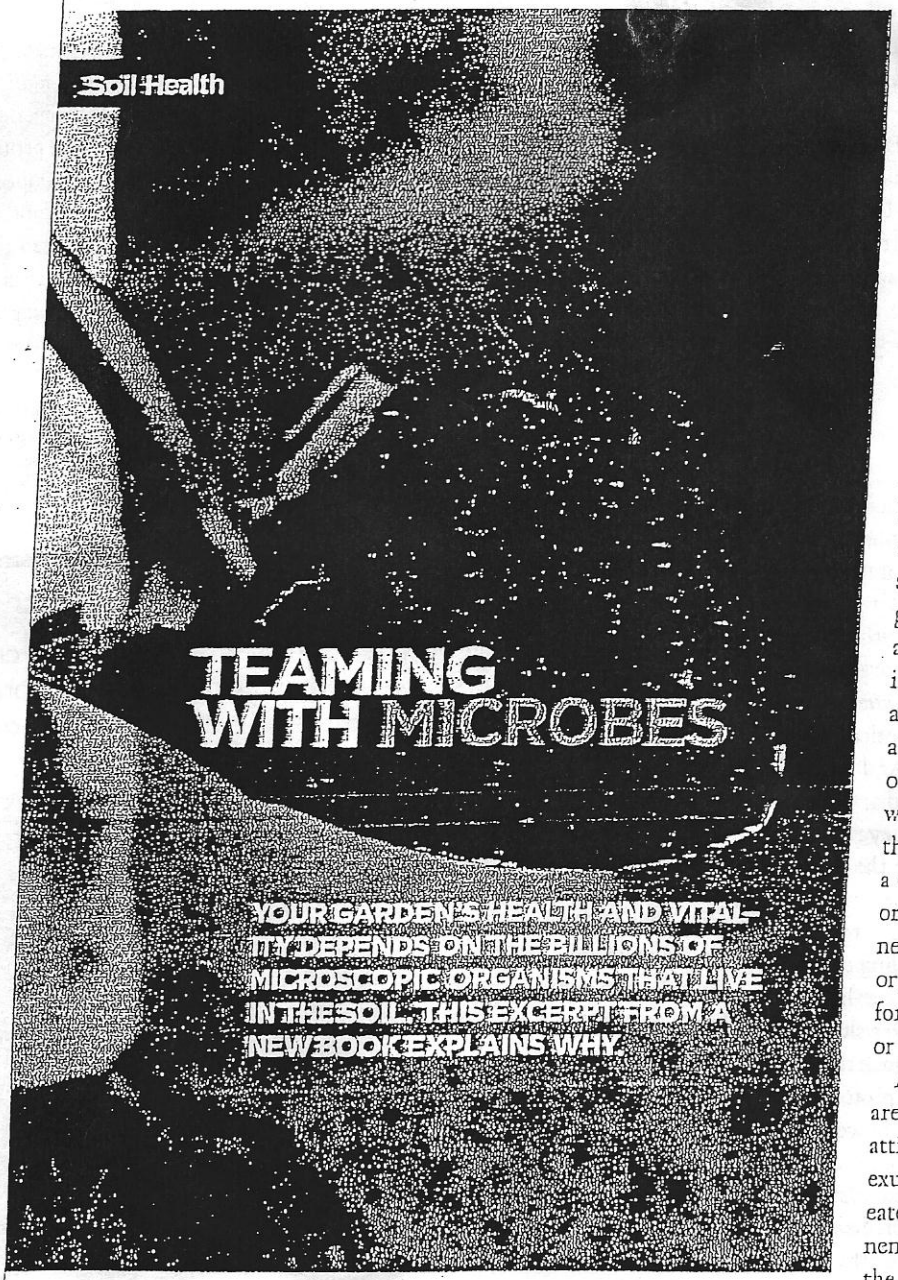


Why should a gardener be knowledgeable about how soils and soil food webs work? Because then you can manage them so they work for you and your plants. By using techniques that employ soil food web science as you garden, you can eliminate the need for fertilizers, herbicides, fungicides, and pesticides (and a lot of accompanying work). The billions of living organisms will be continuously at work throughout the year, doing the heavy chores: providing nutrients to plants, building defense systems against pests and diseases, and loosening soil and increasing drainage to provide necessary pathways for oxygen and carbon dioxide. You won't have to do these things yourself.

—Jeff Lowenfels and Wayne Lewis

How Does It Work?

Most gardeners think of plants as only taking up nutrients through root systems and feeding the leaves. Few realize that a great deal of the energy that results from photosynthesis in the leaves is actually used by plants to produce chemicals they secrete through their roots. These secretions are known as *exudates*.

Root exudates are in the form of carbohydrates (including sugars) and proteins. Amazingly, their presence wakes up, attracts, and grows specific beneficial bacteria and fungi living in the soil that subsist on these exudates and the cellular material sloughed off as the plant's root tips grow. All this secretion of exudates and sloughing off of cells takes place in the *rhizosphere*, a zone immediately around the roots, extending out about a tenth of an inch, or a couple of millimeters. The rhizosphere, which can look like jelly or jam under the electron microscope, contains a constantly changing mix of soil organisms, including bacteria, fungi, nematodes, protozoa, and even larger organisms. All this "life" competes for the exudates in the rhizosphere, or its water or mineral content.

At the bottom of the soil food web are bacteria and fungi, which are attracted to and consume plant-root exudates. In turn, they attract and are eaten by bigger microbes, specifically nematodes and protozoa (remember the amoebae, paramecia, flagellates, and ciliates you should have studied in biology?), which eat bacteria and fungi (primarily for carbon) to fuel their metabolic functions. Anything they don't need is excreted as wastes, which plant roots are readily able to absorb as nutrients. How convenient that this production of plant nutrients takes place right in the rhizosphere, the site of root-nutrient absorption.

Plants control the food web for their own benefit, an amazing fact that is too little understood and

surely not appreciated by gardeners. Studies indicate that individual plants can control the numbers and the different kinds of fungi and bacteria attracted to the rhizosphere by the exudates they produce. During different times of the growing season, populations of rhizosphere bacteria and fungi wax and wane, depending on the nutrient needs of the plant and the exudates it produces.

Why Synthetic Fertilizer Fails

When you apply a chemical fertilizer, a tiny bit hits the rhizosphere, where it is absorbed, but most of it continues to drain through the soil until it hits the water table. Not so with nutrients locked up inside the soil organisms, a state known as *immobilization;* these nutrients are eventually released as wastes, or mineralized. And when the plants themselves die and are allowed to decay, the nutrients they retained are again immobilized in the fungi and bacteria that consume them.

Chemical fertilizers negatively impact the soil web by killing off entire portions of it. What gardener hasn't seen what table salt does to a slug! Fertilizers are salts; they suck the water out of the bacteria, fungi, protozoa, and nematodes in the soil. Since these microbes are at the very foundation of the soil food web nutrient system, you have to keep adding fertilizer once you start using it regularly. The microbiology is missing and not there to do its job, feeding the plants.

Building Soil Structure

Bacteria are so small they need to stick to things, or they will wash away; to attach themselves, they produce a slime, the secondary result of which is that individual soil particles are bound together. Fungal hyphae, too, travel through soil particles, sticking to them and binding them together, threadlike, into aggregates.

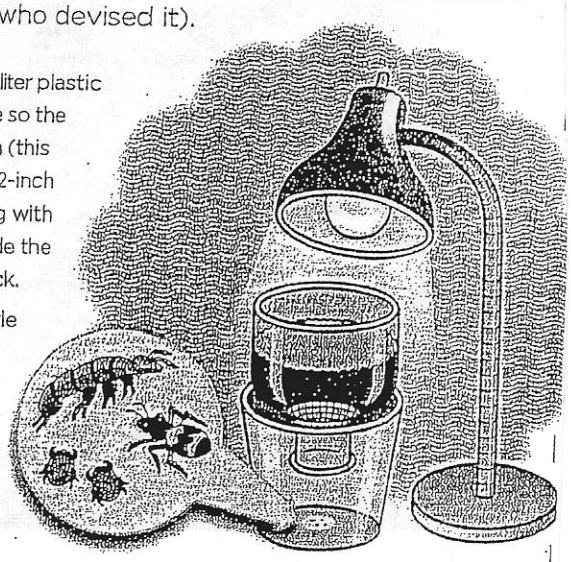
Worms, together with insect larvae and moles and other burrowing animals, move through the soil in search of food and protection, creating pathways that allow air and water to enter and leave the soil. The soil food web, then, in addition to providing nutrients to roots in the rhizosphere, also helps create soil structure: The activities of its members bind soil particles together even as they provide for the passage of air and water through the soil.

Now that you have an idea of what populates your soils, it is time to take whatever action is necessary to ensure that your soil food webs give your plants what they need in the way of nutrients and protection. Compost, mulch, and compost tea are the tools for soil food web gardeners. These tools feed the microbes that feed the plants. And if you keep the microbes happy, healthy, and diverse, you will surely have excellent results.

Excerpted from Teaming with Microbes: A Gardener's Guide to the Soil Food Web, *by Jeff Lowenfels and Wayne Lewis,* *© 2006, by permission of Timber Press (timberpress.com).*

Soil Census

Want to find out how healthy your soil is? Just count the creatures living in it. Here's how—no biology degree or electron microscope needed; just a "Berlese funnel" (named for Giovanni Berlese, the scientist who devised it).



- Cut off the bottom of a 2-liter plastic soda bottle. Turn the bottle so the pouring side is facing down (this is the funnel). Next place a 2-inch square of window screening with 1/16- to 1/8-inch openings inside the bottle so it settles in the neck.
- Set the mouth of the bottle into a quart-size container (yogurt or cottage cheese type) to act as a repository to collect organisms that fall into it through the screen and to keep the funnel stable.
- Fill the funnel with soil and duff, the organic debris that is on the top few inches of soil. Take your sample down to about 8 inches.
- To get the life in the soil to move from the soil into the container, apply heat by putting a 60-watt bulb about 6 inches over the open end of the funnel. The light and heat will drive the microarthropods (e.g., mites and springtails) out of the soil and into the container. Leave it alone for three days or up to a week.
- Now it's time to count your catch. Look at the container's contents with a magnifying glass. In healthy organic soil, you can expect to see hundreds of mites, tiny beetles, springtails, and more. These feed on the smaller microbes, and their presence signals that you have healthy levels of protozoa and nematodes, which in turn feed on bacteria and fungi.

Adapted from Teaming with Microbes *with permission from Timber Press.*