HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

MODERN ACHIEVEMENTS OF BIOLOGY IN THE STUDY OF THE HUMAN MICROBIOME

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Abstract: The human microbiome is a complex collection of microorganisms that inhabit various organs and systems of the human body. Modern advances in molecular biology, genomics, and bioinformatics have significantly expanded our understanding of the structure, functions, and role of the microbiome in maintaining human health. The purpose of this study is to analyze the current state of biological research on the human microbiome and assess its significance for medicine and disease prevention. The study employs methods of analysis and synthesis of current scientific publications. It has been established that the microbiome has a significant impact on metabolism, immunity, neuroendocrine regulation, and the development of various pathological conditions. Promising areas include the development of personalized methods for microbiome correction and the use of microbiome technologies in preventive and clinical medicine.

Keywords: biology, human microbiome, microbiota, genomics, metagenomics, gut microbiota, immunity, probiotics, human health, bioinformatics.

INTRODUCTION

The development of modern biology has led to the formation of new ideas about humans as a complex ecosystem that includes not only the body's own cells but also numerous communities of microorganisms. The collection of bacteria, archaea, fungi, viruses, and other microorganisms that inhabit the human body is known as the microbiome.

In the last two decades, the study of the microbiome has become one of the most rapidly developing areas of biological science. Thanks to the introduction of high-throughput DNA sequencing methods, researchers have been able to study microorganisms without the need to cultivate them in laboratory conditions. This has significantly expanded our knowledge of the species diversity of the human microbiota and the mechanisms of its interaction with the host organism.

Special attention is paid to the intestinal microbiome, which contains trillions of microorganisms and is considered as an independent metabolic system. Disruption of the microbiota composition is associated with the development of obesity, diabetes mellitus, cardiovascular diseases, inflammatory bowel diseases, allergies and some neurological disorders. The relevance of the study is due to the need to systematize modern scientific data on the role of the human microbiome and the prospects for its application in biomedical technologies.

The purpose of the study is to analyze the current achievements of biology in the study of the human microbiome and determine its significance for maintaining health and preventing diseases.

MATERIALS AND METHODS

The study was based on an analysis of modern scientific publications on the human microbiome.

The study materials included articles published in international scientific journals indexed in the Scopus, Web of Science, PubMed, and Google Scholar databases in recent years.

The following methods were used in the work:

analysis of scientific literature;

comparative analysis of research results;

systematization and generalization of scientific data;

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the method of scientific description.

The main focus was on research related to the study of intestinal microbiota, molecular genetic methods for analyzing the microbiome, and its role in the development of various diseases.

RESULTS

The analysis showed that modern biology has made significant progress in studying the human microbiome.

One of the most important achievements has been the introduction of next-generation sequencing (NGS) methods, which allow for the precise determination of the genetic composition of microorganisms. The use of metagenomic analysis has enabled the identification of thousands of previously unknown microbial species.

It has been established that the human microbiome contains over 100 trillion microorganisms, and the combined genes of these microorganisms far exceed the number of human genes. The most diverse microbial community is located in the gastrointestinal tract.

Research has shown that the intestinal microbiota performs a number of vital functions:

participates in the digestion of food;

provides the synthesis of B vitamins and vitamin K;

regulates energy metabolism;

supports the barrier function of the intestines;

participates in the formation of the immune response.

The existence of a close relationship between the intestines and the central nervous system, known as the "gut-brain axis", has been established. Microorganisms are capable of synthesizing neuroactive substances that affect the emotional state, cognitive functions, and human behavior.

Modern research also demonstrates a relationship between microbial imbalance (dysbiosis) and the development of various diseases. Changes in the composition of the microbiota have been identified in obesity, type 2 diabetes, Crohn's disease, ulcerative colitis, autism, Parkinson's disease, and depressive disorders.

An important achievement is the development of technologies for correcting the microbiome. Probiotics, prebiotics, synbiotics, and fecal microbiota transplantation are currently being actively studied as promising methods for restoring microbial balance.

DISCUSSION

The data obtained indicate that the microbiome is an important biological factor that affects almost all physiological processes in the human body.

Modern methods of molecular biology have allowed us to move from a descriptive study of the microflora to an analysis of its functional activity. Research on metabolomics and metatranscriptomics is particularly important, as it allows us to study the biochemical processes occurring in microbial communities. The development of bioinformatics plays a key role in processing vast amounts of genetic information. The use of artificial intelligence allows for the prediction of microbiome changes and the assessment of disease risk.

In recent years, the concept of personalized medicine based on individual characteristics of the human microbiome has been actively developing. It is expected that in the future, the analysis of the microbiota will become an important element in diagnostics and treatment planning.

Despite the significant progress, there are still a number of unresolved issues. Further research is needed to understand the mechanisms of interaction between microorganisms and human cells, as well as the long-term consequences of targeted changes to the microbiome.

CONCLUSION

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Modern advances in biology have significantly expanded our understanding of the human microbiome and its role in maintaining health. Thanks to the development of genomics, metagenomics, and bioinformatics, we can now study the composition and functions of the body's microbial communities in detail.

It has been established that the microbiome plays a crucial role in regulating metabolism, immune responses, and the functioning of the nervous system. Disruptions in the microbial balance have been linked to the development of various chronic diseases. Promising areas for further research include the development of personalized microbiota correction methods, the improvement of microbiome diagnostic technologies, and the implementation of microbiological research results in clinical practice.

Thus, the study of the human microbiome is one of the most promising areas in modern biology, offering new opportunities for the prevention, diagnosis, and treatment of diseases.

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