

Soil Biology: Key Educational Messages

Use this outline along with the Soil Biology Quick Facts below to organize a soil biology presentation or to identify key points to feature in printed materials.

I. Soil is alive!

- A. In most ecosystems, more life and diversity lives underground than above.
- B. Energy flows from the sun, through plants, and through many trophic levels of soil organisms.
- C. Soil organisms can be divided into six groups: bacteria, fungi, protozoa, nematodes, arthropods, and earthworms. Each group of organisms plays important roles. Even within each group, there is great diversity in form and function.
- D. The rhizosphere is the interface between plant roots and the soil environment. It is the location of much soil biological activity and plant-microbe interactions including symbioses, pathogenic infection, and competition.
- E. Soil organisms are part of a living system. Ecosystem characteristics largely determine the structure of soil communities. Weather determines daily and seasonal variations in biological activity.
 1. The types of species present and their level of activity depends on micro-environmental conditions including temperature, moisture, aeration, pH, pore size, and types of food sources.
 2. Arid systems have few earthworms, but have termites, ants and other invertebrates that serve similar functions.
 3. Grasslands have near equal amounts of fungal and bacterial biomass, or may be dominated by bacteria. Coniferous forests may have 100 to 1000 times more fungal biomass than bacterial biomass.

II. We need soil organisms for the services they provide. They play critical roles in plant health and water dynamics.

- A. Soil organisms are an integral part of the cycling of nutrients through the environment. They drive:
 1. Decomposition,
 2. Mineralization (E.g., protozoa and nematodes excrete excess nitrogen into the soil when they eat nitrogen-rich bacteria and fungi.)
 3. Storage and release of nutrients,
 4. Degradation of pollutants before they reached groundwater or surface water,
 5. Carbon cycling, carbon sequestration, and soil organic matter transformations,
 6. Nitrogen cycling (N fixation, denitrification, nitrification).

C. Soil biological activity substantially affects soil structure including the size of soil pores, the stability of soil aggregates, and the existence of macropores. Soil structure impacts how water flows over, into, and through soil and how much water is held within reach of plant roots.

1. Large, burrowing invertebrates (e.g., earthworms, ants, termites, beetles) create macropores that allow rapid flow of water into or through soil.

2. Even tiny arthropods produce fecal pellets that are mixtures of soil and organic matter. These become stable soil aggregates.

3. Fungi and bacteria produce substances that help bind soil particles together and stabilize soil aggregates.

4. Soil organic matter can be physically protected from degradation within stable soil aggregates.

D. Plant pest dynamics depend on the whole mix of organisms in the soil. Some organisms prey on or compete with disease-causing organisms. Some bacteria release plant growth factors that directly increase plant growth.

E. In arid lands, biological soil crusts seem to be important for all the purposes listed above. They help fix nitrogen, stabilize the soil surface, affect water flow, and prevent the establishment of some exotic plant species.

F. Mycorrhizal fungi help plants acquire nutrients from the soil and they help stabilize soil aggregates.

G. Resilience is the ability of a soil to recover its functions after a disturbance such as fire, compaction, tillage, etc. The mix of organisms in the soil partially determine a soil's resilience.

III. Management affects soil organisms

A. We know that land management practices change the soil community. The link between specific changes and soil function is less clear.

B. Soil biological crusts are very sensitive to trampling.

C. Reducing tillage tends to result in increased growth of fungi, including mycorrhizal fungi.

D. Soil compaction, lack of vegetation, or lack of plant litter covering the soil surface tends to reduce the number of soil arthropods.

Soil Biology Quick Facts

- The tips of small plant roots move through the soil with a twisting screw-like motion. Mature trees can have as many as 5 million active root tips.
- A single spade full of rich garden soil contains more species of organisms than can be found above ground in the entire Amazon rain forest.

- Although the soil surface appears solid, air moves freely in and out of it. The air in the upper 8 inches of a well-drained soil is completely renewed about every hour.
- The plants growing in a 2-acre wheat field can have more than 30,000 miles of roots, greater than the circumference of the Earth.
- The wonderful "earthy" smell of newly plowed ground is believed to result from chemicals produced by micro-organisms. One of these chemicals, called geosmin, is produced by actinomycetes, organisms that have some properties of both bacteria and fungi.
- Soil can act as either a sink or a source of greenhouse gases. An estimated 30 percent of the carbon dioxide, 70 percent of the methane, and 90 percent of the nitrous oxide released to the atmosphere each year pass through the soil.
- It takes about 4,000 to 6,000 pounds of crop residue per year to maintain the content of organic matter in a soil.
- Modern farming practices that minimize soil disturbance (plowing) and return plant residues to the soil, such as no-till farming and crop rotations, are slowly rebuilding the Nation's stock of soil organic matter.
- Of the carbon returned to the soil as plant residue, about 5 to 15 percent become tied up in the bodies of organisms and 60 to 75 percent is respired as carbon dioxide back to the atmosphere. Only 10 to 25 percent is converted to humus in the soil.
- "We know more about the movement of celestial bodies than about the soil underfoot."
---Leonardo Da Vinci, circa 1500's
- "Every time you take a step in a mature Oregon forest, your foot is being supported on the backs of 16,000 invertebrates held up by an average total of 120,000 legs."
-Dr. Andrew Moldenke, Oregon State University.
- Even in agricultural soils, more than a thousand arthropod legs support your every step.
- One cup of soil may hold as many bacteria as there are people on Earth.
- Bacteria and actinomycetes are exceedingly tiny. Yet, because of their tremendous numbers, they make up half the living biomass in some soils.
- The weight of all the bacteria in one acre of soil can equal the weight of a cow or two.
- Actinomycetes have cells like bacteria, but grow as long filaments like fungi. Like fungi, they help degrade tough materials, but unlike fungi, they prefer high pH (over 7.0).
- A teaspoon of farm soil may contain tens of yards of fungi. The same amount of soil from a coniferous forest may hold tens of miles of fungi.
- Nematodes are amazingly diverse. Twenty thousand species have been described, but it is thought that 500,000 species may exist. Five thousand soil species have been described.
- Earthworms move from lower strata up to the surface and move organic matter from the soil surface to lower layers. Where earthworms are active, they can turn over the top 6 inches of soil in 10 to 20 years.