**The Human Microbiome**

**Learning Objectives:**

1. Understand what a Microbiome is and the most important one in the human body.
2. Explain the role microorganisms play within the human body.
3. Learn the mutualistic relationship between the human body and microorganisms within it.
4. Explain what is used/collected to study the human gut microbiome.
5. Explain the pros and cons of current research methods.
6. Understand the importance of the Human Microbiome Project and how it will affect the future study of microorganisms

**Vocabulary words:**

* Microbiome
* Microorganisms
* Gastrointestinal tract (GI tract)
* Mutualistic relationship
* Autoimmune disease
* Pathogen
* Ribonucleic acid (RNA)
* 16s ribosomal RNA (rRNA)
* Human Microbiome Project (HMP)

**Section 1.1: What is a Microbiome?**

 The microbiome is a fairly recent discovery in the microbiological field with its existence not being officially recognized until the late 1990s1. A **Microbiome** is any specific group of microorganisms that live in an environment. It is not just an environment, such as oceans, soil, and plants that have a microbiome. Humans and animals have their own unique microbiome as well, living on the surface of skin as well as inside the body. **Microorganisms** consist of multiple eukaryotic and prokaryotic organisms including, bacteria, viruses, protozoa, and fungi. The number of microorganisms in a human body outnumbers human cells ten to one1. These dynamic and complex microorganisms play a significant role in the homeostasis within all these environments, living through multiple mutualistic relationships to both help themselves and their host. The microbiome has been linked to perform key tasks that help the human body function.

**Section 1.2: Roles of the Human Gut Microbiome**

Perhaps the most significant microbiome, in concern to human health and function, is the gut microbiome. The gut is the common name for the human **gastrointestinal tract (GI tract).** A human’s GI tract consists of hollow organs creating one of the most extensive paths of entering and exiting the body. The path consists of the mouth where everything enters, then it proceeds through the esophagus, stomach, small and large intestines, and finally everything exits the body via the anus. In humans alone, 60 tons of food passes through the gut system, and carried along with this food is a large quantity of microorganisms1. This passage of food and microorganisms creates an estimated ratio of 1:1, human to bacterial cells within the human GI tract2.

Besides the gut dealing with intake and absorption of nutrients, the gut microbiome specifically affects human development, immunity, and nutrition1. An Individual’s gut microbiome is currently considered to begin development at birth, with significant colonization of specific microorganisms during the first two years of life. This development in the formative years of life is furthered by the health a human experiences during this stage of life. The health of these infants is affected by encounters with fevers and infections, the medication and different antibiotics given to them, and any changes made in their diet2. After roughly two years of life, an infant’s gut microbiome contains a configuration and function similar to that of an adult’s gut microbiome. After these formative years different changes in the composition of the microorganisms in the gut affects the day-to-day health of humans.

**Section 1.3: Pros and Cons of Human Gut Microbiome on Health**

The existing gut microbiome has a **mutualistic relationship** with the human body, meaning that the body helps the microorganisms by providing their environment required for continued survival, as well as, all the nutrients they need to live and reproduce. While this is happening in turn the bacteria and other microorganisms are providing the body with the ability to digest food, manage and protect the immune system from pathogenic bacteria attempting to cause disease, and produce key vitamins1. Among these important vitamins are B vitamins, including B12, riboflavin, and thiamine that helps metabolize food into energy and keeps the skin, gut lining, and blood cells healthy and functioning properly. Another Vitamin the gut microbiome helps produce is vitamin K, which is necessary for blood coagulation1. It is this give and take from both parties that causes this mutualistic relationship. It is only those microorganisms that previously exist in the body’s microbiome or those that are meant to pass through, however, that benefit the host.

 Many **autoimmune diseases**, which are diseases where a body’s immune system mistakenly attacks its own cells like they are foreign pathogens, are caused by a dysfunction in the microbial composition within the gut microbiome2. A **pathogen** is any microorganism that causes a disease. Pathogenic microbes gathering to an unhealthy proportion within the gut can cause autoimmune diseases including, diabetes, rheumatoid arthritis, muscular dystrophy, and fibromyalgia1. This unbalance of healthy and unhealthy gut microorganisms gather in the gut over time and change gene activity, as well as metabolic processes. The body responds to this by producing an abnormal immune response against the substances and tissues that are already typically present within the body1. This response is then classified as an autoimmune disease within that person.

**Section 1.4: How is the Microbiome Studied?**

 The reason the gut microbiome is just now being investigated and focused on is that until recently, scientists were unable to study and research inside the human body. With new and efficient research techniques these areas can now be explored. The main way of studying the gut microbiome, is to collect and analyze RNA, more specifically the 16s ribosomal RNA. **RNA**, or Ribonucleic acid, acts as the messenger during DNA transcription that carries information on the synthesis of amino acids and proteins.In many bacteria specifically RNA carries genetic information, similar to how DNA carries this information in eukaryotes3. **16s ribosomal RNA** is specifically important for the process of surveying the composition of microorganisms in the gut because this gene is present within all bacteria. This gene, besides being universal within all bacteria, also contains highly variable regions that are specific to each bacterium. The variable regions allow researchers to specifically identify individual bacterial genus within the gut.

In order to identify the composition of microorganisms in the gut without harming a human, scientists will often collect the 16s ribosomal RNA from fecal samples. For this process, a laboratory will receive a sample of fecal matter from a human, the feces is then homogenized in a sterile buffer, filtered to remove solid matter, next it is cleaned, processed, and sent up for sequencing to identify the 16s rRNA. Though using this method of collecting information is the best scientists have at the moment, there are still weaknesses to this method. The main problem is that it does not distinguish between live and dead cells, and it does not inform about the functions of the species that are present. This means that scientist will know how much of a specific microbe is present in the gut microbiome, but they will not know if the microbe is currently having an affect on the gut and what specific affect they do or do not have. Scientists still have a lot left to be discovered about the best research techniques for microorganisms in the human gut microbiome.

**Section 1.5: The Human Microbiome Project (HMP)**

In order to learn more about the affects of the gut microbiome on human health and what specific microorganisms are involved with it, a worldwide initiative was put in place. This initiative is called the **Human Microbiome Project (HMP)**, and its mission is to map the human microbiome and give insight into unknown species and genes, which might be residing within1. The initiative is sponsored and provided for by the National Human Genome Research Institute, which is a smaller part of the National Institutes of Health1. It began in 2008, as a specific extension from the Human Genome Project, whose goal is to map the entire human genome that is predicted to have over 20,000 genes1.

This initiative is so important to human health because much is still unknown about how the microbiome influences immune system susceptibility to specific pathogenic microorganisms1. With further knowledge of the specific causes and affects of the gut microbiome on human health many diseases in the future can be diagnosed quicker, understood better, or maybe even be prevented. This could all be based on diet and intake of chemicals, including antibiotics and medication, into the body alone. The need to be able to study the gut microbiome in whole, like what the Human Microbiome Project aims to do, is what will help scientists and doctors with this uncertainty. The requirement to culture bacteria, archaea, and eukaryotes outside of their natural growth environment is the greatest dependent on if this is possible. Until a new way to study microorganisms within the human gut microbiota is discovered, no further advancement will be achieved. The importance of understanding the gut microbiome is crucial to the advancement of human health.

**References**

1 Hair, M., & Sharpe, J. (2014). The Human Microbiome. *The Center for Egocentrics and*

*Environmental Health*. Retrieved March 3, 2019, from

https://depts.washington.edu/ceeh/downloads/FF\_Microbiome.pdf.

2 Thursby, E., & Juge, N. (2017). Introduction to the human gut microbiota. *Biochemical*

*Journal,474*, 1823-1836. doi:10.1042/BCJ20160510

3 R. (n.d.). What is RNA? Retrieved March 5, 2019, from

https://www.rnasociety.org/about/what-is-rna/