More than a gut feeling: The science behind the human gut microbiome

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The human gut microbiome is many things. It includes microbes we inherit from our mothers during birth and through breastfeeding. It can change because of diet, stress, and anxiety management, amongst other factors. But what is the microbiome, and how does it relate to human health?

The term 'microbiome' was coined to describe the collective community of bacteria, viruses, fungi, and other microbes that colonise a particular space or ecosystem – for example, the soil. Indoor spaces like homes, offices, and hospitals also have distinct microbiomes, as do all surfaces and objects. And most life forms have their own microbiomes that adapt to and take advantage of the conditions presented by the host. But aren't bacteria the cause of diseases like tuberculosis or pneumonia?

IS BACTERIA GOOD OR BAD?

This is where the concept of beneficial bacteria (those that help our health) and pathogenic bacteria (those that cause diseases) becomes relevant. Many bacteria live in and on our bodies and contribute to maintaining health. 'The human body has several distinct microbiomes on the skin, in the mouth, and in our airways,' explains Prof. Godfrey Grech from UM's Department of Pathology. 'That is known as a mutualistic symbiosis – a relationship where both the bacteria and the host (us) benefit.'

But how do we benefit? One of the most consequential microbiomes for human health is the gut microbiome in the digestive system. According to Grech, approximately 100 trillion bacteria live in our large intestine (also known as the colon). That is 12 thousand times more bacteria in one person than there are people in the world!

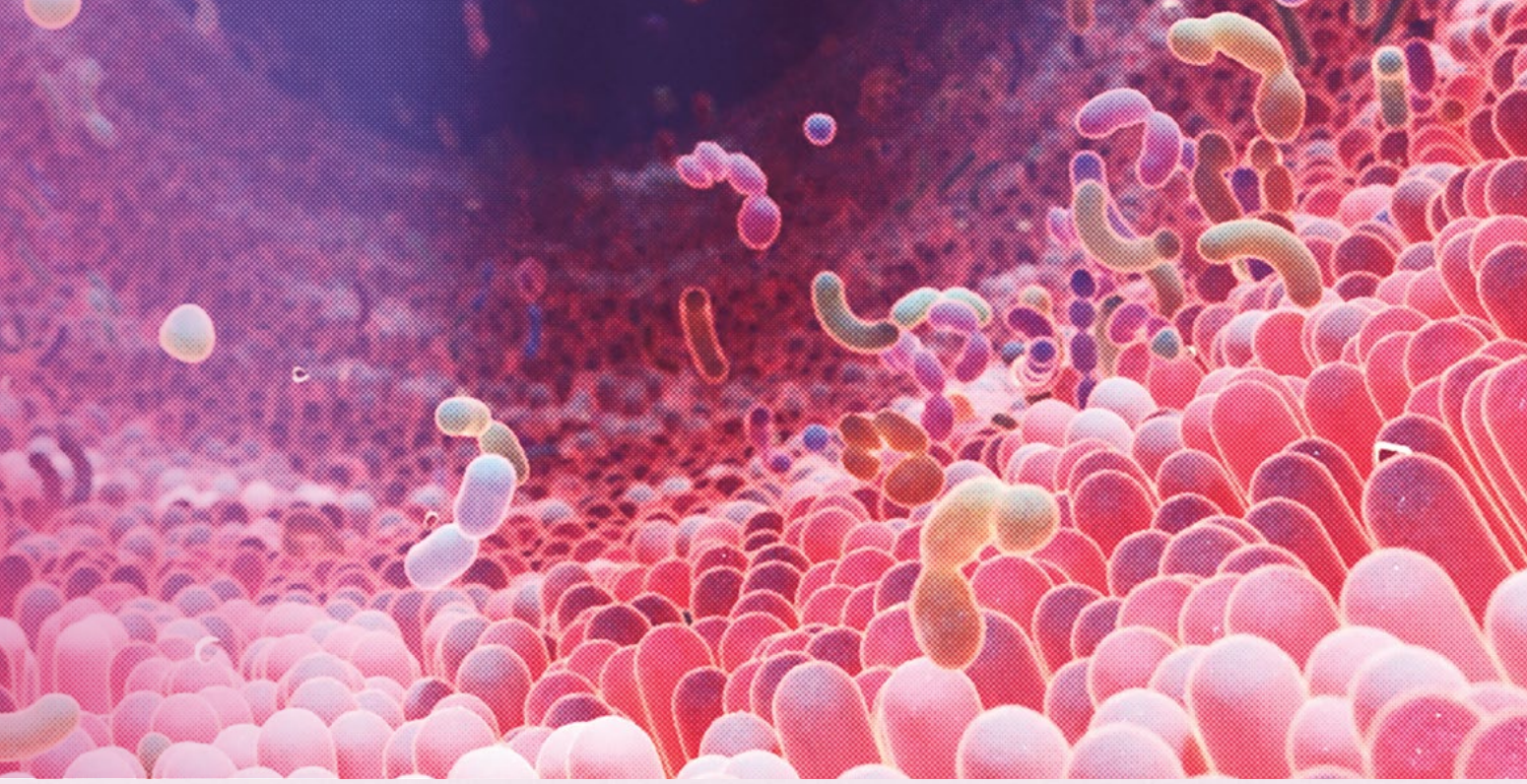
The gut microbiome is responsible for constantly exchanging chemical signals with the body's cells and helping digest nutrients. This microbiome does things that the gut can't, such as:

- liberating or synthesising nutrients from food, especially from plants and their polyphenols;
- living off non-digestible substrates like fibre;
- producing thousands of metabolites (useful chemicals);
- making vital short-chain fatty acids that are involved with immunity;
- keeping the gut and colon healthy; and
- moderating the body's inflammatory responses.

However, the gut microbiome relies on a careful balance of certain types of bacteria. When off balance, dysbiosis of the gut microbiota occurs, which leads to several diseases.

HOW THE GUT MICROBIOME AFFECTS EVERYTHING

The gut microbiome is deeply interconnected with various human systems like the brain, immune system, liver, metabolism, and even the lungs.



However, this also means that when the gut is in dysbiosis, the body may also experience anxiety, depression, hypertension, cardiovascular diseases, obesity, diabetes, inflammatory bowel disease, and cancer.

Taking a closer look at the gut-brain link, 'up to 90% of neurotransmitters are produced in the gut,' explains Grech. 'This includes serotonin, the happy hormone, and dopamine, the reward hormone.' That means that even neurotransmitters that are involved in social behaviour are affected and regulated by the gut microbiome. 'So even what we call butterflies in our stomach is an example of hormonal regulation and just goes to show how complex this gut-brain relationship is,' laughs Grech. When we are nervous, stress hormones like adrenaline or cortisol are released, which can stop the intestines from functioning or increase the blood flow to certain stomach areas, creating that feeling.

The link between systems can be negatively affected by stress, lack of sleep, poor nutrition, and no exercise. For example, chronic stress elevates cortisol levels, impeding gut motility and altering microbial composition. This creates a vicious cycle, where an imbalanced microbiome further influences mood and stress responses.

The same is observed for immunity. In the intestines, the helper T cells are key players in maintaining a balance between immune defence against harmful pathogens and tolerance to beneficial bacteria and food antigens. In cases of a prolonged imbalance, these cells change their properties, and instead of suppressing the remaining immune cells, they will start activating them. This leads to chronic inflammation that drives more immune problems. These effects suggest the importance of understanding more about how the gut microbiome affects other parts of the body.

MICROBIOME AND PUBLIC HEALTH IMPLICATIONS

Despite significant advancements, studying the microbiome presents unique challenges. Sampling methodologies, such as relying on faecal samples as proxies for intestinal microbiota, introduce variability that age, individual routines, and hormonal levels only exacerbate. Furthermore, the dynamic and individualised nature of the microbiome itself also complicates comparisons across individuals.

'Still, it all depends on the question that we want to answer,' says Grech. Up until now, regulating gut inflammation through dietary and lifestyle interventions offers promising avenues for mitigating related conditions. In severe cases and when pathogenic bacteria take over, faecal microbiota transplants are used. However, integrating early microbiome-based diagnostics could enhance accuracy and reduce unnecessary procedures in all cases.

Prevention strategies are also gaining momentum in microbiome research. Promoting dietary diversity and reducing exposure to endocrine disruptors may preserve microbial balance, mitigating risks of chronic diseases. The need to understand the gut microbiome and its links across the body extends beyond individual health, bearing implications for public health and preventive medicine as well. And so inevitably, the microbiome's role in nutrient metabolism only makes it all the more vital in our approach to addressing malnutrition and fostering healthier populations.