglobin/HbH) Buffer System

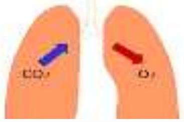
Carbonic Acid (H2CO3) – Bicarbonate ($HCO3^-$) Buffer System

- Major buffer of metabolic acid/base present in Plasma & Kidneys.
- Regulates blood pH

Some CO_2, the end product of cellular metabolism, is carried to the lungs for elimination, and the rest dissolves in body fluids, forming carbonic acid that dissociates to produce bicarbonate (HCO_3^-) and hydronium (H_3O^+) ions. More of the HCO_3^- is supplied by the kidneys.

$CO_2 + H_2O \leftrightarrow H_2CO_3$

$H_2CO_3 + H_2O \leftrightarrow H_3O^+ + HCO_3^-$



Regulation of blood pH

- The lungs and kidneys play important role in regulating blood pH.
- The lungs regulate pH through retention or elimination of CO_2 by changing the rate and volume of ventilation.
- The kidneys regulate pH by excreting acid, primarily in the ammonium ion (NH_4^+), and by reclaiming HCO_3^- from the glomerular filtrate (and adding it back to the blood).

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Proteins act as a third type of blood buffer

- Proteins contain – COO^- groups, which, like acetate ions (CH_3COO^-), can act as proton acceptors.
- Proteins also contain – NH_3^+ groups, which, like ammonium ions (NH_4^+), can donate protons.
- If acid comes into blood, hydronium ions can be neutralized by the – COO^- groups
- $- COO^- + H_3O^+ \rightarrow - COOH + H_2O$
- If base is added, it can be neutralized by the – NH_3^+ groups
- $- NH_3^+ + OH^- \rightarrow - NH_2 + H_2O$

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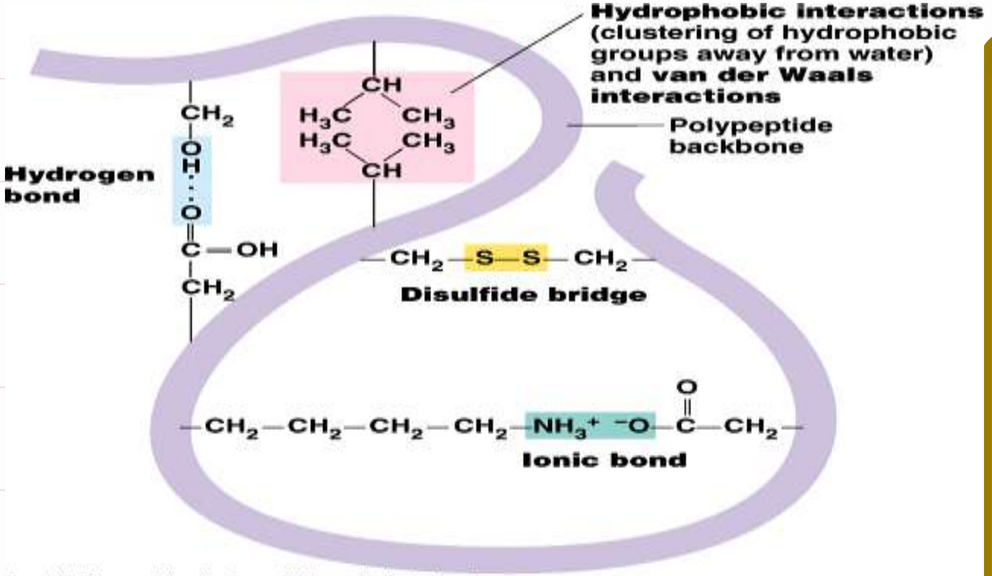

THANK YOU