Composting

Generations of gardeners have consistently come up with the same chain of logic: a fertile soil is the key to growing garden vegetables; compost is the key to a fertile soil. The first step in a healthy garden is learning to make good compost. It's not difficult. Compost wants to happen.

Compost is the end result of the decomposition of organic matter. It is a black crumbly material that looks like a rich chocolate cake. Compost is produced by managing the breakdown of organic material in a pile called a compost heap. Compost enhances soil fertility because fertile soil and compost share a prolific population of organisms whose food is decaying organic matter. The life processes of these organisms help make nutrients from the organic matter and the minerals in the soil available to growing plants.

Good compost is not an accident. It comes about through a process involving microorganisms, organic matter, air, moisture, and time that can be orchestrated in anyone's backyard. No machinery is necessary and no moving parts need repair. All you need to do is heap up the ingredients as specified below.

Don't pass up weeds, shrub trimmings, or cow pies. If you mix together a broad range of organic matter with different mineral compositions, the resulting compost will cover the nutrient spectrum.

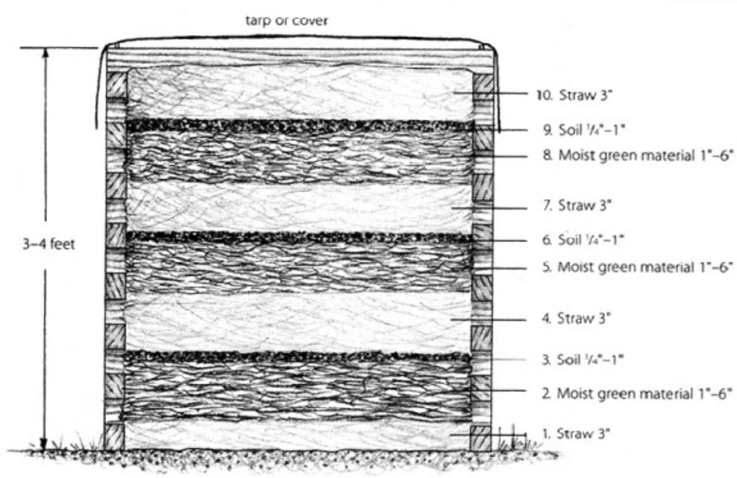
If using just plant material (as opposed to adding manure), divide the compost ingredients into those that are green and moist and those that are brown and dry. The best possible dried material is straw, because the stems are hollow and thus guarantee that oxygen will be available for the decomposition process.

Build the compost pile in a handy site with water available. Start with a base of 3" of straw or other dried material, then added 1-6" of green material, then 3" more straw, then more green.

The thickness of the green layer depends on the nature of the material. Loose, open material such as green bean vines or tomato stems can be applied in a thicker layer, while denser material that might mat together, such as kitchen scraps or grass clippings, should be layered thinly (1-2").

Sprinkle a thin covering of soil on top of each green layer, ½" or so. This adds minerals and microorganisms that enhance the decomposition process. If the garden soil is very sandy, you might want to find some clay to add to the heap as the soil layer.

The decomposition process literally gives off heat; the temperature inside can reach 160 degrees. The ingredients should be slightly moist, like a squeezed-out sponge. The green material is higher in nitrogen, the brown high in carbon, the combination of the two is optimum for breakdown. Air is also necessary. When composting fails, it is usually because he ingredients are packed into an airless mass and the activities of aerobic (oxygen-breathing) bacteria are inhibited.



Layers of material in a compost pile.

A well-made compost heap is odorless. A bad smell indicates that something is amiss. When the heap is too wet or compacted the process becomes anaerobic (without air), and a different bacterial population takes over. The anaerobic bacteria create sewage-like odors. If the heap is made with too much green material, it will have a strong ammonia odor because the bacteria are volatizing the extra nitrogen. You can improve both situations by forking the material into a new pile alongside and piling it more loosely with additional layers of straw.

If the pile fails to heat up, it is probably too dry, and the bacterial activity is inhibited. Add water, remembering the analogy of the squeezed-out sponge. Another reason the pile may fail to heat is too much carbon material (dried) relative to nitrogen-rich material (green). In this case you may need to refashion the pile, adding more nitrogenous material. When carbon, nitrogen, water and oxygen are in reasonable balance, the pile with actually give off steam on cool mornings.

Piles can be held in place in various ways—using wire fencing, lumber or straw bales. Try to optimize oxygen availability to the pile. A pile larger than 8 feet square is too large for air to reach the center. Even with a 6-foot-square pile, it is a good idea to put a stake in the center while building it, and then remove it upon completion to allow direct air access to the center.

Straw bales work well as retaining walls because 1) they keep the pile moist right to the edge, 2) the bales provide insulation in cool weather, and 3) after a year or two the bales can be used as compost.

The pile will settle quickly once decomposition starts; the ideal situation would be to be able to add more layers as the settling takes place to maintain the depth of the pile. A wooden lid can be used in winter to keep snow off the pile but still have it accessible to dump kitchen scraps.

The heat of composting reaches its peak a few weeks after the heap is completed and then dies down. By then the microorganisms have used up the easy fuel of the initial breakdown process. The subsequent breakdown can be speeded by turning the pile.

Sawdust and leaves are not good compost items. Sawdust breaks down very slowly. Leaves tend to mat and create airless conditions. Leaves can be piled separately and will decompose over time, if kept a little moist. They are broken down by fungi, so matting and oxygen availability is not an issue.

Animal manure is valuable as a soil additive, once broken down. When adding it to the compost pile, limit the quantity to no more than 20% of the total.

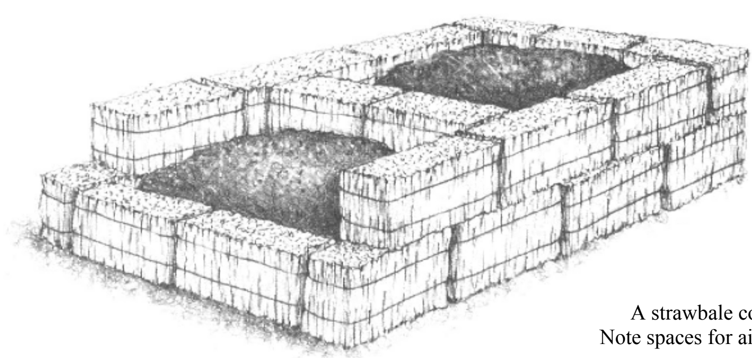
Compost can be used after the first heating/cooling cycle, although not all materials will be broken down. This stage of decomposition might best be added in the fall, so that breakdown can continue over winter. To get finer compost from this stage screen it through a wire mesh.

For thoroughly decomposed compost, remix the pile and allow it to heat and cool again.

The finest compost, like good wine or cheese, is a product of time. It needs to mature. To achieve full compost maturity, you must turn the heap a second time, cover it, and let the compost age until it is one to two years old. At that point, it will achieve a wonderful chocolate fudge cake texture throughout. This material is a close as you can get to miracle plant food, and is the secret to the success of homemade potting soils.

Once you have compost, what do you do with it? Rather than digging it deeply into the soil, consider spreading it on top of the soil and mix it shallowly with a rake. The quality of plant growth is superior if you duplicate nature's system of leaving organic matter on the surface to be mixed by earthworms and other soil creatures.

How much to spread? For first applications, 1" depth of compost is recommended. Once the soil seems to have adequate humus, ¼" or ½" a year will be sufficient.

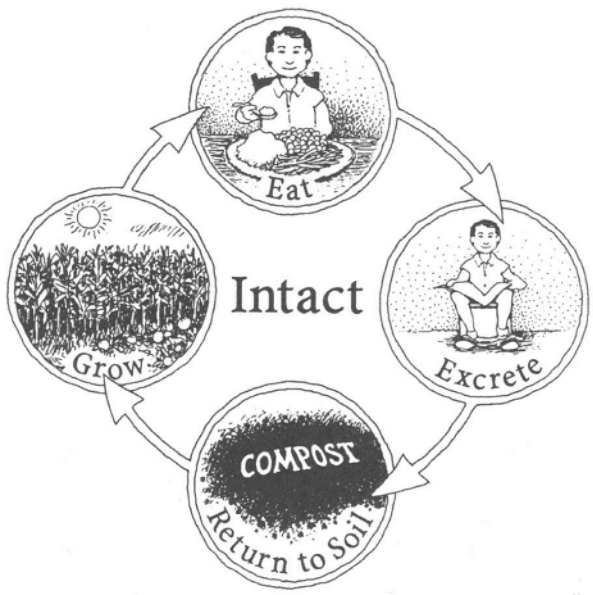


A strawbale compost pile-
Note spaces for air between bales

Chinese proverb:
To be happy for a week, get married;
to be happy for a month, kill a pig; t
o be happy for a lifetime, plant a garden.

Humus, Humility, and Humanure

by Dana Visalli



It came as a bit of a shock when someone pointed out to me that nature wastes nothing. Nature throws nothing away, nor does it create any garbage whatsoever. This is in noticeable contrast to humans, especially those of us living in the United States, where each individual creates an average of five pounds of garbage per day. Our cumulative total is 250 million tons annually. The problem that nature has is that it lives on a finite planet, where all of the resources necessary for life were delivered when the earth was formed. If these resources were actually *thrown away*, then there would be less potential for life to flourish with each passing day. Instead, nature not only recycles resources, but in fact the elements that make life possible are flowing constantly from the air and soil into plants, from plants to animals and back into the air and the earth.

About 25 of the 94 naturally occurring elements on earth (surely you remember the Periodic Table of Elements on the inside cover of your chemistry book?) are necessary building blocks in both plants and animals. For plants, three rise to the top of the list as being crucial for plant health—nitrogen, phosphorus and potassium. These are the common constituents of our plant fertilizers, often referred to by their chemical symbols, N (nitrogen), P (phosphorus) and K (potassium).

Nitrogen, phosphorus and potassium are limiting factors in agriculture; if one of them isn't present in adequate abundance, plant productivity will be reduced. That's why we fertilize. If we continually take crops off of land, we are taking these three elements (and many others) out of the soil. They will either have to be replaced or the soil will become depleted.

In our current agricultural system we depend on the fossilized solar energy in petroleum to replace these critical components of the soil. In modern agriculture, nitrogen fertilizer is produced using natural gas, and phosphorus and potassium are mined, crushed, and transported utilizing the energy in gasoline and diesel. The journey for the food and fiber that comes out of the soil is a one-way trip, from the field, to the human consumer, and then *thrown away* into the garbage or *flushed away* in the toilet.

These two methods of sustaining life—nature's relentless cycling of nutrients and human society's one-way transport from soil to garbage dump—have markedly different life expectancies. Nature has been cycling the earth's critical elements for nearly 4 billion years now, with no end in sight. Our society's linear transport of nutrients will roughly coincide with the Age of Oil, which started in 1859, and is predicted to last about 200 years, to 2059.

Note: All information and graphics in this article are from the highly recommend *Humaure Handbook: A Guide to Composting Human Manure*, by Joseph Jenkins society's linear transport of nutrients will roughly coincide with the Age of Oil, which started in 1859, and is predicted to last about 200 years, to 2059.

If we want our culture to be sustained beyond 2059, we will have to learn to emulate nature and cycle the elements and nutrients necessary to life back into the soil. Because we happen to live on a finite planet, that will of necessity have to include the byproduct of our own metabolism, which we call excrement or humanure. Humanure is rich in the vital elements of life; it is composed of 6% nitrogen, 4% phosphorus and 2% potassium. And, it is available in great abundance. Every human being produces about 1000 pounds of humanure per year. Multiply that by the 6.5 billion people on the planet and see how much annual fertilizer you come up with. Imagine *throwing away* that quantity of vital life elements.

Our aversion to using humanure as fertilizer has two sources. One is that the material can harbor human pathogens if not composted properly. The second source is that humans have somehow forgotten that they are actually a product of the earth—we are literally made of soil and air. Unless you were dropped off here by a spaceship, there are no other options. We arise from the earth and when we die we go back to the earth. It's a rather spiritual phenomenon. But having forgotten this simple truth, we have developed a shyness or a fear of the natural cycles that make life possible. And that includes cycling the byproducts of our own lives back into the ecosystem.

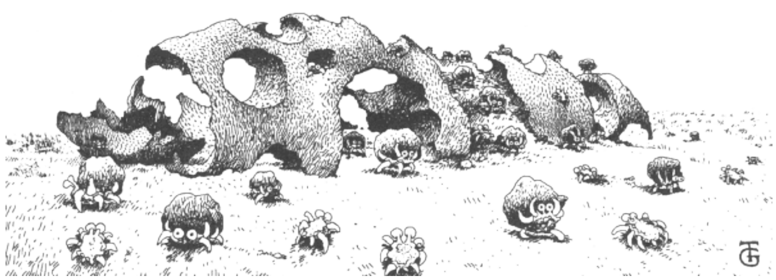
Humanure can be easily and safely composted and made completely safe to use as fertilizer. For the full details, consult *The Humanure Handbook: A Guide to Composting Human Manure* by Joseph Jenkins, available at your favorite bookseller or as a loan from the PSM office.

Briefly, the three critical elements to composting humanure are:

1) Creating a compost pile that has the necessary carbon: nitrogen (C/N) ratio for aerobic bacteria to break the manure down into humus. The ideal C/N ratio for bacterial decomposition is 30:1. Humanure has a C/N ratio of about 10/1 (it is high in nitrogen), so it is necessary to add high carbon material like straw to the compost pile. When properly built, a humanure compost pile does not give off any offending odor.
2) Adequate oxygen. The bacteria that break down the manure are aerobic—they require oxygen to function properly. Oxygen is easily made available by using bulky, hollow material such as straw in the compost pile.
3) Heat. Aerobic bacterial action produces heat; compost piles can warm to 140 degree or higher. Complete pathogen destruction in the humanure is guaranteed by arriving at a temperature of 143 degrees F for one hour, 122 degrees for one day, or 115 degrees for a week.
4) Time. Letting the compost pile "cure" for a year after it has finished the aerobic decomposition will offer a guarantee that all potential pathogens are destroyed.

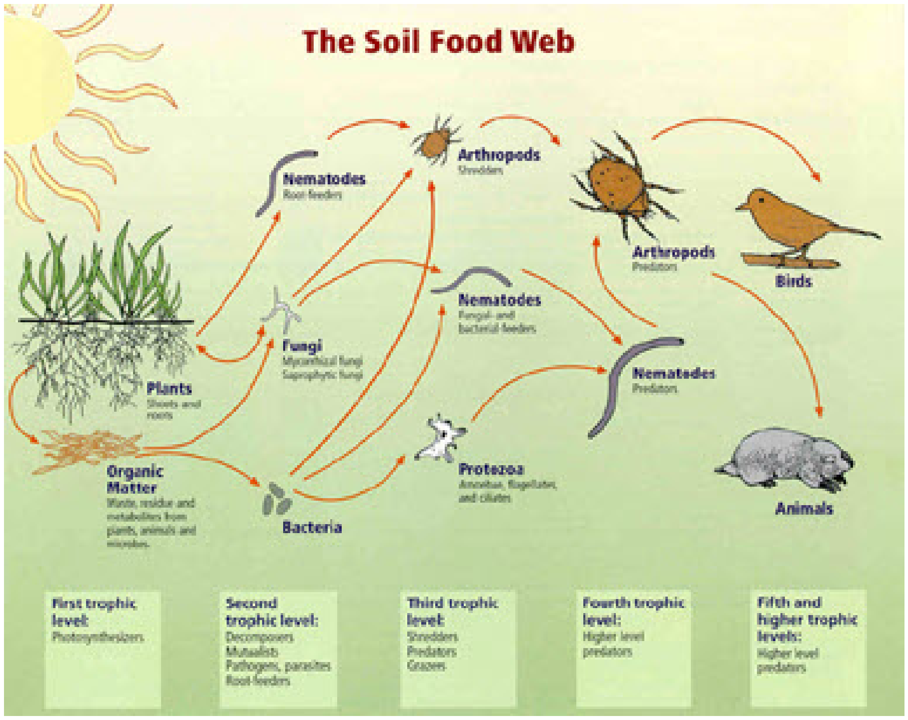
The end product of this decomposition process is humus—organic matter rich in critical nutrients, like the composted steer or chicken manure we purchase at the feed store. These nutrients give life to plants, which give life to us, and then they go back into the living soil in an endless cycle.

The Latin root for humus, humility, and humanure are all the same, and translates as "earth." Reintegrating our lives with the endless cycling of nutrients and elements is an act of humility in that it brings us out of the imaginary world we create inside our heads and back down to earth, which is a good place to be.



The Real Dirt on Dirt: Nurturing the Soil Ecosystem

By Dana Visalli



From a plant's perspective, all the good things in life are temporary. Water falls from the sky only to quickly percolate away through the soil and wash to the sea. The all-important element nitrogen is dragged out of the atmosphere by nitrogen-fixing bacteria, only to become volatile ammonia and evaporate back to the sky. Phosphorus is available only as rock-dust—ground-up mountains—delivered to the soil at geologic speed. Even carbon, the basic building block of plant tissue, escapes to the atmosphere as the gas carbon dioxide when plants decompose. What's a plant to do?

The only way to create a continually moist, nutrient-rich soil ecosystem is to slow down the escape of these critical nutrients and water from the soil. Nature has chipped away at this challenge for 450 million years—the approximate amount of time that life has existed on land—and has come up with a "living soil" that continually cycles the important ingredients of life in place, rather than letting them escape. The home gardener can emulate nature and create vibrant soil, even here amid the rocky regolith of the Methow Valley.

Take nitrogen for example. This element is critical to plant growth. For better and for worse most of the world's supply of this element is in the atmosphere, which is 78% nitrogen. It exists there as N2, two atoms that are chemically so tightly bound together that they are useless to plants. Eons ago, when bacteria were the only life on the planet, certain bacterial species developed a method of splitting atmospheric nitrogen apart in order to incorporate it into their own chemistry. We know of these today as the nitrogen-fixing bacteria that live on the roots of the Legume Family (which includes peas, beans and alfalfa) and a few other plant genera (in our area, alder, bitterbrush, Sheperdia and Ceanothus are all hosts to nitrogen-fixing bacteria). There are also free-living nitrogen-fixing bacteria in the soil.

Thanks to certain bacteria then, atmospheric nitrogen is "cracked" and made available in the soil. But initially it is tied up in the body of these bacteria,

Nematodes, a man's best friend. Most soil nematodes are beneficial.

and when they die much of the nitrogen would return to the atmosphere if not somehow intercepted. Nature is nothing if not opportunistic, and over time a long food-chain evolved to capitalize on this nitrogen bonanza. A host of larger (but still very small) creatures have evolved to capture this nitrogen as it is passed from species to species. This menagerie has become so abundant and complex that it is estimated that a teaspoon of fertile soil can contain a billion bacteria, a million protozoans (one-celled creatures like amoeba and paramecium), hundreds of microarthropods (small insects, spiders and their kin), and up to one hundred beneficial nematode worms.

As this armada of organisms live and die, eat and excrete, they cycle the very same nutrient molecules through the soil over and over again. One of the most important reservoirs of nutrients is animal excrement, to the great discomfort of the peculiarly unecological, urban-industrial, 21st century human mindset. We are generally reconciled to returning animal manures to the soil, but the fact that our own excreta is a vital component of ecosystem health seems to be a bitter pill for us to swallow.

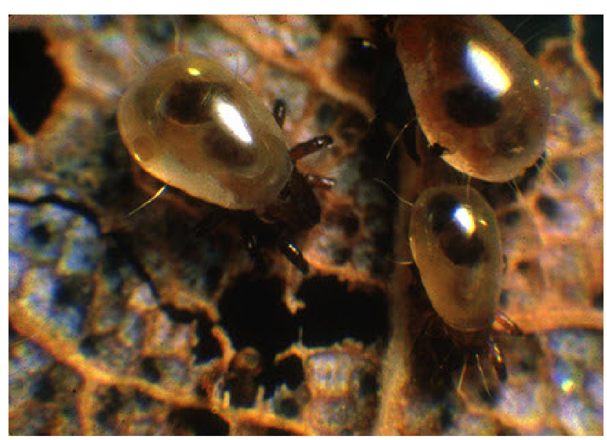
Bacteria and fungi are the decomposers of the organic world, and as such they are critical for nutrient retention. The ratio of one to the other, bacteria to fungi, varies widely in different ecosystems. In grasslands bacteria dominate in the soil by a ratio of 10:1 or more. In conifer forests, the cool, moist, acidic conditions favor fungi, which out-compete bacteria by from 10:1 to 100:1. In agricultural soils, like your garden, the ideal ratio of bacteria to fungi is 1:1. Because both are decomposers, a continual supply of organic matter in the form of compost and/or mulch is necessary. Bacteria are more active in warm, moist soils, and will dominate in summer. Fungi favor cool, moist conditions, and will perform best under a layer of mulch in spring and fall. In areas like the Methow where snow accumulates on the soil surface, such that the soil does not actually freeze, fungal activity may continue at high levels throughout the winter.

The best way nurture a healthy microbial ecosystem in a home garden is to routinely apply organic material, such as compost and partially decomposed humus. To keep garden soil healthy, the amount of organic matter added must be equal to what the bacteria and fungi use each year. The rest of the animal zoo in the soil will follow the humus, which retains moisture in the soil, and feeds the decomposers that liberate nutrients for the rest of the crowd.

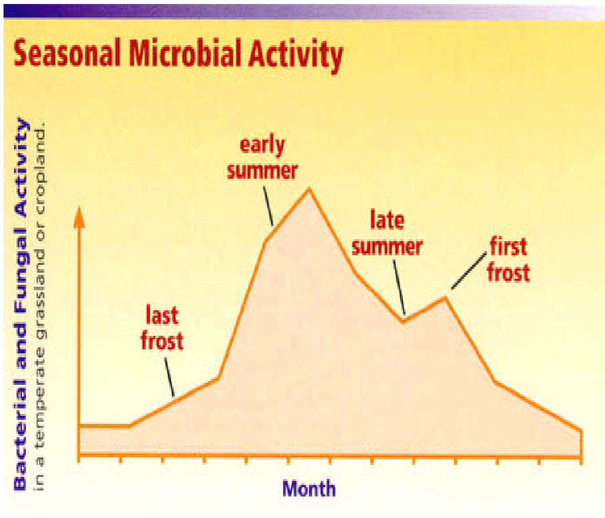
One simple test for soil texture—the mix of mineral soil, decomposing humus and compost—is to squeeze moist soil into a ball. If the sample falls apart when you open your hand, you've got sand, not soil. The same test can be used to assess moisture. In the Methow's sandy soils, 50-70% available soil moisture is desirable in the first six inches of soil. Below 50% moisture, sandy soil will not clump together when squeezed into a ball (but pure sand will not stick together under any circumstances).

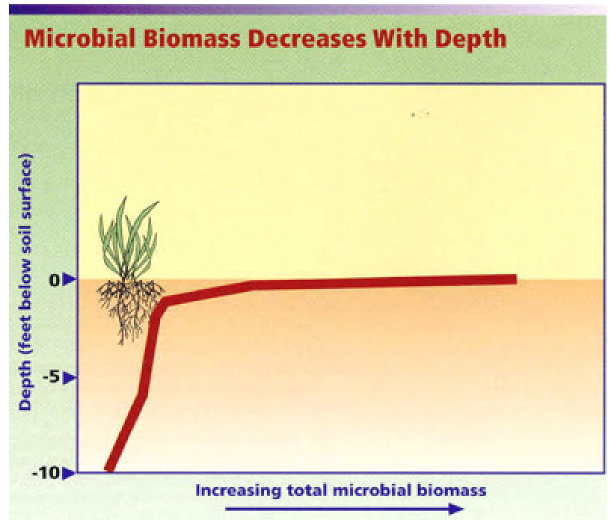
It is quite possible to add too much humus. Remember that it is bacteria that decompose humus, and bacteria require large amounts of nitrogen. An overly large population of bacterial decomposers will monopolize the available nitrogen, stunting plant growth.

Imagine driving through a Methow forest with a caterpillar tractor with the blade down. Obviously this would be quite disruptive to the multitude of organisms that had developed over time because of the stability of the forest ecosystem. The same is true for the impact of plowing and rototilling on the multitude of organisms that live in agricultural (garden) soil. Disturbed soil is a disturbed ecosystem, and there are numerous invader species, from parasitic nematodes to knapweed, that will be delighted to take advantage of this traumatized environment.



Soil mites shred organic matter and make the material easier for bacteria to decompose.





It may be necessary to enhance poor soil initially by screening out large rocks, aerating to a foot or more of depth (about half the volume of good soil is pore space, usually filled equally by air and water), and infusing it with partially decomposed humus or compost (10% of the soil by bulk). After that, is healthier for both the garden and gardener to simply add compost (1/2" to 1") to the soil surface annually and hoe it into the topsoil. This will emulate natural ecosystems, where most of the humus and 75% of the biological activity is in the top 6 inches of soil. These no-till garden soils should be aerated occasionally with a broadfork, which is an overgrown pitchfork that is used to lift the soil in place.

A soil springtail, magnified many times.

Plants grown in soil where competing organisms have been knocked back with chemicals are more susceptible to disease-causing organisms. If the numbers of bacteria, fungi, protozoa, nematodes and arthropods are lower than they should be for a particular soil type due to the use of chemicals, the soil's "digestive system" doesn't work properly. Decomposition will be low, nutrients will not be retained in the soil, and they will not be cycled properly. Ultimately, nutrients will be lost through the groundwater or through erosion because organisms aren't present to hold the soil together.

In truly sustainable gardening, no nutrients would be imported from outside the garden area, because importing infers that some other piece of the good earth is being depleted in order to enrich our own plot of ground. A number of organic farmers and gardeners have studied this conundrum, and briefly put, the resolution is for growers to have enough agricultural land that half or more of the garden or farm is dedicated each year to growing a green manure crop (a plant species that produces an abundance of cellulose, and preferably fixes nitrogen in the soil) that is then incorporated back into the soil. This reduces the short-term carrying capacity (the number of people that can be fed) from any given area of land, but ensures that soil fertility will increase through the years rather than be depleted.

Physicist Albert Bartlett of the University of Colorado has noted that "modern agriculture is a means of turning oil into food." The 450 million-year-old biological system described above is completely circumvented in modern agriculture, and nitrogen and phosphorus are simply pumped into the soil through the use of fossil fuels. The so-called "Green Revolution" was in fact black; it was petroleum-driven. Now that conventional petroleum production on the planet is about to peak (it peaked in the United States in 1970), it is going to be necessary to abandon our penchant for to turning oil into food, and relearn the ancient art of turning soil into food.

Further Reading:
The Soil Biology Primer by Elaine Ingham, can be borrowed from The Methow Naturalist or read or purchased online ($14) at http://soils.usda.gov/sqi/concepts/soil_biology/biology.html.