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MELISA OSBORNE

(Micro)Biome Beads

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With thanks to:
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Graduate Program in Bioinformatics, Boston University

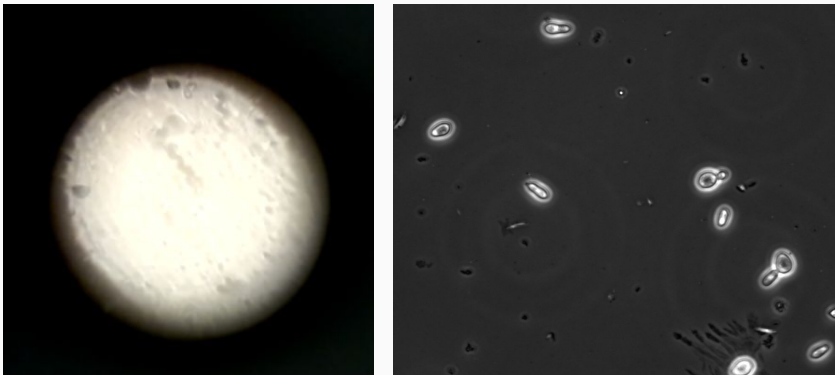
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Microbes are the organisms that we cannot see

Chances are you are familiar with the animals that are around you in your neighborhood every day and the communities that they build - called **ecosystems**.

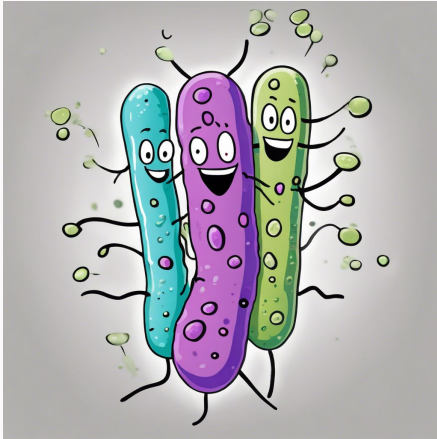
Yet every day we are also surrounded by living things we cannot see, microbial organisms or **microbes**, which also build ecosystems on and around their plant and animal neighbors, like us.



Left: Spirulina algae visualized at 100x magnification with a paper microscope (Foldscope); Right: Yeast cells of *Yarrowia lipolytica* observed at 60X magnification with phase contrast

A **MICROBE** is an organism that is usually single celled and too small to see with the naked eye.

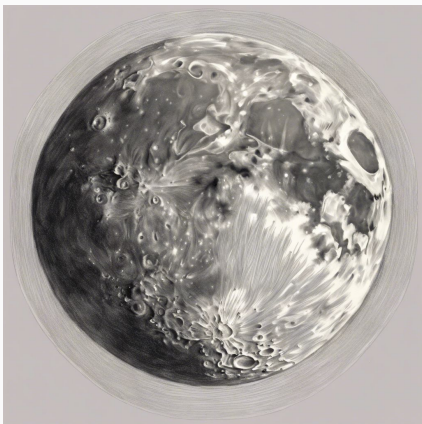
To a microbe, you seem as big as the moon



1/1,000,000
meters long



1 meter tall

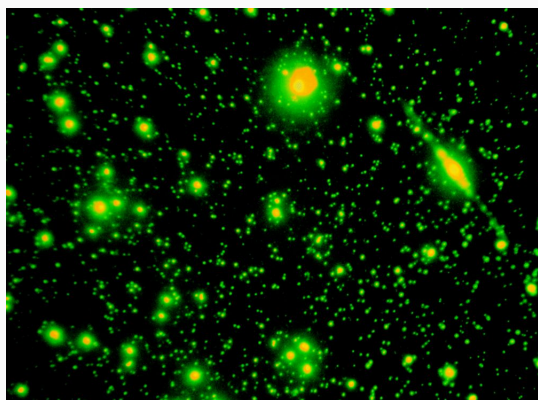


3,500,000
meters wide

Microbes live everywhere, and microbiomes are found everywhere

Microbes are everywhere - on the ground, in the water, on your skin, and in your gut.

They affect the health of plants, animals, and the environments in both positive and negative ways. A **MICROBIOME** is the group of unique microbes specific to one environment or setting.



One tiny drop of water!
Millions of microbes!

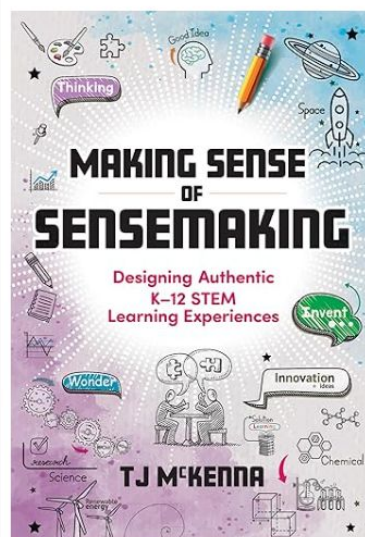
Jed Fuhrman *Nature* 1999

Learning About Microbiomes

The concepts behind microbiomes can be abstract and difficult to teach, but sense-making approaches can be applied to this process for hands-on learning that relates to the high school science curriculum.

The introduction of tools for sense-making in science education is a growing area as exemplified by sites like

<https://www.ngssphenomena.com/> and education resources from OpenSciEd.



(Micro)Biome Beads - A Tactile Way to Experience Microbes

Developed for Boston University Microbiome Day in 2023 (Annual event by the BU Microbiome Initiative) as a way to have fun with the microbes researchers work on in a hands-on way, Biome Beads has grown to an activity aimed at teaching everyone of all ages about the microbial phenomena in the world around us and the importance of microbes in daily living on earth.



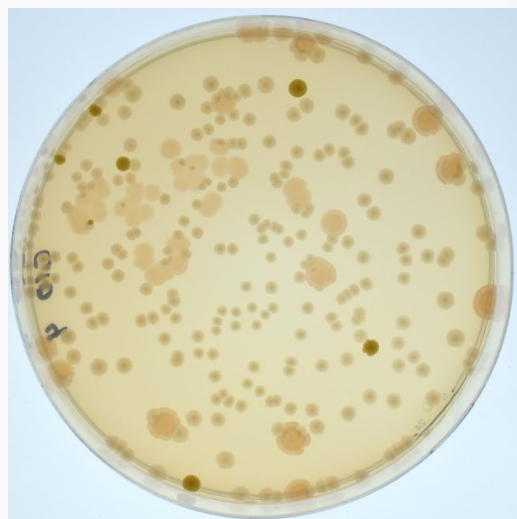
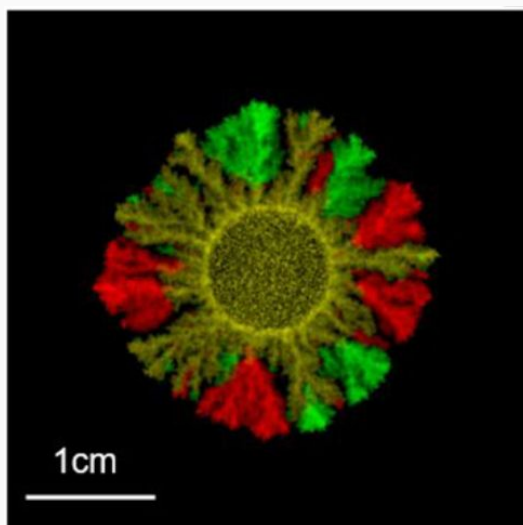
Microbial Phenomena



At its heart, while individual microbes are not visible to the naked eye and usually require microscopy; groups of microbes and microbial phenomena are present in the world around us. Above is a picture of a lake experiencing eutrophication - that is when the algae, a photosynthetic microbe, grow in overabundance due to excess nutrients (Photo attribution to Smaack, CC BY-SA 4.0 <<https://creativecommons.org/licenses/by-sa/4.0>>, via Wikimedia Commons).

More examples can be seen on the next page and at the site microphenomena.net

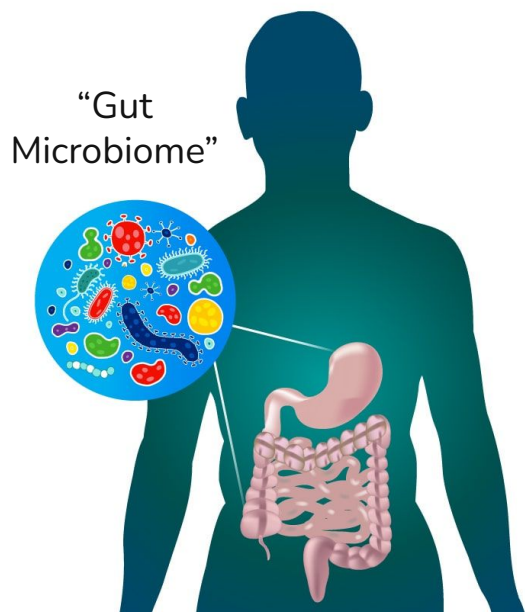
Microbial Phenomena Gallery



From top left, clockwise - lichens, a microbial symbiosis of fungi and algae (credit: Melisa Osborne); algal bloom (Nasa satellite image); a community of microbes grown on an agar plate (credit: Alan Pacheco); a computer simulation of two bacteria labeled with fluorescence in the same colony (credit: Ilija Dukovski, Segre Lab).

Industry Example: Probiotics

Microbes and microbiomes have many biotechnology and health applications, one example is “probiotics”. Probiotics are products that can help human cells (pro => supports; biotic => life or cell) and many probiotics used for gut microbiome health are ingested, like yogurt.



Yogurt = Probiotic

Introduces
“Good Microbes”



Biome Beads Hands-On Learning

A crafting activity to visualize the types of microbes that occupy habitats on and around us.

Introduces the concept that microbes (single celled organisms) live in the world around us, have important roles on the planet, and can be measured and cataloged to better understand these roles.

Defines the term microbiome and explain why it is an important area of current research in biology and microbiology.

Understand how microbiomes are linked to the well being of humans and other animals and global ecosystems like the ocean.

DELIVERABLE:

An object - a bracelet or keychain - will be built as a representation of one of the many microbiomes in the world at large.

BIOME BEADS Activity Overview

Objective:

Build a BiomeBeads bracelet that is representative of a microbiome that you find interesting using the information on the microbiome cards as a guideline.

Materials:

Thread and/or Key Chain materials (provided)

Microbiome card of interest (provided)

Silicone beads for each microbe (provided)

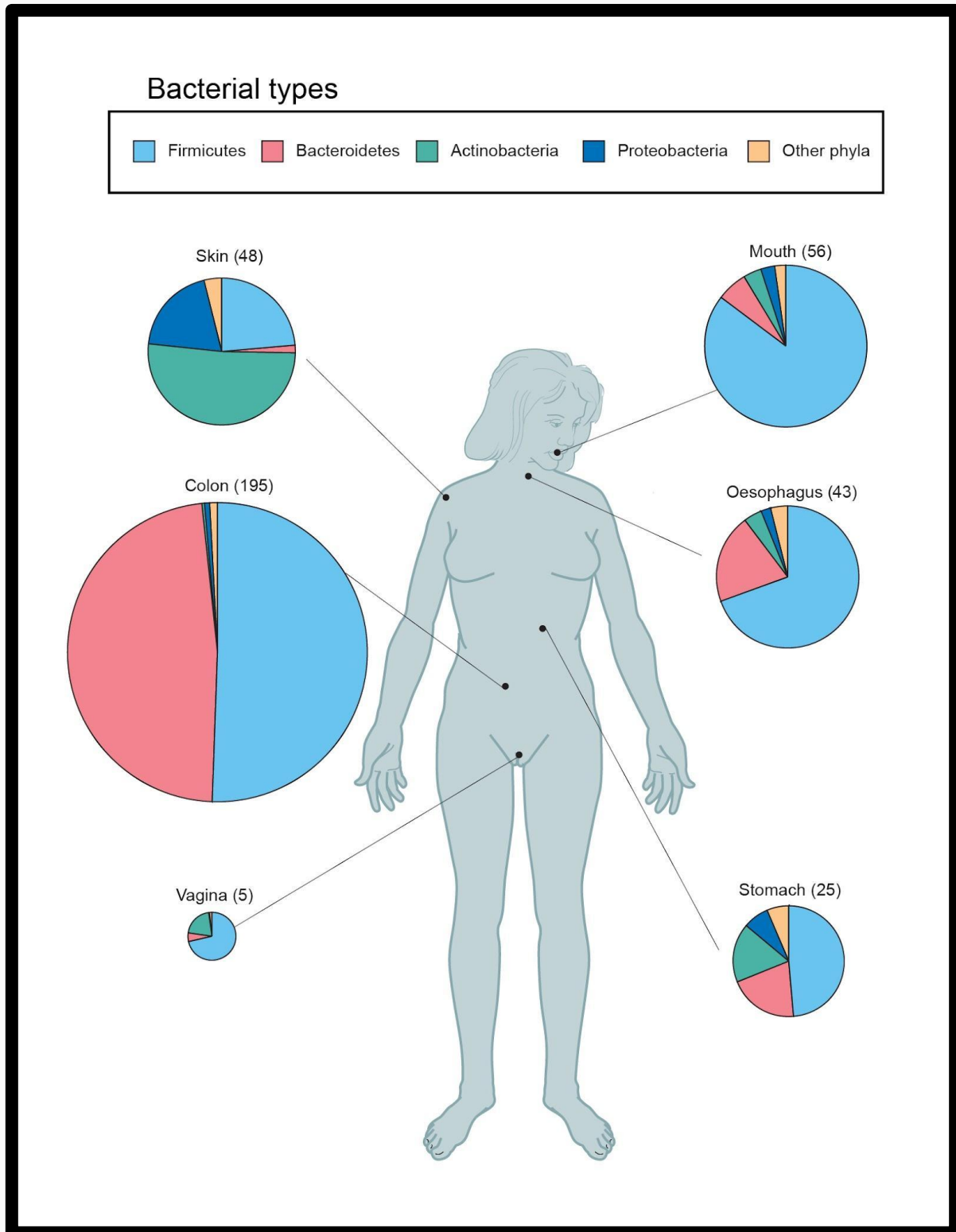
Scissors (not included)

Instructions:

Use the biome bead cards as a template for constructing a bracelet that represents the microbe. You can be exact in how you construct your community or you can be more visually based in how you decide to design your bracelet. Let the microbiome inspire you!

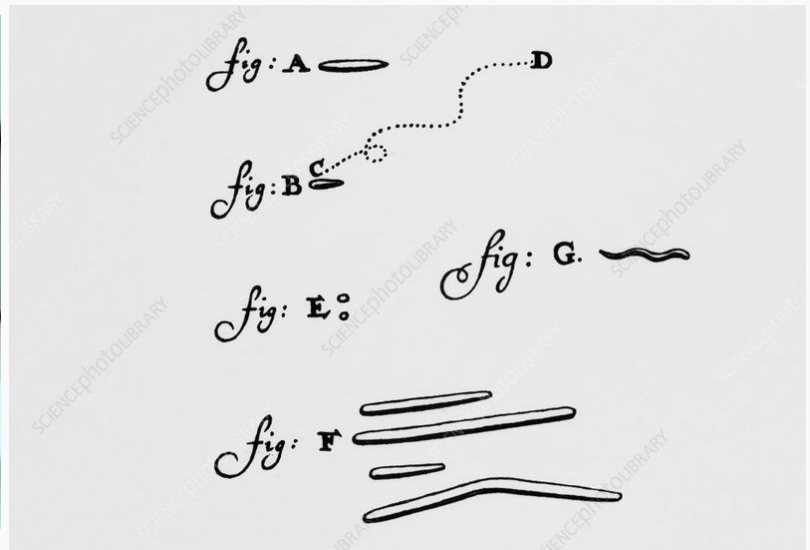


Human Microbiome - Overview



Human Microbiome NHGRI
(Wikimedia Commons)

Human Microbiome - Oral



Credits (Clockwise from Top Left) - Dr. Melisa Osborne and Ian Osborne, Original Illustration by Anton Leeuwenhoek photographed by Dr. Jeremy Burgess Science Photo Library, Welch et al PNAS

<https://www.pnas.org/doi/epdf/10.1073/pnas.1522149113>

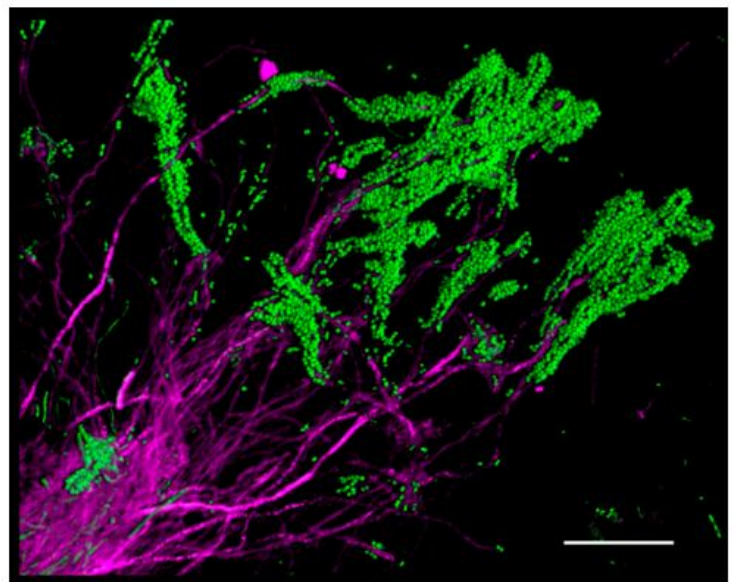
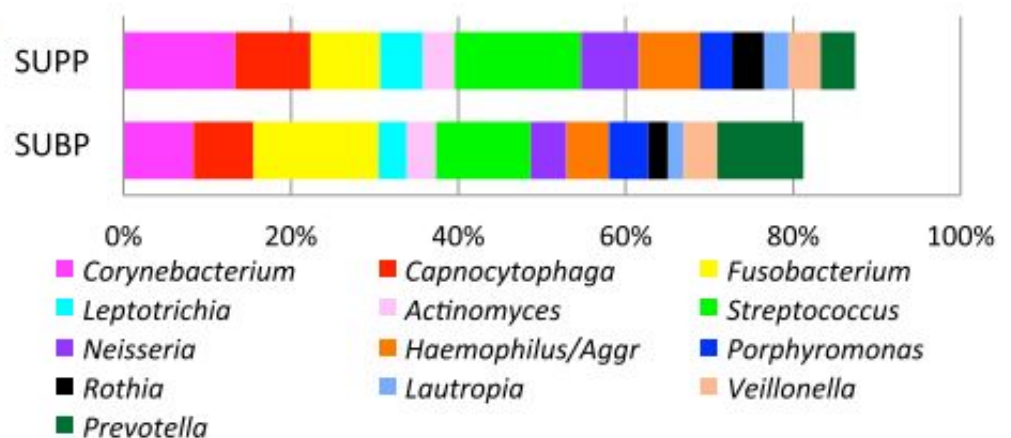


Fig. 2. Corncob structures formed by *Corynebacterium* and cocci in plaque. *Corynebacterium* cells (magenta) are visible as long filaments, with cocci (green) bound to the tips of the filaments. Partially disrupted plaque was hybridized with a probe for *Corynebacterium* and a universal bacterial probe. Image was acquired using a Zeiss Axiolmager 63× Plan-Apochromat 1.4 N.A. objective and Apotome structured illumination. (Scale bar: 20 μm.)

Relative Abundance of Oral Bacteria

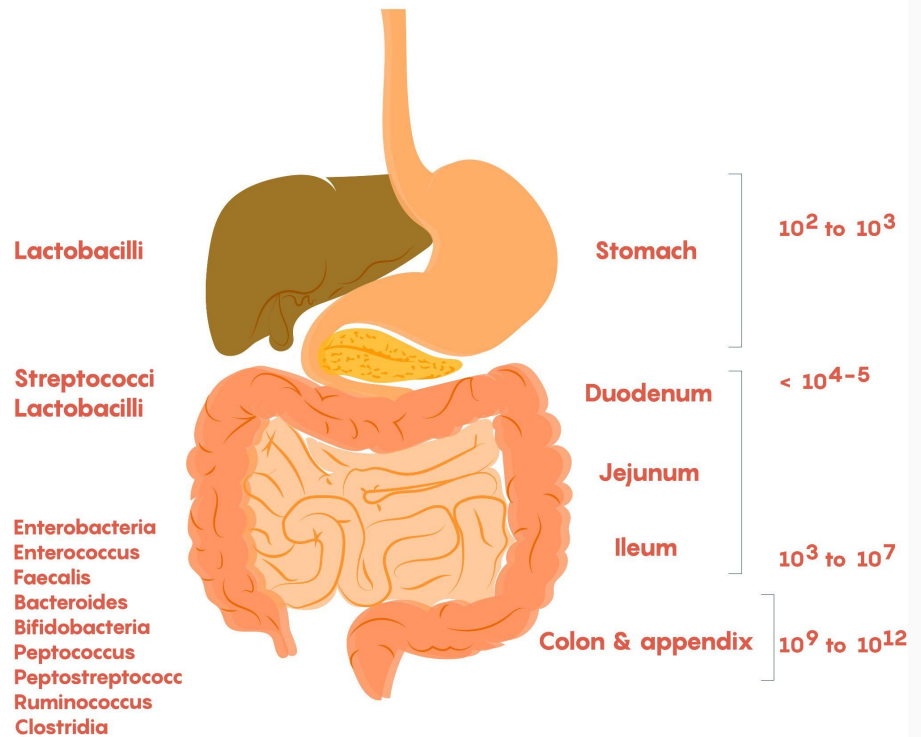


Human Microbiome Gut

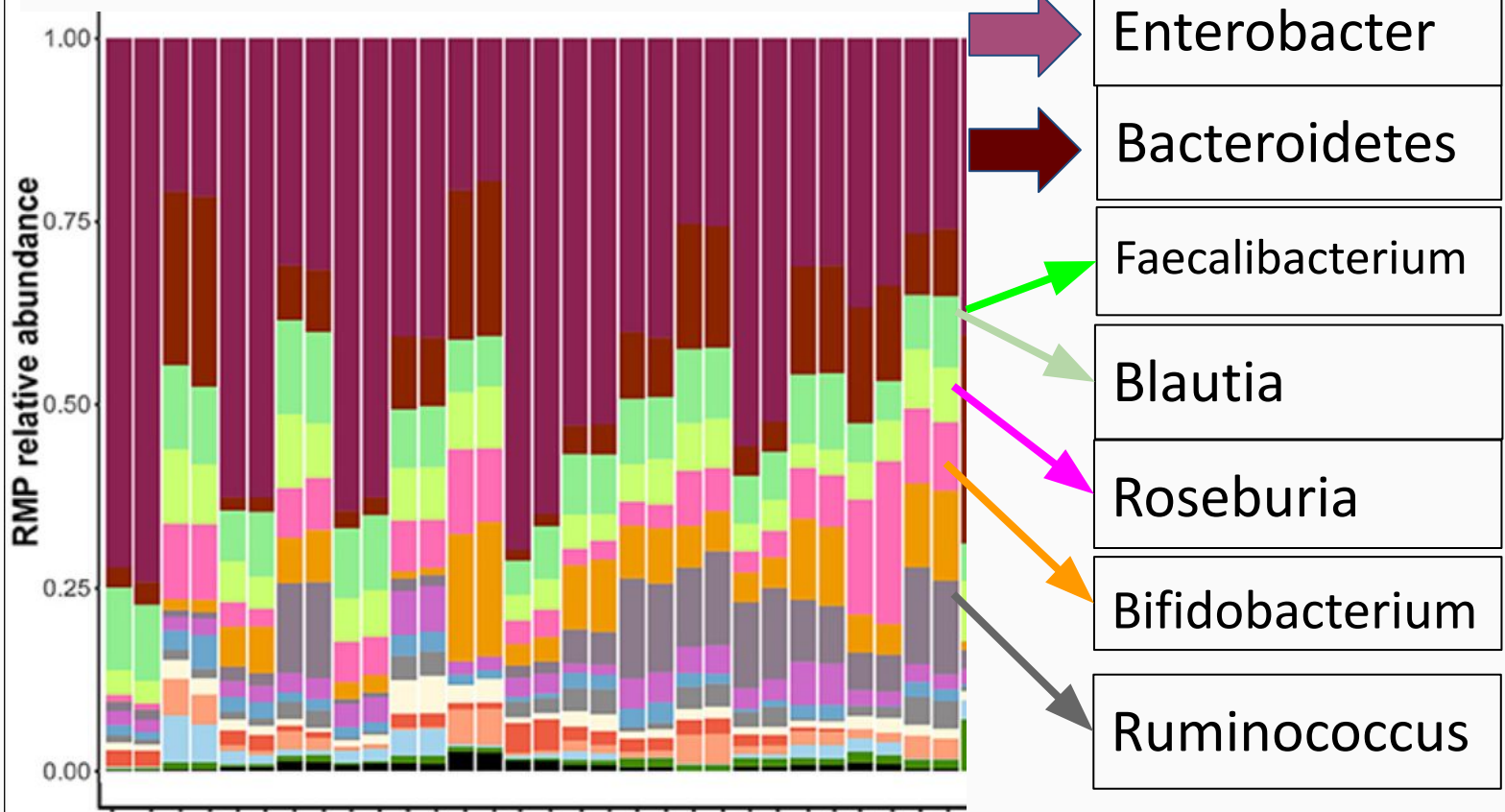
By Dr William Ju, University of Toronto -
<http://neuroscience.openetext.utoronto.ca/chapter/chapter-1-the-gut-microbiome-and-its-impact-on-the-brain/>, CC BY 4.0,
<https://commons.wikimedia.org/w/index.php?curid=139935345>

Intestinal Microflora

10^{14} microorganisms, >500 species



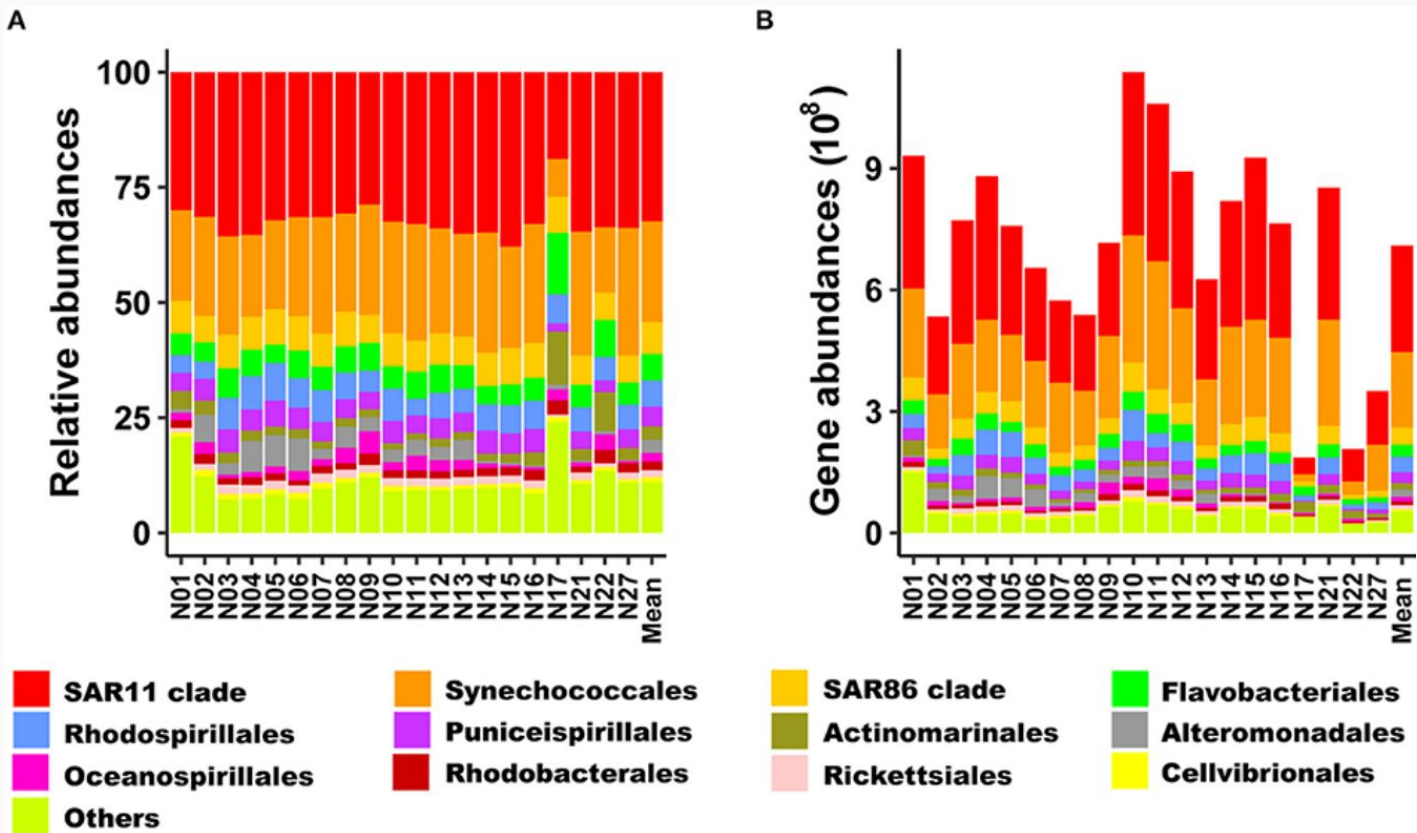
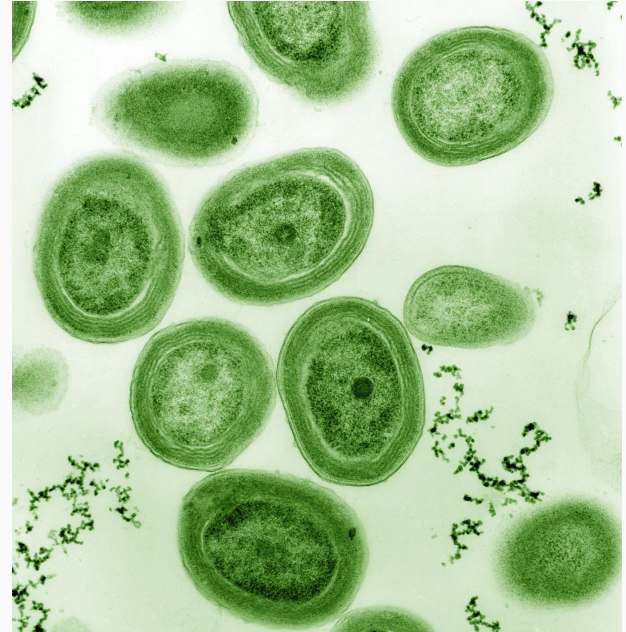
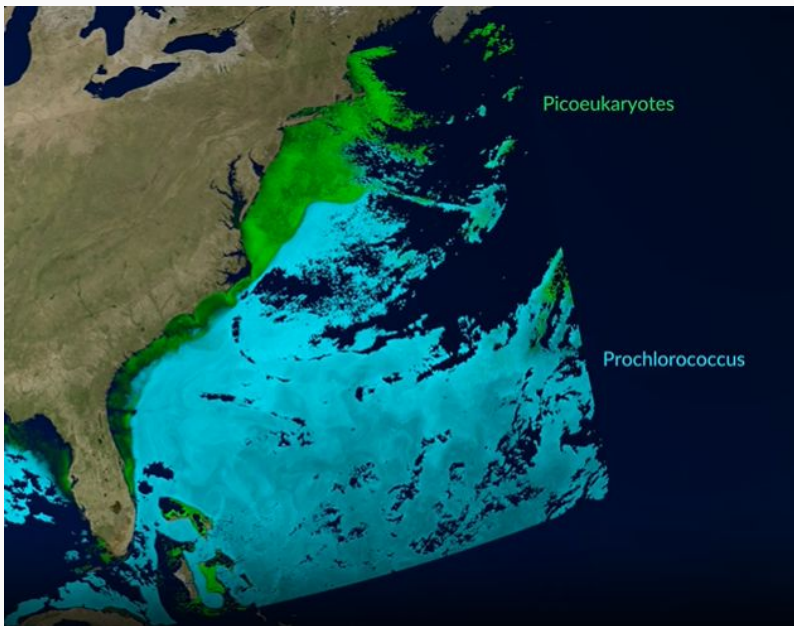
Human Gut Associated Bacteria



Source: Galazzo et al , 2022

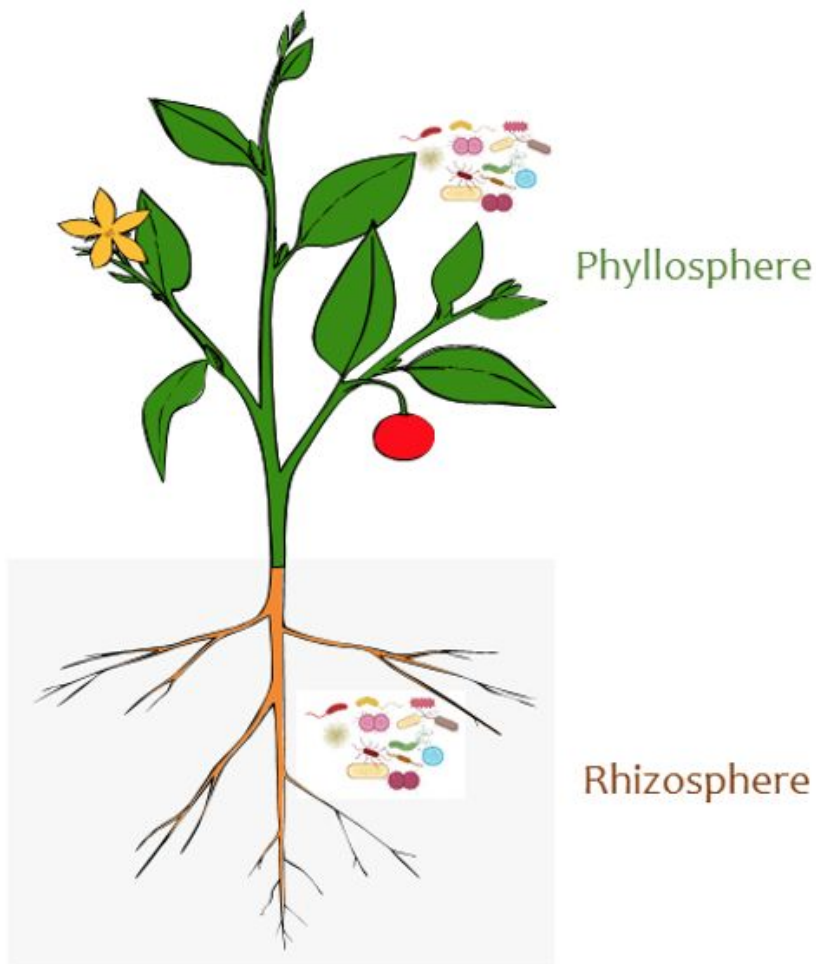
<https://www.frontiersin.org/articles/10.3389/fcimb.2020.00403/full>

Ocean Microbiome - Marine

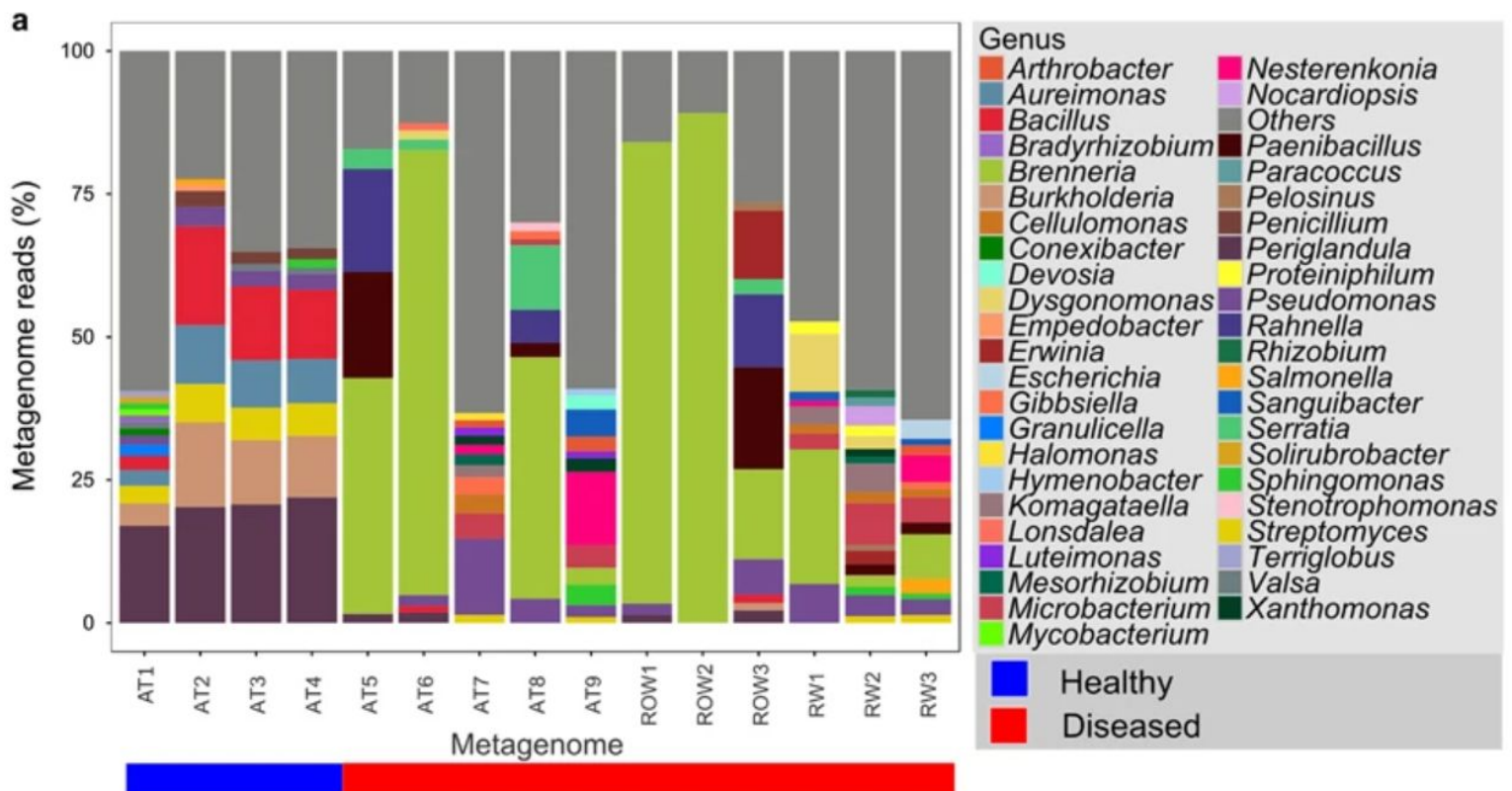


Credits (Clockwise from Top Left) - NASA Scientific Visualization Studio (<https://svs.gsfc.nasa.gov/5259/>) , Luke Thompson from Chisholm Lab and Nikki Watson from Whitehead, MIT Wikipedia Commons, Dr. Melisa Osborne, Kong et al, 2021
<https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2020.599614/full>

Plant Microbiome - Roots & Soil



Credits - left: plant microbiome definition, By Sheng-Yang He - [1], CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=93793003>); below: Phyllosphere in complex polyspecies disease as outlined in Denman et al 2018 - <https://www.nature.com/articles/ismej2017170>)



Contact Info & Kit Requests



Open source materials are shared at
<https://www.microphenomena.net/>

If you would like a pre-assembled kit or kits, email melosbor@bu.edu
Free kits are available on a first come, first serve basis at the moment.

We are just beginning the work to build connections and a support system for supplies and kit distribution at scale, If you'd like to get involved, please use the same email above.

Additional Resources and Biological Background

Some references to check out:

Galazzo, G., van Best, N., Benedikter, B. J., Janssen, K., Bervoets, L., Driessen, C., Oomen, M., Lucchesi, M., van Eijck, P. H., Becker, H. E. F., Hornef, M. W., Savelkoul, P. H., Stassen, F. R. M., Wolffs, P. F., & Penders, J. (2020). How to Count Our Microbes? The Effect of Different Quantitative Microbiome Profiling Approaches. *Frontiers in cellular and infection microbiology*, 10, 403.
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<https://doi.org/10.1038/nbt.3935>

Tara Ocean Foundation., Tara Oceans., European Molecular Biology Laboratory (EMBL). et al. Priorities for ocean microbiome research. *Nat Microbiol* 7, 937–947 (2022). <https://doi.org/10.1038/s41564-022-01145-5>

“Taxonomy (Biology).” [https://en.wikipedia.org/wiki/Taxonomy_\(biology\)](https://en.wikipedia.org/wiki/Taxonomy_(biology)) (Accessed 04/02/2024).

Whipps et al. 1988. Mycoparasitism and plant disease control.” Pages 161-87 in NM Burge, editor. *Fungi in Biological Control Systems*. Manchester University Press. Manchester, UK.

Microbiome Careers

The study of microbiomes learning about subjects ranging from cell biology to environmental biology and to health and medicine.

Careers studying the microbiome can involve health care, biotechnology, and even engineering and industrial biology and agriculture.

Microbiome Careers

Environmental/ Government	
Study microbiomes useful in energy production, environmental cleanup, industrial processing, and toxic waste reduction	National Parks, State Wildlife Agencies, Army Corp of Engineers
Industrial	
Study microbes and isolate the genes that give them their unique abilities to survive under extreme conditions.	Food & Drug Administration, U.S. DOA, Food & Beverage Suppliers, DOD
Information Technology	
Compare microbes using DNA and protein sequences to determine biochemical function of specific organisms.	DOD, Computer Science Depts, Research Facilities, National Institutes of Health
Medical/ Pharmaceutical	
Study disease response to environmental or medicinal influences of microbes and microbial products.	NIH, Hospitals, Pharmaceutical Companies, Department of Health and Human Services
Research Labs	
Study microbes to determine an evolutionary structural, functional, and comparative analysis of genes and genomes from various organisms	CDC, NHGRI, Hospitals, Health Dept., Private Companies, Research Universities
Education	
Teach others about the systems and advances in microbiome research. Conduct your own research, write grants and publications, and teach/train students.	Community Colleges, Science Depts., Universities, Public Health Schools

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