Lesson Sheet 1 — Microorganisms

Terminology. microorganisms = microbes = microscopic organisms

Definition. **microorganisms**: organisms too small to see with the naked eye.

Microorganisms include, archaea, bacteria, fungi, algae, protozoa, microscopic plants, and microscopic animals (example of a microscopic animal, tardigrades or “Water Bears”).

(Note. Some people will include viruses as microbes, while others will not because they need a host to thrive.)

Pathogen: disease causing by either producing toxins or by causing cell damage.

Pathogens include, bacterial, fungal, viral, parasitic, and prionic (proteins that can cause disease).

Only a fraction of 1% of all microbes are known to be pathogenic.

Microbiome, all of the microorganisms, their genome (complete set of genes/genetic materials), their habitat (a body or part of a body), and their surrounding environmental conditions. Examples: human microbiome, the intestinal microbiome, a forest microbiome, an aquifer microbiome, compost microbiome, etc. See Human Microbiome Project, Earth Microbiome Project.

Microbiota, the microorganisms in a particular environment, usually only the archaea, bacteria, and fungi (lower eukaryotes)—other microorganisms (micro-animals) are excluded. **Metagenome** refers specifically to the genome of a microbiota. Ex., the gut microbiota.

How to see them: microscopes, electron microscopes, genetic analysis (DNA sequencing).

Microscopes use optical lenses to magnify very small organisms or other objects, usually from 40 to 400 times (40x - 400x) for the common compound or light microscope. Some can do 1,000x or 1,500x, and while others can do 2,500x to as high as 5,000x, the objects may appear fuzzy and, so, the resolution may not be any better than at 1,000x or 1,500x.

Note. To see all of the microbes listed in EM-1 (used in making bokashi), especially the phototrophic bacteria, need at least 1,000x.

Electron microscopes uses electrons instead of light to magnify objects into a non-color image. Magnification ranges from 20,000x for the Scanning Electron Microscope to 20 million times for the Transmission Electron Microscope.

Genetic analysis, specifically by **DNA sequencing**, is a way to determine the genome, and therefore, what microbes may exist in a sampling. This is an important method, especially since many microbes cannot be cultured in a lab making it difficult to study them (they either die outside their habitat, or they need other microbes to multiply thereby complicating distinguishing them from the others).

Tree of Life (science/biology). In the past, the tree of life in biology, usually a diagram to describe the relationship between all known organisms, consisted a large portion of it with animals and plants. In 2016, a New View of the Tree of Life (see links below), in one version of the diagram (“reformatted view”), all of the visible life, specifically 1 of 4 branches of the eukaryotes (multicellular organisms from fungi to humans), were put on a single, albeit thick, line or branch. The rest of the diagram consisted of archaea and bacteria, about a third of which was only just recently discovered (as of 2015) as a result of genomic studies of different microbiomes (environmental samplings from different parts of the world). This indicates how little we still know about the microbial world, what exists, and their interactions.
Ref. ‘Massive “Tree of Life” map connects 2.3 million organisms,’ 9/22/2015, http://inhabitat.com/tree-of-life-redesigned-to-reflect-thousands-of-new-species/; “A new view of the tree of life” by Laura A. Hug, et al, Nature Microbiology, April 2016, http://www.nature.com/articles/nmicrobiol201648/

Microbes are everywhere. Microbes have been found in almost every part of the earth, including in ice core samples from deep within both the arctic and antarctic; near very hot volcanic vents at the bottom of the ocean; high up in the stratosphere; in battery acid; in the coolant water of nuclear reactors; in core samples from drillings going down 2.5 km (1.55 miles) below the ocean floor; and so on.

Microbes are responsible for the establishment, maintenance, and **cycle of life**. They terraformed the planet, making it possible for higher life forms to evolve. A significant portion of the oxygen in the atmosphere are due to microbes, besides plant photosynthesis.

Microbes **communicate** with one another via chemical and electrical signals they produce, but these signals also happen to be used by other organisms: the human gut, human brain (neurons); plant roots (bacterial and fungal interactions). See also quorum sensing, root microbiome, rhizosphere microbiome.

Microbes play a significant role in **digestion** in all organisms, plants and animals. Food chain diagrams usually only portray microbes as decomposers, supplying chemicals (food/energy) to plants. Not many will also mention the role of microbes within each and every animal. See also decomposers (generally, digest their food outside their body—bacteria, fungi) versus detritivores (digest food inside their body, usually dead organic matter—earthworms, pillbugs, slugs, dung flies).

Microbes are what makes **composting** possible (see psychrophiles, mesophiles, thermophiles, hyperthermophiles), an integral part of the cycle of life. Microbial life, its diversity and population density, attracts other life, including worms and insects which consume microbes.

Microbes also play an important part in **fermentation**—where microbes break down complex molecules (e.g., carbohydrates) into simpler ones (e.g., CO_2 and alcohol). There are different kinds of fermentation producing different results, done by different microorganisms: methane fermentation (by methanogens, in bio-digesters), yeast fermentation (bread, wine, beer), lacto-fermentation (sauerkraut, cheeses), and the **bokashi** method is a lacto-yeast-phototrophic fermentation (bokashi = fermented organic matter).

Biological vs. chemical. The application of microbes to soil, whether directly or with compost or bokashi, is a biological way in which to improve soil health (soil structure, nutrient bioavailability, metabolites, humus, attracts life); while direct feeding and treatment of plants with agricultural chemicals (fertilizers, pesticides, herbicides, fungicides) has large negative effects on soil countering what microbes can do.