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# СУЩНОСТЬ И ЗНАЧЕНИЕ МАТБОЛИЗМА ДЛЯ РАЗНЫХ ГРУПП ЖИВЫХ ОРГАНИЗМОВ

# ESSENCE AND SIGNIFICANCE OF METABOLISM FOR DIFFERENT GROUPS OF LIVING THINGS

*АННОТАЦИЯ. В данной статье рассмотрен процесс метаболизма, его этапы и комплексы реакций, характерные для каждого из них. Кратко описаны функции и значение метаболизма для живых организмов, механизм действия ферментов как биологических катализаторов. Уделено внимание веществам, участвующим в данном процессе, а также классификации живых организмов по типу питания и механизму превращения энергии.*

*ABSTRACT. The paper deals with the process of metabolism, the stages of its development, its main functions and the significance of this process for living organisms. The attention is focused on the substances that act in the process and the classification of living things.*

*КЛЮЧЕВЫЕ СЛОВА: клетка, организм, гомеостаз, обмен веществ, катаболизм, анаболизм, фотосинтез, хемосинтез, белки, нуклеиновые кислоты, ДНК.*

*KEY WORDS: cell, organism, homeostasis, metabolism, catabolism, anabolism, photosynthesis, chemosynthesis, proteins, nucleic acids, DNA.*

Homeostasis is the process by which the internal environment of the body is kept relatively stable despite changes in the external environment. The body regulates its internal environment in many ways. It senses changes in the environment and responds by making changes in functions. This is a dynamic process.

The body can adapt to many changing conditions, but there are limits to these conditions. The body's cells will not function well if they are too cold or too hot, our heart rates cannot endlessly increase and we cannot lose excessive water without putting our cells, tissues and organs at risk. As a result, reaching or exceeding these limits can be dangerous, so our body tends to function within certain normal ranges.
Homeostatic regulation extends far beyond the control of temperature. Homeostasis includes regulation of the pH of the Blood at 7.365 (a measure of alkalinity and acidity). All animals also regulate their blood glucose, as well as the concentration of their blood. Mammals regulate their blood glucose with insulin and glucagon.

Insulin effectively transports glucose to the body's cells by instructing those cells to keep more of the glucose for their own use. If the glucose inside the cells is high, the cells will convert it to the insoluble glycogen to prevent the soluble glucose from interfering with cellular metabolism. Ultimately this lowers blood glucose levels, and Insulin helps to prevent hyperglycemia. When insulin is deficient or cells become resistant to it, diabetes occurs. Glucagon encourages cells to break down stored glycogen or convert non-carbohydrate carbon sources to glucose via gluconeogenesis, thus preventing hypoglycemia. The kidneys are used to remove excess water and ions from the blood. These are then expelled as urine. The kidneys perform a vital role in homeostatic regulation in mammals, removing excess water, salt, and urea from the blood. These are the body's main waste products.

Many diseases are the result of disturbance of homeostasis, a condition known as homeostatic imbalance. As it ages, every organism will lose efficiency in its control systems. The inefficiencies gradually result in an unstable internal environment that increases the risk for illness. In addition, homeostatic imbalance is also responsible for the physical changes associated with aging. Even more serious than illness and other characteristics of aging is death.

Diseases that result from a homeostatic imbalance include diabetes, dehydration, hypoglycemia, hyperglycemia, gout, and any disease caused by a toxin present in the bloodstream. All of these are the result of the presence of an increased amount of a particular substance. In ideal circumstances, homeostatic control mechanisms should prevent this imbalance from occurring, but sometimes the mechanisms do not work efficiently enough or the quantity of the substance exceeds the levels at which it can be managed. In these cases, medical intervention is necessary to restore the balance.

Metabolism is the set of chemical reactions that happen in the cells of living organisms to sustain life. These processes allow organisms to grow and reproduce, maintain their structures, and respond to their environments. Metabolism is usually divided into two categories. Catabolism breaks down organic matter, for example to harvest energy in cellular respiration. Anabolism uses energy to construct components of cells such as proteins and nucleic acids.

Together, these two general metabolic networks have three major functions: (1) to extract energy from nutrients or solar energy; (2) to synthesize the building blocks that make up the large molecules of life: proteins, fats, carbohydrates, nucleic acids, and combinations of these substances; and (3) to synthesize and degrade molecules required for special functions in the cell.

The chemical reactions of metabolism are organized into metabolic pathways, in which one chemical is transformed through a series of steps into another chemical, by a sequence of enzymes. Enzymes are crucial to metabolism because they allow organisms to drive desirable reactions that require energy and will not occur by themselves, by coupling them to spontaneous reactions that release energy. As enzymes act as catalysts they allow these reactions to proceed quickly and efficiently. Enzymes also allow the regulation of metabolic pathways in response to changes in the cell's environment or signals from other cells. The metabolism of an organism determines which substances it will find nutritious and which it will find poisonous. For example, some prokaryotes use hydrogen sulfide as a nutrient, yet this gas is poisonous to animals. The speed of metabolism, the metabolic rate, influences how much food an organism will require, and also affects how it is able to obtain that food.

A striking feature of metabolism is the similarity of the basic metabolic pathways and components between even vastly different species. For example, the set of carboxylic acids that are best known as the intermediates in the citric acid cycle are present in all known organisms, being found in species as diverse as the unicellular bacteria Escherichia coli and huge multicellular organisms like elephants.

Catabolism is the set of metabolic processes that break down large molecules. These include breaking down and oxidizing food molecules. The purpose of the catabolic reactions is to provide the energy and components needed by anabolic reactions.

The most common set of catabolic reactions in animals can be separated into three main stages. Stage 1 – stage of digestion. The large organic molecules like proteins, lipids and polysaccharides are digested into their smaller components outside cells. Stage 2 – release of energy. Once broken down these molecules are taken up by cells and converted to yet smaller molecules, usually acetyl coenzyme A (acetyl-CoA), which releases some energy. Stage 3 - the acetyl group on the CoA is oxidised to water and carbon dioxide in the citric acid cycle and electron transport chain, releasing the energy that is stored by reducing the coenzyme nicotinamide adenine dinucleotide (NAD+) into NADH.

Anabolism is the set of constructive metabolic processes where the energy released by catabolism is used to synthesize complex molecules. In general, the complex molecules that make up cellular structures are constructed step-by-step from small and simple precursors. Anabolism involves three basic stages. Firstly, the production of precursors such as amino acids, monosaccharides, isoprenoids and nucleotides, secondly, their activation into reactive forms using energy from ATP, and thirdly, the assembly of these precursors into complex molecules such as proteins, polysaccharides, lipids and nucleic acids.

Organisms differ in how many of the molecules in their cells they can construct for themselves. Autotrophs such as plants can construct the complex organic molecules in cells such as polysaccharides and proteins from simple molecules like carbon dioxide and water. Heterotrophs, on the other hand, require a source of more complex substances, such as monosaccharides and amino acids, to produce these complex molecules. Organisms can be further classified by ultimate source of their energy: photoautotrophs and photoheterotrophs obtain energy from light, whereas chemoautotrophs and chemoheterotrophs obtain energy from inorganic oxidation reactions.

Photosynthesis is a chemical process that converts carbon dioxide into organic compounds, especially sugars, using the energy from sunlight. Photosynthesis occurs in plants, algae, and many species of bacteria, but not in archaea. Photosynthetic organisms are called photoautotrophs, since they can create their own food. In plants, algae, and cyanobacteria, photosynthesis uses carbon dioxide and water, releasing oxygen as a waste product. Photosynthesis is vital for all aerobic life on Earth. In addition to maintaining normal levels of oxygen in the atmosphere, photosynthesis is the source of energy for nearly all life on earth, either directly, through primary production, or indirectly, as the ultimate source of the energy. The rate of energy capture by photosynthesis is immense, approximately 100 terawatts, which is about six times larger than the power consumption of human civilization.

Photosynthesis occurs in two stages. In the first stage, light-dependent reactions or light reactions capture the energy of light and use it to make the energy-storage molecules ATP and NADPH. During the second stage, the light-independent reactions use these products to capture and reduce carbon dioxide.

Although photosynthesis can happen in different ways in different species, some features are always the same. For example, the process always begins when energy from light is absorbed by proteins called photosynthetic reaction centers that contain chlorophylls. In plants, these proteins are held inside organelles called chloroplasts, while in bacteria they are embedded in the plasma membrane. Some of the light energy gathered by chlorophylls is stored in the form of adenosine triphosphate (ATP). The rest of the energy is used to remove electrons from a substance such as water. These electrons are then used in the reactions that turn carbon dioxide into organic compounds. In plants, algae and cyanobacteria, this is done by a sequence of reactions called the Calvin cycle, but different sets of reactions are found in some bacteria, such as the reverse Krebs cycle in Chlorobium.

Chemosynthesis, in biochemistry, is the biological conversion of one or more carbon molecules (usually carbon dioxide or methane) and nutrients into organic matter using the oxidation of inorganic molecules (e.g. hydrogen gas, hydrogen sulfide) or methane as a source of energy, rather than sunlight, as in photosynthesis. Chemoautotrophs, organisms that obtain carbon through chemosynthesis, are phylogenetically diverse.

Most of the structures that make up animals, plants and microbes are made from three basic classes of molecule: amino acids, carbohydrates and lipids (often called fats). As these molecules are vital for life, metabolic reactions either focus on making these molecules during the construction of cells and tissues, or breaking them down and using them as a source of energy, in the digestion and use of food. Many important biochemicals can be joined together to make polymers such as DNA and proteins.

Proteins are made of amino acids arranged in a linear chain and joined together by peptide bonds. Each different protein has a unique sequence of amino acid residues: this is its primary structure. Just as the letters of the alphabet can be combined to form an almost endless variety of words, amino acids can be linked in varying sequences to form a huge variety of proteins.

Organisms vary in their ability to synthesize the 20 common amino acids. Most bacteria and plants can synthesize all twenty, but mammals can synthesize only eleven nonessential amino acids. Thus, nine essential amino acids must be obtained from food.

Many proteins are the enzymes that catalyze the chemical reactions in metabolism. Other proteins have structural or mechanical functions, such as the proteins that form the cytoskeleton, a system of scaffolding that maintains the cell shape. Proteins are also important in cell signaling, immune responses, active transport across membranes, and the cell cycle.

Carbohydrates are aldehydes or ketones with many hydroxyl groups that can exist as straight chains or rings. Carbohydrates are the most abundant biological molecules, and fill numerous roles, such as the storage and transport of energy (starch, glycogen) and structural components (cellulose in plants, chitin in animals). The basic carbohydrate units are called monosaccharides and include galactose, fructose, and most importantly glucose. Monosaccharides can be linked together to form polysaccharides in almost limitless ways.

Lipids are the most diverse group of biochemicals. Their main structural uses are as part of biological membranes such as the cell membrane, or as a source of energy. Lipids are usually defined as hydrophobic biological molecules that will dissolve in organic solvents such as benzene or chloroform. The fats are a large group of compounds that contain fatty acids and glycerol.

The two nucleic acids, DNA and RNA are polymers of nucleotides, each nucleotide comprising a phosphate group, a ribose sugar group, and a nitrogenous base. Nucleic acids are critical for the storage and use of genetic information, through the processes of transcription and protein biosynthesis. Nucleotides also act as coenzymes in metabolic group transfer reactions.

Metabolism involves a vast array of chemical reactions, but most fall under a few basic types of reactions that involve the transfer of functional groups. This common chemistry allows cells to use a small set of metabolic intermediates to carry chemical groups between different reactions. These group-transfer intermediates are called coenzymes. Each class of group-transfer reaction is carried out by a particular coenzyme and a set of enzymes that consume it.

One central coenzyme is adenosine triphosphate (ATP), the universal energy currency of cells. There is only a small amount of ATP in cells, but as it is continuously regenerated, the human body can use about its own weight in ATP per day. ATP acts as a bridge between catabolism and anabolism, with catabolic reactions generating ATP and anabolic reactions consuming it. It also serves as a carrier of phosphate groups in phosphorylation reactions.

A vitamin is an organic compound needed in small quantities that cannot be made in the cells. In human nutrition, most vitamins function as coenzymes after modification; for example, all water-soluble vitamins are phosphorylated or are coupled to nucleotides when they are used in cells. Nicotinamide adenine dinucleotide (NADH), a derivative of vitamin $B_3$ (niacin), is an important coenzyme that acts as a hydrogen acceptor.

Inorganic elements play critical roles in metabolism; some are abundant (e.g. sodium and potassium) while others function at minute concentrations. About 99% of a mammal's mass is made up of the elements carbon, nitrogen, calcium, sodium, chlorine, potassium, hydrogen, phosphorus, oxygen and sulfur. Organic compounds (proteins, lipids and carbohydrates) contain the majority of the carbon and nitrogen; most of the oxygen and hydrogen is present as water.

The abundant inorganic elements act as ionic electrolytes. The most important ions are sodium, potassium, calcium, magnesium, chloride, phosphate and the organic ion bicarbonate. The maintenance of precise gradients across cell membranes maintains osmotic pressure and pH.

Transition metals are usually present as trace elements in organisms, with zinc and iron being most abundant. These metals are used in some proteins as cofactors and are essential for the activity of enzymes such as catalase and oxygen-carrier proteins such as hemoglobin. Metal cofactors are bound tightly to specific sites in proteins; although enzyme cofactors can be modified during catalysis, they always return to their original state by the end of the reaction catalyzed.

The cell metabolism is mainly involved in the extraction of energy that is used for many activities. This biological process is very much important for an organism, which is involved in obtaining chemical energy, synthesizing complex molecules and converting nutrient molecules into usable forms for further use. Without this process, a cell dies with lack of energy to carry out biological reactions. If a cell starts to die, finally an organism ends.

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