KSKL Teacher Guide | Chapter 3: Soil Biology: The living components of soil

Chapter summary

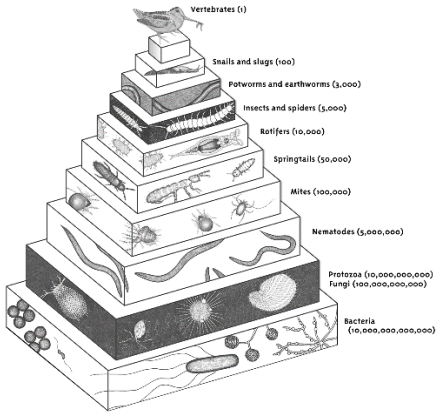
Soil is literally full of life. A handful of soil has more living organism than there are people on planet Earth. And most of them are very small. But despite their microscopic size, the activity of these organisms is vital for life as we know it. They decompose dead plants and animals, break down pollutants, recycle carbon, provide nutrients to plants, and even help give soil structure allowing plant roots to get oxygen and moisture. Life above the soil depends on life in the soil.

Background Information

Soil as a habitat

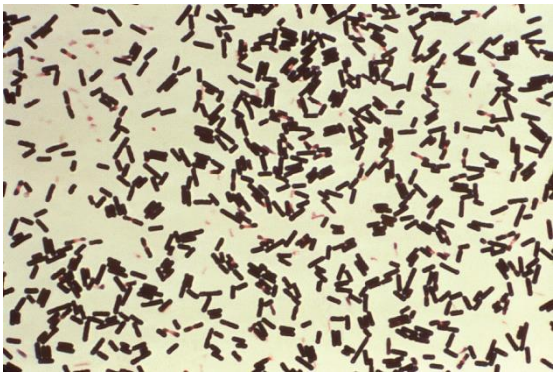
Soil is a complex habitat consisting of mineral and organic particles; living organism including plant roots, microbes and larger animals; and pore spaces filled with air and/or water. These properties change in space and time. Soil also receives a lot of carbon-based materials, some natural plant and animal wastes, and some from human activities (e.g. pollutants). Soil acts as a biological incinerator: soil organisms decompose these materials allowing for the growth of more soil organisms.

Organisms of the soil



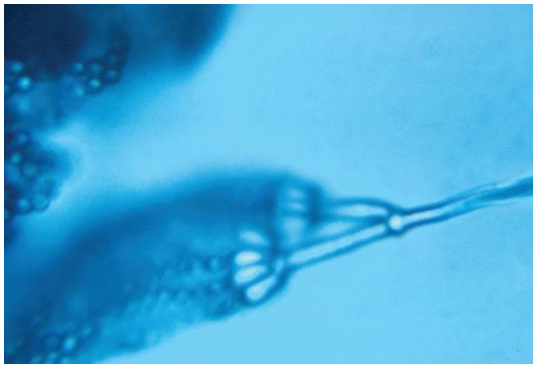
Soil organisms are incredibly diverse, in part because of the diversity of ways they can obtain energy. Soil organisms can be classified by their size, diet, requirements for oxygen and/or activity (what they do in the soil). **[Figure 3-4]**

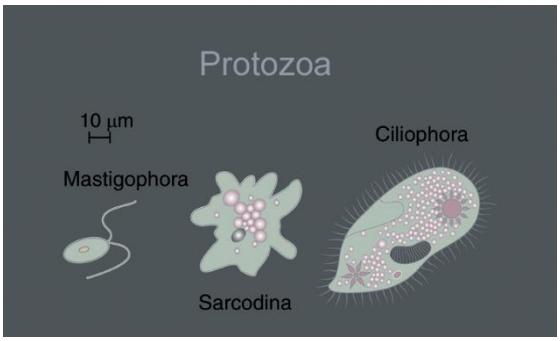
Viruses are amongst the smallest of soil biota, often less than 0.2 µm long. They reproduce inside the living cells of other organisms, infecting and hijacking the cell's machinery. We can find up to 10^{10} viral articles per gram of soil.



Bacteria and *Archaea* are unicellular microscopic organisms, usually around 1 – 3 µm in size. The are prokaryotes, meaning they lack a nuclear membrane and other specialized membrane-bound organelles. Common shapes include round cocci, rods, and spirals. Different types of bacteria can use a wide variety of substrates as an energy source (electron donor), including both organic and inorganic compounds. They can also use different electron acceptors: aerobic bacteria and archaea use oxygen, while anaerobes have evolved to live in the absence of oxygen, instead using nitrate, ferric iron or sulfate. **[Figure 3-7]**

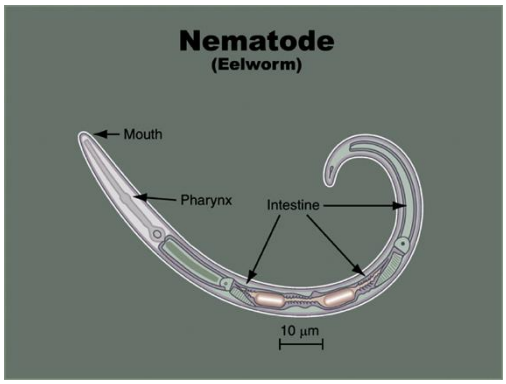
Fungi are a huge group of eukaryotic organisms that range from single cell microscopic yeasts to large multicellular mushrooms. Many soil fungi have a vast array of spreading filamentous structures called hyphae, which work like plant roots to gather substrates from a wide area. Fungi are usually not as numerous as bacteria and archaea, but because of their large size, they often have more biomass. **[Figure 3-11]**





Protists are a large group of microscopic, eukaryotic, mainly unicellular organisms. *Algae* are plant-like protists that contain chlorophyll and photosynthesize like plants. *Protozoa* are animal-like protists that eat organic matter or bacteria and reproduce by splitting. Fungus-like protists include *slime molds* that feed on organic matter and bacteria. **[Figure 3-12]**

Larger fauna are important in the soil food web, can help break down organic materials and help structure soil through their burrowing. *Nematodes* are non-segmented worms and are the most numerous of larger fauna. Nematodes are noted for their parasitic attack on plants, but most in soil are beneficial. Other important fauna are arthropods such as mites and springtails, and worms, such as potworms and earthworms. **[Figure 3-13]**

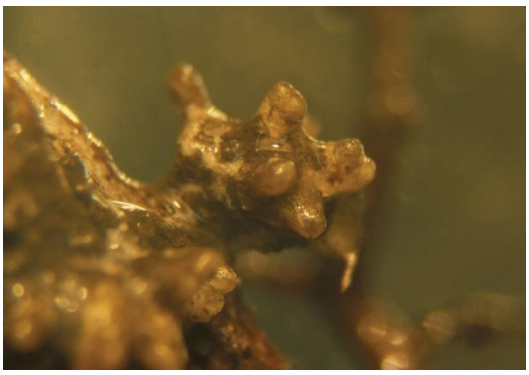


Life above the soil depends on life in the soil

Soil organisms active in decomposition are critical for recycling elements that are tied up in living tissues. Without this recycling, the finite quantity of elements would become limiting. Two key elements for plants, especially in agricultural soils, are nitrogen and phosphorus.

Microbes help convert nitrogen into forms available to plants (ammonium and nitrate). *Nitrogen fixers* are either free living or symbiotic with higher plants and convert nitrogen gas from the atmosphere into ammonia. Decomposers break down nitrogen-containing organic matter, releasing ammonia. *Nitrifiers* convert ammonia into nitrate. *Denitrifiers* convert nitrate back to nitrogen-containing gasses that are lost to the atmosphere. **[Figure 3-17]**

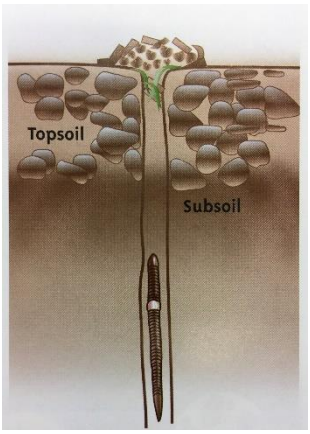
Microbes also help plants acquire phorphorus. Decomposers mineralize organic forms of phosphorus. Some microorganisms produce organic acids that release phosphorus from mineral forms. Some plants develop a symbiotic relationship with fungi, called mycorrhizae: an extensive network of fungal hyphae radiates out from the plant roots, reaching beyond what the plant can get alone, helping them get nutrients like phosphorus. **[Figure 3-19]**



Managing for healthy soils

Life above the soil depends on building and maintaining a healthy soil. Soil health is defined as the "the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans". A healthy soil ecosystem has a diversity of organisms and a balanced food web. We can help build and maintain soil health by using practices that help incorporate soil organic matter, encourage earthworms, and promote soil structure:

Organic matter is the main "food" for many soil microbes, and the decomposition of organic matter supplies plants with key nutrients. The level of organic matter in the soil at any one time is a balance of what is being added and what is being decomposed. Planting cover crops instead of leaving soil bare is a good way to increase the amount of plant organic matter going into the soil. **[Figure 1,** Image: NRCS**]**



Earthworms are "nature's plow" and are active in turning, mixing and aerating the soil. Practices that provide organic matter (their food) and reduce disturbance of their habitat (like intensive tilling) can help encourage earthworms. **[Figure 3-22]**

Soil with good structure has a wide range of pore (empty) spaces between the soil particles, and provides good living conditions for soil organsims and roots. Microbes produce gums and gels or hyphae that help bind soil particles together. Feeding microbes organic matter and reducing disturbance of soil structure (like intensive tillage) helps maintain soil structure.