



ACID-BASE BALANCE IN BIOLOGICAL SYSTEMS

КИСЛОТНО-ЩЕЛОЧНОЙ БАЛАНС В БИОЛОГИЧЕСКИХ СИСТЕМАХ

Academic Lyceum of Tashkent Pharmaceutical Institute

Khamidova Aziza

Annotation. *Acid-base balance is a critical physiological process essential for maintaining homeostasis in biological systems. This thesis explores the mechanisms regulating pH levels, the role of buffer systems, and the impact of imbalances on health. The findings highlight the complexity of acid-base regulation and its importance in sustaining life.*

Keywords. *Acid-base, cellular metabolism, biological system, acidosis, bicarbonate buffer system, protein buffer system, phosphate buffer system.*

The acid-base balance is a critical aspect of biological systems, ensuring that the body's pH levels are maintained within a narrow range to support life. Proper balance is vital for the functioning of enzymes, cellular metabolism, and overall homeostasis. Any deviation from this balance can result in serious health consequences. This article explores the mechanisms, importance, and regulation of acid-base balance in biological systems.

Understanding pH and Its Role:

The pH scale measures the hydrogen ion concentration ($[H^+]$) in a solution, ranging from 0 to 14. A pH of 7 is neutral, values below 7 are acidic, and above 7 are basic (alkaline). In biological systems, the normal pH range of blood is approximately 7.35 to 7.45, which is slightly alkaline. Maintaining this range is essential, as even small deviations can disrupt cellular processes, leading to conditions such as acidosis ($pH < 7.35$) or alkalosis ($pH > 7.45$).

Buffer Systems in the Body:

The body relies on several buffering systems to maintain acid-base balance:

1. Bicarbonate Buffer System

- The bicarbonate buffer system is the primary regulator of pH in the blood. It consists of carbonic acid (H_2CO_3) and bicarbonate ions (HCO_3^-).

- The reaction can shift in either direction:

- If the blood becomes too acidic, bicarbonate binds to hydrogen ions to form carbonic acid, which is then converted to CO_2 and exhaled by the lungs.

2. Protein Buffer System

- Proteins, such as hemoglobin, act as buffers by binding to hydrogen ions or releasing them as needed. Hemoglobin, in particular, plays a critical role in regulating blood pH by interacting with CO_2 and H^+ during oxygen transport.



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3. Phosphate Buffer System

- The phosphate buffer system operates primarily in intracellular fluids. It involves dihydrogen phosphate (H_2PO_4^-) as a weak acid and hydrogen phosphate (HPO_4^{2-}) as a weak base to neutralize excess H^+ or OH^- ions.

REGULATORY MECHANISMS

Three key systems work together to maintain acid-base homeostasis:

1. Respiratory Regulation

- The respiratory system controls the removal of CO_2 , which influences blood pH. Increased respiration (hyperventilation) removes more CO_2 , reducing acidity. Conversely, slower respiration (hypoventilation) retains CO_2 , increasing acidity.

2. Renal Regulation

- The kidneys regulate blood pH by excreting hydrogen ions (H^+) and reabsorbing bicarbonate (HCO_3^-). This process is slower but more effective for long-term acid-base balance.

3. Cellular Buffering

- At the cellular level, ion exchange processes, such as the exchange of H^+ and potassium (K^+), help maintain pH balance.

Disruptions in Acid-Base Balance

Several conditions can disrupt the acid-base balance:

1. Acidosis

- Respiratory Acidosis: Caused by inadequate CO_2 elimination due to lung diseases or hypoventilation.
- Metabolic Acidosis: Results from excessive acid production (e.g., in diabetic ketoacidosis) or bicarbonate loss (e.g., diarrhea).

2. Alkalosis

- Respiratory Alkalosis: Caused by excessive CO_2 loss due to hyperventilation (e.g., anxiety, high altitudes).
- Metabolic Alkalosis: Results from excessive bicarbonate or acid loss (e.g., vomiting, diuretic use).

CONCLUSION:

The acid-base balance is crucial for the proper functioning of biological systems. Through the coordinated actions of buffer systems, the respiratory system, and the kidneys, the body effectively maintains pH within a narrow range. Understanding these mechanisms is vital for diagnosing and treating disorders related to acid-base imbalances, ensuring overall health and homeostasis.