PERSPECTIVES

The Microbiome: A Foundation for Integrative Medicine

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Abstract

Context: No organ system better integrates interconnectivity across specialties and disciplines than the microbiome. Scientific focus is shifting from microbes as harbingers of disease toward microbes as symbiotic, balanced, commensal ecologies.

Objective: The study intended to discuss and examine the human microbiome, including its development in early life; its impact on various physiological processes that occur throughout the body; and its relationship to dysbiosis; and to investigate microbial mechanisms with clinical applicability across medical specialties.

Setting: The study took place at Biocidin Botanicals in Watsonville CA, USA.

Results: Accumulating research upholds the human microbiome as both a predictive biomarker for disease risk and a viable treatment option for modulating the course of illness. Prebiotic and probiotic interventions continue to demonstrate clinical utility, particularly for gastrointestinal, dermatological, inflammatory, metabolic, and mental-health disorders.

Conclusions: Just as germ theory revolutionized infection control in the twentieth century, microbiome systems science stands to transform the conceptualization of health as the balanced coexistence of human and microbial cells in the twenty-first century.

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In the blossoming era of integrative medicine, no organ system better integrates interconnectivity across specialties and disciplines than the microbiome.

Research on the microbiome continues to expand, broadening the understanding of the many ways in which microbiota impact human health. Scientific focus is shifting from microbes as harbingers of disease toward microbes as symbiotic, balanced, commensal ecologies. Medical paradigms must now adapt to this new framework, with integrative healthcare practitioners considering the microbiome's foundational role in supporting a whole-body approach to wellness.

The Microbiome

The trillions of microbes found throughout the human body include archaea, viruses, phages, fungi, and bacteria, with bacteria tending to be the most prominent microbiota, particularly in terms of species.[1] Known collectively as the microbiome, these microorganisms have co-evolved as integral to human physiology.

Microbiomes exist throughout the body, in the oral cavity, intestinal tract, esophagus, and lungs, on the skin, and elsewhere. Once thought of as a collection of freeloading commensal organisms that had simply found a ready source of food, the microbiota is now understood to exist in an intricate, symbiotic relationship with the host.[2]

The term microbiome encompasses the collective genome and activity associated with a specific host habitat or environment. It's involved in nutrient and xenobiotic metabolism and in the development and function of the endocrine system, immune system, and gut barrier.[3] Through intricate signaling networks, microbiota coordinate bidirectional communication between the environment and host. It's estimated that each person is inhabited by a microbiota consisting of 10^{14} organisms, outnumbering the number of host cells by an order of magnitude.[4]

Gut microbiota comprise 1000-1500 bacterial species. However, an individual's microbiome includes only approximately 160 bacterial species, indicating that the microbiome's composition differs substantially between individuals and is related to environmental changes and genetic inheritance.[5]

Bacteria prefer to live in communities referred to as biofilms, and this preference for community living, together with their remarkable communication abilities, gives bacteria an advantage within a microbiome. To build a community, bacteria communicate and interact with one another through small molecules known as autoinducers. Through a process known as quorum sensing (QS), they assess their numbers—intraspecies communication—and determine whether other bacterial species are present in the community—interspecies communication.[6] Biofilm colonies excrete a sticky matrix of molecules called extracellular polymeric substance (EPS) to create a mechanical barrier that protects the internal organisms.[7]

Development in Early Life

The gut microbiome's colonization and development is critical during the first years of life. A massive colonization of the infant's gut by different microorganisms starts at birth and may have long-lasting consequences owing to its intimate interaction with the immune system.

Several factors influence the development of the gut microbiome from childhood to adulthood, such as the mode of delivery—vaginal or cesarean; prematurity; antibiotic treatments; infant feeding practices—breastfeeding or formula feeding; introduction of foods; exposure to animals—pets; environmental exposures; number of siblings; or psychological stress.[8] During childhood, a significant increase occurs in microbial diversity, defined as the variety and abundance of species; while during adolescence, there is an increase in richness, defined as the larger total number of species.[9]

Microbial Ecosystems and Dysbiosis

The gut microbiota are part of an intricate ecosystem that comprises the indigenous microbiota, the host's mucosal epithelium, and elements of the host's immune system. As a stable ecosystem, interdependencies exist between the various components that contribute to the survival of each element. When balanced, this microbial ecosystem continually changes and adapts to support homeostasis and health. However, dysbiosis and the loss of key microbes contribute to disease onset and progression.

Dysbiosis is a compositional and functional alteration in the microbiota in individuals with disease compared with healthy people. It can feature a loss of beneficial microorganisms, an expansion of potentially harmful microbes, and/or a loss of overall microbial diversity. However, since researchers still don't agree on what constitutes a healthy microbiome, it's unclear how to define an impaired one. Due to the dynamic and changing nature of the microbiome, some researchers believe that the term dysbiosis isn't applicable, because it has no units and no adequate definition.[10]

Insights Across Medical Specialties

The microbiome is a common interface between the external and internal worlds, bringing together lifestyle, relationships, stress levels, nutrition, genetics, environment, and medical treatments. As such, it provides the framework for holistically caring for human beings rather than treating isolated symptoms.

Cutting-edge medical investigation continues to illuminate microbial mechanisms with clinical applicability across medical specialties.

Gastroenterology

Mainstream healthcare practitioners have begun to recognize and accept that microbial perturbation may cause or contribute to many gastrointestinal disorders rather than isolated colonic inflammation or dysfunction. For example, small intestinal bacterial overgrowth (SIBO) and intestinal permeability, or leaky gut, can allow translocation of antigenic bacterial components, which triggers downstream inflammatory cascades while altering bile-acid composition and metabolism.

Studies show that obese people with or without nonalcoholic fatty liver disease (NAFLD) have a higher incidence of SIBO and that those suffering from NAFLD exhibit increased intestinal permeability.[11] One study's authors, Gudan et al, found that intestinal dysbiosis, endotoxemia, and bacterial translocation can contribute to inflammation, which seems to disrupt the functioning of the gut-liver axis and can influence the incidence and progression of NAFLD.[11]

Neurology

Breakthroughs related to the microbiome-gut-brain axis continue to occur regarding the gut and neurological connections in emotional disturbances, psychiatric illness, and neurological disorders.

The gut-brain axis (GBA) connects the network of nerves in the gastrointestinal tract—the enteric nervous system—and the central nervous system (CNS) through multiple communication pathways. Communication is bidirectional, meaning the gastrointestinal tract influences the brain, and the brain, in turn, affects the gastrointestinal tract. Communication from the gut microbiome to the CNS primarily occurs through microbial-derived intermediates, with the best-described examples including short-chain fatty acids (SCFAs), secondary bile acids, and tryptophan metabolites.[12]

Accumulating evidence suggests that gut microbiota significantly influence the gut-brain connection, affecting mental state, emotional regulation, neuromuscular function, and regulation of the hypothalamic-pituitary-adrenal (HPA) axis.[13,14] Psychosocial stress may disrupt gut permeability and microbial balance to generate inflammation, driving anxiety and depression. Chronic-fatigue patients demonstrate overgrowth of D-lactic acid-producing bacteria, which can cross the blood-brain barrier and induce neurological symptoms.[15]

Healing intestinal permeability and correcting microbial disturbances can help attenuate systemic inflammation and resolve brain fog and fatigue. According to Chudzik et al., certain strains of prebiotics and probiotics can reduce clinical signs and symptoms of depression.[16] The future of neuropsychiatric medicine should integrate microbiome-modulating approaches through the gut-microbiome-brain nexus.

Endocrinology

Hormone modulation represents another avenue for interventional endocrinology by supporting optimal microbiome composition. The development and regulation of the hypothalamic-pituitary-adrenal axis and behavior are shaped by the gut microbiome. The organism's ability

to physiologically adapt to external stressors hinges on the essential functions of central integrative systems.[17]

Gynecology

Estrogen metabolism and elimination are intimately intertwined with the microbiome. The estrobolome is a specific collection of bacteria from the enteric microbiome whose products can influence estrogens. It metabolizes and modulates the body's circulating estrogen, which affects weight, mood, libido, and lifetime accumulation of estrogens.

Estrogen levels fluctuate with menstruation partially due to chemical transformation by specific microbes. These bacteria, through hormone modulation, can affect development in puberty and may underpin risks for hormone-responsive cancers.[18,19] In polycystic ovarian syndrome, rebalancing the microbiome appears foundational for restoring ovulatory cycles by reducing testosterone-mimicking metabolites of dysbiotic flora.[20] The microbiome also facilitates crosstalk between bone cells and immune components, which has spurred osteoporosis research on probiotic formulations to reduce inflammatory osteoclastic activity.[21]

Dermatology

The gut-skin axis (GSA) describes how the microbiome influences skin health and how the skin's immune-signaling and health, in turn, affect the microbiome. Compromise of the relationship between gut microbes and the immune system can trigger subsequent effects on the skin and even cause development of skin diseases.

Szari and Quinn have examined the use of probiotics and prebiotics, both of which modify the microbiome, for the prevention of eczema.[22] Additionally, numerous scientific studies in recent years have shown significant skin and gut dysbiosis among patients with psoriasis.[23] Olejniczak-Staruch et al found a positive influence for orally administered probiotics on the course of dermatosis.[23] Ultimately, microbial insight offers clinical benefit across specialties; it may serve as a predictive biomarker for disease risk and a therapeutic adjunct for modifying the course of illness.

Dentistry

In the mouth, a complex interplay occurs between microorganisms—bacteria, archaea, viruses, fungi, and protozoans, the immune system, and various habitats in the body. Chronic oral inflammatory conditions, such as gingivitis and periodontitis, are common, impacting nearly 50% of the population globally.[24]

Also, what grows in the mouth will grow in the gut, with 700+ species of bacteria residing there. One milliliter of saliva contains approximately 108 microbial cells, and individuals swallow one liter or more daily. A flourishing microbial community is essential for both oral and systemic health. Oral microbial dysbiosis contributes to various systemic issues and diseases, impacting the gastrointestinal system—inflammatory bowel disease, liver cirrhosis, and pancreatic cancer; the nervous system—Alzheimer's disease; the endocrine system—diabetes; pregnancy outcomes; obesity; polycystic ovary syndrome; the immune system—rheumatoid arthritis and HIV, and the cardiovascular system—atherosclerosis.[25]

Nutrition and Lifestyle

Perhaps most significantly, the microbiome represents integrative and lifestyle medicine's emphasis on circumstance, environment, and daily living patterns as fundamental foundations for health. Chronic stress, lack of sleep, smoking, toxin exposures, and ultra-processed diets disturb microbial ecology to generate inflammation and disturb resilience.

Restorative approaches such as yoga, nature immersion, and mindfulness meditation can help balance neurochemistry by nourishing a diversity of beneficial flora. Probiotic foods enrich the microbiome, which may have been damaged by antibiotic overuse or modern lifestyle habits that contribute to dysbiosis.

Beyond probiotics alone, traditionally fermented foods and spore-based probiotics nourish commensal microorganisms that biotransform phytochemicals from prebiotic plant foods into bioactive metabolites accessible to human cells. Essentially, each meal feeds our microbial cooperatives, which ultimately feed us; their metabolites becoming internal messengers that affect our physiology.

Future of Integrative Care

Accumulating research upholds the human microbiome as both a predictive biomarker for disease risk and a viable treatment option for modulating the course of illness. Prebiotic and probiotic interventions continue to demonstrate clinical utility, particularly for gastrointestinal, dermatological, inflammatory, metabolic, and mental-health disorders. Diet, stress reduction, and toxin avoidance can further help to prevent the microbial disruption underlying chronic disease.

The microbiome integrates lifestyle, environment, nutrition, and psychological-health foundations with applied functional medicine and psychoneuroimmunology. It provides the common language linking Eastern healing traditions emphasizing terrain—body ecology—and toxicity with Western mechanistic, precision medicine.

Integrative medicine built on systems biology and root-cause resolution requires a foundational framework. The microbiome offers the integral building blocks for that framework while supporting core integrative principles, such as doctor as teacher and patient empowerment.

Just as germ theory revolutionized infection control in the twentieth century, microbiome systems science stands to transform the conceptualization of health as the balanced coexistence of human and microbial cells in the twenty-first century. Integrative medicine based on this

microcosm-macrocosm continuity may prove ever more compelling and prescient in the coming decades.

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