

## THE HUMAN MICROBIOME AS AN OBJECT OF MEDICAL MICROBIOLOGY AND A PATHOGENETIC FACTOR IN CHRONIC DISEASES

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### **Abstract**

The human microbiome is the totality of microorganisms that colonize the body's various biotopes and function as an integrated metabolic and regulatory system. From the perspective of medical microbiology, the microbiome is regarded as an independent functional component of the macroorganism, involved in maintaining homeostasis, regulating the immune system, metabolic processes, and barrier function. Current research, including data from the Human Microbiome Project, confirms the key role of the microbiome in maintaining physiological equilibrium and in the development of pathological processes. Disruption of the microbial balance (dysbiosis) is accompanied by changes in the taxonomic composition and functional activity of microbial communities, which leads to impaired epithelial barrier function, activation of the innate immune system, and the formation of chronic systemic inflammation. Dysbiosis is considered an important pathogenetic mechanism in the development of inflammatory, metabolic, autoimmune, and neuropsychiatric diseases. The study of the microbiome is one of the most promising areas of medical microbiology, opening up new opportunities for the diagnosis, prevention, and therapy of chronic diseases.

### **Keywords**

microbiome, medical microbiology, dysbiosis, intestinal microbiota, homeostasis, chronic inflammation, immune regulation, biofilms, metagenomics.

Medical microbiology has traditionally viewed microorganisms primarily as the causative agents of infectious diseases. However, the development of molecular genetic research methods has made it possible to establish that a significant portion of microorganisms exists in a symbiotic state with the host organism and performs vital physiological functions. The human microbiome is a complex ecological system that includes bacteria, archaea, viruses, and fungi which colonize the skin, mucous membranes, and gastrointestinal tract. The large intestine is characterized by the highest density of microorganisms, where their concentration reaches 10<sup>12</sup>

cells per gram of contents [2,4,7,15,22,25,26,34].

The collective genome of the microbiota (the microbiome) significantly exceeds the human genome in the amount of genetic information it contains and provides a wide range of metabolic functions that the host organism lacks. Morphofunctional and taxonomic characteristics of the microbiome. From a microbiological standpoint, the microbiome is primarily represented by the following bacterial phyla: Firmicutes, Bacteroidetes, Actinobacteria, Proteobacteria, and Verrucomicrobia. The dominant genera are: Bifidobacterium, Lactobacillus, Bacteroides, Clostridium, and Escherichia. Microorganisms exist predominantly within biofilms, which are structured microbial communities surrounded by an extracellular matrix. Biofilms provide microorganisms with resistance to immune factors and adverse environmental conditions.

The microbiome is characterized by the following properties: stability of taxonomic composition, functional redundancy, metabolic cooperation, the capacity for self-regulation, and resistance to external influences. Functions of the microbiome in the human body [1,3,5,10,21,27,29,32,35,40].

1. Barrier function. The microbiome provides colonization resistance by competing with pathogenic microorganisms, producing bacteriocins, stimulating mucin synthesis, and maintaining the integrity of the epithelial barrier. This prevents colonization by pathogenic and opportunistic microorganisms.

2. Metabolic function. Microorganisms participate in the fermentation of polysaccharides, the synthesis of short-chain fatty acids, the synthesis of B-group vitamins and vitamin K, bile acid metabolism, and the regulation of energy metabolism. Short-chain fatty acids provide energy to epithelial cells and have anti-inflammatory properties.

3. Immunoregulatory function. The microbiome plays a key role in the development of the immune system by stimulating lymphoid tissue, regulating T-lymphocyte activity, controlling cytokine production, and establishing immunological tolerance. The physiological interaction between the microbiome and the immune system ensures the maintenance of immune homeostasis.

4. Regulation of systemic physiological processes. Microbial metabolites are involved in regulating the neuroendocrine system, metabolism, inflammatory processes, and the gene expression of the host organism. Dysbiosis, as a microbiological and pathogenetic process, represents a disruption in the quantitative and qualitative composition of the microbiome, accompanied by a decrease in the biodiversity and functional activity of microbial communities [8,9,13,16,18,19,20,24,31,37].

The primary microbiological signs of dysbiosis are a decrease in obligate anaerobes, an increase in opportunistic microorganisms, disruption of the biofilm

structure, and changes in metabolic activity. The role of dysbiosis in the pathogenesis of chronic diseases. Disruption of the microbiome leads to increased epithelial barrier permeability, translocation of bacterial components, activation of the immune system, and the development of chronic inflammation. Dysbiosis is associated with the development of inflammatory bowel disease, metabolic syndrome, type 2 diabetes, obesity, autoimmune diseases, allergic diseases, and neuropsychiatric disorders. Chronic inflammation induced by microbial components is a key pathogenetic mechanism of these diseases.

The effect of antibiotics on the microbiome. Antibacterial drugs cause a decrease in microbial diversity, disrupt the structure of microbial communities, promote the selection of resistant microorganisms, and lead to long-term changes in the microbiome. This increases the risk of developing chronic diseases and secondary infections. Prospects for modern medical microbiology. Current directions include metagenomic analysis of the microbiome, the development of microbiome-oriented therapies, the use of probiotics and prebiotics, microbiota transplantation, and personalized medicine. Studying the microbiome opens new avenues for the diagnosis and treatment of diseases [6,11,12,14,17,23,28,30,33,36,38,39].

The human microbiome is therefore a crucial subject of medical microbiology, representing a complex symbiotic system that maintains the body's homeostasis. A disruption of this microbial balance is a key pathogenetic factor in the development of chronic diseases. Further study of the microbiome is a strategically important direction for modern medicine and microbiology.

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