Solutions , Acids and Bases

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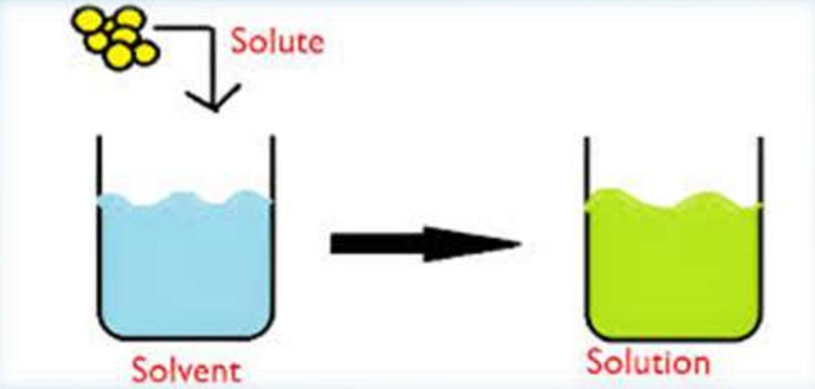
Objective :

- we will explore the concept of solutions.
- Discuss the different types of solutions in the body.
- And highlight their importance in medical practice.
- Understanding the principles of acid-base balance is vital for diagnosing and managing various medical conditions.

I. Understanding Solutions:

A. Definition:

A solution is a homogeneous mixture composed of two or more substances. In a solution, the solute is evenly distributed and dispersed within the solvent.



B. Solvent

The solvent is the substance that dissolves the solute. In biological systems, water is the primary solvent, and most solutions in the body are aqueous solutions

C. Solute

The solute is the substance that is dissolved in the solvent. It can be a solid, liquid, or gas.

II. Types of Solutions in the Body

1 Intracellular Solutions:

- **Definition**: Intracellular solutions are solutions found within cells.
- **Composition**: These solutions primarily consist of water, ions (e.g., potassium[K^+], magnesium[Mg^{+2}], proteins, and other molecules necessary for cellular functions.
- **Significance**: Intracellular solutions help maintain cell structure, facilitate metabolic reactions, and enable cellular communication.

2 Extracellular Solutions:

- **Definition**: Extracellular solutions are solutions found outside the cells.

Composition:

a. Interstitial Fluid: This is the fluid that surrounds the cells in tissues. It consists of water, ions (e.g., sodium[Na^+], chloride[Cl^-], nutrients, gases, and waste products.

b.Plasma: is the liquid component of blood. It contains water, ions, proteins (e.g., albumin, globulins), hormones, and other substances.

- **c. Lymph:** Lymph is a fluid that circulates through the lymphatic system. It resembles interstitial fluid but also contains immune cells and waste products.
- **Functions**: The extracellular solutions facilitate nutrient and waste exchange between cells and the bloodstream, help maintain blood volume and pressure, and support immune responses.

Body Fluid Compartments Ratio

1

Intracellular Fluid (ICF)

The **ICF** represents the fluid inside the cells. It accounts for approximately **two-thirds** of the total body fluid.

2

Extracellular Fluid (ECF)

The **ECF** includes interstitial fluid, plasma, and lymph. It constitutes approximately **one-third** of the total body fluid.

3

Importance

Maintaining the balance between the **ICF** and **ECF** is crucial for proper cellular function, tissue hydration, and overall fluid homeostasis.

Q. If the ratio of ICF to ECF becomes one-third and two-thirds, respectively, what might happen ?

III. Electrolyte Solutions

A. Definition:

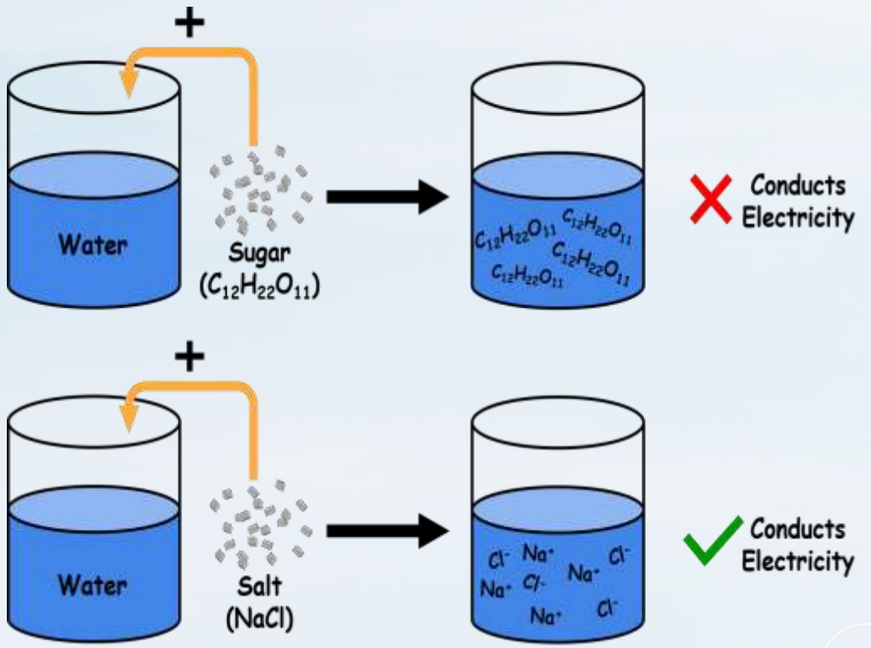
Electrolytes are substances that dissociate into ions when dissolved in water, allowing them to conduct electrical currents.

Examples:

Common electrolytes in the body include Na^{+}, K^{+}, Cl^{-}, Ca^{+2}, and Mg^{+2}.

B. Role of Electrolytes:

Electrolyte Balance: Electrolytes maintain proper hydration, pH balance, nerve conduction, muscle function, and enzyme activity.



How to measure the Electrolytes

- **Electrolyte analyzers** are instruments used to measure the concentration of electrolytes in biological samples such as *blood, serum, plasma, or urine*. Electrolytes are electrically charged ions that play crucial roles in various physiological processes, including maintaining fluid balance, regulating nerve and muscle function, and facilitating cellular activities.

IV. Clinical Significance of Solutions:

A. Fluid and Electrolyte Imbalances:

1. **Dehydration**: Insufficient fluid intake or excessive fluid loss can lead to dehydration, resulting in electrolyte imbalances, decreased blood volume, and impaired organ function.

2. **Electrolyte Disorders**: Abnormal levels of electrolytes can cause medical conditions such as hyponatremia (low sodium), hyperkalemia (high potassium), or hypocalcemia (low calcium). These disorders require prompt diagnosis and appropriate management.

B. Intravenous Solutions:

1. **Definition:** Intravenous **(IV)** solutions are sterile fluids administered directly into the bloodstream.

2. **Uses**: **IV** solutions are used for fluid replacement, electrolyte supplementation, medication administration, and nutritional support in various medical conditions.

3. **Types**: Common IV solutions include isotonic (e.g., normal saline 0.9%), hypotonic (e.g., 0.45% saline), and hypertonic (e.g., 3% saline) solutions.

Example for Iso. ,Hyper. & Hypotonic solutions

- Red blood cells behave (see figure below). When red blood cells are in a hypertonic (higher concentration) solution, water flows out of the cell faster than it comes in. This results in ***crenation*** **(shriveling)** of the blood cell.
- On the other extreme, a red blood cell that is hypotonic (lower concentration outside the cell) will result in more water flowing into the cell than out. This results in swelling of the cell and potential *hemolysis* (bursting) of the cell. In an **isotonic solution** , the flow of water in and out of the cell is happening at the same rate.

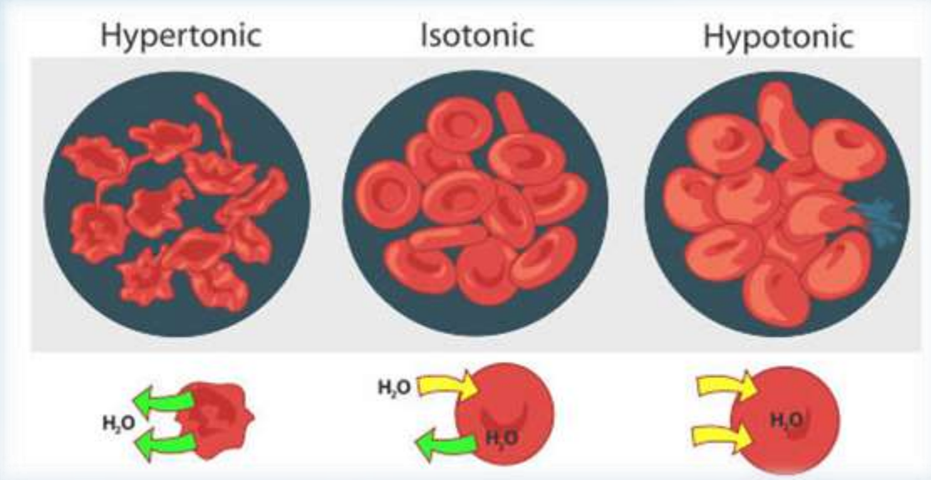
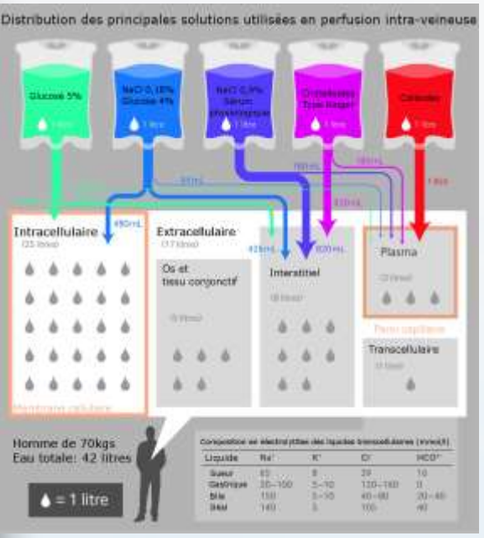


Figure : Red blood cells in hypertonic, isotonic, and hypotonic solutions.

Electrolyte Concentration in IV solutions

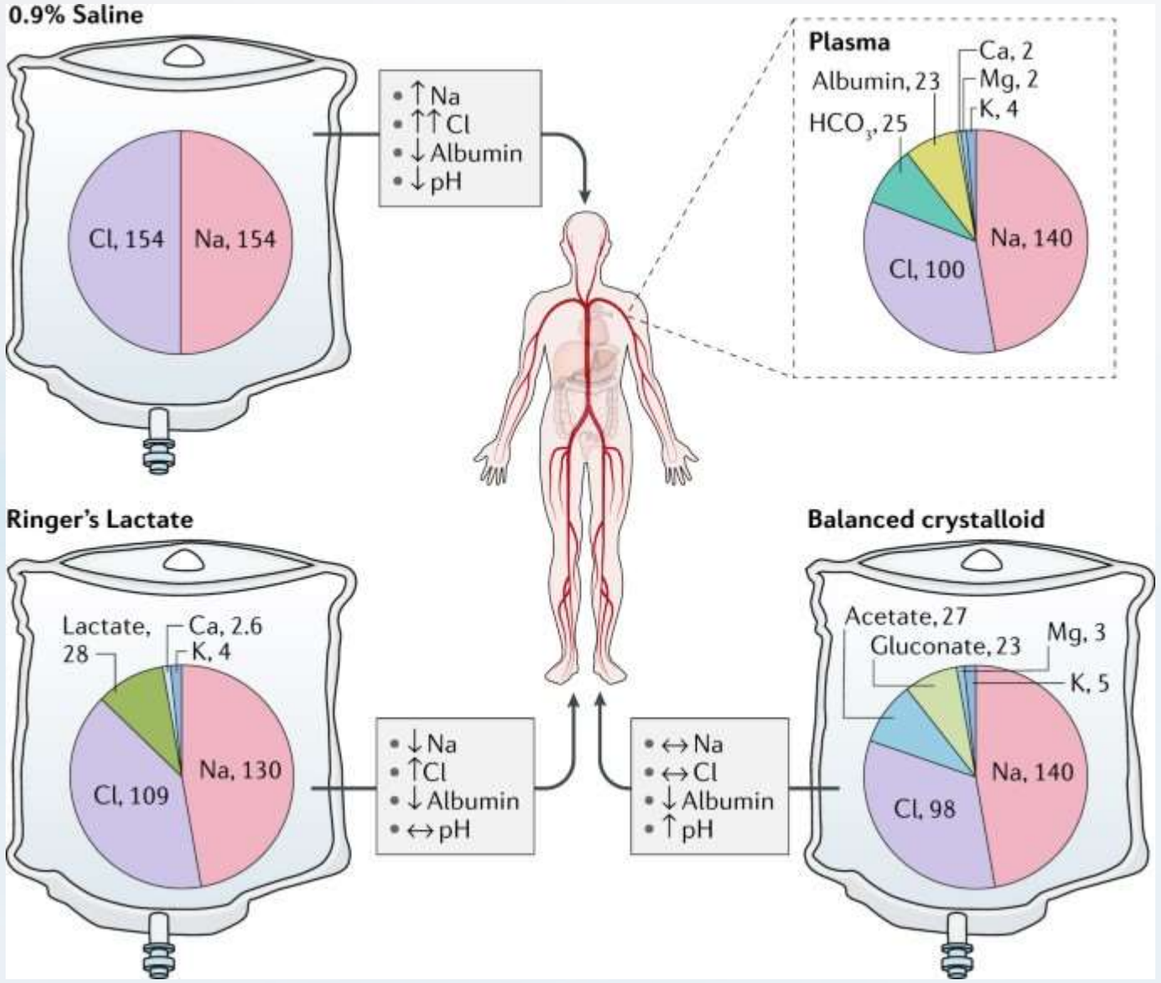
TABLE 9.7 Electrolyte Concentrations in Intravenous Replacement Solutions

Solution	Electrolytes (mEq/L)	Use
Sodium chloride (0.9%)	Na^+ 154, Cl^- 154	Replacement of fluid loss
Potassium chloride with 5.0% dextrose	K^+ 40, Cl^- 40	Treatment of malnutrition (low potassium levels)
Ringer's solution	Na^+ 147, K^+ 4, Ca^{2+} 4, Cl^- 155	Replacement of fluids and electrolytes lost through dehydration
Maintenance solution with 5.0% dextrose	Na^+ 40, K^+ 35, Cl^- 40, lactate$^-$ 20, HPO_4^{2-} 15	Maintenance of fluid and electrolyte levels
Replacement solution (extracellular)	Na^+ 140, K^+ 10, Ca^{2+} 5, Mg^{2+} 3, Cl^- 103, acetate$^-$ 47, citrate^{3-} 8	Replacement of electrolytes in extracellular fluids



Conclusion

- solutions in the human body, including intracellular and extracellular solutions,
  play a vital role in maintaining homeostasis and facilitating physiological processes.
- Electrolytes are essential for proper fluid balance and cellular function.
- Understanding solutions and their significance is crucial for medical professionals in diagnosing ,managing fluid and electrolyte imbalances



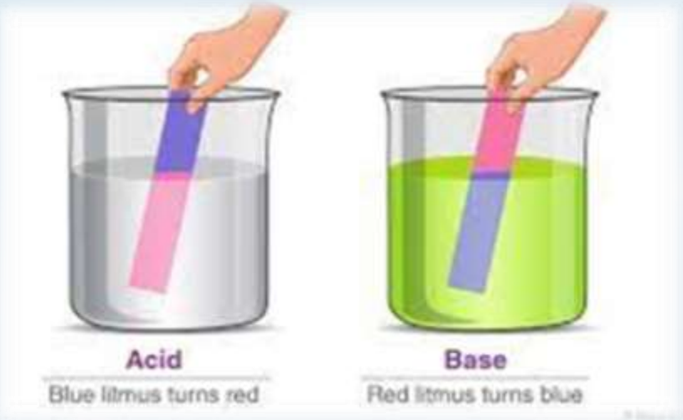
The Nature of Acids and Bases

Acids

- Acids release hydrogen ions and have a pH less than 7. They are commonly found in the human body.
- They play a crucial role in digestion and are used in medical treatments.

Bases

- Bases accept hydrogen ions and have a pH greater than 7. They are important in maintaining the body's pH balance.
- Antacids and many medications are based on the principles of bases.



Strengths and Limitations

Strengths	Limitations
Essential for physiological processes	May cause tissue damage if mishandled
Critical in medical diagnostics	Corrosive properties

Understanding pH Levels

7	<7	>7
Neutral	Acidic	Basic

$HClO_4$	ClO_4^-
H_2SO_4	HSO_4^-
HI	I^-
HBr	Br^-
HCl	Cl^-
HNO_3	NO_3^-
H_3O^+	H_2O
HSO_4^-	SO_4^{2-}
H_3PO_4	$H_2PO_4^-$
HF	F^-
HNO_2	NO_2^-
CH_3CO_2H	$CH_3CO_2^-$
H_2CO_3	HCO_3^-
H_2S	HS^-
NH_4^+	HN_3
HCN	CN^-
HCO_3^-	CO_3^{2-}
H_2O	OH^-
HS^-	S^{2-}
C_2H_5OH	$C_2H_5O^-$
NH_3	NH_2^-
H_2	H^-
CH_4	CH_3^-

Undergo complete acid ionization in water

Do not undergo base ionization in water

Do not undergo acid ionization in water

Undergo complete base ionization in water

Chemical Safety for Acids &Bases

1

Handle with Care

Protective equipment and proper handling prevent accidents and chemical exposure.

2

Storage Guidelines

Following storage requirements ensures the integrity of acid and base solutions.

3

Emergency Protocols

Knowing emergency procedures is critical for dealing with spills and exposure.

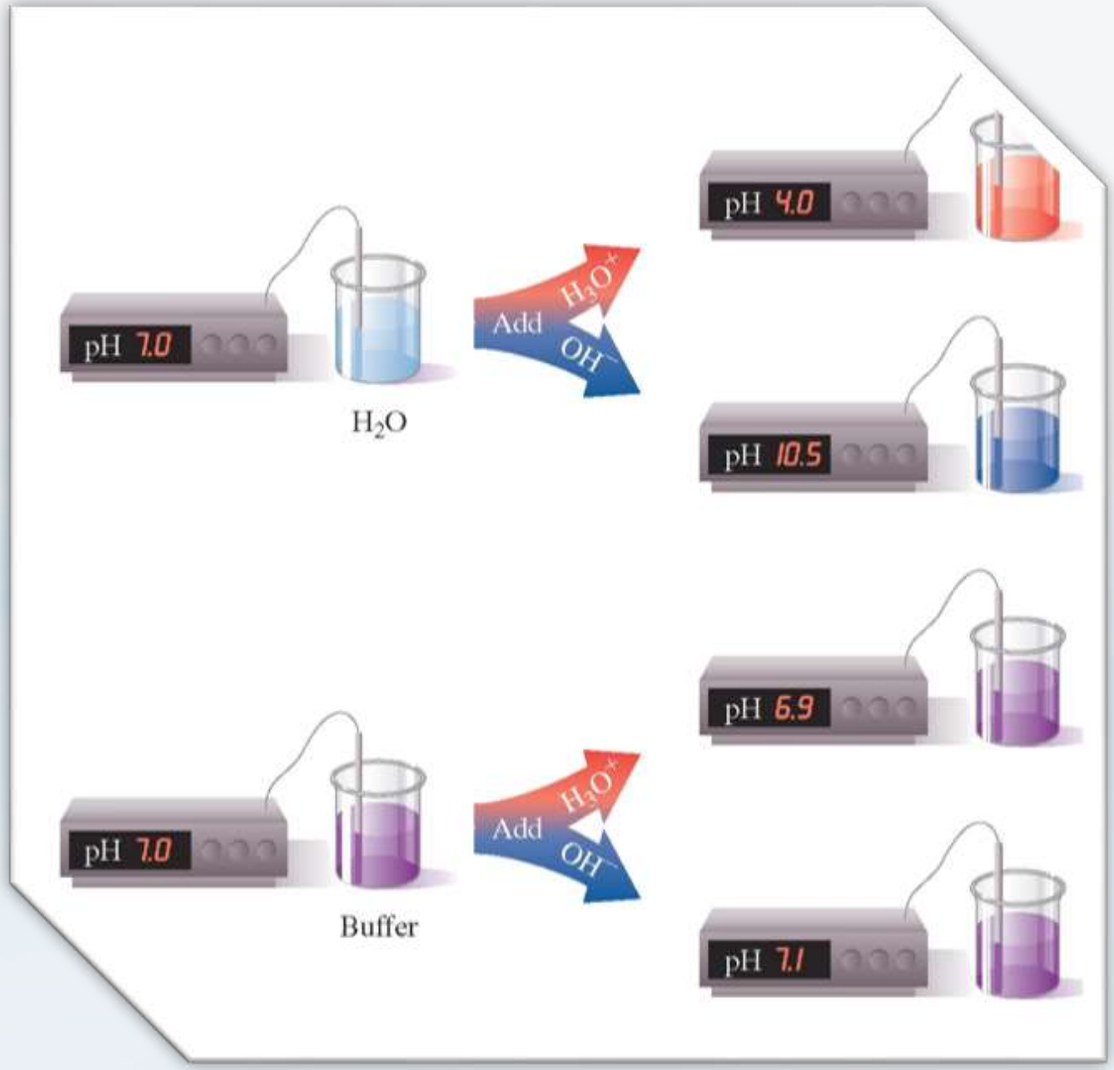
Buffer Solutions

Importance in Medicine

Buffers maintain stable pH levels in physiological systems, playing a crucial role in medical applications.

Laboratory and Clinical Use

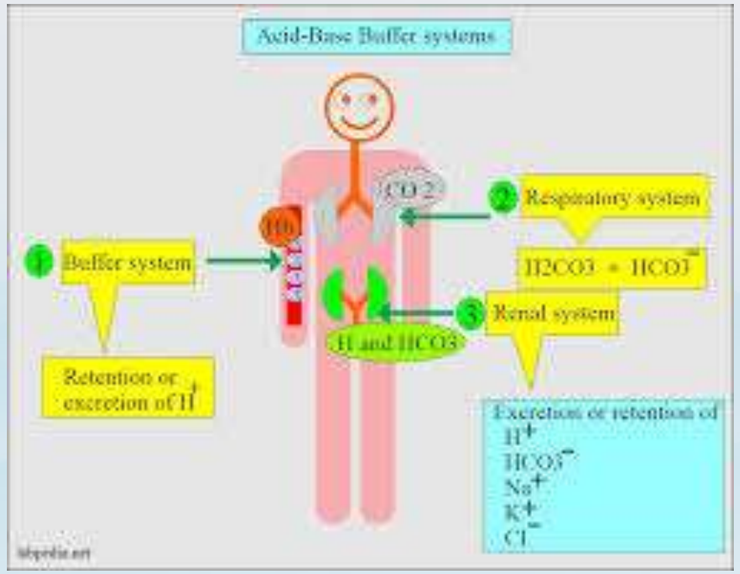
They are utilized in various laboratory techniques and are essential for certain clinical tests.



Acid-base Balance

- **Acid-base balance** refers to the equilibrium between acids and bases in the body's fluids, particularly the blood. The body maintains a delicate balance to ensure optimal functioning of physiological processes. The pH scale, ranging from 1 to 14, measures the acidity or alkalinity of a solution.
- A pH of 7 is considered neutral, below 7 is acidic, and above 7 is alkaline.
- In the human body, three primary mechanisms maintain acid-base balance: 1. the respiratory system, 2. renal system, and 3.chemical buffering systems.

Mechanisms maintain acid-base balance



The respiratory system

The respiratory system plays a fundamental role in regulating acid-base balance through the elimination of carbon dioxide (CO_2). By altering the rate and depth of breathing, the body can adjust CO_2 levels and maintain the pH within a narrow range.

The renal system

The renal system, specifically the kidneys, contributes to long-term regulation of acid-base balance. The kidneys **excrete** acidic or alkaline urine to maintain the proper pH. They also **reabsorb** and generate bicarbonate (HCO_3^-) to regulate systemic pH.

Chemical buffering systems

Chemical buffering systems act as immediate buffers to prevent rapid changes in pH. The bicarbonate buffer system is the most crucial buffering system in the blood, where bicarbonate ions (HCO_3^-) and carbonic acid (H_2CO_3) maintain the pH balance.

Clinical Perspective of Acid-Base Balance

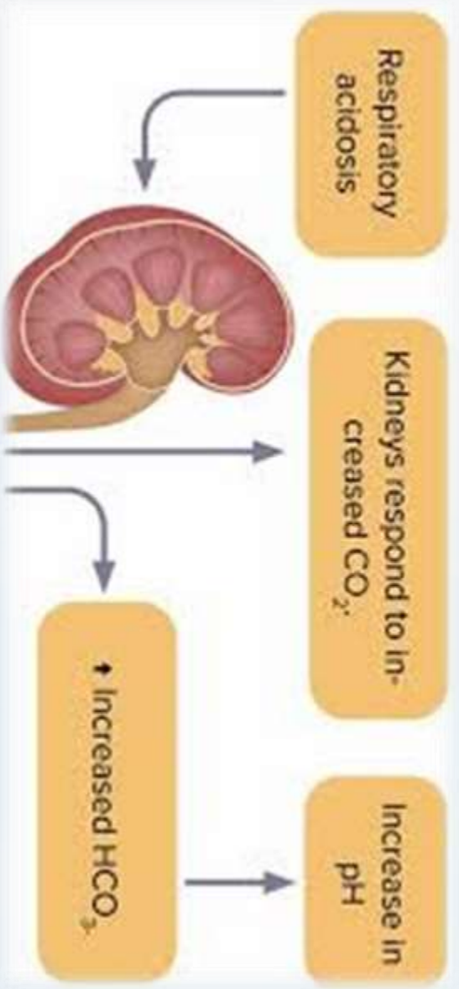
Understanding acid-base disorders helps us diagnose and manage a wide range of medical conditions. There are **four primary acid-base disturbances**

1 Respiratory Acidosis:

This occurs when there is an excess of carbon dioxide in the blood due to hypoventilation or impaired gas exchange. Conditions such as chronic obstructive pulmonary disease (COPD), pneumonia, or respiratory muscle weakness can lead to respiratory acidosis.

2 Respiratory Alkalosis:

This results from excessive elimination of carbon dioxide due to hyperventilation. Causes may include anxiety, high altitude, fever, or certain lung diseases. Respiratory alkalosis leads to decreased levels of carbon dioxide and can affect the body's overall acid-base balance.



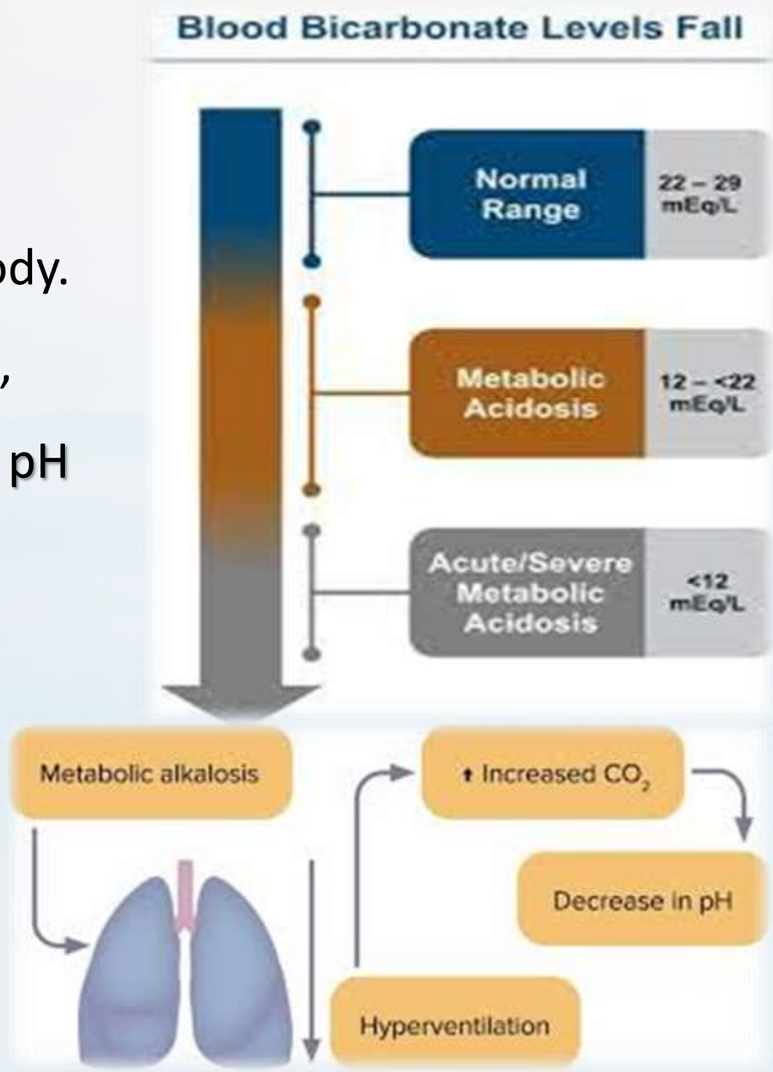
Clinical Perspective of Acid-Base Balance

3 Metabolic Acidosis

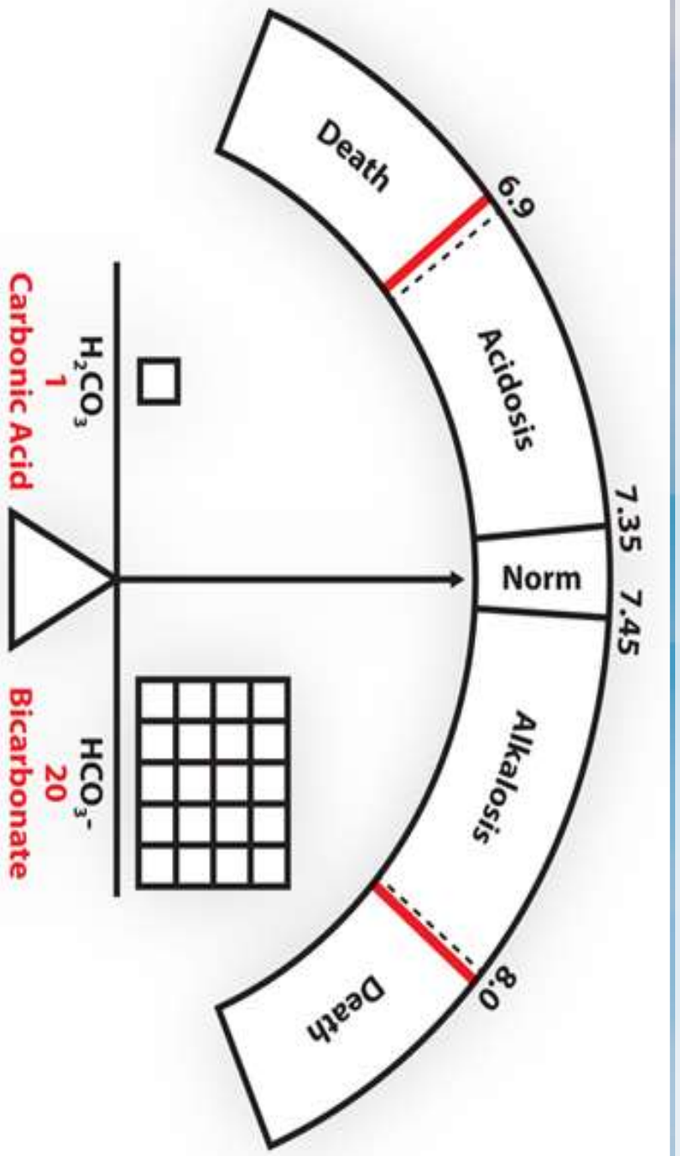
This occurs when there is an excess of acid or a loss of bicarbonate in the body. Common causes include diabetic ketoacidosis, renal failure, severe diarrhea, and certain drug overdoses. Metabolic acidosis leads to a decrease in blood pH and can have severe consequences if left untreated.

4 Metabolic Alkalosis

This arises from an excessive loss of acid or an increase in bicarbonate levels. Causes may include prolonged vomiting, excessive use of diuretics, or certain hormonal disorders. Metabolic alkalosis leads to an elevation in blood pH and disrupts the acid-base balance.



Acid-Base disorders



1

To diagnose acid-base disorders

we rely on arterial blood gas **(ABG)** analysis, which measures pH, partial pressure of carbon dioxide (pCO_2), bicarbonate levels (HCO_3^-), and other parameters. ABG results help us identify the specific acid-base disturbance and guide appropriate treatment.

2

Treatment of acid-base disorders

involves addressing the underlying cause. For instance, in respiratory acidosis, improving ventilation or treating the underlying lung condition is crucial. In metabolic acidosis, correcting the underlying cause and restoring bicarbonate levels may be necessary.

In summary

- a comprehensive understanding of acid-base balance is essential for medical professionals.
- By recognizing and managing acid-base disorders, we can optimize patient care and improve clinical outcomes.

- Remember, mastering the principles of acid-base balance and its clinical perspective is a stepping stone toward becoming competent and compassionate healthcare providers.

- As future physicians, you will encounter patients with acid-base disturbances, and your knowledge will help you make accurate diagnoses and provide appropriate interventions.

Thanks for your attention

Any Questions… ?

for further information ,Pls check the text book : Chemistry: an introduction to general, organic, and biological chemistry 13th Edition .