20.7: Human Microbiome

Beneficial Microbes: The pharmacy in the gut

While some bacteria can cause disease, others play beneficial roles in human health. We have co-evolved with microbes in and on our body, with everyone having a unique set of microorganisms. The most abundant and well-studied microbiome is found in the gut. It has been estimated that the number of bacteria in the human gut may outnumber the cells in the body by an order of magnitude. Thus, one may consider the gut microbiome as a multicellular organ similar in size to the liver. Indeed, it is sometimes referred to as our “forgotten organ”.

Generally, the microbiome within a given body habitat can be defined as the diversity and abundance distribution of distinct types of microorganisms. This microbial composition is highly influenced by individual factors such as diet, age, lifestyle, ethnicity, and host health, among others. Although no taxa are observed to be universally present among all individuals, some microbial patterns demonstrate broad prevalence. Most bacteria belong to the genera *Bacteroides*, *Clostridium*, *Fusobacterium*, *Eubacterium*, *Ruminococcus*, *Peptococcus*, *Peptostreptococcus*, and *Bifidobacterium*.

The evolution of microbiome during life

Recent research suggests early in-utero microbial exposure during pregnancy. Following birth, the newborn’s digestive tract is quickly colonized by microorganisms from the mother (vaginal, fecal, skin, breast milk, etc.) and the environment in which the delivery takes place. Following birth, the microbiome that enters and evolves in the infant's gut is dependent upon a number of factors, with delivery mode and feeding regime (breastfeeding vs infant formula feeding) of prime importance in the early days and weeks of life. By the age of 2 to 3 years, the microbiome becomes essentially established, having reached a steady state, and remains relatively stable throughout life. However, the gut microbiome continuously changes in response to daily variations in diet, lifestyle, age, and host physiological and immunological health.
Health benefits of the microbiome

On the basis of the currently available literature, the gut microbiome is known to contribute to a number of important functions in the host, from protective, immunomodulatory, metabolic to trophic roles. These are promoted via a number of mechanisms. For example, members of the gut microbiome can produce anti-inflammatory factors, pain relieving compounds, antioxidants, and vitamins to protect and nurture the body. Additionally, they may prevent attachment and action of harmful bacteria that can produce toxins causing chronic disease. This close and specific contact with human cells, exchanging nutrients and metabolic wastes, makes symbiotic bacteria essentially a human organ.

Gastrointestinal infection prevention

The indigenous intestinal microbiome serves as a line of resistance to colonization by exogenous microbes such as *Clostridium difficile* and *Helicobacter pylori*, and thus assists in competitive exclusion of pathogens preventing the potential invasion, termed colonization resistance. Indeed, antibiotic-associated diarrhea occurs when antibiotic treatment disturbs the natural balance of the gut microbiome causing harmful bacteria (i.e., *Clostridium difficile*) to proliferate and multiply. Oral probiotics may reduce antibiotic-associated diarrhea significantly.

![Schematic representation of the cross-talk interaction of indigenous microbiome and oral probiotics with the intestinal epithelium. Intestinal microbiome protects the mucosa from invasion by pathogens. These probiotic bacteria may also allow beneficial effects through the release of nutrients (vitamins, SCFAs sugars) which are absorbed in the small intestine. Human microbes and probiotics would also interact with MALT macrophages and naive lymphocyte cells, allowing a mucosal anti-inflammatory response.](https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/20%3A_Immune_Sy...

Immunomodulatory effects

Commensal bacteria can interact with the host immune system in ways that control the host's immune response and counteracts the development of the disease. The complex interactions that may occur between ingested probiotic bacteria, commensals and the mucosal surface are possible because of the mucosa-associated immune system, typically organized into MALT (Mucosal Associated Lymphoid Tissue, such as Peyer's patches). This cross-talk interaction enhances cellular immune response characterized by activation of macrophages, antigen-specific cytotoxic...
T-lymphocytes, and the release of various cytokines. Furthermore, some probiotics may be effective in the prevention and/or alleviation of allergies and auto-immune diseases like irritable bowel syndrome and inflammatory bowel diseases (Crohn’s disease and ulcerative colitis).

Nutritional benefits

The metabolic activity of the gut microbiome makes an important contribution to the nutritional status of the host, via its ability to synthesize certain vitamins and various bioactive metabolites, such as short-chain fatty acids (SCFA) that then become bioavailable to the host. It has been reported that consumption of yogurt containing *Lactobacillus bulgaricus* or *acidophilus* could alleviate lactose intolerance during gastric passage through their enzyme lactase. However, the major metabolic function of the colonic microflora is the fermentation of nondigestible carbohydrates, which are key sources of energy in the colon. These carbohydrates also include large polysaccharides (i.e., resistant starches, pectins, and cellulose) and some oligosaccharides that escape digestion, as well as unabsorbed sugars and alcohols. Other benefits of the gut microbiome on human health, such as a role in supporting the health of the reproductive tract, oral cavity, lungs, skin, and gut-brain axis is currently under investigation.

Probiotic imbalance

When the normal composition of the microbiome is thrown off balance there is a potential risk of disease. A decrease in microbiome diversity has been linked to cancer, asthma, Parkinson, obesity, Alzheimer, type-2 diabetes, cardiovascular disease and possibly even autism in comparison to healthy subjects. Over the counter probiotics can help. In order to arrive alive to their workplace (i.e. the gastrointestinal tract), orally administered probiotics must be able to resist stomach acid, bile and the effects of digestive enzymes. Certain mechanisms of action (such as the delivery of certain enzymes to the intestine) may not require live cells to play a physiologic benefit. Hence, a probiotic must contain as many live bacteria as claimed on the label. In addition, to survive the stomach and arrive at the intestine in optimal numbers, probiotic strains must be able to adhere to the intestinal epithelium and/or mucus, persist and multiply in the gut to maintain its metabolic activity and confer their probiotic properties in the human body.

Summary

- Probiotics are generally recognized to be a good form of therapy to keep harmful, intestinal microorganisms in check, aid digestion and nutrient absorption, and contribute to immune function.
- Probiotics are reported to improve microbial balance in the intestinal tract.
- Local microbiome and oral probiotics synthesize certain vitamins and various bioactive metabolites for their host.
- The gut microbiome maintains a person healthy. Imbalance in the quantity and quality of the bacteria may lead to various metabolic and mental diseases.

Resources

- BIOENGINEERED, 2016, VOL. 7, NO. 1, 11–20: [http://dx.doi.org/10.1080/21655979.2015.1126015](http://dx.doi.org/10.1080/21655979.2015.1126015)
- REVIEW: Beneficial Microbes: The pharmacy in the gut, Daniel M. Linares, Paul Ross, and Catherine Stanton,
The bacteria in our guts can break down food the body can't digest, produce important nutrients, regulate the immune system, and protect against harmful germs. And while we can’t control all the factors that go into maintaining a healthy gut microbiome, we can manipulate the balance of our microbes by paying attention to what we eat. Shilpa Ravella shares the best foods for a healthy gut.

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