



THE HUMAN MICROBIOME AND ITS ROLE IN KEEPING US HEALTHY

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YOUNG REVIEWERS:



ABBAS
AGE: 13



ABED
AGE: 11



ABDULLAH
AGE: 13



ARWA
AGE: 14



BLQEES
AGE: 10



FATIMA
AGE: 11



HASSAN
AGE: 14

Humans are complex ecosystems made up of human cells and small organisms called microbes. The diverse group of microbes living in and on the body is called the microbiome. By looking at the genes of these organisms, the Human Microbiome Project showed that each part of the body has its own set of microbes. For the body to be in good health, the microbiome must be in balance. The microbiome keeps us healthy in several ways. For example, it helps digest and absorb nutrients, train the immune system, and protect us from harmful microbes and chronic infections. Changes to the normal composition of the microbiome, known as dysbiosis, can lead to certain diseases. In this article, we will explain the role of the microbiome in maintaining human health. We will also explain the influence of factors like genes, age, diet, antibiotic use, lifestyle, and others on the composition of the microbiome and some of the diseases that can result.

MICROBES

Comprise a variety of microscopic organisms, such as bacteria, viruses, fungus, archaea, and some protist species.

HUMAN MICROBIOME

The bacteria, viruses, fungi, and other microbes that live on or inside the human body.

IMMUNE SYSTEM

Is a complex network of organs, cells, and proteins. It serves to protect the body from infections.

METABOLISM

Refers to the collection of metabolic activities necessary for life to exist within an organism.

DYSBIOSIS

A change or imbalance in the composition of the human microbiome, usually associated with disease.

DIVERSE

Is an adverb that refers to a variety of distinctions, variations, or differences within a system, group, or environment.

WHAT IS THE MICROBIOME?

Human bodies are complex ecosystems that contain both human cells and many microorganisms called **microbes**, including bacteria, viruses, and fungi. Collectively, all of these microbes are called the **human microbiome** [1]. The human microbiome is made up of trillions of microbes that live in or on our skin, mouths, noses, intestines, and other body areas [2]. The exact composition of the human microbiome varies from person to person, and it is influenced by a variety of factors, including each person's diet, age, genes, and lifestyle. These microbes can affect the **immune system**, **metabolism**, and even our moods and behaviors! They also help us digest food, they produce vitamins, and they protect us from harmful bacteria that could cause disease. The human microbiome is very important for scientists to study since it plays so many roles in keeping our bodies healthy.

When the human microbiome is disrupted—a condition called **dysbiosis**—many diseases can result. These diseases include inflammatory bowel disease, celiac disease, allergies, asthma, diabetes, and even cancer. Research tells us that staying healthy requires maintaining the balance and health of the microbiome.

WHERE ARE THESE MICROBES FOUND?

The human microbiome was first discovered by Anthony van Leeuwenhoek of the Netherlands, in the early 1700s. He used a microscope to examine samples taken from the mouth and other samples taken from poo. He observed the presence of microorganisms in these samples and detected variations in the odor between the samples. Later research found that microbes live in several main sites in the body, which we will briefly describe (Figure 1).

Gut

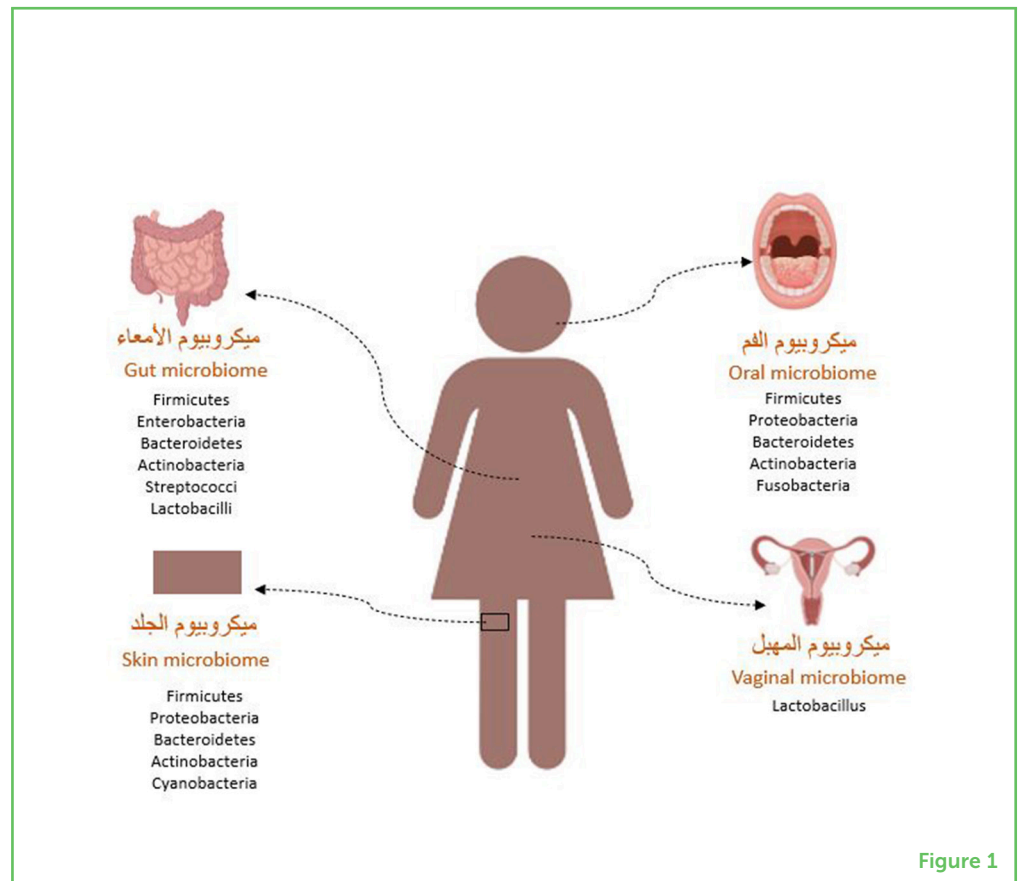
The gut microbiome is the most studied and most diverse group of microorganisms in the human microbiome. It consists of trillions of microorganisms that live in the digestive system, including viruses, fungi, bacteria, and others. These organisms play an important role in food digestion, the production of vitamins, and the regulation of the immune system. Imbalances in the composition of the gut microbiome can lead to various gastrointestinal issues like inflammation of the small intestine, which can contribute to several diseases such as inflammatory bowel disease (IBD), Crohn's disease, or celiac disease. Additionally, this imbalance can also lead to obesity, type 2 diabetes, and other diseases.

Mouth

The oral microbiome is the group of microorganisms that live in the mouth. The mouth is home to the second most **diverse** microbial

Figure 1

The human microbiome consists of all the microbes living on or in the human body, but the organisms that make up the microbiome vary across regions of the body. The names of the major types of bacteria found in each region are listed. The figure was created with BioRender.com.



community in the human body, with more than 1,000 species of bacteria. The human oral microbiome varies greatly from birth to adolescence [3]. It evolves and becomes more diverse as a child grows up. The oral microbiome plays a vital role in maintaining oral health and preventing tooth decay. Oral microbiome disorders can cause gingivitis and bad breath.

Skin

The skin is the barrier between the body and the environment, and it is home to a large variety of microorganisms. These microorganisms are a natural part of normal skin and play important roles in protecting it from diseases and maintaining its health and function. The skin microbiome is affected by biological factors such as age, genes, sex, diet, and hygiene, and by environmental factors such as humidity and temperature. Changes in the composition of the skin microbiome can result in skin problems such as acne, eczema, and psoriasis [4]. An understanding of the skin microbiome and its interactions with biological and environmental factors could lead to new methods of keeping the skin healthy and treating skin diseases.

Vagina

The vaginal microbiome refers to the group of microorganisms that live in the vagina. It is essential for maintaining vaginal health

PROBIOTICS

Refers to live microorganisms that are meant to improve health when ingested or used topically.

and preventing infections. The vaginal microbiome is affected by many factors, including hormones, sexual activity, contraceptive use, and personal hygiene practices [5]. The composition of the vaginal microbiome can change for many reasons, including sexually transmitted diseases. Research has indicated that using **probiotics**, such as supplements containing *Lactobacillus* strains, can help to maintain a balanced microbiome, which in turn may maintain vaginal health. On the other hand, certain medicines like antibiotics can cause imbalance in the vaginal microbiome.

WHAT CAN AFFECT THE HUMAN MICROBIOME?

In all parts of the body, the human microbiome can change. This means that types of organisms can increase or decrease in number, depending on many factors (Figure 2). Here are just some of the factors that can affect the composition of the human microbiome:

- **Genetic makeup:** An individual's genes can affect the diversity of the body's microbiome. Individuals that secrete H antigens and have an active FUT2 gene, for instance, typically have a more varied gut microbiota with a wider variety of bacteria that can use these glycans as an energy source. However, those who lack these glycans in their gut due to a non-functional FUT2 gene (also known as non-secretors) may have a less diversified microbiome because some bacteria may not be able to grow in the absence of these carbohydrates.
- **Method of birth:** Babies born by natural (vaginal) birth receive the mother's vaginal microbes. Babies born by Cesarean section are exposed to the mother's skin microbiome and microbes from the surrounding environment. Breastfeeding can also affect the formation and development of a baby's microbiome.
- **Diet:** Diet is one of the most influential factors in the formation and function of the human microbiome [6]. Food ingredients, such as fiber, carbohydrates, proteins, and fats, can make some bacterial species reproduce faster than others. A diet rich in processed foods, added sugars, and unhealthy fats can negatively affect the microbiome by decreasing beneficial bacteria and increasing harmful bacteria.
- **Lifestyle and environmental factors:** Various factors, including daily hygiene, use of antimicrobial products, exposure to pollution, and physical activities can affect the composition and diversity of the microbiome.
- **Medications:** Some medicines, especially antibiotics, significantly affect the composition of the human microbiome. While antibiotics can kill harmful bacteria that cause disease, they can also kill bacteria that are beneficial to human health. This can lead to an imbalance in the microbiome. Studies have found that some

beneficial bacterial species may be permanently lost or greatly reduced after a course of antibiotics.

- Age: Some changes in the microbiome's composition and function occur as we age. At birth, the microbiome is relatively simple, but it diversifies rapidly and becomes more stable as a baby grows. Microbiome diversity during childhood is important for developing the immune system, which helps to keep children healthy.

Figure 2

(A) When the human microbiome is in balance, it contributes to health in many important ways. (B) Several factors can upset the composition of the microbiome, disturbing the balance, and leading to an unhealthy condition called dysbiosis. (C) Human microbiome dysbiosis is associated with several diseases and disorders. The figure was created with BioRender.com.

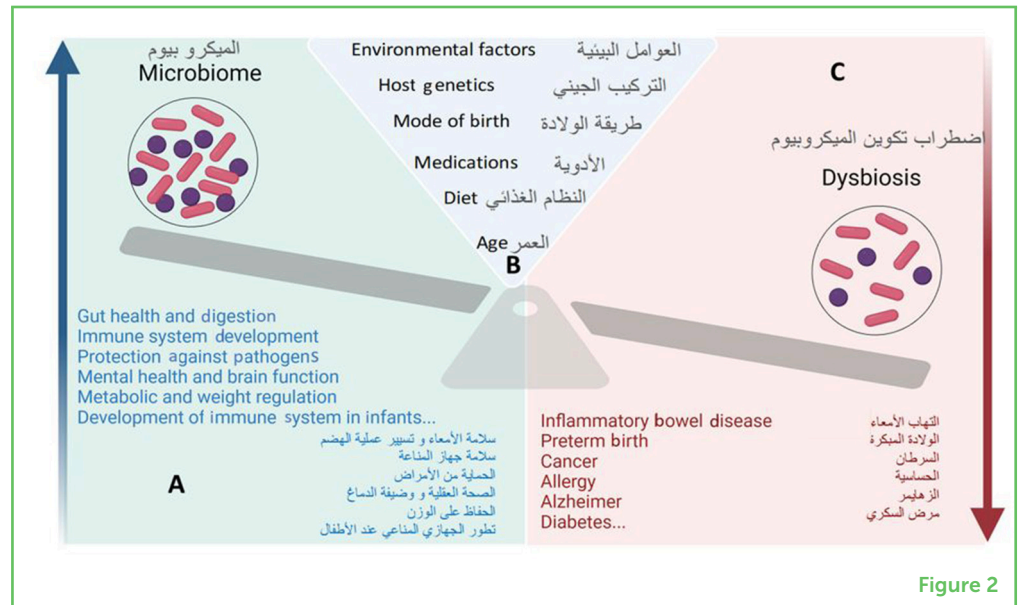


Figure 2

HOW DOES THE MICROBIOME KEEP US HEALTHY?

We have already mentioned some of the ways that the human microbiome helps to maintain human health. Here are some key points that highlight the microbiome's importance in keeping us healthy:

Gut Health and Digestion

The gut microbiome plays a vital role in digestion and nutrient absorption. By producing digestive enzymes that humans cannot make, the gut microbiome helps us to digest complex carbohydrates and fiber that our bodies could not digest on their own. Microbes also manufacture vitamins that are important in a healthy diet, such as vitamins K and B.

Protection From Diseases

The microbiome is considered a barrier against disease-causing organisms. For example, in women, certain bacteria in the healthy vaginal microbiota produce lactic acid, which creates an acidic environment that helps prevent the growth of harmful bacteria that can cause an infection called bacterial vaginosis [7].

Mental Health and Brain Function

Research shows a strong relationship between the gut microbiome and mental health. The microbiome produces natural “feel-good” chemicals such as serotonin and dopamine, which are essential for regulating mood and behavior. The gut microbiome also has its own two-way communication system with the brain, via the nervous system. Changes in the composition of the microbiome have been linked to several mental health disorders, including anxiety and depression, and some brain diseases such as Alzheimer’s disease and autism.

Healthy Weight

The composition of the gut microbiome has been associated with weight-related diseases, such as obesity and type 2 diabetes. Some microbes can affect the way energy is extracted from food and some can also affect the way fat is stored in the body. Notably, the digestion of complex carbohydrates and the fermentation of dietary fibers are both facilitated by the gut microbes. However, short-chain fatty acids (SCFAs), which act as an energy source and communicate hunger with the brain, are created because of these processes. This may support calorie and appetite regulation and consequently, it maintains a healthy weight.

Development of the Immune System

The first years of life are crucial for the development of the immune system. During this stage, exposure to various microbes helps the immune system to form properly. A healthy immune system reduces the risk of allergies, asthma, and autoimmune diseases later in life.

CONCLUSION

In conclusion, the human microbiome plays an important role in maintaining human health. The factors affecting its composition may vary. A balanced and diverse microbiome provides a variety of benefits, including proper digestion, absorption of nutrients, regulation of the immune system, and protection from pathogens. However, disorders or imbalances in the composition of the microbiome lead to various diseases, including inflammatory bowel disease, allergies, diabetes, and even mental health issues.

Understanding the relationship between the microbiome, health, and disease is a broad field of scientific research. While more research is still needed, efforts are underway to develop microbiome-based treatments and therapies, such as probiotics, probiotic nutrients mean the nutrients and chemicals that support the growth and activity of probiotics, and gut microbiome transplantation which is a medical treatment in which the fecal matter from a healthy donor is

transplanted into the gastrointestinal tract of a recipient to restore or modify their gut microbiome, and this fecal matter contains a diverse variety of microbes. Overall, the study of the human microbiome could change our ideas about health and how we manage disease.

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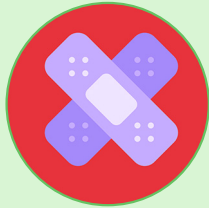
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YOUNG REVIEWERS

ABBAS, AGE: 13

I am Abbas from Kuwait and I am in middle school. One of my hobbies is writing comic books, and I want to become a psychologist.



ABED, AGE: 11

Abed wants to become a doctor when he grows up. He is from the Kingdom of Saudi Arabia, Mecca in particular. He loves reading and enjoys discussing what he reads with friends. He enjoys reading stories, novels, and science, especially biology. Abed has many hobbies such as swimming and football. He is also talented in drawing.

ABDULLAH, AGE: 13

Abdullah wants to become a doctor when he grows up. He is from the Kingdom of Saudi Arabia, Mecca in particular. He loves reading and enjoys discussing what he reads with friends. He enjoys reading stories, novels, and science, especially biology and physics. Abdullah has many hobbies such as swimming and football. He is also talented in drawing.

ARWA, AGE: 14

I am Arwa, and I love biology so much, I wish to study more biology later. I am 14 years old and going to high school next year, God willing. I truly enjoy reading about human microbiome!

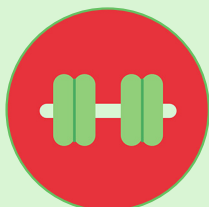


BLQEES, AGE: 10

My name is Blqees, 10 years old and I am studying in the fourth grade. I participated in an online training workshop entitled The Amazing Adventures of Viruses for 2 weeks in 2020 with Dr. Suzan Nassif, at Ibn Al Hakeem Office. I also participated in a workshop at Bani Walid University on simplifying science for children, entitled (The Amazing Adventures of Bacteriologists) in July 2023. My Hobbies are reading and drawing.

FATIMA, AGE: 11

My name is Fatima and I am 11. My hobbies are drawing and cooking, and I want to be a doctor when I grow up.





HASSAN, AGE: 14

I am Hassan and I am in high school. My hobbies include Lego and video games. I want to be a pilot.

AUTHORS

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Marwa Saadaoui is a research specialist in the Laboratory of Microbiome and Biomarkers Discovery at Sidra Medicine, Qatar. In 2012, Marwa received her master's degree in biotechnology from the Higher Institute of Biotechnology of Sfax, Tunisia. Marwa currently works on Dr. Souhaila Al Khodor's team and is involved in various projects related to the role of the microbiome in health and disease, as well as biomarker discovery.



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Dr. Al Khodor is the Director of Maternal and Child Health Division in the Research Branch at Sidra Medicine, Qatar. Dr. Al Khodor received her master's degree and Ph.D. in microbiology and immunology from the University of Louisville, Louisville, KY, USA (2005–2008). She is interested in understanding the role the role of the microbiome in health and disease. Dr. Al Khodor has over 67 peer-reviewed publications. She currently serves as an assistant specialty chief editor for *Frontiers in Cellular and Infection Microbiology* and is the section editor for metagenomics in the *Journal of Translational Medicine*. *salkhodor@sidra.org

