# Microbiome Bioinformatics and Health

What is a microbiome?

A **microbiome** is the full collection of genes of all the **microbes** in a community. The size of the human microbiome (all of the genes from all of our microbes) outnumbers the size of the human genome (all of our genes in a human) by about 100 to 1.

A **microbe** is very small living organism, such as bacteria, protozoa, fungi, algae, amoebas, and slime molds.

1 µm
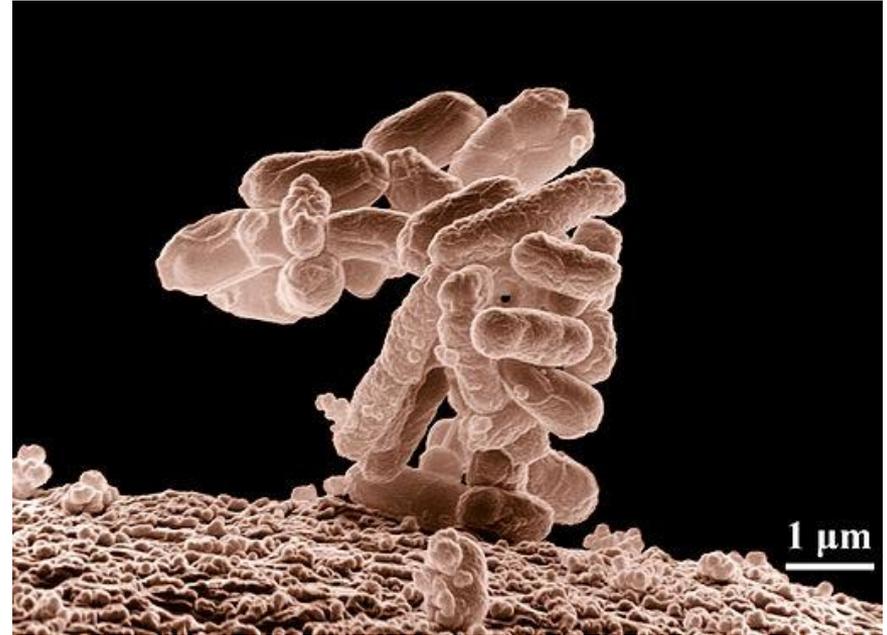
Microbiomes in Health

- The microbes in our microbiome are important both inside and outside our bodies
  - Microbe genes code for enzymes that break down food we cannot digest on our own
  - Microbe genes code for proteins that build vital nutrients needed by our bodies
  - Microbe genes code for molecules that kill other harmful bacteria
  - Microbe genes code for enzymes that convert skin oils to natural moisturizers that keep skin soft, flexible and crack free
- Our microbiome is involved in our nutrition, immunity, protection from infection, maintenance of protective barriers, organ development and more.

Your microbiome is important to your health!

Microbiomes in Disease

- Microbes such as harmful viruses and bacteria cause diseases
    - Harmful bacteria cause strep throat and food poisoning
    - Harmful viruses cause measles and the flu
- Disruption to our microbiome can cause disease because a disrupted microbiome allows harmful bacteria to cause harm.
    - Acne
    - Dental cavities
    - Cancer
    - Gastric ulcers
    - Inflammatory bowel disease (IBD)

Maintaining a healthy microbiome can help us avoid some diseases!

What is a healthy microbiome?

If microbiomes are important for maintaining human health and can contribute to disease when imbalanced, then we need to know the makeup of a healthy human microbiome
- What types of microbes are present in a healthy microbiome?
- What are these microbes doing?

But the healthy microbiome from one person is not the same as a healthy microbiome from another person, and not even the same in different locations on the same person!
- Researchers take samples from hundreds of individuals and different body locations

How do we study a microbiome?
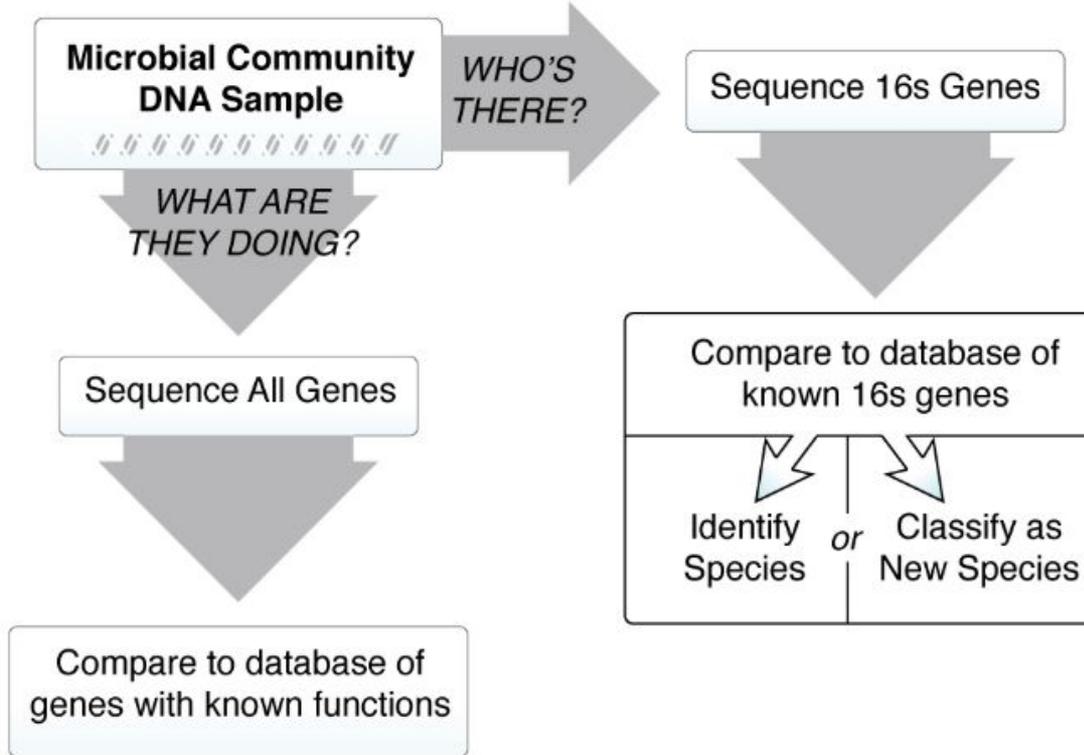
Sequencing the microbiome

- DNA Sequencing is used to identify the microbes in a sample
- Sequence a marker or short, unique DNA sequence to help identify the microbial population
  - One common DNA marker is the gene that codes for the 16S subunit of ribosomal RNA (16s rRNA), an important part of the cell's protein-building machinery
  - All bacteria have the 16S rRNA gene, but the exact DNA sequence is unique to each species
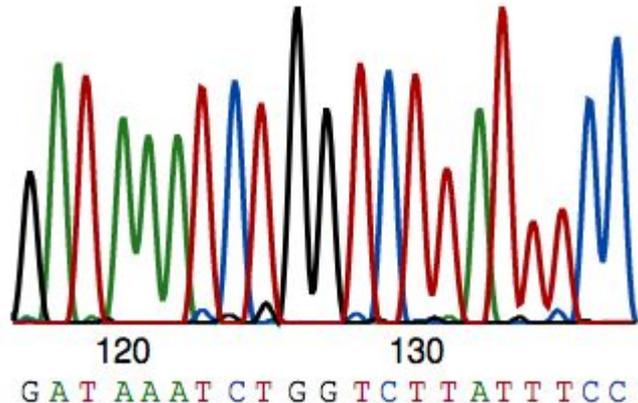
Role for Bioinformatics in microbiome research

- The sequence from each 16s rRNA is searched against a database (DB) of all known sequences
  - If they find a match, they can identify the species
  - If they do NOT find a match, they have discovered a new species

- This search involves aligning the test sequence against all other sequences in the DB, and calculating a sequence similarity score for each pair of sequences
  - The sequence pair with the highest score means that this sequence pair shares the highest similarity or relatedness
- The bioinformatics tool used for this pairwise alignment is called **BLAST** - Basic Local Alignment Search Tool

Nucleotide BLAST
nucleotide ▶ nucleotide

Whose microbiome is unhealthy?

Exercise:

Gut samples from Romeo and Juliet were amplified and their 16S rRNA marker genes sequenced. We found lots of different sequences but chose one very common one from each sample. One of them is healthy, but the other has lots of abdominal pain. Which person might need to see a doctor?

Link to Microbiome Bioinformatics Exercise: https://tinyurl.com/yad6zb2v

References and Additional Resources

1. Material adapted from Learn.Genetics - https://learn.genetics.utah.edu/content/microbiome/

2. NCBI BLAST - https://blast.ncbi.nlm.nih.gov/Blast.cgi

3. Helicobacter pylori infection -
   https://www.mayoclinic.org/diseases-conditions/h-pylori/symptoms-causes/syc-20356171

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