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Exploring the Fascinating Microbial World within Us

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Abstract: ***Microbes are the smallest living organisms of the biosphere which are not visible to naked eyes & are well known for their intriguing features. They inhabit nearly all places of this planet, both hospitable & inhospitable ones. They have the greatest diversity in nutrition pattern, habit & habitat, forms etc. They play a key role in ecological balance & a world without them is difficult to imagine. But have you ever that besides living in such a varied environment they also live within us ? Does a human body harbor microbes? If yes, then what type of microbes, what is their location & what role do they play in our body? This article answers all these questions.***

Keywords: Microbiota, Microbiome, Prebiotics, Symbiosis, Dysbiosis, bacteriocins, conjunctival microbiota, colonic bacteria, opportunistic bacteria

1. Introduction

Microbes are the smallest living organisms of the biosphere which are not visible to the naked eyes and are well - known for their intriguing features. They inhabit nearly all places on this planet both hospitable & inhospitable ones, like hotsprings, deep - sea hydrothermal vents, alimentary canals of ruminants, salt marshes etc. The most surprising discovery made after years of research on microbes & human body is that microbes even exist within us. Not only one or two types, rather a whole diversified group of microbes including viruses, bacteria, archae, protists, fungi etc. inhabit different tissues & organs of our body. Though it is known that viruses & bacteria are usually pathogens but beneficial microbes exist in our body & help in key physiological functions. An estimate shows that there are about 10 times as many microbial cells in our body as there are human cells. It includes around 380 trillion viruses & trillions of bacteria ($3.8 * 10^{13}$ in a 70 kg "reference man"). Scientists say that only 43% of the body's total cell count is made up of human cells, the rest are microscopic colonists. Another estimate has shown that human genome has 23000 genes where as human **microbiome** has more than 10, 00, 000 genes. Further 99% of our DNA genes are in microbe cells. This whole ecological community of mutualistic, symbiotic, pathogenic & commensal microbes subsisting in & on the body of all multicellular organisms is termed as **microbiota/ microflora/ microfauna.**

2. The Intriguing Human Microbiota

Microorganisms survive in different places of human body, adjusting to its surrounding conditions & in a way provide benefits to the health and well being. Let's see the microbiota of our different organs, how they came into existence, their role & how age & other factors affect the microbiota.

The Gut Microbiota:
The collection of bacteria, archae & eukarya colonizing the human gut predominantly in the colon is called gut microbiota/ gut flora. After birth due to illness, intake of medicines & changes in diet - gut microbiota develops. Gut microbiota differs from person to person depending on an individual's mode of delivery, diet & age. Like vaginally delivered babies contain abundant lactobacilli while C - section infants have more *Clostridium* species. Fecal microbiota of vaginally delivered babies shows greater resemblance to their mother's microbiota. Similarly in early stages of development there is a low diversity of microbiota, dominated only by two phyla, Actinobacteria & Proteobacteria. During the first year of life, the microbial diversity increases and by around 2.5 years of age the composition, functions & diversity of infant microbiota resembles those of adult microbiota. In adulthood, although composition of gut microbiota is stable but still it is subject to certain changes & over the age of 65, there is an increased abundance of Bacteroidetes & *Clostridium* cluster IV. Gut is the place of our body which harbors the maximum microbial diversity including these five major types of gut microflora - **Actinobacteria, Firmicutes, Bacteroidetes, Proteobacteria & Verrucomicrobia.** Apart from these some **opportunistic bacteria** which take advantage of disrupted gut microbiota or breached integumentary barriers are also found. Some of the most vital roles played by these microbes are to help maintain the integrity of mucosal barrier, to provide nutrients or to protect against pathogens. **Colonic bacteria** ferment complex carbohydrates into metabolites such as short chain fatty acids (acetate, butyrate & propionate). Acetate is produced by Bacteroidetes and butyrate by Firmicutes. Lactic acid bacteria are key organisms in production of vitamin B12. *Bifidobacteria* are the main producers of folate. Several other vitamins like vit K, riboflavin, biotin, nicotinic acid, pantothenic acid, thiamine & pyridoxine are also synthesized by gut microbiota.

The microbiota populations are also affected by diet. High - carbohydrate diets favor the *Prevotella* genus while high - protein & high - fat diets favor Bacteroidetes microbial species. Degradation of proteins occurs at the distal end of colon where conditions are suitable for secretion of proteolytic bacteria. Dietary fibres like starch, insulin, oligosaccharides are partially degraded by bacterial species in the colon while cellulose cannot be degraded by bacteria. These undegraded & semi - degraded fibres are then excreted through feces. Some carbs like starch & non -

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starch polysaccharides which cannot be metabolized by the host, act as important energy source for microbial growth (called **prebiotics -** non - digestible component of food that benefits the host by stimulating the growth of microbiota) and can be degraded by proteolytic enzymes into short chain fatty acids & various gases. Consumption of western diet rich in fat & low in fibres reduces the amount of reduced Bacteroidetes & increases increased Firmicutes resulting in obesity. Eating less veggies & fruits reduces population of microbiota which in turn enhances triglyceride level, inflammation, insulin resistance & LDL cholesterol - all these are the prime causes of diseases & this dysregulation of immune system of the host is called **Dysbiosis.** On the other hand, consumption of a balanced Mediterranean diet & foods rich in fibres & low in fats balances the GIT microbial composition which regulates the immune system and protects the host from various diseases, this condition of healthy gut flora is called as **Symbiosis**. A plant - based polysaccharide rich diet reduces reduced Firmicutes & increases increased Bacteroidetes thus increasing gut transit time. GI microbiota composition & function has also been linked to aging, obesity, cirrhosis, heart's activity, neuro-developmental & cardiovascular diseases.

Intake of antibiotics also disrupts the gut microbiota since they kill the good commensal bacteria and it takes time for them to colonise again. So often we don't feel like eating when we are taking our prescribed antibiotics and hence the doctor prescribes **probiotics** (spores of bacteria enclosed in capsules), jelosil, digene etc. to counter the drastic effects of antibiotics.

Skin Microflora:
The skin is another habitat for many microbes, especially bacteria. The type & density of bacteria are determined by anatomic location, local humidity, amounts of sebum & sweat production and the hormones & age of the host. Prenatally human skin is sterile but after birth it becomes a resident of commensal, symbiotic or parasitic bacteria. Many commensal bacteria of skin flora protect the host from pathogenic bacteria directly (ex - *Staphylococcus aureus* stain 502A release species - specific antibiotic substances called **bacteriocins** that inhibit other virulent staphylococcal organisms) & indirectly as bacteria can induce the host to produce cytokine or stimulate phagocytosis (ex - *Propionibacterium acnes* release fatty acids from lipid breakdown acidifying skin's environment & inhibiting the growth of *Streptococcus pyogenes*). Actinobacter inhabit the dry areas of skin, lipophilic bacteria like *Corynebacterium striatus* & *Propionibacterium* colonize areas rich in lipids or sebum and moist areas have abundance of *Staphylococcus* & *Corynebacterium* species. All these bacteria help in maintaining cutaneous immunity and normal skin pH.

Eye Microflora:
Human eye also contains microbiota which includes bacteria like *Chlamydia trachomatis, Haemophilus influenzae, Staphylococcus aureus, Moraxella* spp., *Staphylococcus viridans* and some viruses like the Torque Teno Virus (TTV), the Merkel Cell Polyomavirus (MCP) and Human Papillomavirus (HPV) – found on the conjunctiva and the cornea. But the ocular microbial population is very small because our tears contain antimicrobial enzymes called bactericides, like lysozyme, which breakdown their cell walls and make it difficult for them to survive and reproduce. However some pathogens like *Neisseria gonorrhoeae* are able to infect conjunctiva since they have special processes which help them to attach to the epithelium of conjunctiva. The **conjunctival microbiota** in normal conditions plays an important role in healthy functioning of the eye. But in immune compromised, after ocular surgery or trauma, these bacteria can be a main source of infection. Research has also shown that there is no significant difference in microbial florae in right and left eye, older patients harbor more bacterial colonies than young and males have a more sterile conjunctival sac than females.

ENT Microflora:
Our nose, nasal cavity and nasopharynx consist of some important microflora adhering to the epithelial layer. Micrococcus, *Corynebacterium, Bifidobacterium, Haemophilus* spp. etc are the normal flora of nose while *E. coli* and *Proteus* spp. can be found in the nasopharynx. Despite of several constraints these microbial populations survive here and provide some benefits like commensal bacteria suppress opportunistic pathogen colonization and even directly kill or inhibit their growth by secreting toxins. The outer ear, being moist and warm and containing cerumen, is a favorable place for microbes to live (ex - *Staphylococcus epidermidis, Propionibacterium acnes* etc). Inner ear being filled with lymph fluid is not colonized by any microbes. Throat contains Actinomycetes, *Bordetella, Enterococcus, Streptococcus, Lactobacillus* etc. Species of some bacteria may turn opportunists provided favorable conditions are present. For example, beta - *Hemolytic streptococci* responsible for tonsillitis are predominant among opportunistic normal flora.

3. Conclusion

So as we can see microorganisms colonize nearly all vital parts of our body. They help regulate our normal metabolism and homeostasis, thereby protecting us from pathogenic or disease - causing microbes. But any imbalance caused to the composition or function of the microbial community of our body by unhealthy lifestyle can make some of them opportunists which harm our body. A healthy microbiota is the key to healthy living. And to keep our microbiota in its normal state we have to take good care of every organ of our body. Research is going on to know more about our peculiar microbial friends.

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