AMERICAN ACADEMIC PUBLISHER

INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

ISSN NUMBER: 2692 - 5206 Volume 6. No 04. Aprel ,2026

BIOPHYSICAL MECHANISMS OF ABSORPTION IN THE GASTROINTESTINAL TRACT

Teacher of Termez branch of Tashkent State Medical University:
Xayitova Yulduzxon Davlatovna
Students of Termez branch of Tashkent State Medical University:
Zokirov Abrorbek Akbar ugli
Abdishukurov Doniyor Shuxratjon ugli

Annotation: The biophysical foundations and mechanisms of substance absorption in the gastrointestinal tract are analyzed in detail. The process of absorption through the cell membrane, its selective permeability, and its dependence on the concentration gradient are described. Types of passive transport—simple diffusion, facilitated diffusion, and osmosis—are explained, as well as processes that occur with energy expenditure. In addition, the processes of endocytosis and exocytosis, which play an important role in the entry and exit of large molecules into and out of the cell, are also clarified.

Keywords: gastrointestinal tract, absorption, villus, passive transport, active transport, osmosis, endocytosis, exocytosis

Introduction

The gastrointestinal tract is one of the most important systems in the human body, responsible for the digestion and absorption of nutrients. After nutrients enter the body, they are broken down through complex physical and chemical processes and subsequently pass through the intestinal wall into the blood and lymph. This absorption process is based on biophysical principles and is closely related to the transport of substances across the cell membrane.

The mechanisms of absorption occur through different pathways: passive transport (diffusion, osmosis, and facilitated diffusion) as well as energy-dependent active transport processes. In addition, some large molecules enter the cell via endocytosis. Special structures of the intestinal wall—villi and microvilli—increase the absorptive surface area and enhance the efficiency of the process.

The aim of this article is to study the biophysical mechanisms of absorption in the gastrointestinal tract, as well as to highlight their characteristics and significance in the functioning of the human body.

Main Part: General Biophysical Basis of Absorption

The absorption of substances in the gastrointestinal tract mainly occurs in the small intestine. The intestinal mucosa is covered with villi and microvilli, which significantly increase the absorptive surface area and ensure efficient uptake of nutrients. Inside the villi, there are blood capillaries and lymphatic vessels through which the absorbed substances are distributed throughout the body.

The absorption process is fundamentally based on the semipermeable properties of the cell membrane. The membrane consists of a phospholipid bilayer and has selective permeability. Small and lipid-soluble molecules can easily pass through the membrane, whereas large and charged substances are transported with the help of specific carrier proteins.

The movement of substances across the membrane depends on several factors: concentration gradient, electrical potential difference, molecular size, and solubility. The concentration gradient is the main driving force of passive transport. Substances pass through the intestinal wall via two main pathways: transcellular (through the cell) and paracellular (between the cells).

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 04. Aprel ,2026

The circulatory system rapidly carries away absorbed substances, maintaining the concentration gradient and ensuring the continuity of the absorption process. The lymphatic system plays a crucial role mainly in the transport of fats and fat-soluble vitamins. Thus, absorption is a complex, multifactorial process based on fundamental biophysical principles.

Passive Transport Mechanisms

Passive transport is the process by which substances move across the cell membrane without the expenditure of energy, following their natural concentration gradient. In the gastrointestinal tract, passive transport plays an important role in the absorption of nutrients and water.

a) Simple Diffusion

In simple diffusion, substances move from an area of higher concentration to an area of lower concentration. This process is characteristic of oxygen, carbon dioxide, fat-soluble vitamins, and some lipid molecules. The rate of diffusion depends on the concentration difference, membrane permeability, and the molecular properties of the substance.

b) Facilitated Diffusion

Facilitated diffusion occurs with the help of specific carrier proteins. Although it is a passive process, it increases the speed of substance transport and ensures selectivity. For example, glucose and certain amino acids enter intestinal epithelial cells through facilitated diffusion.

c) Osmosis

Osmosis is the movement of water across a semipermeable membrane. Water moves from a region of lower solute concentration to a region of higher solute concentration. In the gastrointestinal tract, osmosis is important for maintaining fluid balance and regulating the volume of intestinal contents.

Passive transport mechanisms do not require energy; however, their efficiency and rate depend on the morphological properties of the cell membrane and the blood supply of the intestine. Therefore, passive transport ensures the effective natural absorption of nutrients in the body.

Active Transport Mechanisms

Unlike passive transport, active transport requires energy (usually in the form of ATP) and enables substances to move against their concentration gradient. In the gastrointestinal tract, this mechanism ensures the adequate absorption of essential nutrients into the body.

a)Ions and Pumps

Special ion pumps in the cell membrane (such as the sodium-potassium pump) move sodium ions out of the cell and bring potassium ions into the cell. This process is important for maintaining ionic balance within the cell, generating membrane potential, and supporting the absorption of substances.

b) Active Transport of Glucose and Amino Acids

Glucose and many amino acids are essential for the body and enter cells through specific carrier proteins. In some cases, they are co-transported with sodium ions. This mechanism is faster and more efficient than passive transport and ensures that these substances are supplied to the body in sufficient amounts.

c) Energy-Dependent Selective Transport

Active transport is specific to certain substances, allowing the cell to selectively absorb them into the intestinal epithelium in required amounts. Moreover, the transport system can adapt to conditions of excess or deficiency of substances, functioning in a regulated manner.

Active transport plays a crucial role in maintaining the stability of intestinal absorption. It ensures the uptake of nutrients even when passive transport is insufficient, thereby supporting the body with adequate energy, vitamins, and minerals.

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 04. Aprel ,2026

Endocytosis and Exocytosis Processes

In the gastrointestinal tract, large molecules and some proteins cannot pass through the cell membrane by simple diffusion. In such cases, endocytosis and exocytosis mechanisms are involved.

a) Endocytosis

Endocytosis is the process by which substances are engulfed by the cell membrane and enter the cell in the form of vesicles (small sacs). This mechanism is important for the absorption of large proteins, lipid complexes, and certain vitamins. For example, in infants, immunoglobulins obtained from the mother's milk pass through the intestinal epithelium via this pathway.

b) Exocytosis

Exocytosis is the process by which large or charged molecules are transported out of the cell. This mechanism plays an important role in the secretion of enzymes, mucus, and other substances produced by the intestinal epithelium into the intestinal lumen.

Endocytosis and exocytosis not only facilitate the transport of substances but also regulate their amounts inside and outside the cell. These processes are essential for maintaining cellular nutrient balance and ensuring the stability of the biophysical environment within the intestine.

Factors Affecting Absorption

The effective absorption of substances in the gastrointestinal tract depends on a number of internal and external factors: The number and condition of villi and microvilli determine the absorptive surface area. When they are reduced or damaged, the absorption of substances decreases significantly.

Blood flow in the vessels rapidly removes absorbed substances and maintains the concentration gradient. This process ensures the continuity of passive transport.

The pH and temperature in the intestine must be optimal. For example, certain enzymes function only at specific pH levels, which directly affects the efficiency of absorption.

The size, charge, and solubility of molecules (whether water-soluble or fat-soluble) determine the rate of absorption. Fat-soluble vitamins are mainly absorbed via the lymphatic system, whereas water-soluble substances are primarily absorbed into the bloodstream.

Conclusion

Absorption in the gastrointestinal tract is based on complex biophysical and biochemical mechanisms. It occurs through passive transport (diffusion, facilitated diffusion, and osmosis), active transport (ion pumps and active transport of glucose and amino acids), as well as the passage of large molecules via endocytosis and exocytosis. The villi and microvilli of the intestinal wall significantly increase the absorptive surface area, contributing to efficient nutrient uptake.

Absorption is influenced by blood circulation, lymph flow, pH level, temperature, and the physicochemical properties of substances. At the same time, the overall health condition of the organism also affects the efficiency of nutrient absorption.

In general, the biophysical mechanisms of absorption in the gastrointestinal tract are fundamental processes that ensure the adequate supply of nutrients to the body, and their efficiency is vital for maintaining life.

References:

1. Ismailov E., Mamatqulov N., Xodjayev G'., Norboyev N. *Biophysics*. Tashkent: Cho'lpon, 2013.
2. Bazarbayev M.I., Mullajonov I., Rakhimova X.J. et al. *Biophysics*. Tashkent, 2017.
3. Bozorboyev M.I., Mullajonov I. *Biophysics*. Tashkent: Yangi asr avlodi, 2018.
4. Ismailov E. et al. *Biophysics (Textbook)*. Tashkent, 2012.

AMERICAN ACADEMIC PUBLISHER

INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

ISSN NUMBER: 2692 - 5206 Volume 6. No 04. Aprel ,2026

5. Abdukarimov A.A. *Fundamentals of Medical Biophysics*. Tashkent: Abu Ali ibn Sino Publishing House, 2019.
6. Karimov U.K. *Physiology of the Gastrointestinal System*. Tashkent, 2020.
7. Abdukarimov A.A. *Human Physiology*. Tashkent: Abu Ali ibn Sino Publishing House, 2017.