Probiotics and Microbiome Health: Enhancing Gut Health and Nutrition

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Abstract

Probiotics, which are live bacteria, play a significant role in supporting gut health and overall well-being when consumed. It is well recognized that probiotics, which include species like Lactobacillus and Bifidobacterium, improve the balance of gut microbes, alter immunological responses, reduce intestinal pH and stop pathogenic colonization. Since the early 1900s, their significance has been recognized and scientists like Metchnikoff have connected them to lifespan. Human health is significantly influenced by the gut microbiota which is a varied ecosystem of bacteria, fungus and viruses that affects immunity, illness prevention and digestion. Chronic disorders like obesity, diabetes and inflammatory ailments can be affected by dietary practices, environmental variables and lifestyle decisions that affect the composition of the microbiome. By encouraging the growth of beneficial bacteria and enhancing intestinal health, probiotics can improve the gut microbiota and result in decreased inflammation and improved metabolic processes. The influence of probiotics on gut gene expression and their capacity to regulate immunological responses are highlighted by recent research. Although probiotic supplements have demonstrated potential in the treatment of illnesses like metabolic disorders, irritable bowel syndrome and severe diarrhea, the exact mechanisms are still unclear and need more investigation. Diet has a significant impact on the gut microbiota; diets high in fiber and plant-based foods encourage the growth of beneficial bacteria.

Keywords: Nutrition, Probiotics, Microbiome, Health, Disease.

1. Introduction

Probiotics are live microorganisms that, when consumed in enough amounts, benefit the host's health. They have been reaffirmed as pertinent and suitable for both present and future uses. According to research from Canada and Italy, one of the key benefits of probiotics is their role in supporting a healthy gut microbiome. Through mechanisms that are common to most probiotics, the overall benefit of probiotics on gut microbiota comes from improving the gut environment. The panel also examined two broad advantages of probiotics that are frequently mentioned: promoting a healthy immune system and digestive tract (Hill et al., 2014). Traditional fermented foods, good commensal bacteria, or environmental sources are the sources of probiotics. They work by modifying host epithelial and immunological responses, as well as by influencing the commensal microbiota's makeup or function (Sanders et al., 2013). Recent research has shown that human physiology and disease are significantly influenced by the microbiome, which is the collection of bacteria, viruses and fungi that reside in and on the human body (Srivastava et al., 2022). Most people believed that the number of microorganisms on and in the human body was enormous and mostly unknown. The group of plants that coexist with people was referred as "the normal flora" and was viewed as a mystery. It is currently referred as the "microbiome" in its whole. The term "gut health" is commonly used by the food business and in medical literature. It includes the gastrointestinal (GI) tract's advantageous roles, including as effective digestion and nutritional absorption, the lack of GI disorders, a stable and balanced intestinal microbiota, strong immune function and general well-being (Blaser, 2014).

Researching gut health requires a multifaceted approach. It ought to be examined from the perspectives of microbiology, immunology and nutrition supply. If antibiotics are removed from feed, the microbial imbalance that commonly causes the impact on gut health will worsen. Pathogen-induced gut damage will result in poor gut health, which will impact the effectiveness of nutrient utilization. Acute, short-term infections are frequently less costly than subclinical infections, which do not exhibit visible lesions. One such instance is necrotic enteritis in chickens (Fathima et al., 2022). When creating diets and controlling feeding practices, dietary elements that affect gut microbiota and the immune system should be taken into account. Nutrition and health are intertwined. The gut is where the two interact most frequently. Therefore, "gut health" is a very broad topic that necessitates a multidisciplinary perspective that includes nutrition, immunology, microbiology, endocrinology and gut physiology. Despite significant advancements in molecular tools for characterizing microorganisms, the science identifying the functions of microorganisms in nutrition and health is still in its infancy, if gut microflora is considered as an example (Choct, 2009).

2. Probiotics

Probiotics are live, beneficial microorganisms that support microbial balance, particularly in the gastrointestinal system. These are typically regulated as foods or dietary supplements and often include lactic acid bacteria, such as Lactobacillus and Bifidobacterium species and the yeast Saccharomyces boulardii. Probiotics offer various benefits, such as lowering gut pH, limiting the colonization and invasion of harmful organisms and modulating the immune response. However, the effects of probiotics can vary between different species or strains. Despite being widely regarded as safe and well-tolerated, gas and bloating are frequent adverse effects. Although they are uncommon, systemic infections can happen, thus their usage should be cautious in patients who are extremely ill, immunocompromised or have central venous catheters (Williams, 2010).

Beneficial active bacteria known as probiotics colonize the human intestines and alter the flora's makeup in specific host areas. Probiotic use to control gut flora and boost host immunity has drawn a lot of attention lately. According to recent research, probiotics have a major impact on the gut microbiota's makeup. They can enhance the immune system, inhibit the colonization of harmful bacteria in the intestine and support the formation of a protective intestinal mucosal barrier. Because human immunity and gut microbiota are closely related, using probiotics to regulate the gut microbiome has proven to be a very successful strategy for boosting human immunity (Wang et al., 2021).

2.1 History of probiotics

Louis Pasteur identified the microorganisms responsible for fermentation, while E. Metchnikoff linked the longer lifespans of Bulgarian farmers to their frequent intake of fermented dairy products like yogurt. He proposed that the putrefactive effects of gastrointestinal metabolism that led to disease and aging may be counteracted by Lactobacilli. Metchnikoff viewed Lactobacilli as probiotics, or "probios," that are beneficial to the host's life rather than antibiotics; probiotics may improve health and delay the aging process. Animals were domesticated and humans started consuming fermented foods during the Neolithic era of the Stone Age. Most likely, accidental contaminations in conducive conditions were a significant factor. A Chinese manual for treating acute diarrhea or food poisoning from the fourth century mentions fecal microbiota transplantation. Fecal transplantation is currently more effective than vancomycin at curing Clostridium difficile infections and preventing their recurrence (Gasbarrini et al., 2016).

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2.2 Common Probiotics and their health benefits

Live cells known as probiotics are beneficial bacteria that may offer nutritional benefits due to their various advantageous traits. When controlled in adequate amounts, they also promote health. Probiotic strains have strong effects on enhancing human health. Lactobacillus, Bifidobacterium, Pediococcus, Lactococcus, Bacillus and commonly utilized yeast strains are the primary probiotic categories. In the discipline of microbiology, probiotics have recently attracted a lot of attention, particularly because of their function in normal physiology and the effects they have on human health during infections. Probiotic use has produced encouraging results in numerous carefully planned clinical trials. For example, as a therapeutic alternative for the management, prevention, and control of a number of conditions and illnesses, such as inflammatory bowel syndrome, urogenital infections, Helicobacter pylori infections, gastrointestinal diseases, allergies and urogenital infections and colon cancer (Abatenh et al., 2018).

One dietary component that may help to lower the incidence of cancer is probiotic microorganisms. Studies have shown that several species of Lactobacillus and Bifidobacterium may reduce the amounts of carcinogenic enzymes produced by intestinal flora, while the precise mechanisms are still being studied (Huang et al., 2022). They achieve this by restoring intestinal permeability, balancing gut microflora, producing antimutagenic organic acids, and enhancing the host's immune response. By lowering serum cholesterol and controlling blood pressure, foodstuffs that contain probiotic bacteria may help prevent coronary heart disease. The formation of end fermentation products, direct cholesterol assimilation, and disruption of gut-based cholesterol absorption are some of the hypothesized processes that influence systemic blood lipid levels and mediate an antihypertensive effect. Probiotic strains delivered through dairy products have been found to enhance treatment outcomes in women with bacterial vaginosis, likely by promoting the natural Lactobacilli balance in the vaginal microbiota (Kechagia et al., 2013).

2.3 Mechanism of action in the gut

Lactic acid bacteria and other probiotics are beneficial due to non-pathogenic microorganisms that promote health when consumed in adequate amounts. Ongoing research explores the molecular mechanisms and potential applications of probiotics. They are believed to exert their effects through various pathways, including immune modulation in the gut, neurotransmitter production, strengthening the intestinal mucosal barrier, and preventing pathogens from adhering to intestinal surfaces (Shu et al., 2023). Recent developments in our knowledge of the health advantages of probiotics and their new uses in food business are highlighted in this chapter. Probiotics have potential as supportive therapy for gastrointestinal illnesses, cancer, hypertension and hypercholesterolemia because of their capacity to affect gut microbiota and modify immune responses. Their functional properties have led to their use in dairy, beverage and baking industries. Additionally, innovative techniques now enable probiotics to withstand gastrointestinal stress and harsh processing conditions, enhancing their viability for effective commercial use in food processing (Latif et al., 2023).

3. Microbiome

The microbiome has recently been recognized as a core element in human health and disease. Through their interactions with their host, a wide variety of bacteria inhabit the gut, a biological niche that has an impact on almost every aspect of human biology. New technologies are starting to uncover significant facets of host-microbe interactions. Most people believed that the number of microorganisms on and in the human body was enormous and mostly unknown. The group of plants that coexist with people was referred as "the normal flora" and was viewed as a mystery. Now referred to as the "microbiome" in its whole, its purpose has been disputed since the days of Pasteur and Metchnikoff, when it was thought to be either necessary or expensive for life (Blaser, 2014). To achieve this, large-scale population studies have explored the typical diversity and composition of microbiomes in healthy individuals, examining their taxonomic makeup and functional capabilities. These studies also consider factors like geography, diet and lifestyle that may influence the microbiome (Lloyd-Price et al., 2016).

3.1 Gut microbiome

Despite having almost identical genetic compositions, humans exhibit a great deal of phenotypic variability due to the minor variations in our DNA. Understanding the diversity within the "healthy microbiome" has been a major challenge since the 1960s and has persisted through the Human Microbiome Project and subsequent studies (Avery et al., 2021). A key step toward addressing these complexities involves identifying the core and essential microbiome characteristics that support health, as well as defining the typical range of these traits in healthy populations. This foundation aids in recognizing and rectifying microbial imbalances linked to disease. Interest in the microbiome has increased within the last 15 years. Although research on gut microorganisms has been ongoing for decades, recent research has significantly expanded the focus on their roles beyond traditional infectious diseases. Numerous studies, for instance, have documented alterations in the gut microbiota in relation to cancer, diabetes, liver disease, obesity and even neurodegenerative illnesses (Gates et al., 2022).

Novel therapies may be derived from the human gut microbiome. Remarkably, there were 12,900 articles about the gut microbiota between 2013 and 2017, accounting for four-fifths of all papers that examined this subject over the previous 40 years. The amount of metagenomic information gathered when comparing sick and healthy patients can lead to the false claim that a bacterium is causally connected to the prevention or emergence of a disease. In reality, environmental factors such as dietary habits, intestinal motility, medication use and the frequency and consistency of feces all affect the microbiota's makeup and should be taken into account. As important examples, the cases of the bacteria Prevotella copri and Akkermansia muciniphila were examined (Cani, 2018). Through a number of processes, the human gut microbiota has a major influence on brain health. 1. Bacterial structural elements, like lipopolysaccharides, stimulate the innate immune system at a low level. However, dysbiosis, bacterial overgrowth in the small intestine, or increased intestinal permeability may cause excessive stimulation that leads to inflammation in the central nervous system and throughout the body. 2. The adaptive immune system may react inappropriately to some bacterial proteins that interact with human antigens. 3. Under some circumstances, even advantageous metabolites, such short-chain fatty acids, may have neurotoxic consequences. Bacterial enzymes can produce neurotoxic metabolites, such as ammonia and D-lactic acid. 4. Microbes in the gut can produce hormones and neurotransmitters that are exactly the same as those the human body produces. These chemicals' bacterial receptors affect the pathogenicity and development of microorganisms. 5. Via the vagus nerve, gut bacteria can directly activate afferent neurons in the enteric nervous system, transmitting messages to the brain.

Through these processes, gut microorganisms can affect mood, memory, cognition, sleep patterns and the hypothalamic-pituitary-adrenal axis, which regulates the stress response. Additionally, they have been connected to conditions like fibromyalgia, alcoholism, restless legs syndrome, chronic fatigue syndrome and probably multiple sclerosis as well as the neurological effects of celiac disease. Probiotics, prebiotics and dietary changes are therapeutic ways to alter the gut flora (Galland, 2014).

3.2 Human Microbiome

Despite having almost identical genetic compositions, humans exhibit a great deal of phenotypic variability due to the minor variations in our DNA. Since the 1960s and until the Human Microbiome Project, one of the main challenges in microbiome research has been to comprehend the heterogeneity within the "healthy microbiome." An essential first step in addressing these challenges is identifying and cataloging the microbiome characteristics that promote health and establishing the typical ranges of these traits in healthy populations. This foundational knowledge helps to pinpoint microbial imbalances associated with disease. To this end, large-scale population studies have explored the diversity and taxonomic composition of microbiomes in healthy individuals, while also considering factors like geography, diet and lifestyle that may influence these microbial communities (Lloyd-Price et al., 2016).

4. Probiotics and microbiome balance

Human health is preserved by the foods we eat, the makeup of our gut flora, and the usage of probiotics and prebiotics. The gut microbial population needs to be in balance for the host and microbiota to coexist in a mutually beneficial interaction that preserves homeostasis. Given the capabilities of contemporary technology, it is now feasible to create prebiotic bacteria that will benefit the microbiome while also making it easier to eradicate harmful proinflammatory bacteria or other factors that contribute to dysbiosis. The human gut is a complex ecology of host cells, bacteria and preexisting nutrients that cooperate as a "virtual" organ system to promote host nutrition and maintenance illustrated in fig. 1.

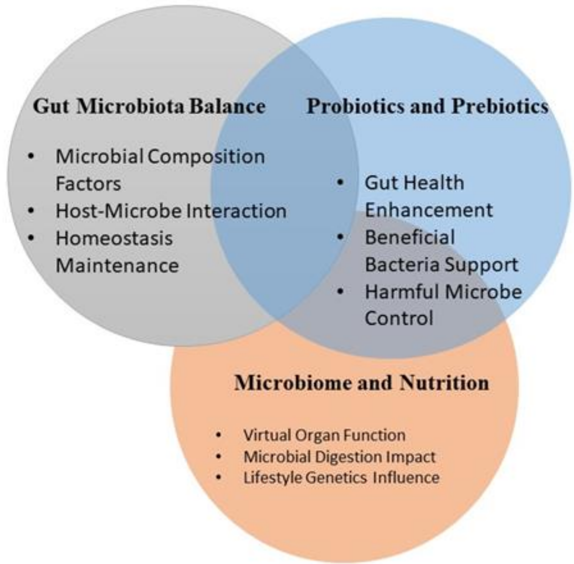

Fig.1. Gut microbiota balance, probiotics, and nutrition shape health.

Gut microbiota (GM) is the ecological community of commensal, pathogenic, and symbiotic bacteria in the human body's gastrointestinal tract (GIT). In the human gastrointestinal tract, there are around 100 trillion microorganisms, including bacteria, viruses, fungus, and protozoa. Firmicutes, Bacteroidetes, Actinobacteria, Proteobacteria, Fusobacteria and Verrucomicrobia are the six bacterial phyla to which the majority of these microorganisms belong. Yet, each person's enterotype, or basic community structure, varies to varied degrees according to their lifestyle, body mass index, genetics, and other environmental factors (Sehrawat et al., 2021).

5. Gut health and nutrition

In addition to providing the necessary nutrients for our bodies, the foods in our diet also act as substrates for the gut microbiome, which is the mutualistic microbial flora that inhabits our gastrointestinal tract. A broad range of metabolites are produced by the metabolism of undigested dietary components. Therefore, the structure, makeup and function of the gut microbiome which interacts with the mucosal immune system and gut epithelium to maintain intestinal homeostasis in a healthy state are shaped by the food we eat. Numerous illnesses, including inflammatory bowel disease (IBD), are associated with modifications to the gut microbiome. Targeting the gut microbiota in IBD with nutritional therapy is gaining attraction. Recent years have seen a boom in research on how nutrition affects the structure of the gut microbiota, but few have examined gut physiology (Zhang, 2022).

Fruit, vegetables and dietary fiber have long been touted for their health advantages. Understanding the complex interactions between diet, microbiota and the gut epithelium is essential to offering an explanation for the notable geographical variations in colorectal cancer incidence that are most likely due to nutrition. Although other pathways are also significant, dietary fiber can function as a prebiotic by promoting the growth of saccharolytic bacteria. Not all soluble fiber has the "contrabiotic" function of keeping bacteria from sticking to the epithelium. In contrast to dietary fructans, which were formerly believed to be beneficial prebiotics, pectins (galacturonans) in particular might promote inflammation due to the negative consequences of high butyrate levels (Wu et al., 2021). Additionally, this implies that potentially harmful fecal butyrate concentrations may contribute to ulcerative colitis. Certain dietary glycans may also be able to prevent the epithelial adherence of lectins, whether they are bacterial lectins like the galactose-binding lectin expressed by Fusobacterium nucleatum, which is linked to colon cancer, or dietary lectins like those found in legumes. On the other hand, emulsifiers included in processed meals have the ability to promote inflammation or cancer by altering the microbiota and increasing bacterial translocation. Despite the rising knowledge of the effects of dietary components on all-cause mortality and the development of public health messaging, concentrating on a single condition is of limited utility. Humans still don't fully understand the complex connections between food, the microbiota and health (Rhodes, 2021).

5.1 Foods to support your gut

The gut microbiota's organization is significantly influenced by diet. There is mounting evidence that the taxonomic, genetic and metabolic features of our microbiota have been significantly impacted by changes in modern living, especially the high-fat and high-sugar Western diet. Chronic conditions include allergies, inflammatory bowel disease (IBD), atherosclerosis, obesity and type 2 diabetes may become more prevalent as a result of these changes (Luo et al., 2024). The epidemiology of numerous chronic inflammatory diseases has undergone significant shift in the last three decades. Unknown sources of chronic low-grade systemic inflammation are linked to diseases such as atherosclerosis, metabolic syndrome, rheumatoid arthritis, and IBD. Some of these diseases, like IBD, are influenced by genetic factors, but environmental variables, including food, play a part. Fruit-based diets and vegetables seem to have anti-inflammatory and gastrointestinal health benefits. One important receptor for specific dietary components is the aryl hydrocarbon receptor (AhR), a transcription factor presents in immune cells, epithelial cells, and some tumor cells. This receptor is affected by a variety of exogenous and endogenous AhR ligands, including those present in broccoli, phytochemicals, natural compounds, and bacterial metabolites (Tilg & Moschen, 2015).

5.2 Common myths about gut health and nutrition

The ancient notion of autointoxication holds that digestive waste products are a key cause of many, if not all, ailments and can poison the body. It was the dominant medical theory in the 19th century and gave rise to "colonic quackery" in a number of forms. It appeared to have some scientific support around the turn of the century. Colonic irrigation was exposed as quackery and then declined once it became evident that the scientific justification was flawed and that it was not only pointless but also perhaps harmful. Colonic irrigation is making a comeback now, based on nothing less than the ancient false promises and the remarkable influence of special interests. Even colonic irrigation specialists nowadays can only offer theories and anecdotes in its support (Ernst, 1997)

Numerous physiological and pathological processes that affect humans are significantly influenced by the gut microbiota. According to recent research, commensal bacterial activity may be a determining factor in the effectiveness of certain treatment strategies (Zhao et al., 2022). Antibiotics are extremely useful tools in the battle against infectious diseases. However, they can also have long-lasting negative impacts on the host by changing the microbiota's makeup and functioning. Concerns over the widespread and perhaps improper use of antimicrobial drugs are raised by the advent of multidrug-resistant bacteria. Here, we examine the most current findings about the relationships among host pathophysiology, microbiota, and antibiotics, emphasizing technology platforms, mechanistic understandings, and therapeutic approaches to improve disease resistance while maintaining the advantageous roles of the microbiota (Becattini et al., 2016).

The most common cardio-metabolic disorders in people worldwide are obesity and associated comorbidities. According to recent data, all extremely common chronic degenerative diseases share a common characteristic of persistent low-grade inflammation. The gut microbiota is a full ecosystem in this regard that contributes to a number of processes, such as vitamin synthesis, metabolic regulation, immune system regulation, and appetite regulation. One of the numerous reasons linked to obesity is dysbiosis, which has been recognized due to the decrease in Bifidobacterium in the gut and the resulting short-chain fatty acid (SCFA) synthesis, which increases intestinal permeability and decreases the action of incretins. Bacteria, bacterial endotoxins and toxic bacterial metabolites enter the bloodstream and cause systemic inflammation.

The sensible treatment of childhood constipation is still hampered by a number of commonly held preconceptions and prejudices. Approximately 9.5% of children worldwide experience chronic constipation, despite the widespread belief that it is not a frequent ailment. Despite the fact that most patients have functional constipation, most doctors still believe that organic diseases are the cause of constipation, which leads to significant misconceptions about the etiology of constipation. Contrary to the belief that children typically outgrow constipation without lasting issues, research indicates that constipation can result in serious bowel and psychological effects. It significantly impacts quality of life, potentially leading to long-term health and educational challenges (Rajindrajith et al., 2023).

5.3 Diet diversity and gut health

Diet has an impact on how the gut microbiota and its mammalian host interact. The organization of the microbiological population is influenced by dietary intake, which also provides substrates for microbial metabolism. Small chemicals produced by the microbiota can impact numerous vital physiological functions and be absorbed by the host. Dietary variations may lead to age-dependent and sociocultural variations in the gut flora. Examples include variations in the intestinal microbiota of infants who are breastfed as opposed to formula-fed, or variations in the microbial richness of individuals who follow a Western diet that is heavy in fat and meat against those who follow an agrarian plant-based diet (Albenberg & Wu, 2014).

6. Impacts of probiotics on gut health

Dietary nutrients can be transformed by intestinal microbes into metabolites, which are physiologically active compounds that influence the host's regulatory functions. By encouraging advantageous activities within microbial communities and restoring the balance of the gut microbiome, probiotics may help reduce or prevent intestinal or systemic disorders as well as gut inflammation (Haneishi et al., 2023).

6.1 Effects of probiotics on gut microbiota

According to a study conducted on germ-free and conventionally raised mice, the gut microbiota influenced the expression of numerous genes in the human or mouse intestinal tract, including those related to immunity, nutritional absorption, energy metabolism, and intestinal barrier function. Interestingly, the mucosa of the small intestine showed the largest changes (Paone et al., 2022). According to a recent human study, probiotics can also change the patterns of gene expression in the gastrointestinal tract (Taverniti et al., 2021). In addition to receiving probiotic medication (Lactobacillus acidophilus Lafti L10, Lactobacillus casei CRL-431, and Lactobacillus rhamnosus GG) before and after a 6-week intervention period, healthy participants underwent an esophagogastroduodenoscopy to obtain duodenal specimens. Changes in transcriptional networks were found when the transcriptional patterns of human genes were analyzed in samples taken from probiotic-treated patients.

6.2 Diet and its effects on the gut microbiota

The notion that diet can affect gut flora has been studied by scientists since the 1960s. In order to comprehend the connection between nutrition and the makeup and function of the gut microbiome, recent research has concentrated on analyzing intestinal microbiota and metagenomes using animal models. The microbiome, which in turn affects gut metabolism, can be directly impacted by human food. A high-fat, high-sugar Western diet can cause quick alterations in the gut microbiota, increasing the proportion of firmicutes and decreasing the presence of Bacteroidetes, according to research on human fecal microbiota implanted into germ-free mice (Hemarajata and Versalovic, 2013).

7. Recent advances on probiotics linked to the gut microbiome

According to recent studies on the microbiome, every aspect of immunology and physiology can be greatly impacted by the gut microbiota. Recent research has shown that probiotics can change the gut microbiota's structure, while the precise mechanism underlying this effect is still unclear. The relative abundances of beneficial gut bacteria, which are generally reduced in disease situations, are restored by regular probiotic treatment. Oral probiotic administration improved the disease state by (1) promoting the differentiation and function of regulatory T cells, (2) reducing the inflammatory response, (3) changing the gut environment, and (4) increasing the proportions of gut microbiota that produce beneficial metabolites or short-chain fatty acids, including the genera Bifidobacterium, Faecalibacterium, Akkermansia, etc. (Kim et al., 2019).

Conclusion

In conclusion, as more study focuses on the mechanisms and advantages of these microbes, it is increasingly clear how probiotics, the gut microbiota and overall human health are intertwined. Probiotics have demonstrated significant potential in the management and prevention of gastrointestinal and systemic illnesses through mechanisms such as controlling gut pH, enhancing immune responses and fostering beneficial microbial communities. The foundation for contemporary uses that go much beyond digestion was laid by historical insights from Pasteur's fermentation findings to Metchnikoff's early awareness of the advantages of probiotics. The necessity of a balanced diet full of a variety of nutrients is highlighted by the fact that the gut microbiome, with its enormous collection of microbes, is essential to metabolic, immunological, and physiological functions. While probiotics' effects can vary by strain and individual factors, ongoing research continues to demonstrate their promise in health maintenance and disease prevention. However, precise mechanisms and their full implications for health remain an area of active inquiry, necessitating further studies to deepen our understanding and optimize probiotic use. Diet, lifestyle and the careful use of supplements are integral in maintaining gut homeostasis and promoting overall well-being.

References

1. Abatenh, E., Gizaw, B., Tsegay, Z., Tefera, G., & Aynalem, E. (2018). Health benefits of probiotics. J Bacteriol Infec Dis, 2(1).
2. Albenberg, L. G., & Wu, G. D. (2014). Diet and the intestinal microbiome: associations, functions, and implications for health and disease. Gastroenterology, 146(6), 1564-1572.

3. Avery, E. G., Bartolomaeus, H., Maifeld, A., Marko, L., Wiig, H., Wilck, N., ... & Müller, D. N. (2021). The gut microbiome in hypertension: recent advances and future perspectives. Circulation research, 128(7), 934-950.
4. Becattini, S., Taur, Y., & Pamer, E. G. (2016). Antibiotic-induced changes in the intestinal microbiota and disease. Trends in molecular medicine, 22(6), 458-478.
5. Blaser, M. J. (2014). The microbiome revolution. The Journal of clinical investigation, 124(10), 4162-4165.
6. Cani, P. D. (2018). Human gut microbiome: hopes, threats and promises. Gut, 67(9), 1716-1725.
7. Choct, M. (2009). Managing gut health through nutrition. British poultry science, 50(1), 9-15.
8. Ernst, E. (1997). Colonic irrigation and the theory of autointoxication: a triumph of ignorance over science. Journal of Clinical Gastroenterology, 24(4), 196-198.
9. Fathima, S., Hakeem, W. G. A., Shanmugasundaram, R., & Selvaraj, R. K. (2022). Necrotic enteritis in broiler chickens: a review on the pathogen, pathogenesis, and prevention. Microorganisms, 10(10), 1958.
10. Galland, L. (2014). The gut microbiome and the brain. Journal of medicinal food, 17(12), 1261-1272.
11. Gasbarrini, G., Bonvicini, F., & Gramenzi, A. (2016). Probiotics history. Journal of clinical gastroenterology, 50, S116-S119.
12. Gates, E. J., Bernath, A. K., & Klegeris, A. (2022). Modifying the diet and gut microbiota to prevent and manage neurodegenerative diseases. Reviews in the Neurosciences, 33(7), 767-787.
13. Haneishi, Y., Furuya, Y., Hasegawa, M., Picarelli, A., Rossi, M., & Miyamoto, J. (2023). Inflammatory bowel diseases and gut microbiota. International journal of molecular sciences, 24(4), 3817.
14. Hemarajata, P., & Versalovic, J. (2013). Effects of probiotics on gut microbiota: mechanisms of intestinal immunomodulation and neuromodulation. Therapeutic advances in gastroenterology, 6(1), 39-51.
15. Hill, C., Guarner, F., Reid, G., Gibson, G. R., Merenstein, D. J., Pot, B., ... & Sanders, M. E. (2014). The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. Nature reviews Gastroenterology & hepatology, 11(8), 506-514.
16. Huang, R., Wu, F., Zhou, Q., Wei, W., Yue, J., Xiao, B., & Luo, Z. (2022). Lactobacillus and intestinal diseases: Mechanisms of action and clinical applications. Microbiological Research, 260, 127019.
17. Kechagia, M., Basoulis, D., Konstantopoulou, S., Dimitriadi, D., Gyftopoulou, K., Skarmoutsou, N., & Fakiri, E. M. (2013). Health benefits of probiotics: a review. International Scholarly Research Notices, 2013(1), 481651.
18. Kim, S. K., Guevarra, R. B., Kim, Y. T., Kwon, J., Kim, H., Cho, J. H., ... & Lee, J. H. (2019). Role of probiotics in human gut microbiome-associated diseases. 18(5), 1335-1340.
19. Latif, A., Shehzad, A., Niazi, S., Zahid, A., Ashraf, W., Iqbal, M. W., ... & Korma, S. A. (2023). Probiotics: mechanism of action, health benefits and their application in food industries. Frontiers in microbiology, 14, 1216674.
20. Lloyd-Price, J., Abu-Ali, G., & Huttenhower, C. (2016). The healthy human microbiome. Genome medicine, 8, 1-11.
21. Luo, M., Zhao, F., Cheng, H., Su, M., & Wang, Y. (2024). Macrophage polarization: an important role in inflammatory diseases. Frontiers in immunology, 15, 1352946.
22. Paone, P., Suriano, F., Jian, C., Korpela, K., Delzenne, N. M., Van Hul, M., ... & Cani, P. D. (2022). Prebiotic oligofructose protects against high-fat diet-induced obesity by changing the gut microbiota, intestinal mucus production, glycosylation and secretion. Gut Microbes, 14(1), 2152307.
23. Rajindrajith, S., Devanarayana, N. M., Thapar, N., & Benninga, M. A. (2023). Myths and misconceptions about childhood constipation. European journal of pediatrics, 182(4), 1447-1458.
24. Rhodes, J. M. (2021). Nutrition and gut health: the impact of specific dietary components–it's not just five-a-day. Proceedings of the Nutrition Society, 80(1), 9-18.
25. Sanders, M. E., Guarner, F., Guerrant, R., Holt, P. R., Quigley, E. M., Sartor, R. B., ... & Mayer, E. A. (2013). An update on the use and investigation of probiotics in health and disease. Gut, 62(5), 787-796.
26. Sehrawat, N., Yadav, M., Singh, M., Kumar, V., Sharma, V. R., & Sharma, A. K. (2021, May). Probiotics in microbiome ecological balance providing a therapeutic window against cancer. In Seminars in cancer biology (Vol. 70, pp. 24-36). Academic Press.
27. Shu, L. Z., Ding, Y. D., Xue, Q. M., Cai, W., & Deng, H. (2023). Direct and indirect effects of pathogenic bacteria on the integrity of intestinal barrier. Therapeutic Advances in Gastroenterology, 16, 17562848231176427.
28. Srivastava, A., Prabhakar, M. R., Mohanty, A., & Meena, S. S. (2022). Influence of gut microbiome on the human physiology. Systems Microbiology and Biomanufacturing, 1-15.

29. Taverniti, V., Cesari, V., Gargari, G., Rossi, U., Biddau, C., Lecchi, C., ... & Guglielmetti, S. (2021). Probiotics modulate mouse gut microbiota and influence intestinal immune and serotonergic gene expression in a site-specific fashion. Frontiers in Microbiology, 12, 706135.
30. Tilg, H., & Moschen, A. R. (2015). Food, immunity, and the microbiome. Gastroenterology, 148(6), 1107-1119.
31. Wang, X., Zhang, P., & Zhang, X. (2021). Probiotics regulate gut microbiota: an effective method to improve immunity. Molecules, 26(19), 6076.
32. Williams, N. T. (2010). Probiotics. American Journal of Health-System Pharmacy, 67(6), 449-458.
33. Wu, D., Ye, X., Linhardt, R. J., Liu, X., Zhu, K., Yu, C., ... & Chen, S. (2021). Dietary pectic substances enhance gut health by its polycomponent: A review. Comprehensive Reviews in Food Science and Food Safety, 20(2), 2015-2039.
34. Zhang, P. (2022). Influence of foods and nutrition on the gut microbiome and implications for intestinal health. International journal of molecular sciences, 23(17), 9588.
35. Zhao, H., Zhang, W., Cheng, D., You, L., Huang, Y., & Lu, Y. (2022). Investigating dysbiosis and microbial treatment strategies in inflammatory bowel disease based on two modified Koch's postulates. Frontiers in Medicine, 9, 1023896.