MEDICAL CHEMISTRY
GENERAL CHEMISTRY

University Of Fallujah

College Of Medicine

Lecture : Medical Chemistry (5) (Acid & Bases)

Stage : 1st Stage

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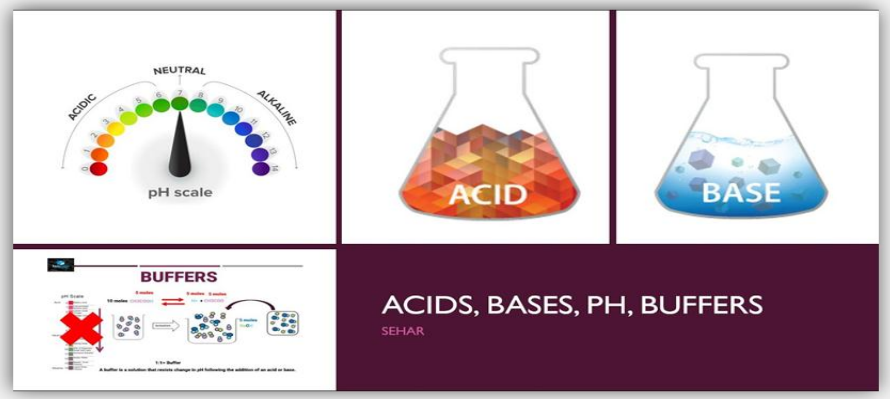
Department: Chemistry and Biochemistry department

Date: 11 / 12 / 2025

Learning Objective :

- Define acids, bases, and their properties.
- Differentiate between strong and weak acids and bases.
- Explain the pH scale and how it measures acidity or alkalinity.
- Define what a buffer is and its role in maintaining pH balance and Describe key buffering systems in the human body, such as the bicarbonate buffer system.
- Explain the physiological mechanisms maintaining blood pH within the normal range (7.35-7.45).
- Distinguish between acidosis and alkalosis (metabolic and respiratory origins).
- Relate acid-base balance concepts to disorders such as respiratory acidosis or metabolic alkalosis .

ACID AND BASES



- **Introduction :**
- Living organisms are sensitive to the acidity of aqueous solutions in their internal and external environments. The pH of human blood must be kept at precisely 7.4. **a sustained increase or decrease of only 0.2 pH units could mean death.**
- So :-
- Acids: -Substances that donate protons (H+).
- Examples: Hydrochloric acid (HCl), Sulfuric acid (H2SO4).

- Bases: -Substances that accept protons or donate hydroxide ions (OH-).
- Examples: Sodium hydroxide (NaOH), Ammonia (NH3).

ACID AND BASES

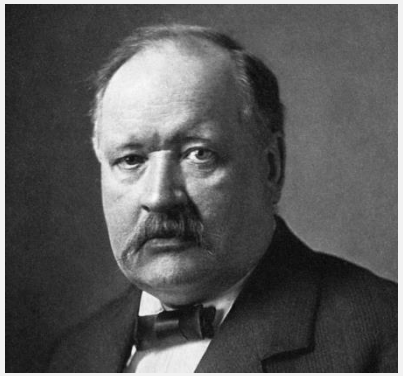
- **Some classifications of acids and bases**

1. Arrhenius acids and bases.
2. Bronsted-Lowry acids and bases.
3. Lewis acids and base.

The Arrhenius Theory	The Brønsted-Lowry Theory	The Lewis Theory
Acids are substances that contain hydrogen Bases are substances that contain hydroxyl , OH, group	An acid is a proton donor (H^+). A base is a proton acceptor .	Acids are electron pair acceptors . Bases are electron pair donors .
HCl and NaOH	NH_3 and H_2O	BF_3 and NH_3

ACID AND BASES

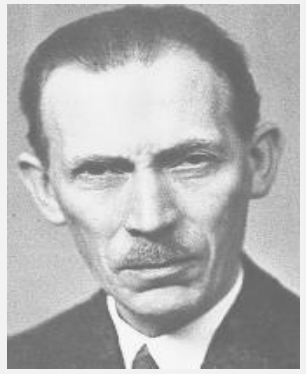
- **Some classifications of acids and bases**



Svante Arrhenius (1859–1927)

1. Arrhenius acids and bases : In 1884, Arrhenius defined that an acid is a substance that gives H+ and a base one that gives OH- . Namely, if an acid is HA and a base BOH. Acids and bases are electrolytes that form aqueous solutions with unique properties.

- Arrhenius, a Swedish chemist, was the first to characterize acids and bases in terms of their chemical properties.
- According to Arrhenius, acids are solutes that produce hydrogen ions H aq in aqueous solutions, while bases produce hydroxide ions, OH aq when dissolved in water .
- This model fails to satisfactorily account for the basic properties of compounds that do not contain the hydroxide ion, such as ammonia (NH3(aq)).



J. Brønsted (1879–1947)

ACID AND BASES

- **Some classifications of acids and bases**

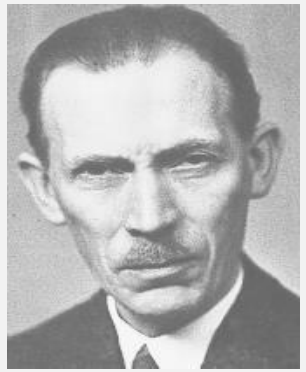
T. Lowry (1874–1936)

2. Brønsted-Lowry's acid and base: In 1923, Johannes Brønsted of Denmark and Thomas Lowry of England recognized that, in most acid-base interactions, a proton (H+ ion) is transferred from one reactant to another.

- According to Brønsted and Lowry, when hydrogen chloride reacts with water, a proton is transferred from a hydrogen chloride molecule to a water molecule, forming a hydronium ion and a chloride ion.

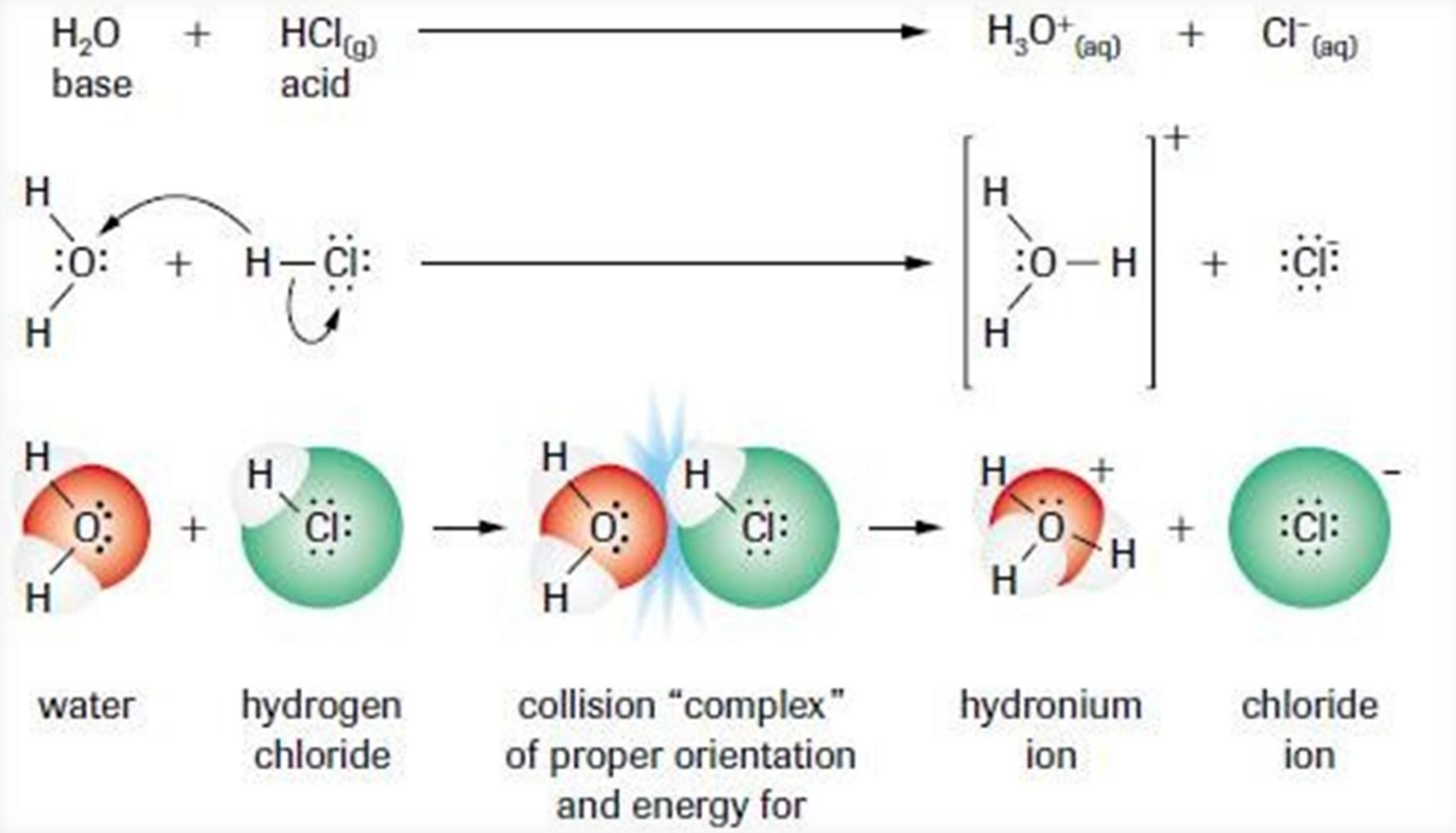
- Hydrogen chloride acts as a Brønsted Lowry acid water acts as a Brønsted Lowry base Notice the single arrow in the equation, indicating that hydrogen chloride is a strong acid, ionizing quantitatively (when it reacts with water

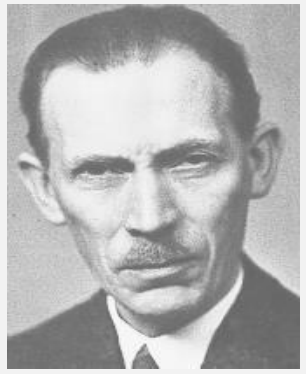
ACID AND BASES



J. Brønsted (1879–1947)

T. Lowry (1874–1936)





J. Brønsted (1879–1947)

ACID AND BASES

- **Some classifications of acids and bases**

T. Lowry (1874–1936)

When ammonia reacts with water, a water molecule acts as a Brønsted Lowry acid, donating a proton to ammonia, the Brønsted Lowry base Notice the double arrow in the equation, indicating that ammonia is a weak base, ionizing incompletely and forming a dynamic equilibrium with the products of the reaction.

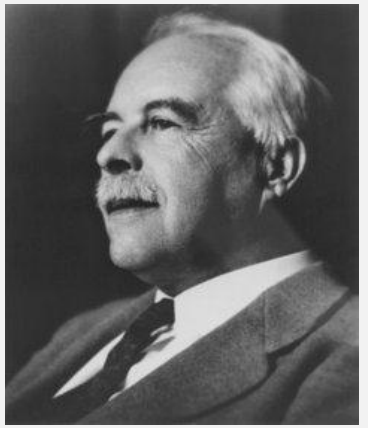
$$NH_{3(g)} + H_2O_{(l)} \rightleftharpoons NH_{4(aq)}^{+} + OH_{(aq)}^{-}$$

base acid

a Brønsted–Lowry acid is a proton donor, and
a Brønsted–Lowry base is a proton acceptor.

ACID AND BASES

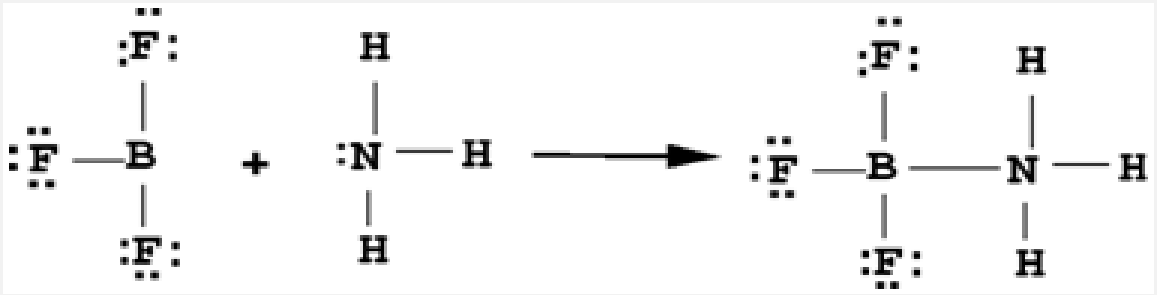
- **Some classifications of acids and bases**



Gilbert N. Lewis(1875–1946)

3. A Lewis acid is defined to be any species that accepts lone pair electrons .

A Lewis base is any species that donates lone pair electrons .

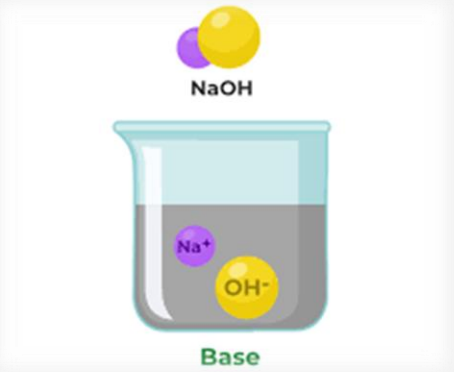


ACID AND BASES

- **Properties of acids**

1. pH values lower than the neutral value of 7
2. Sharp sour Taste
3. React with certain metals to liberate hydrogen gas
4. Soluble in water release H ions in solution
5. Are often corrosive
6. Strong acids can damage the skin and be dangerous
7. Are neutralized bases
8. They react with carbonates and bicarbonates to give off carbon dioxide gas
9. React with active metals to release hydrogen gas

ACID AND BASES



- **Properties of bases:**

1. The pH of the solution lies between 8 and 14
2. Soluble bases are called alkalis, e g sodium hydroxide, NaOH potassium hydroxide, KOH, and ammonium hydroxide, NH 4 OH .
3. Bases are oxides or hydroxides of metallic elements
4. Bases and alkalis will react with acids to neutralize them, forming salts plus water.
5. All alkalis contain a hydroxide ion, OH that will react with and pick up a H ion to form a water molecule.
6. Bitter taste .
7. Soapy feeling when in a solution .
8. Restore blue color to litmus that was turned red by an acid .

ACID AND BASES

- **Strong Acids and Weak Acids , Strong Bases and Weak Bases**

Strong Acids:
- Completely dissociate in water (e.g., HCl, H2SO4).

Weak Acids:
- Partially dissociate in water (e.g., Acetic acid, Carbonic acid).

Strong Bases:
- Fully dissociate in water to release OH- (e.g., NaOH, KOH).

Weak Bases:
- Partially dissociate or accept protons in water (e.g., NH3).

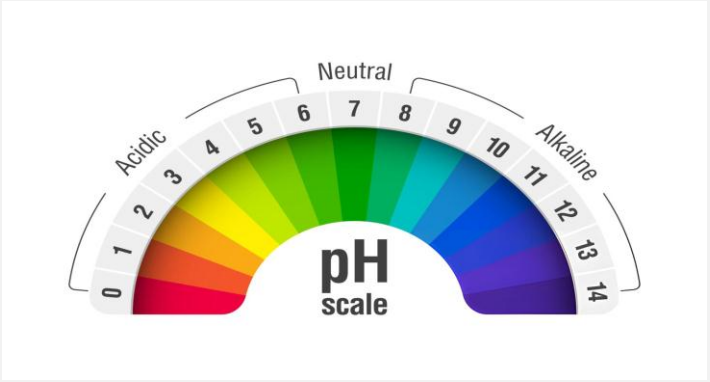
Strong acid	Strong base	Weak acid	Weak base
	NaOH	HCOOH	NH_3
$HClO_4$	$Ca(OH)_2$	HNO_2	$(CH_3)_2NH$
HI	KOH	CH_3COOH	CH_3NH_2
HNO_3	CsOH	HCN	
HCl	LiOH	HF	
HBr	$Ba(OH)_2$		
H_2SO_4			

ACID AND BASES

- **Strong Acids and Weak Acids , Strong Bases and Weak Bases**

Acid	Formula	Strength	Occurrence
Nitric acid	HNO_3	Very strong	Found in the lab
Sulphuric acid	H_2SO_4	Strong	Found in the lab
Hydrochloric acid	HCl	Strong	Produced by the stomach
Ethanoic acid	CH_3COOH	Weak	Found in vinegar
Citric acid	$C_6H_8O_7$	Weak	Found in the juice of citrus fruits (e.g. lemons and oranges)
Tartaric acid	$C_3H_6O_6$	Weak	Found in grape juice
Carbonic acid	H_2CO_3	Weak	Found in lemonade

ACID AND BASES



- **The pH Scale**

- pH is a measure of hydrogen ion concentration, determining acidity or basicity.
- Scale: 0 (Highly acidic) to 14 (Highly basic), with 7 being neutral.

* Examples:

1. - Stomach acid: pH ~1.5
2. - Pure water: pH 7
3. - Blood: pH ~7.4 (slightly basic).

pH	Examples of solutions
0	Battery acid, strong hydrofluoric acid
1	Hydrochloric acid secreted by stomach lining
2	Lemon juice, gastric acid, vinegar
3	Grapefruit juice, orange juice, soda
4	Tomato juice, acid rain
5	Soft drinking water, black coffee
6	Urine, saliva
7	"Pure" water
8	Sea water
9	Baking soda
10	Great Salt Lake, milk of magnesia
11	Ammonia solution
12	Soapy water
13	Bleach, oven cleaner
14	Liquid drain cleaner

ACID AND BASES

- Importance of pH in the Human Body

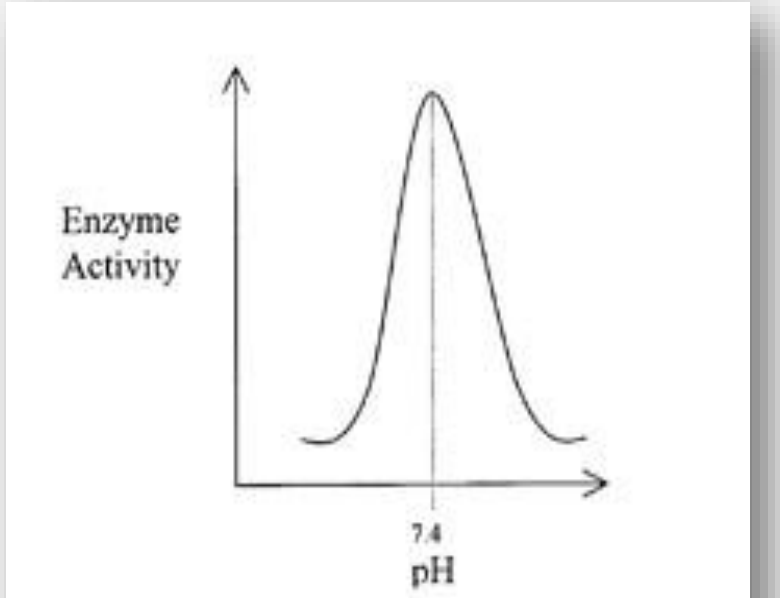
1. Digestive system:
   Stomach acid (pH ~1.5-3.5) aids in food breakdown.
2. Cellular function:
   Enzymes have optimal pH ranges for activity.
3. Blood pH:
   Slight deviations can disrupt vital functions (normal range: 7.35-7.45).

ACID AND BASES

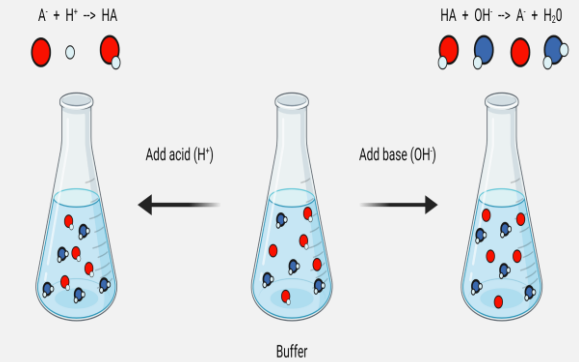
- **The Importance of Hydrogen Ion Concentration:**

Hydrogen ion concentration has a widespread effect on the function of the body's enzyme systems. The hydrogen ion is highly reactive and will combine with bases or negatively charged ions at very low concentrations.

- Proteins contain many negatively charged and basic groups within their structure. Thus, a change in pH will alter the degree ionization of a protein, which may in turn affect its functioning. The figure behind shows the relationship between enzyme and the pH.



Curve showing relationship between Enzyme Activity and pH



ACID AND BASES

- **Buffers: Role and Importance**

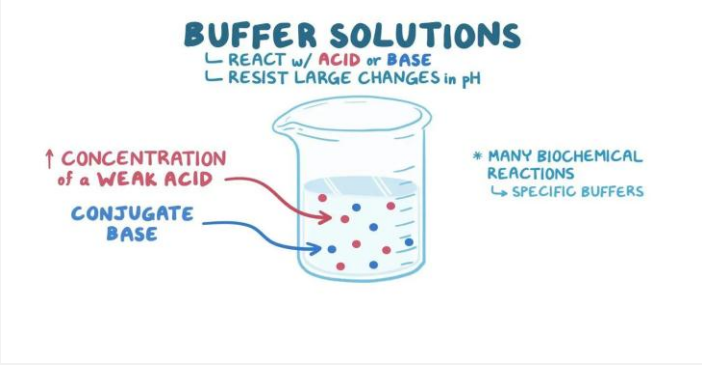
- Buffers are solutions that resist pH changes when acids or bases are added. In normal water (non buffered solution) if you add a small amount of a strong acid or base, it will cause the pH of the water to change significantly Two drops of 1 mol dm-3 HCl added to water will change the pH from 7 to 4 .

- Most chemical reactions occurring in our bodies work best in a specific pH range Blood, for example, works at pH 7.4 and any variation of 0.2 units either way would Render the person seriously ill .

* Examples:

1. The bicarbonate buffer system in blood maintains pH balance.

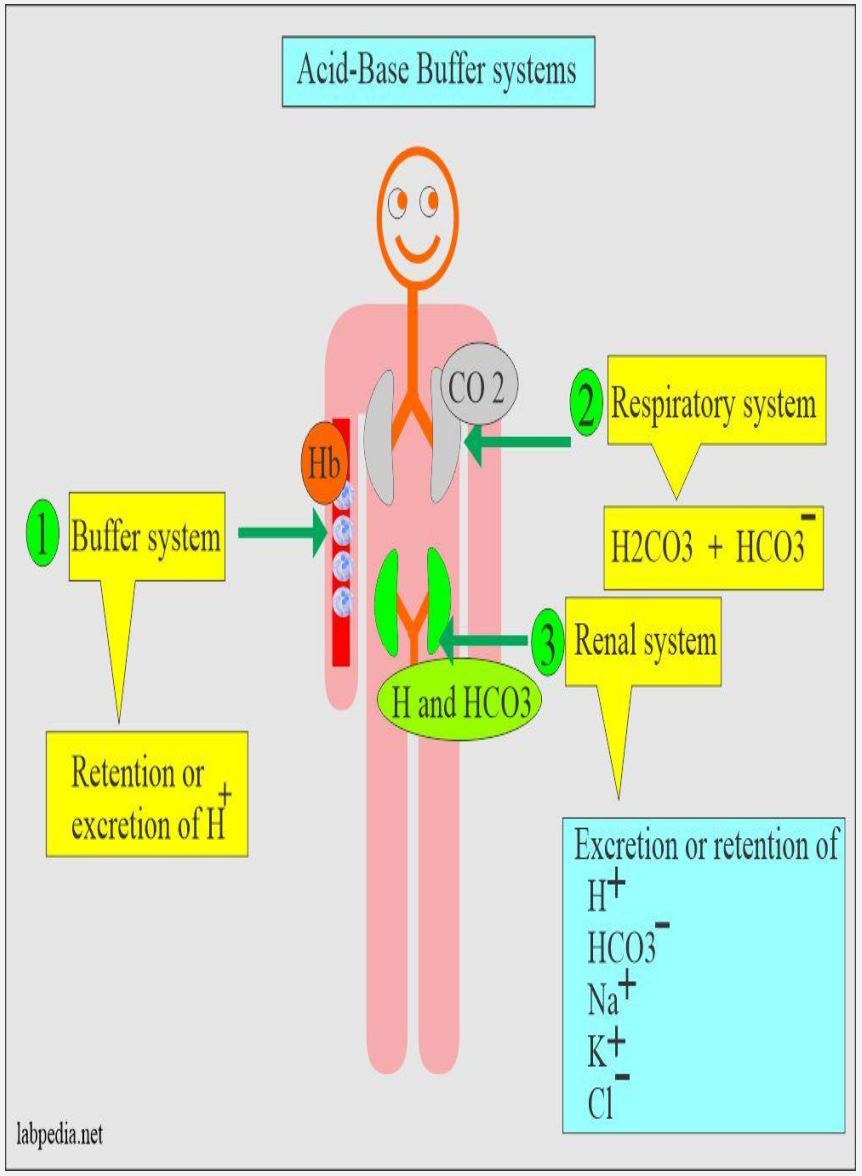
-((Buffer solutions are important living things because if the pH of cellular fluids is not maintained at certain critical levels the plant or animal could die)).



ACID AND BASES

- **Types of Buffers in the Body**

1. Bicarbonate Buffer System:
- Regulates blood pH via CO2 and HCO3-.
2. Protein Buffer System:
- Hemoglobin and plasma proteins act as buffers.
3. Phosphate Buffer System:
- Operates primarily in intracellular fluid.



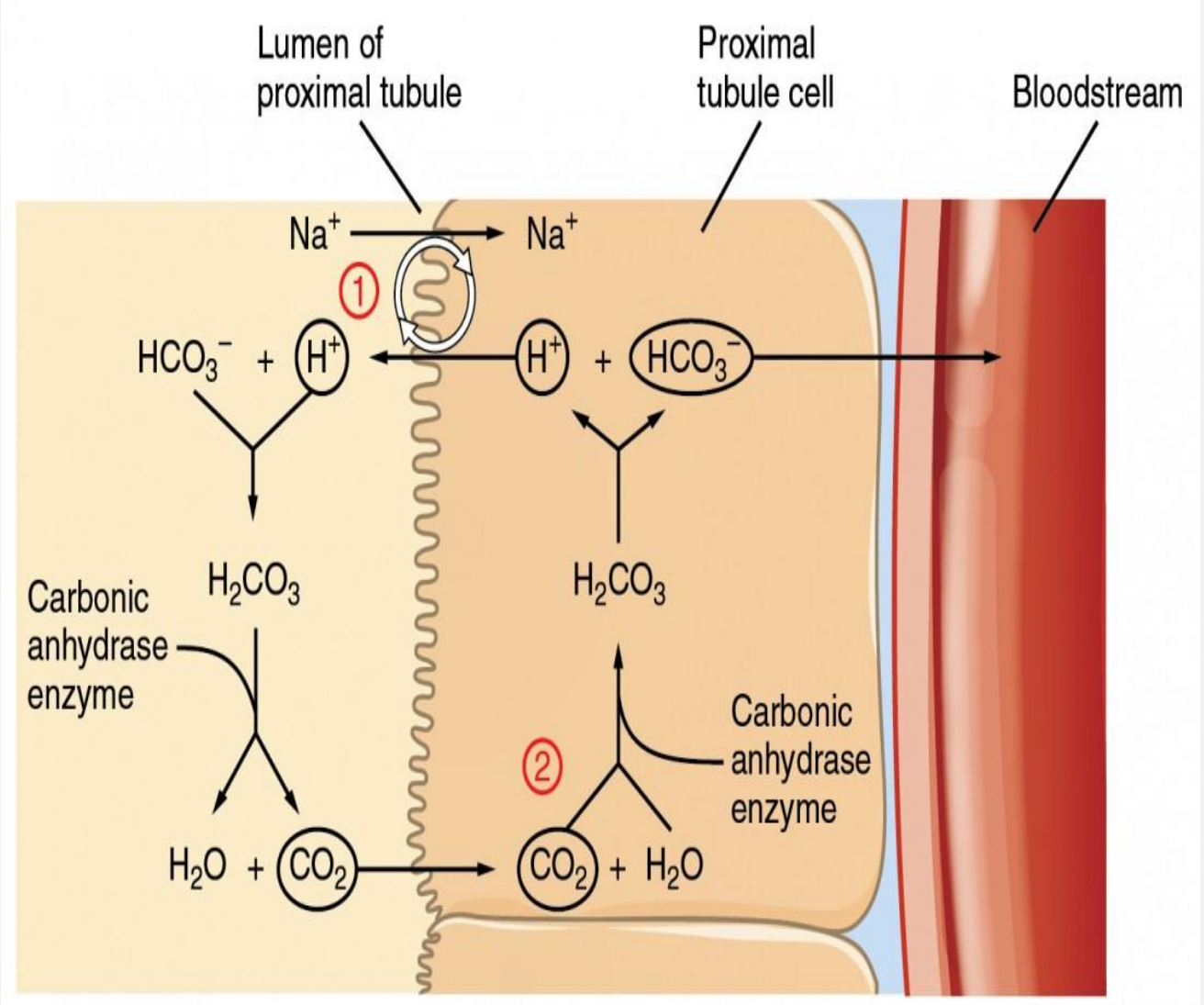
ACID AND BASES

- **Acid-Base Balance in Blood**

- The body maintains a tightly regulated blood pH of ~7.35–7.45. Blood is normally slightly basic, alkaline, with a pH range of 7.35 to 7.45. To function properly, the body maintains the pH of blood close to 7.40.

* Key systems involved:

1. - Buffer systems (e.g., bicarbonate buffer).
2. - Respiratory system (regulates CO2 levels).
3. - Renal system (regulates H+ and bicarbonate excretion).



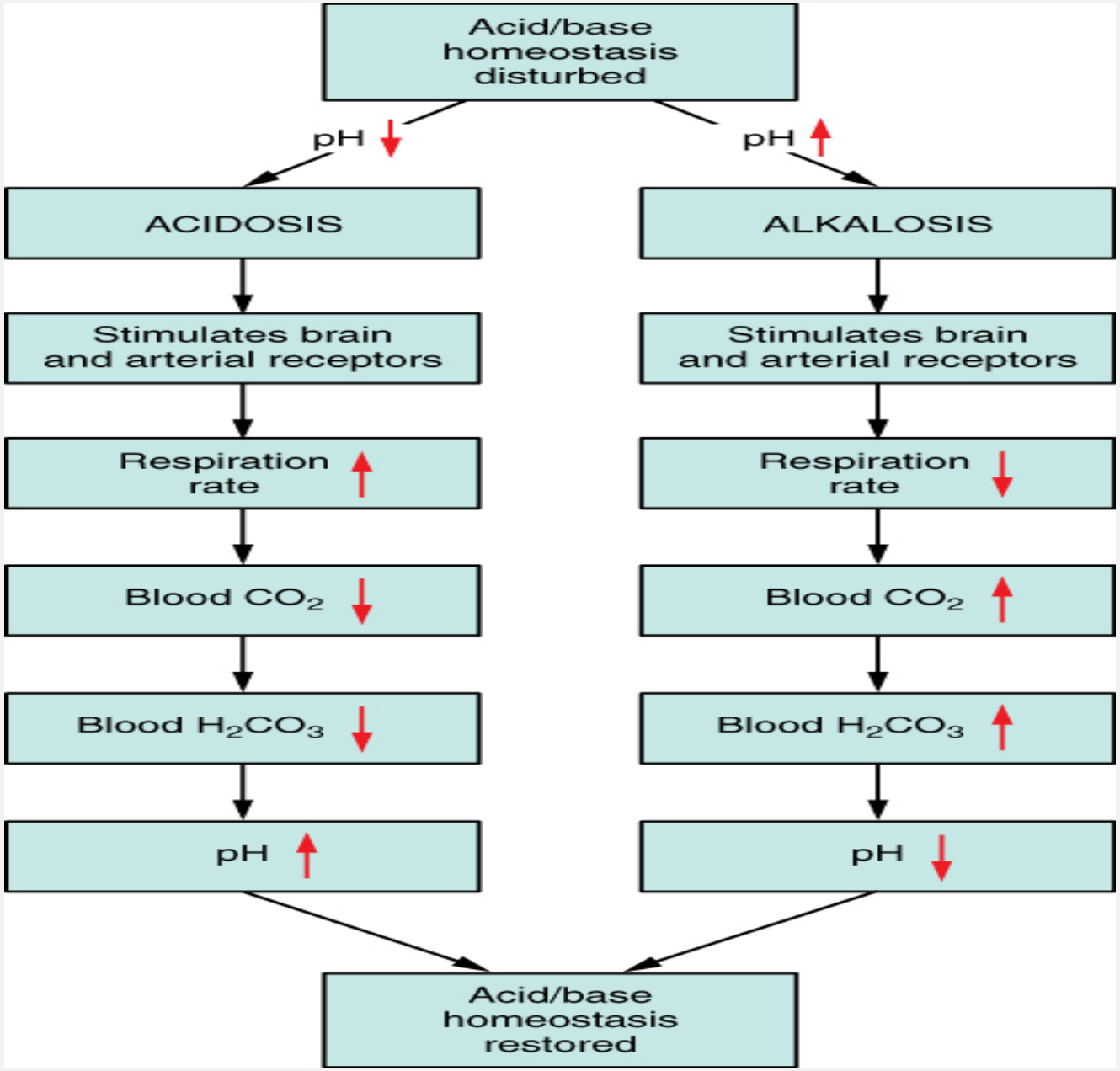
ACID AND BASES

- **Acid-Base Balance in Blood**

- The most important pH buffer system in the blood involves carbonic acid (a weak acid formed from the carbon dioxide dissolved in blood) and bicarbonate ions (the corresponding weak base)

- The bloods acid-base balance is controlled by the body because even minor deviations from the normal range can severely affect the brain, arteries, the heart, muscles, and many organs It can contribute to overwhelming the body leading to serious disease such as cancer .

ACID-BASE BALANCE IN BLOOD



ACID AND BASES

- **Good acid-base balance and blood pH levels promote:**

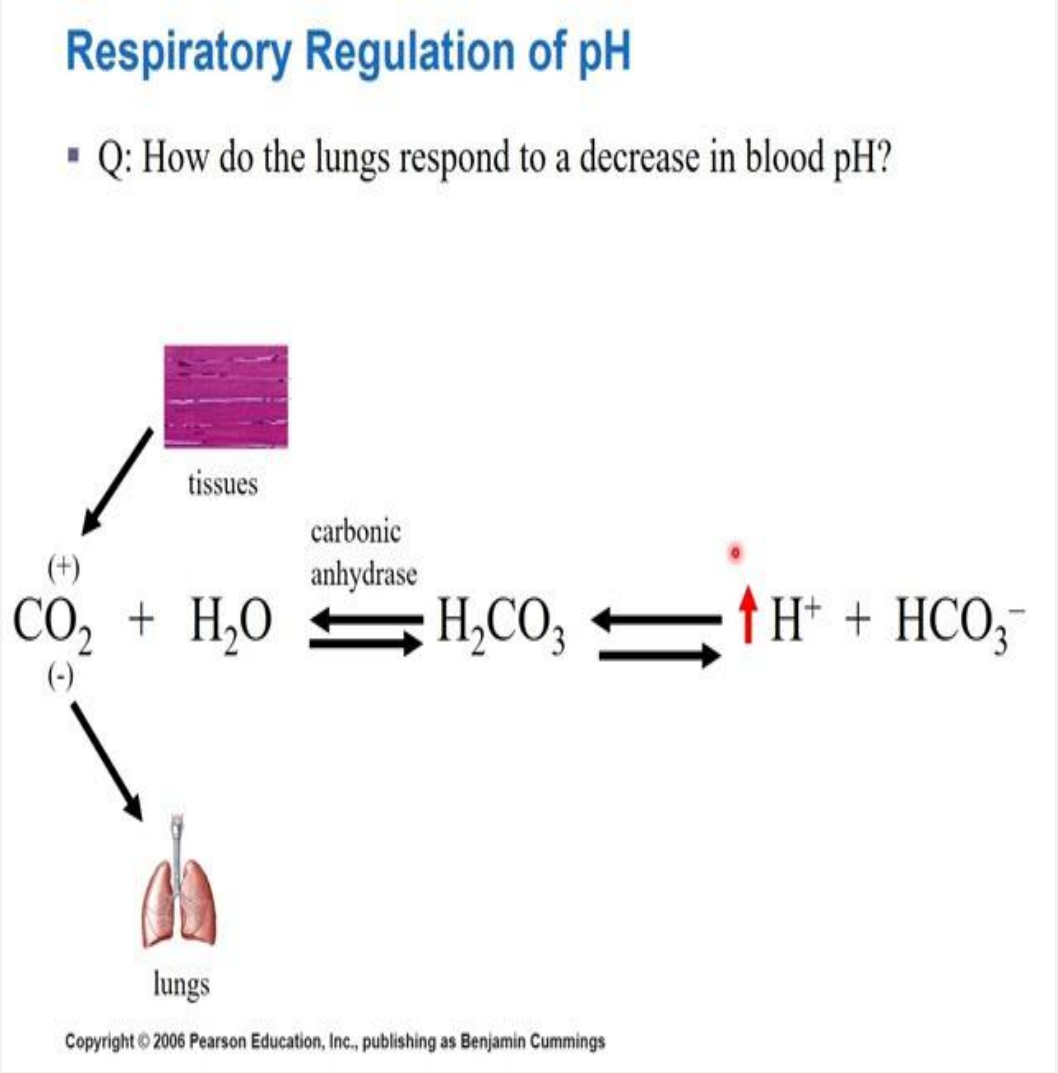
1. Healthy cholesterol levels.
2. Healthy blood sugar balance.
3. Proper fat metabolism.
4. Normal energy balance.
5. Disease resistance.
6. The body's ability to flush toxins.

ACID AND BASES

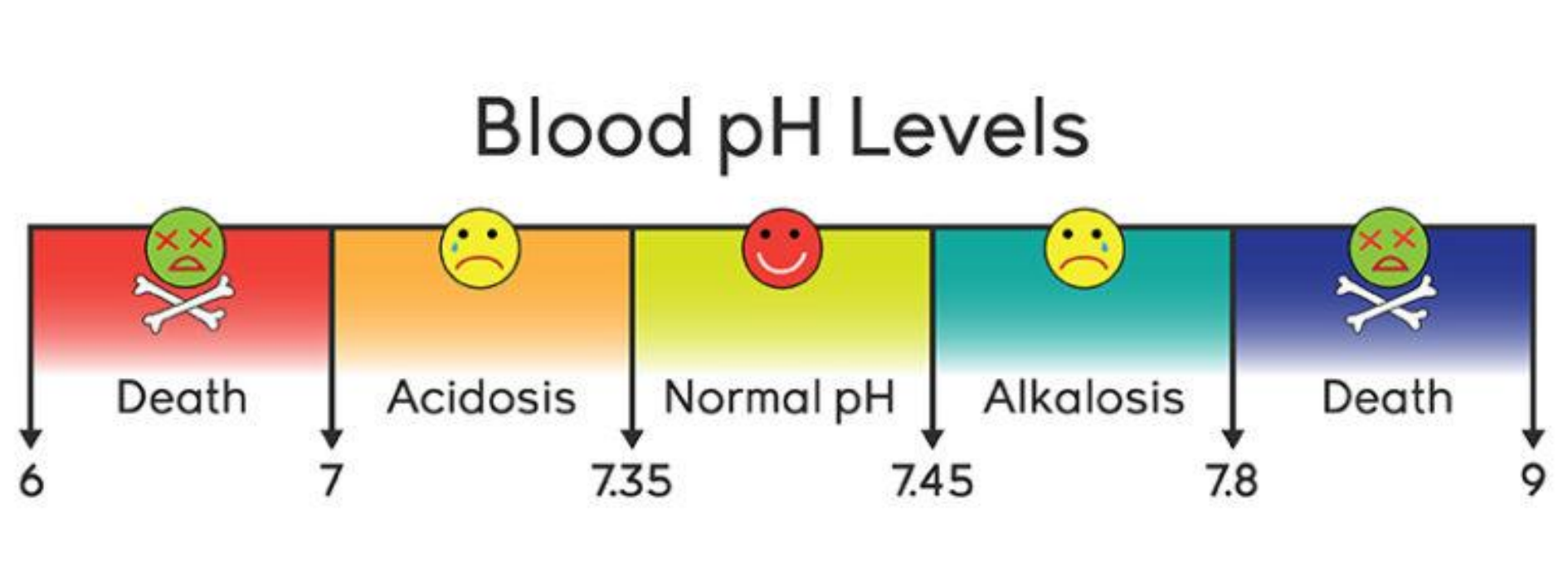
- **Role of the Respiratory System in pH Regulation**

- The lungs regulate blood pH by controlling CO2 levels:

1. Hyperventilation:
   - Decreases CO2, raising blood pH (alkalosis).
2. Hypoventilation:
   - Increases CO2, lowering blood pH (acidosis).



ACID AND BASES



ACID AND BASES

- **Role of the Kidneys in pH Regulation**

- The kidneys maintain pH balance by:

1. Excreting hydrogen ions (H^+).
2. Reabsorbing bicarbonate (HCO_3^-) into the blood.

- These mechanisms act slower than respiratory regulation but provide long-term balance.

ACID AND BASES

- The Bicarbonate Buffer System

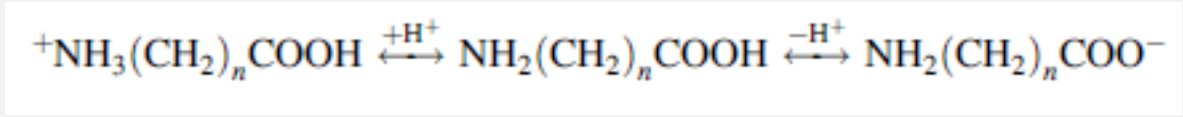
- H_2CO_3 (carbonic acid) $\rightleftharpoons$ H^+ + HCO_3^- (bicarbonate ion).

This system helps neutralize excess acids or bases in the blood.

ACID AND BASES

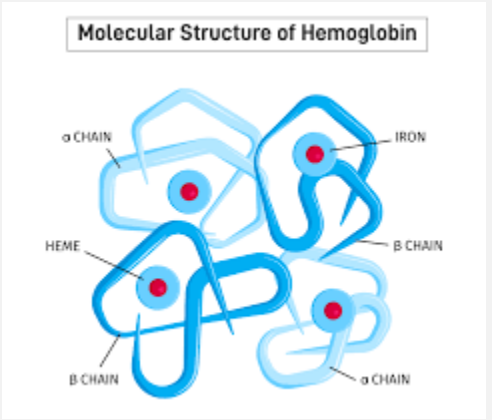
- **Protein buffers**

- Proteins are the most abundant materials in the body Proteins have long chains of carbon compounds, as many as 1000 or more, and have amino acid side chains sticking out of them One protein of general formula could be $NH_3 (CH_2)n\ COOH$:



* An adverse external influx of acids could be removed by the protein buffer soaking up the H ions to form a positive ion, hence restoring the original pH .

ACID AND BASES



- **Protein buffers**

- Haemoglobin (a compound of iron and proteins) buffers the blood system using the proteins present This is essential for controlling the pH of the blood, which is necessary due to the uptake of acidic CO_2 gas formed when cells use carbohydrates, glucose, to give energy .

ACID AND BASES

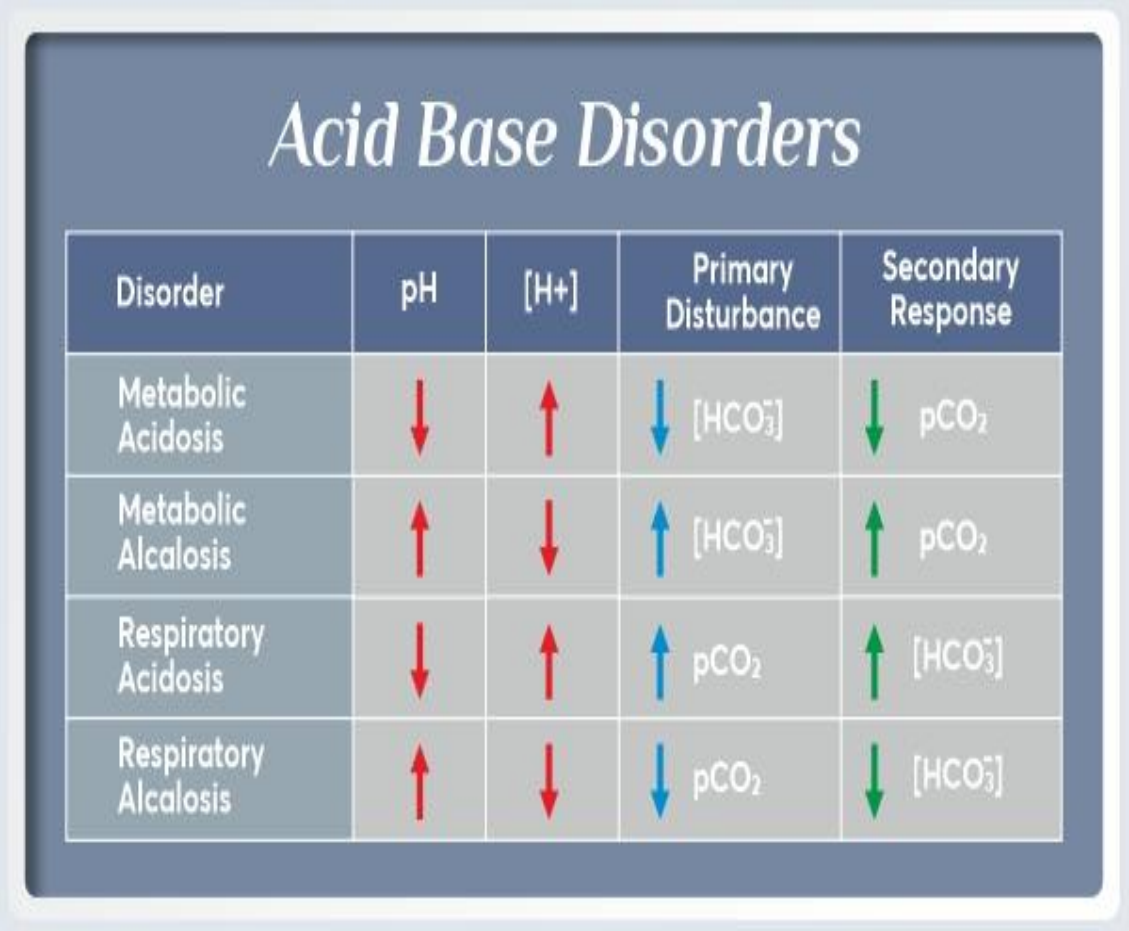
- Disorders of Acid-Base Balance

1. Acidosis (pH < 7.35):

- Causes: Respiratory (e.g., hypoventilation) or metabolic (e.g., diabetic ketoacidosis). The blood has too much acid (or too little base), resulting in a decrease in blood pH.

2. Alkalosis (pH > 7.45):

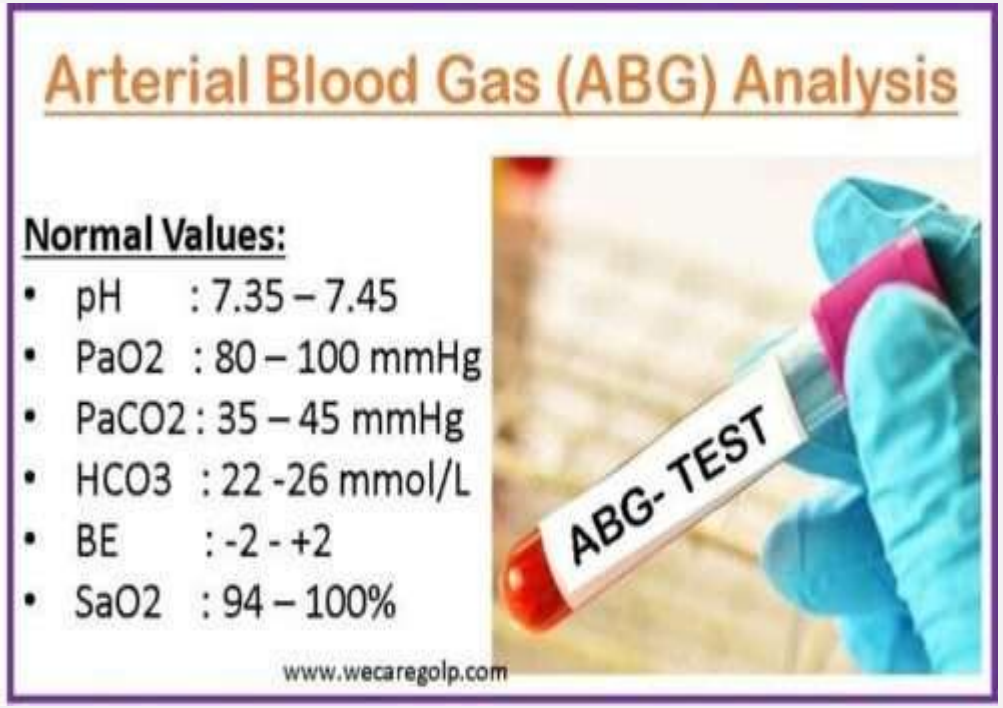
- Causes: Respiratory (e.g., hyperventilation) or metabolic (e.g., excessive bicarbonate intake). The blood has too much base (or too little acid), resulting in an increase in blood pH .



ACID AND BASES

- **Measurement of Blood pH**

Arterial blood gas (ABG) analysis measures pH, CO2, and bicarbonate levels to assess acid-base status.



Applications of Buffers in Medicine :

1. Intravenous fluids:
   Maintain pH and electrolyte balance.
2. Antacids:
   Neutralize stomach acid to relieve heartburn.
3. Diagnostic tests:
   Blood gas analysis for acid-base disorders.

ACID AND BASES

- **Biological Significance**

1. Enzyme Function:
- Enzymes require an optimal pH to function effectively.
2. Oxygen Transport:
- Hemoglobin's ability to bind oxygen is influenced by pH (Bohr effect).

ACID AND BASES

- **Summary**

1. Acids and bases are defined by their ability to donate or accept protons.
2. The pH scale measures the acidity or basicity of solutions.
3. Buffers and physiological systems maintain acid-base balance in blood.
4. Imbalances can lead to acidosis or alkalosis, requiring medical intervention.


THANK YOU
FOR YOUR
ATTENTION