THE BENEFITS OF COMPOSTING

Note: The following are verbatim excerpts from the Rodale Book of Composting (2018 version-275 pages), The purpose is to:

1) *remind us how, as humans, we are linked to the cycle of life that inveribly includes the lfe patterns of nature, that uses the recycling process to provide nourishment for the ongoing annual natural life cycle, and even upon demise, as nourishment for new life.*
2) *educate us about the vast quantities of recycleable materials that are ending up in our municipal trash heaps, and how we can do our small part to reduce this collosial waste, and*
3) *advise us on how we should design our composting operation at FVT so that it provides us with a reliable source of quality humus, in the most cost effecient manner possible, and that best utilizes the equipment and expertise we have available to us.*

Underlines have been used to highlight concepts that may be particularly beneficial to our composting design and operation at FVT.

Doug H. (excuse the typos, etc, they are mine)

1) INTRODUCTION

Plants, animals, insects, and people are all inextricably linked in a complex web of interrelationships with air, water, soil, minerals, and other natural resources playing vital roles. Compost, too, plays an important role. There is a cycle, a continuity, to life.

We are only at the very beginning of an understanding of all the parts of this cycle of life. But we are learning that upsetting the life patterns of only one kind of plant or animal, even in a seemingly minor way, can have effects on many other living things. All of the environmental problems we face are rooted in a failure to appreciate the life cycle and to keep it intact. We can use understanding of the interrelationships of living things in active ways to increase the productivity of our fields, forests, orchards, and gardens. Composting is one way to work within the life cycle in the furthering of our welfare.

Compost is more than a fertilizer, more than a soil conditioner. It is a symbol of continuing life. Nature has been making compost since the appearance of primitive life on this planet, eons before humans first walked the earth. Leaves falling to the forest floor are soon composted, returning their nutrients to the trees that bore them. The dead grass of the meadow, seared by winter's frost, is made compost in the dampness of the earth beneath. The birds, the insects, and the animals of field and forest contribute their wastes and eventually their bodies, helping to grow food so that more of their kind may prosper. The greenness of the earth itself is a strong testament to nature's continuing composting program.

Drought Protection: Soil is improved when compost holds more moisture. The permeability of soils amply supplied with organic matter is a potent weapon against drought damage. Water is soaked up like a sponge and stored on the soil granules (100 pounds of humus can hold 195 pounds of water).

Aeration: is also extremely important to soil health. Air plays a vital role in the maintenance of soil productivity. Plant roots and the majority of beneficial soil organisms need to breathe to proliferate. Organisms that can handle poor aeration—known as anaerobic conditions perform the vital functions needed to properly decompose organic matter and release its nutrients to feed the plants. Without air, soils tend to become alkaline, organic matter content decreases, active humus becomes deactivated, total and active humus content decreases, nitrogen content is reduced, and the carbon/nitrogen (C/N) ratio is lowered.

Nutrients When Plants Need Them: Compost is an excellent vehicle for carrying nutrients to your soil and plants. In a well-planned and executed composting program, in fact, food crops and ornamentals will need no other form of fertilization besides good compost. "For example, when composted, manure releases 50 percent of its nutrients in the first season and a decreasing percentage in subsequent years. This means that with constant additions of compost, the reserves of plant nutrients in the soil are being built up to the point where, for several seasons, little fertilizer of any kind may be needed. No fertilizer chemical can claim that.

The greater the variety of materials used in making compost, the greater will be the variety of nutrients contained in it. This includes not only the major elements—nitrogen, phosphorus, and potassium (N-P-K)—but also the minor elements, or micronutrients.

Although micronutrients are needed by plants in very small amounts in comparison with major elements, they are nevertheless just as essential to plant growth and reproduction.

A Better Buffer: By adding humus to the soil, compost helps plants overcome soil pH levels that are either too low (acidic) or too high (alkaline). Humus acts as a buffer in the soil. Garden and crop plants are less dependent upon a specific soil pH when there is an abundant supply of humus. Soils in certain regions of the United States exhibit characteristic pH levels. Throughout the Southwest, soils are typically alkaline. High pH levels reduce the number of soil microorganisms and make growing vegetables—most of which prefer slightly acidic conditions—difficult or impossible. In both cases, the addition of humus to the soil reduces plants ’reliance on specific soil pH levels.

Earthworms: In passing soil and organic matter through their bodies, earthworms gradually make acidic soil less acidic and alkaline soil less alkaline, slowly drawing any out-of-balance soil into the neutral range. Compost feeds earthworms and allows them to multiply, thus enhancing their ability to correct soil pH. A compost mulch keeps soil temperatures in the range earthworms need to survive, and it encourages such active soil builders as red worms and brandling worms that require copious amounts of organic matter in the surface soil. Earthworms and compost work together in many ways to improve soil for growing plants, including improved aeration as they tunnel through the soil, and secretions similar to glomalin that help form stable soil aggregates.

CHEMICALS VERSUS COMPOST

It should be obvious, if you have read this far about the benefits of compost, that chemical fertilizers are no substitute for compost. Chemicals supply major nutrients—period—in quick-release forms. Plants obtain fast growth, but long-term benefits are few. And living soil and living plants need far more than a few isolated chemical elements. Plants take their nourishment through infinitely complex biological processes that we still do not understand fully. To use chemical fertilizers to the neglect of compost is to disregard the soil’s need for life.

LIFE INSIDE A COMPOST HEAP

The two most important aspects of a compost pile are the chemical makeup of its components and the population of organisms in it. Compost piles are intricate and complex communities of animal, vegetable, and mineral matter, all of which are interrelated, and all of which play a part in the breakdown of organic matter into humus.

Humus: Humus, the relatively stable end product of composting, is rich in nutrients and organic matter and highly beneficial to both the soil and crops grown in the soil. The major elements found in humus are nitrogen, phosphorus, potassium, sulfur, iron, and calcium, varying in amounts according to the original composition of the raw organic matter thrown on the heap. Minor elements are also present, again in varying amounts depending on the type of compost. The N-P-K percentages of finished compost are relatively low, but their benefit lies in the release of nitrogen and phosphorus in the soil at a slow enough rate that plants can use them and that they aren’t lost through leaching.

Soil mixed with humus becomes a rich, dark color that absorbs far more heat than nonorganic soils, making it a more favorable environment in which to grow crops and ornamental plants.

2) HOW COMPOST IS PRODUCED

The road from raw organic material to finished compost is a complex one, because both chemical and microbial processes are responsible for the gradual change from one to the other. The raw materials that you add to your compost can be anything of biological origin. Wood, paper, kitchen trimmings, crop leavings, weeds, and manure can all be included in the heap. As compost is broken down from these raw materials to simpler forms of proteins and carbohydrates, it becomes more available to a wider array of bacterial species that will carry it to a further stage of decomposition.

Through complex, biochemical processes, these substances and the rest of the decomposed material form humus. There is some evidence that humus is largely the remains of microbial bodies. The microorganisms of the compost heap, like any other living things, need both carbon from the carbohydrates, and forms of nitrogen from the proteins in the compost substrate. To thrive and reproduce, all microbes must have access to a supply of the elements of which their cells are made. They also need an energy source and a source of the chemicals they use to make their enzymes. The principal nutrients for bacteria, actinomycetes, and fungi are carbon (C), nitrogen (N), phosphorus (P), and potassium (K). Sulfur and magnesium are important minor nutrients, while micronutrients such as boron, manganese, copper, zinc, iron, selenium, and molybdenum, among others, are essential components of the enzyme systems that all organisms need to grow and reproduce.”

The ideal C/N ratio for most compost microorganisms is about 25:1, though it varies from one compost pile to another. When too little carbon is present, making the C/N ratio too low, nitrogen may be lost to the microorganisms because they are not given enough carbon to use with it. It may float into the atmosphere as ammonia and be lost to the plants that would benefit by its presence in humus. Unpleasant odors from the compost heap are most often caused by nitrogen being released as ammonia. Materials too high in carbon for the amount of nitrogen present (C/N too high) make composting inefficient, so more time is needed to complete the process.

Composting can be defined in terms of availability of oxygen. Aerobic decomposition means that the active microbes in the heap require oxygen, while in anaerobic decomposition, the active microbes do not require oxygen to live and grow. When compost heaps are located in the open air, as most are, oxygen is available and the biological processes progress under aerobic conditions. Temperature, moisture content, the size of bacterial populations, and the availability of nutrients limit and determine how much oxygen a heap uses.

The amount of moisture in your heap should be as high as“possible, while still allowing air to filter into the pore spaces for the benefit of aerobic bacteria. Individual materials hold various percentages of moisture in compost and determine the amount of water that can be added. For example, woody and fibrous materials, such as bark, sawdust, wood chips, hay, and straw, can hold moisture equal to 75 to 85 percent of their dry weight. “Green manures,” such as lawn clippings and vegetable trimmings, can absorb moisture equaling 50 to 60 percent of their weight. According to longtime composting advocate and researcher Dr. Clarence Golueke in Composting: A Study of the Process and Its Principles, the minimum content at which bacterial activity takes place is from 12 to 15 percent. Obviously, the closer the moisture content of a composting mass approaches these low levels, the slower will be the compost process. As a rule of thumb, the moisture content becomes a limiting factor when it drops below 45 or 50 percent.

Temperature is another important factor in the biology of a compost heap. Low outside temperatures during winter months slow the decomposition process, while warmer temperatures speed it up. During the warmer months of the year, intense microbial activity inside the heap causes composting to proceed at extremely high temperatures. The microbes that decompose the raw materials basically fall into two categories: mesophilic, those that live and grow in temperatures of 50° to 113°F (10° to 45°C), and thermophilic, those that thrive in temperatures of 113° to 158°F (45° to 70°C). Most garden compost begins at mesophilic temperatures, and then increases to the thermophilic range for the remainder of the decomposition period. These high temperatures are beneficial to the gardener because they kill weed seeds and diseases that could be detrimental to a planted garden.

The bacterial decomposers in compost prefer a pH range of between 6.0 and 7.5, and the fungal decomposers between 5.5 and 8.0. Compost must be within these ranges if it is to decompose. Levels of pH are a function of the number of hydrogen ions present. (High pH levels indicate alkalinity; low levels, acidity.) In finished compost, a neutral (7.0) or“slightly acidic (slightly below 7.0) pH is best, though slight alkalinity (slightly above 7.0) can be tolerated.

Lime is often used to raise the pH if the heap becomes too acid. However, ammonia forms readily with the addition of lime, and nitrogen can be lost.”

Physical Decomposers

The bacteria, actinomycetes, protozoa, and fungi that we have looked at so far have to do mainly with chemical decomposition in the compost heap. The larger organisms, though, that chew and grind their way through the compost heap, are higher up in the food chain and are known as physical decomposers. All of the organisms, from the microscopic bacteria to the“largest of the physical decomposers, are part of a complex food chain in your compost pile.

Millipedes: The wormlike body of the millipede has many segments, each except the front few bearing two pairs of walking legs.

Centipedes. Centipedes are flattened, segmented worms with 15 or more pairs of legs—1 pair per segment. They hatch from eggs laid during the warm months and gradually grow to their adult size. Centipedes are third-level consumers, feeding only on living animals, especially insects and spiders.

Sow bugs. The sow bug is a fat-bodied, flat creature with distinct segments. Sow bugs reproduce by means of eggs that hatch into smaller versions of the adults. Since females are able to deposit a number of eggs at one time, sow bugs may become abundant in a compost heap. They are first-level consumers, eating decaying vegetation.

Snails and slugs. Both snails and slugs are mollusks and have muscular disks on their undersides that are adapted for a creeping movement. Snails have a spirally curved shell, a broad retractable foot, and a distinct head. Slugs, on the other hand, are so undifferentiated in appearance that one species is frequently mistaken for half of a potato. Both snails and slugs lay eggs in capsules or gelatinous masses and progress through larval stages to adulthood.

Their food is generally living plant material, but they will attack fresh garbage and plant debris and will appear in the compost pile.”

Ants. Ants feed on a variety of material, including aphid honeydew, fungi, seeds, sweets, scraps, other insects, and sometimes other ants. Compost provides some of these foods, and it also provides shelter for nests and hills. Ants will remain, however, only while the pile is relatively cool.

Ants prey on first-level consumers and may benefit the composting process by bringing fungi and other organisms into their nests.

Flies. Many flies, including black fungus gnats, soldier flies, minute flies, and houseflies, spend their larval phase in compost as maggots. Adults can feed upon almost any kind of organic material.

All flies undergo egg, larval, pupal, and adult stages. The eggs are laid in various forms of organic matter. Houseflies are such effective distributors of bacteria that when an individual fly crawls across a sterile plate of lab gelatin, colonies of bacteria later appear in its tracks. During the early phases of the composting process, flies provide ideal airborne transportation for bacteria on their way to the pile.

If you keep a layer of dry leaves or grass clippings on top of your pile and cover your garbage promptly while building compost, your pile will not provide a breeding place for horseflies, mosquitoes, or houseflies that may become a nuisance to humans. Fly larvae do not survive thermophilic temperatures.

Earthworms. If bacteria are the champion microscopic decomposers, then the heavyweight champion is doubtless the earthworm. Pages of praise have been written to the earthworm, ever since it became known that this creature spends most of its time tilling and enriching the soil. The great English naturalist Charles Darwin was the first to suggest that all the fertile areas of this planet have at least once passed through the bodies of earthworms.

The earthworm consists mainly of an alimentary canal that ingests, decomposes, and deposits casts continually during the earthworm’s active periods. As soil or organic matter is passed through an earthworm’s digestive system, it is broken up and neutralized by secretions of calcium carbonate from calciferous glands near the worm’s gizzard. Once in the gizzard, material is finely ground prior to digestion. Digestive intestinal juices rich in hormones, enzymes, and other fermenting substances continue the breakdown process. The matter passes out of the worm’s body in the form of casts, which are the richest and finest quality of all humus material, essentially a condensed packet of the essential nutrients extracted from the worm’s diet. Fresh casts are markedly higher in bacteria, organic material, and available nitrogen, calcium, magnesium, phosphorus, and potassium than soil itself. Earthworms thrive on compost and contribute to its quality through both physical and chemical processes.

3) COMPOST AND PLANT HEALTH

All higher plants have the same basic requirements for growth, although their requirements vary widely in amount and degree. The essentials are light, heat, water, air, and certain nutrient elements in reasonable amounts and in suitable balance. Plants obtain needed moisture and nutrients, with the exception of carbon dioxide, from the soil. The soil also helps control the temperature in the root zone and, to a lesser extent, in the aerial portions of plants.

Root growth is greatly influenced by soil temperature. In general, growth of roots increases as temperatures rise to a certain point, then decreases rapidly if temperatures exceed that level. For example, root growth is most rapid in most plants before midsummer.

Most beneficial soil microorganisms multiply rapidly at temperatures between 50° and 104°F (10° and 40°C). Organic matter in soil decomposes more quickly, due to the work of microorganisms, as temperatures rise toward 80.6°F (27°C); beyond this level, soil organism balances may change, and organic matter reserves will be depleted.

Disease organisms are influenced by temperature. Some do better at high temperatures, especially when such temperatures weaken their plant hosts. By helping to maintain soil temperatures at optimum levels for vigorous plant growth, humus improves disease resistance."

Water and Plant Growth

All living tissue contains water. Plants need and absorb more water than they do any other component of the soil. Much of the water they take in is given off again as they transpire, but some is kept in plant tissues and some is broken down to supply the hydrogen and part of the oxygen plants use or store in the form of carbohydrates. Drought is the most common cause of crop failure.

Green tissues of plants contain an average of 75 percent water. Growing tips may be as much as 93 percent water. Some plants contain more water than others. Tomato leaves are 84 percent water, and cabbage leaves 86 percent.

A plant must be turgid—full of water—for vital processes to take place within it. Too little water in leaf tissues causes stomata. Roots are essential for obtaining water and nutrients. Generally, roots grow in response to water need. However, plants differ widely in the amount of root they grow in reaching water. Soils also influence the growth of roots. In test plants, tomato roots at 12 weeks reached a depth of 11 inches in loam, but in other soils they were much shallower. Humus increases the potential for deep root penetration and for firm anchorage of root hairs by improving both soil friability and moisture-holding capacity.

Adding humus to the soil improves both its drainage and water-holding qualities. Heavy, waterlogged soils become less soggy, and light, droughty soils retain more water. This is especially significant in areas where water conservation is a priority.

Macronutrients

Nutrients that are needed in significant quantities by plants are called macronutrients. These include nitrogen, phosphorus, and potassium, the familiar N-P-K of fertilizer labels, as well as calcium, magnesium, and sulfur. All of these are supplied to plants through the soil, while the living plants get carbon, which is a primary constituent of all living tissue, from the air.

Carbohydrates: Although we don't often think about it in these terms, plants manufacture most of what they "eat" themselves, using the raw materials of air and water, plus energy from sunlight. In fact, nearly all (95 to 99.5 percent) of plant tissue is composed of carbon, hydrogen, and oxygen in the form of carbohydrates. The hydrogen and oxygen come from water, and the carbon comes primarily from the carbon dioxide in the atmosphere. Plant roots are continually sloughing off dead cells and actually secreting excess sugars as they grow, which in turn helps to feed the microbial community that surrounds them.

Carbon: One of the key elements recycled through microbial action, carbon is likewise essential to microbe growth. Organic matter is the sole source of carbon

Nitrogen: Nitrogen is a vital component of all protein, essential for the formation of new plant protoplasm. Without sufficient nitrogen, a plant is stunted and turns pale green or yellow, starting with the lower leaves. The stems of members of the grass family, such as corn, will be slender, and the whole plant will lack vigor. (Remember, however, that other conditions, such as excess or lack of moisture, cold weather, or plant disease, can cause the same symptoms.)

The demand for nitrogen is particularly strong when new plant tissue is developing and growth is most rapid. Nitrogen tends to be used more by stems and leaves than in seed production, so plants mature more slowly in soils that are over-rich in nitrogen. Too much nitrogen in plant tissues has been found to make them more susceptible to attack by pests and diseases. Also, excess nitrogen, most often present when fertilizer applications are not timed to match plants'nitrogen needs, leaches easily from the soil and becomes a significant source of water pollution. Release of nitrogen from"humus parallels plant demand, since microbial activity speeds up at the same time. If your plants have nitrogen-deficiency problems, the best way to provide immediate help is with manure tea. (described later)

Phosphorus: Phosphorus is necessary for photosynthesis, for energy transfers within plants, and for good flower and fruit growth. Unlike nitrogen, phosphorus has more to do with plant maturation than with plant growth. Most phosphorus in soil is present in the form of organic matter; the remainder is largely bound up in insoluble calcium, iron, or aluminum compounds. Plants need it in the form of phosphoric acid, which is released primarily through the action of soil microbes as they break down organic matter.

Deficiencies of phosphorus are characterized by stunted early growth, poor root development, and most notably by reddish or purple coloration on the undersides of leaves. Fruit tree leaves become bronzed and lose their luster, and some, like lemon leaves, show spots. Because seed production is influenced by phosphorus, seed abnormalities may also indicate a lack of this element.

Potassium:. Potassium is used by plants in many life processes, including the manufacture and movement of sugars, and cell division. It is necessary for root development and helps plants retain water. Potassium, or potash, in soil is often bound up with silicates. Potassium is not, however, a constituent of the organic compounds within plants.

Symptoms of deficiency appear in older leaves first and take the form of yellowing at the edges. Later, leaf edges turn brown and may crinkle or curl. In the case of corn, streaks appear between the leaf veins, and dry, brown edges and tips appear on leaves. The brown spreads to the entire leaf. On legumes, yellow spots, turning brown, spread inward from leaf edges. Tomato and potato plants also show yellowing of leaf tips and edges and some curling. Beets, carrots, sweet potatoes, radishes, and similar crops are long and small in diameter when they lack potassium.

Compost made with a formula of 6 inches of green matter to every 2 inches of manure provides adequate potassium for garden needs. When the moisture of the green plants is eliminated and the material is broken down, a sizable percentage of the remaining solid matter consists of potassium. If your soil is extremely low in potassium, add greensand or granite dust to the compost heap. Heavy mulching seems to help maintain soil potassium supplies, too. Use wood ashes or any highly soluble potassium source sparingly. They can damage soil organisms with their high salt content, increase alkalinity to undesirable levels,

Calcium: A lack of calcium appears to affect the stems and roots of growing plants. Plants deficient in calcium are retarded in growth and develop thick woody stems; seedlings will have stubby little roots with brownish discoloration. The lower leaves of cereal crops roll in at the edges, and brown spots appear on them. In corn, the leaves sometimes stick together as if glued. Some plants show green veins with yellow tissue between them. Blossom end rot in tomatoes or peppers is a sure indicator of calcium deficiency.

It is difficult to diagnose calcium deficiency because its assimilation is influenced by the balance between magnesium, manganese, and potassium in the soil. Available calcium can be quickly leached from soil by prolonged heavy rains or overzealous irrigation. Calcium-deficiency symptoms often occur on plants growing in acidic or sandy soils.. Calcium deficiencies in neutral or alkaline soils can be corrected with gypsum, which also supplies sulfur.

“**Magnesium**: Although plants need magnesium in smaller quantities than calcium, this element plays a vital role at the center of the chlorophyll molecule, responsible for photosynthesis. It also functions as a carrier for phosphorus, and the two deficiencies often go together. Insufficient magnesium is manifested as discoloration in the tissue between veins, which may cause leaves to look streaked. In some plants, leaves develop a reddish or purplish coloration, and the leaf margins turn brown or yellow while the veins remain green.

Magnesium availability to plants may be blocked by an excess of other elements, most notably potassium. Acidic soils commonly lack magnesium, which is why dolomitic limestone, containing both calcium and magnesium, is often recommended.

Sulfur: Sulfur is another essential component of protein; its deficiency results in symptoms resembling those caused by lack of nitrogen. It is essential for onions, good fruit set in peppers, and tree fruit such as cherries and plums. Soils with adequate organic matter rarely lack sulfur, especially in areas suffering from acid rain.

4) COMPOST AND INSECT CONTROL

The observations of thousands of organic gardeners and farmers indicate that plants grown in a completely organic system, including the copious use of compost, are less likely to sustain insect attack and damage. Scientific experiments have borne out these observations.

The chemical approach to insect control has been to discover substances that will eliminate specific insect species, and then to apply them routinely during the growing season. The broad and deleterious ecological effects of this approach are well known. Organic control of insects, on the other hand, is based on manipulating the entire garden“or farm ecology in such a way that all life-forms are in healthy balance. The predators of harmful insects are allowed to thrive, so insect damage—although not eliminated completely—causes no serious problem. Compost has a vital place in this organic system.

In the compost heap, insects are brought under control not only by microorganisms but also by the intense heat generated inside the heap. Any insect eggs will be destroyed by the heat, and microorganisms will then make short work of the remains. Often, the cool outer edges of the compost heap provide ideal conditions for insect multiplication. If you notice too many flies or sow bugs crawling over your heap, turn it so the insects and their eggs are thrust into the center of the heap, there to perish by heat and bacterial attack. Any heap that attracts more than a normal number of harmful insects should be covered with a thin layer of soil after each application of organic matter. With a little attention, no compost heap should become a breeding ground for the insects you are trying to bring into balance.

5) MATERIALS FOR COMPOSTING

Materials for composting are all around you. Many gardeners need look no further than the home grounds for a sufficient supply. Kitchen wastes, lawn clippings, weeds and plant debris, dog and cat hair—nearly anything that once lived (and is thus organic) is a candidate for the compost heap.

After you have exhausted the home supply and still don't have all the materials you would like, you can plan a series of foraging expeditions, beginning as close to home as possible and ranging out as far as you must in order to fulfill your requirements.

Manure should be the first item on your list, since it is by far the most important ingredient in any heap. If you try, you can get it free for the hauling or at a token fee at poultry farms, riding stables, feedlots, even zoos and wild game farms—any place that holds large numbers of animals in concentration.

Your chances of getting manure at a family farm are not as good, since farmers will probably want their manure for their own fields. Even if you seem to have all the home materials your compost heap can use, try to find a source of manure. Its tremendous bacteria content will bring your heap into biological and chemical balance and aid the rapid reduction of all the other materials.

MATERIALS TO AVOID

Although nearly any organic material can contribute to good compost, there are some that should be avoided, and others should be used only in limited amounts. First, you want your heap to be balanced among green matter, animal wastes, manure, and soil. If you build your heap of 80 percent tankage from the local meat-packing plant, not only will you have a putrid mess, but you will "attract every stray dog, cat, and raccoon within a 5-mile radius. A truckload of grape pomace or a ton of wet hops from the brewery will be equally hard to handle, as will be the neighbors if your heap's odor wafts their way. Strive, then, for a commonsense balance in the materials you select, and be sure to add a layer of soil over the heap every time you add materials that might cause odor or attract vermin.

Human feces should not be used unless they have been properly treated and permitted to age sufficiently. Even then, concerns about disease pathogens make it best to avoid such material or to use it strictly for ornamentals. Urine alone can be used quite safely, however.

Wastes from pet dogs, cats, and birds should not be used on the compost pile. Although dog manure is as rich in nutrients as other manures, it is more difficult and less pleasant to handle than the mixed bedding and manure of cattle and horses. In addition, it may carry organisms parasitic to humans. Special composters designed exclusively for dog droppings offer pet owners a safe alternative.

Cat manure is even more hazardous, especially to pregnant women and small children. Cat droppings may contain Toxoplasma gondii, a one-celled organism that, when transmitted to a pregnant woman, may infect her unborn child, causing brain and eye disease. Toxocara cati is a roundworm, also common in cat feces, that causes similar problems in children. Keep the contents of the litter box away from children and the compost pile.

Bird droppings have been similarly indicated as potential disease sources. Since they are most often mixed with bedding and dropped birdseed from the bottom of the cage, bird droppings will also tend to introduce unwanted weeds into your compost.

Materials that will not decompose readily—large pieces of wood, oyster and clam shells, large quantities of pine needles, rags, brush, cornstalks, heavy cardboard—should not be used in large amounts unless they are shredded first.

MATERIALS FOR ENRICHMENT

There are many substances you can buy to increase your compost's N-P-K content or control its pH. Although it is not necessary to add these materials to the heap, many gardeners find it worth the expense to ensure a high nutrient level in their compost.

Among the materials and products available at garden centers and through mail-order outlets are bagged manure, vermicompost, dried blood, bone-meal, limestone, cottonseed meal, greensand, hoof and horn meal, tobacco wastes, seaweed, peat moss, and other natural products that are valuable to the heap because of their nutrient levels or ability to correct pH.

Many people add lime to their compost to increase its pH. This is not often necessary or "beneficial, and it is not a good idea if you are composting manure, since the lime reacts with the nitrates in the manure to drive off ammonia. If lime is needed, apply it directly to the soil or mix it with the finished compost for potting mixes. The microbes inhabiting your compost heap can often benefit from the calcium in lime, but other forms of calcium, such as eggshells or any marine animal (oyster, crab, clam) shells, pulverized as finely as possible, will serve just as well. Bone-meal and wood ashes are also rich in calcium. Avoid all of these materials if you want compost for acid-loving plants such as rhododendrons, camellias, and blueberries, in which case you may want to use acidic peat instead of soil in your heap,

ACTIVATORS

A compost activator is any substance that stimulates biological decomposition in a compost pile. There are organic activators and artificial activators. Organic activators are materials containing a high amount of nitrogen in various forms, such as proteins, amino acids, and urea, among others. Some examples of natural activators are manure, garbage, dried blood, compost, humus-rich soil, and urine.

Artificial activators are generally chemically synthesized compounds such as ammonium sulfate or phosphate, urea, ammonia, or any of the common commercial nitrogen fertilizers. These materials are not recommended.

There are two ways in which an activator may influence a compost heap: (1) by introducing strains of microorganisms that are effective in breaking down organic matter and (2) by increasing the nitrogen and micronutrient content of the heap, thereby providing extra food for microorganisms.

"**Nitrogen Activators:** The cause of most compost heap "failures" is a lack of nitrogen. Almost invariably, a heap that doesn't heat up or decay quickly enough is made from material that is low in nitrogen. Nitrogen is needed by the bacteria and fungi that do the work of composting, to build protoplasm and carry on their life processes.

In experiments conducted at the Rodale Institute, it was shown that increasing additions of blood-meal (a high-nitrogen activator) produced associated increases in the temperature of the pile, indicating increasing bacterial activity. In the tests, 3 pounds of blood-meal in a 31-pound pile produced the best results.

Good nitrogen activators besides blood-meal (which is expensive when purchased commercially at garden centers) include tankage, manure, bone-meal, and alfalfa meal. Human urine, which contains about 1 percent nitrogen, also makes an "excellent compost activator. Just how much you should add to the heap depends on the nature of the material you are composting. Low-nitrogen materials such as straw, sawdust, corncobs, and old weeds should have at least 2 or 3 pounds of nitrogen supplement added per 100 pounds of raw material. If plenty of manure, grass clippings, fresh weeds, and other high-nitrogen materials are available to be mixed in with the compost, no nitrogen supplement will be necessary."

"**COMMON COMPOSTING MATERIALS**

"**Banana Residue:** The skins and stalks of this tropical fruit contain abundant amounts of phosphoric acid and potash. Banana skins decompose rapidly, a sign that the microbes of decay are well supplied with nitrogen. Banana skins are usually a staple in kitchen scraps, and their use in a compost heap will guarantee lots of bacterial activity. Incorporate banana skins into the core of your compost pile, or cover them quickly with organic matter to avoid attracting flies.

"**Bone-meal :** A slaughterhouse by-product, the pulverized residue of bones is, along with rock phosphate, a major source of phosphorus for the farm and garden. Bone-meal also contains a large percentage of nitrogen, though the content of both minerals depends on the age and type of bones processed. Raw bone-meal usually contains 20 to 25 percent phosphoric acid and 2 to 4 percent nitrogen. Steamed bone-meal, the more commonly available variety, has up to 30 percent phosphorus and 1 to 2 percent nitrogen. Steamed bone-meal is finer than raw bone-meal, so it breaks down more rapidly in the soil or compost heap.

"**Citrus Wastes:** Gardeners living near factories producing orange and grapefruit products should make use of this easily composted residue, though dried citrus pulp is also available in bulk from some feed stores. The nitrogen content of these materials varies accord according to the type of fruit and the density of the skin. The thicker the peel, the more nitrogen it contains.

Orange skins contain about 3 percent phosphoric acid and 27 percent potash (surpassed only by banana skins, with 50 percent potash). Lemons are higher in phosphorus but lower in potash than oranges. Grapefruits average 3.6 percent phosphoric acid, and their potassium content is near that of oranges.

You may use whole waste fruits (culls) in the compost pile, although their nutrient content will be lower due to the high water content. Citrus wastes will break down faster if shredded (the bagged, dried pulp sold as animal feed comes in dime-size chips) and mixed with green matter and a source of nitrogen and bacteria like manure, lawn clippings, or garden soil.

Unfortunately, citrus crops are routinely sprayed by commercial growers. If the spray program is moderate, the chemicals should break down during the composting process without causing harm. To be absolutely sure of what you're adding to your compost, use only fruits and fruit wastes from organic growers.

Coffee Wastes: Earthworms seem to have a particular affinity for coffee grounds, so be sure to use these leftovers on the compost pile, in your worm box, or as a mulch. The grounds are acidic and can be used by themselves around blueberries, evergreens, and other acid-loving plants. Mix the grounds with a little ground limestone for plants needing alkaline or neutral soil.

The nutrient content of coffee residues varies according to the type of residue. Grounds have up to 2 percent nitrogen, 0.33 percent phosphoric acid, and varying amounts of potassium. Drip coffee grounds contain more nutrients than boiled grounds, though the potassium content is still below 1 percent. Other substances found include sugars, carbohydrates, some vitamins, trace elements, and caffeine.

Coffee processing plants sell coffee chaff, a dark material containing over 2 percent nitrogen and potassium. Chaff is useful either as a mulch or in compost.

Apply your coffee grounds immediately, or mix them with other organic matter. They hold moisture extremely well. Left standing, they will quickly sour, inviting acetobacters (vinegar-producing microbes) and fruit flies.

Garbage: Americans routinely throw away mountains of valuable food scraps, setting them out on the curb or grinding them up in disposals and flushing them into overworked municipal sewage systems. Yet kitchen scraps are truly a neglected resource, containing 1 to 3 percent nitrogen along with calcium, phosphorus, potassium, and micronutrients. The material is free, available in quantity every day, and relatively easy to handle.

Kitchen scraps may be dug directly into the garden. Alternatively, they may be composted in heaps or pits. You can conveniently save household garbage until you are ready to layer it into a new or "existing compost pile. Use a plastic bucket with a tight-fitting lid, and each time you add garbage, cover it with a layer of sawdust or peat moss to absorb moisture and odors. When adding kitchen scraps to your compost pile, mix them well with absorbent matter like dead leaves or hay to offset the wetness. Use a predator-proof enclosure, and be sure to keep all scraps well into the pile's core, covering them thoroughly with dirt or additional materials to discourage flies.

Chop or shred all large pieces of matter (potatoes, grapefruit rinds, eggshells, and so on) to hasten decomposition. Meat scraps, fat, or bones should be used with caution in compost piles, for these materials take too long to fully break down and are most attractive to scavenging animals.

Grass Clippings: This is one compostable—a true “green manure”—that most gardeners can produce or obtain in abundance. Even if you don’t have your own lawn, your fellow citizens do; in suburban areas they’ll leave bags of clippings conveniently lined up along the curbsides for your harvesting every garbage collection day.

Freshly gathered green clippings are exceedingly rich in nitrogen and will heat up on their own if pulled into a pile, but because of their high water content, they will pack down and become slimy. This can be avoided by adding grass clippings in thin layers, alternating with leaves, garbage, manure, and other materials, thus preventing them from clumping together. If you discover a mass of matted clippings when you turn your compost, just break it up with a garden fork or spade and layer the pieces back into the pile. Grass clippings and leaves can be turned into finished compost in 2 weeks if the heap is chopped and turned every 3 days. You can profitably mix two parts grass clippings with one part manure and bedding for a relatively fast compost, even without turning.

Clippings that have been allowed to dry out will have lost much of their nitrogen content but are still valuable as an energy source and to absorb excess moisture. Clippings make an excellent mulch in the vegetable or flower garden or around shrubs and trees. As a mulch, clippings look neat and stay in place, and only a light layer (3 to 4 inches) is needed to choke out weeds and seal in moisture.

If you have extra grass clippings on hand later in the season, use them as a green manure. Simply scatter them in an area that has already been harvested and turn them in“any previously applied mulch. The fresh clippings decompose quickly in the soil and stimulate microbial activity by providing abundant nitrogen. More mulch should be added to the surface over winter to prevent exposure of bare soil to the weather. Additionally, you can use clippings as a green manure before planting a late crop, but give the soil a week or 10 days to stabilize before planting. When used this way, grass clippings greatly improve the physical condition of heavy-textured soils.

Not all grass clippings should be removed from the lawn; when left after mowing, their nutrients enrich the lawn itself, without the application of chemical fertilizers. However, most lawns do not need as much enrichment as a full growing season’s clippings will provide. Collecting grass clippings also helps reduce weed growth by removing weed seeds from the lawn.

There is one environmental caution about grass clippings. Many homeowners use various “weed and feed” preparations or any of a half-dozen herbicides in striving for an immaculate lawn. The most troublesome of these chemicals is 2,4-D, a“weed killer that has caused birth defects in lab animals and may be carcinogenic.

Although this systemic, rapid-action plant hormone attacks broad-leaved plants like dandelions, literally causing them to grow themselves to death in hours, 2,4-D doesn’t affect grasses. The narrow-bladed leaves do absorb traces of the hormone but not enough to harm them. Much more 2,4-D remains as a residue in broad-leaved plants, though even this should theoretically be broken down by soil microbes in a week. But beware of grass clippings that may have spray adhering to them from a fresh application. If used as a mulch, such clippings could cause herbicide damage to your garden plants—most of which are broad-leaved.

Ask your neighbors or whomever you gather clippings from what they used on their lawns. (If several mowings and some rains have occurred since the last application of herbicide, the clippings should be clear of 2,4-D residue.) Use your own clippings if you have them, and look around for natural lawns showing a healthy crop of dandelions—a sign that the landowner wisely avoided using herbicides.

Greensand: Greensand is an iron-potassium silicate that imparts a green color to the minerals in which it occurs. Being an undersea deposit, greensand contains traces of many (if not all) of the elements that occur in seawater. Greensand has been used successfully for soil building for more than 100 years. It is a fine source of potash.

Greensand contains from 6 to 7 percent of plant-available potash, but it is released very slowly when applied directly to the soil.”

Leaves: Leaves are a valuable compostable and mulch material abundantly available to most gardeners. Because trees have extensive root systems, they draw nutrients up from deep within the subsoil. Much of this mineral bounty is passed into the leaves, making them a superior garden resource. Pound for pound, the leaves of most trees contain twice the mineral content of manure. The considerable fiber content of leaves aids in improving the aeration and crumb structure of most soils.

Many people shy away from using leaves in compost because they’ve had trouble with them packing down and resisting decay. Leaves don’t contain much nitrogen, so a pile of them all alone may take years to decay fully. But most leaves can be converted to a fine-textured humus in several weeks (or, at most, a few months) if some general guidelines are followed.

Add extra nitrogen to your leaf compost since leaves alone don’t contain enough nitrogen to provide sufficient food for bacteria. Manure is the best nitrogen supplement, and a mixture of five parts leaves to one part manure will break down quickly. If you don’t have manure, nitrogen supplements like dried blood, alfalfa meal, and bone-meal will work almost as well. In general, add 2 cups of dried blood or other natural nitrogen supplement to each wheelbarrow load of leaves.

Don’t let your leaves sit around too long and dry out. As leaves weather, they lose whatever nitrogen content they may have had. This, combined with the dehydration of the cells, makes them much more resistant to decomposition than when used fresh.

Grind or shred your leaves. A compost pile made of shredded material is easily controlled and easy to handle.

Leaf mold is ordinarily found in the forest in a layer just above the mineral soil. It has the merit of decomposing slowly, furnishing plant nutrients gradually, and improving the soil structure as it does so. Leaf mold’s ability to retain moisture is amazing. Subsoil can hold a mere 20 percent of its “weight in water; good, rich topsoil will hold 60 percent; but leaf mold can retain 300 to 500 percent of its weight.

Freshly fallen leaves pass through several stages, from surface litter to well-decomposed humus partly mixed with mineral soil. Leaf mold from deciduous trees is somewhat richer in such mineral foods as potash and phosphorus than that from conifers. The nitrogen content varies from 0.2 to 5 percent.”

Limestone: Limestone is an important source of calcium and, when dolomitic limestone is used, magnesium. It is commonly applied to raise the pH of acidic soils and may sometimes be appropriate when composting very acidic materials such as pine needles. However, compost made from a good variety of materials should have a pH near neutral without the addition of lime. Moreover, it is unwise to use lime with fresh manure or other nitrogenous“materials, as it reacts chemically to drive off ammonia gas and thus loses some of the valuable nitrogen.

If your soil is acidic, it is best to apply lime to it directly, rather than through compost. Any reliable soil test will tell you how much lime is needed. If you live in a humid region, lime should be applied every 3 or 4 years, preferably in the fall so it will become available first thing in the spring. Use a grade fine enough to pass through a 100-mesh screen. In drier climates, where soil pH is naturally neutral or higher, liming is rarely necessary. You may want to use some lime for making potting soil with your compost—use about 1 tablespoon for 20 quarts of soil mix.

Most vegetables and garden plants prefer a slightly acidic to neutral pH, so laboratory liming recommendations generally strive for a pH of 6.5 to 6.8 (a pH of 7 is neutral). Some vegetables—legumes such as beans, peas, and alfalfa, for example—do better with slightly alkaline soil, while many berries prefer acidic conditions. Organic matter in the soil tends to buffer the effects of pH extremes by making nutrients.

Manure: Manure is the most valuable ingredient in the compost pile. A full discussion of using manure in composting will follow.

“**Peat Moss:** This naturally occurring fibrous material is the centuries-old, partially decayed residue of plants. Widely sold as a soil conditioner, mulch, and plant “propagation medium, peat’s major advantages are its water retention (it is capable of absorbing 15 times its weight in water) and fibrous bulk. Dry peat will help loosen heavy soils, bind light ones, hold nutrients in place, and increase aeration. But while its physical effects on soil are valuable, peat isn’t a substitute for compost or leaf mold. Expensive, relatively low in nutrients, and acidic, peat is best used as a seed-flat and rooting medium or as a mulch or soil amendment for acid-loving plants.

If a distinctly acidic compost is needed for certain plants, substitute peat for the soil in your compost pile. Peat compost is beneficial for camellia, rhododendron, azalea, blueberry, sweet potato, watermelon, eggplant, potato, and tomato plants—all of which prefer acidic soil conditions.

“**Pine Needles:** Pine needles are compostable, although they will break down rather slowly because of their thick outer coating of a waxy substance called cutin. Pine needles are also acidic in nature, and for this reason they should not be used in large quantities, unless compost for acid-loving plants is desired. For best results, shred the needles before adding them to the heap.

Evergreen needles have been found to be effective in controlling some harmful soil fungi, such as Fusarium, when used as a mulch or mixed directly into the soil.

Potato Wastes: Potato peels are common components of kitchen scraps. They provide a valuable source of nitrogen (about 0.6 percent as ash) and minor elements for the compost pile. Rotted whole potatoes, chopped or shredded, are worthwhile compost pile additions. The tubers contain about 2.5 percent potash, plus other minerals.”

Sawdust: Sawdust is often useful in the compost heap, although it is better used as a mulch. Some gardeners who have access to large quantities use it for both, with equally fine results. In most areas, lumberyards will occasionally give sawdust free for the hauling. Sawdust is very low in nitrogen. One of the objections against using sawdust is that it may cause a nitrogen deficiency. However, many gardeners report fine results from applying sawdust as a mulch to the soil surface without adding any supplementary nitrogen fertilizer. If your soil is of low fertility, watch plants carefully during the growing season. If they become light green or yellowish in color, side-dress with an organic nitrogen fertilizer such as alfalfa meal, blood-meal, compost, or manure. Regular applications of manure tea will also counteract any slight nitrogen deficit.

Some people are afraid that the continued application of sawdust will sour their soil—that is, make it too acidic.

When used for compost, sawdust is valuable not only as a carbon source but as a bulking agent, allowing good air penetration in the pile. This is true only of sawdust that comes from sawmills or chain saws; the fine material that results from sanding can become packed and anaerobic. Although sawdust is slow to break down, the larger bits you may find remaining in finished compost will not present problems when added to your soil and will improve the texture of heavy soils. Wood wastes such as sawdust also stimulate fungal colonization, helping to extract phosphorus from otherwise unavailable soil reserves.

Wood Chips: Like sawdust and other wood wastes, wood chips are useful in the garden. In some ways, wood chips are superior to sawdust. They contain a much greater percentage of bark and have a higher nutrient content. Since they break down very slowly, their high carbon content is less likely to create depressed nitrogen levels. They do a fine job of aerating the soil and increasing its moisture-holding capacity, and they make a fine mulch for ornamentals. Wood chips promote fungal growth, including mycorrhizae, which improves stable humus, aggregation, and the water-holding capacity of your soil.

Generally, the incorporation of fresh chips has no detrimental effect on the crop if sufficient nitrogen is present or provided. Better yet, apply the chips ahead of a green manure crop, preferably a legume; allow about a year's interval between application and seeding or planting of the main crop. Other good ways to use wood fragments are as bedding in the barn, followed by field application of the manure; as a mulch on row crops, with the partially decomposed material eventually worked into the soil; and adequately composted with other organic materials. Well-rotted chips or sawdust are safe materials to use under almost any condition.

USING MANURE

Manure, the dung and urine of animals, is the most important single ingredient in the compost heap. It is difficult, although not impossible, to make a good compost pile without it. The use of manure as a soil amendment and fertilizer is a time-honored tradition that can be traced from the earliest written words through modern agricultural texts. While one would hesitate to ascribe miraculous properties to such a lowly substance, there are few materials that are as beneficial to composting as manure. Gardeners who compost by the earthworm pit“method find manure to be an almost essential ingredient. It is also important to any rapid composting method that requires a high-nitrogen, high-bacteria heat-up material.

On a broader scale, manure is a resource that we have been wasting at a fearsome rate. Some observers have estimated that between mismanagement and misuse, less than 20 percent of the nutrients in manure ever find their way back to agricultural lands. Considering that there are more than 175 million farm animals in the country and that a single hog, for example, will produce more“than 3,000 pounds of manure annually, the aggregate waste is horrendous. Composting is the best way to reclaim the nutrients and organic matter in manure.

The most common domestic sources of manure are horses, cattle, goats, sheep, pigs, rabbits, and poultry. The dung consists of undigested portions of foods ground into fine bits and saturated with digestive juices in the alimentary tract. Dung contains, as a rule, one-third of the total nitrogen, one-fifth of the total potash, and nearly all of the phosphoric acid voided by the animals. But it is because of the large bacterial population—as much as 30 percent of its mass—that manure is so valuable in the compost heap. The addition of manure provides the necessary bacteria that will quickly break down other materials.

The urine contains compounds from the digested portion of the foods and secretions from the animal body. Urine usually contains about two-thirds of the total nitrogen, four-fifths of the total potash, but very little of the phosphoric acid voided by the animal. Because they are in solution, elements in urine become available much more quickly than the “constituents found in dung. Urines are especially valuable as activators in converting crop residues into humus.

The value of animal manure varies with the food eaten by the animal, the age of the animal, and the physical condition and health of the animal. The richer the animals ’food is in elements essential to plant growth, the more valuable the manure. The manure of animals fed on wheat bran, gluten meal, and cottonseed meal, for instance, will be richer than that from animals fed straw or hay without grains. Likewise, the manure of young animals that are forming bones and muscles from their foods will be poorer in nutrients than the manure of mature animals.”

Chicken Manure: Chicken manure is the “hottest” of all animal manures, meaning that it is the richest in nitrogen, phosphorus, and potassium. Fowls do not excrete urine separately, as mammals do. Chicken droppings must be composted or incorporated with a high-carbon mulch or cover crop before use, or they will burn any plants with which they come into contact. Accumulation of raw chicken manure from large factory chicken farms—both broilers and layers—is a huge environmental problem in places like the Chesapeake Bay watershed. Many chicken farmers use some type of absorbent organic material for litter in their henhouses, such as leaves, shredded straw, wood shavings, ground corncobs, or ground cornstalks. By continually adding to the litter under roosts to catch droppings, they are able to control odors that can cause respiratory problems in chickens as well as discomfort to people. It"also helps conserve the nitrogen content of the manure, which is stabilized by microbial workers rather than being released in the form of ammonia. Avoid cleaning out old poultry house contents, since dry chicken manure (as well as turkey and pigeon manure and bat manure, called guano) is a common incubation site for the spores of a human respiratory disease.

Horse Manure: Horse manure is richer in nitrogen than cattle or swine manure and, like chicken droppings, is called a hot manure. It is also much more prone to fermentation or "fire-fanging," a fairly rapid oxidation that destroys nutrients. Some farmers water horse manure to prevent fire-fanging, but leaching can occur if too much water is added. When using horse manure in the compost pile, mix it with other manures or with large quantities of high-carbon "materials, and add moisture. Horse owners tend to bed their animals extremely well, so stable manure is often largely wood shavings or straw with a small amount of manure mixed in. In these cases, horse manure can be combined with other manures to correct the carbon/nitrogen ratio. Horse manure also prevents the harmful action of denitrifying bacteria.

Sheep Manure: Sheep manure is another hot manure. Like horse manure, it is quite dry and very rich.

Cattle Manure: Cattle manure is moister and less concentrated than that of other large animals. Because of its high water and low nitrogen contents, it ferments slowly and is commonly called a cold manure. Because of their complex digestive systems, cows and other ruminants produce manure that is especially rich in beneficial microorganisms."

MANURE TEA

Another use for manure, apart from composting, is for manure tea, or liquid manure. To make this useful organic fertilizer, place one or two shovelfuls of fresh or dried manure in a permeable bag—burlap works well, but perforated plastic or mesh will also do. The finer the holes in the bag, the less likely it is that weed seeds from the manure will get into your tea. Tie the bag closed, then place it in a barrel or other large container filled with water. Make sure the bag is submerged. Allow your "teabag" to steep for about a week."

6) COMPOSTING METHODS

There are quite a few ways to let nature make compost for you—under the ground, above the ground; in bins, boxes, pits, bags, and barrels; in strips, in sheets, in trenches; in 14 months or 14 days; indoors or outdoors. Nearly all stem from the famous Indore method developed by Sir Albert Howard, and they all (except for anaerobic methods) have the same basic requirements. All composting methods aim simply to meet the needs of the microorganisms that do all the work of turning raw organic matter into humus. Those basic needs“are air, moisture, energy food (carbon) and protein food (nitrogen) in the right proportions, and warmth. Any method involving a pile also needs to be a minimum size or critical mass so that high enough temperatures can be maintained. Beyond that, you will want to ensure that there is a culture of the right organisms ready to get started.

Although innumerable refinements are possible, as long as you keep these basic requirements in mind, you can improvise a variety of ways to achieve the desired goal: the creation of moist, fragrant, fertile humus. Let’s examine those requirements in greater depth, since neglect of any one can result in disappointment and frustration.

AIR: It is possible to make compost without air, or anaerobically, through the activities of a different type of microorganism. However, most home composting systems are aerobic and so require adequate air to be available throughout the pile. Aerobic bacteria are thought to be more beneficial to the soil.

There are various techniques for ensuring aeration, the most common and obvious being to turn the pile at regular intervals. The more frequent the turning, the faster the raw materials decompose, since air is most often the limiting factor in this process. Compost tumblers achieve the same effect with much less effort—you need only rotate the drum every day, and the compost can be finished within 2 weeks.

Some gardeners avoid laborious turning by finding clever ways to introduce air into static piles. Municipal-scale composting operations sometimes use large blowers to force air through their windrows via a network of perforated pipe. This technique can be adapted to a smaller scale by burying perforated drainpipe at intervals within the pile. Natural convection is sufficient to circulate air through such a pile.

You can also induce greater air circulation by building a bin with a bottom lined with hardware”cloth and raised a foot or so off the ground. The wire must be stretched tightly and attached securely to the bin’s frame to support the weight of the pile, which can reach several tons in a large heap. Plastic sheets placed on the ground under the bin can be used to catch any liquids that drain out; these can be poured back onto the pile for more efficient use of nutrients.

MOISTURE: Good compost will be about as damp as a moist sponge. When a handful is squeezed, no drops of moisture should come out. Too little moisture slows down decomposition and prevents the pile from heating up. Microorganisms need a steamy environment. Too much moisture, signaled by a foul odor and a drop in temperature, drives out air, drowns the pile, and washes away nutrients.

It is important to consider drainage when building your pile. If you live in a humid climate, select a site that drains easily so the pile never sits in a pool of water—the organic matter will wick up the excess moisture and create anaerobic conditions. In arid climates, it may be helpful to sink the pile into a shallow pit to trap moisture.

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CARBON/NITROGEN RATIO:"Decomposers need carbon for energy and nitrogen for growth, and it is the composter's job to supply both kinds of materials in roughly the proportions the microorganisms prefer. <u>The ideal C/N ratio for composting is between 25:1 and 30:1, with carbon being the higher number.</u> Precision is unnecessary—with a little experience, you will acquire a feel for the best combinations.

Carbonaceous materials are generally brown or yellow, dry, coarse, and bulky compared with nitrogenous materials, which tend to be green, succulent, gooey, and dense. High-carbon materials are almost always plant materials such as straw, cornstalks, sawdust, and leaves. Nitrogenous materials more often include animal by-products, although it is quite possible to make compost without use of any materials derived from animals. Examples of high-nitrogen materials are grass clippings, alfalfa meal, blood-meal, and poultry manure. A few materials, such as fresh clover, most kitchen garbage, and manure mixed with bedding, already have C/N ratios in the ideal range.

WARMTH AND CRITICAL MASS: <u>Bacteria become dormant when the temperature drops below 55°F</u> (13°C). If properly built, a compost pile's interior will stay well above that temperature even in freezing weather. Northern composters sometimes insulate their piles with leaves, straw, or hay, even to the point of building an enclosure of hay bales to keep things cooking. Decomposition will slow during the winter months, but a pile built in fall and kept covered should be reasonably finished by spring.

To achieve optimum hot-composting temperatures (140°F/60°C) in any season, a minimum pile size is required. Otherwise, the heat generated by the initial organisms quickly dissipates before the pile can reach the right temperature for thermophilic organisms. A pile must be at least 3 feet in each dimension to provide the necessary critical mass. For best heating, try for a heap 4 or 5 feet square on the bottom, rising to 4 feet high. Temperature decreases toward the outside of the pile. When turning, shovel the undigested materials from the outside portions of the pile into the middle. This often causes a second heating as this material gets a chance to decompose in the heart of the heap.

CHOOSING A METHOD:

The choice of a method of composting is an important decision for the gardener, one that must take into account many factors: the space and constructions available, the total need for compost in terms of the area under cultivation and the rate of use, the time to be given to the project, the human and mechanical energy available, the equipment owned or obtainable, the materials at hand or easily procurable, and special crop needs. Methods that meet the requirements of compost organisms form a continuum: from quick, hot composting that requires effort and attention, to slow, cool techniques that are less trouble. Mulching and sheet composting also involve low temperatures and are slower still to contribute much humus to the soil. Each method has its advantages and drawbacks, as well as its stalwart advocates and detractors. All involve acquiring a sensitivity to the well-being of compost's microscopic laborers, which is as much an art as a science. The time needed for a quick compost to be ready to use is generally less than 8 weeks, and may be as little as 2. If we liken composting to a combustion process, it is clear that the more air there is available, the hotter the compost will be. You can tell if compost is working properly by monitoring its temperature; turn it again as soon as the temperature drops. A thermometer is helpful but not essential for this process. Many composters simply shove their arms into the pile to see how hot it is, but those of more delicate sensibilities (or arms) can insert a metal rod for a few minutes and feel the end when it is withdrawn. If it feels hot to the touch, you're in the ballpark. The object is to maintain the temperature in the thermophilic range—113° to 158°F (45° to 70°C)—until decomposition is complete and heating can no longer occur.

Some Like It Hot: The advantages of hot composting relate mainly to its fast turnover. Even in cooler climates, you can process six or more batches in a season. If you have a big garden and limited room for composting, this is the way to go. It's also the most effective way to"build fertility when you're just starting out in a new location. The other major advantage to this method is its temperature. Few weed seeds and pathogens can survive thermophilic temperatures, especially if they are maintained for several weeks. This gives you more leeway to compost materials that should otherwise be avoided.

However, it's best to avoid composting materials that may carry diseases or weed seeds until you are sure of your hot-composting skills.

The major disadvantage of quick composting, with the exception of static piles that use forced aeration, is the labor involved. Not everyone is enthusiastic enough—or able—to be out there turning the compost every few days, especially if the pile is much larger than a 3-foot cube. This is also a less forgiving process than others; if the moisture level or carbon/nitrogen ratio is wrong, you have to make adjustments. Another drawback is that the whole pile must be built at once. If your compost pile is also your household garbage disposal system, kitchen wastes must be stored up until you're ready to start a new pile.

HOT VERSUS COOL: COMPOST PROS AND CONS

HOT

Pros:

- Produces finished compost quickly
- Uses space efficiently
- Builds fertility quickly for new garden locations
- Kills most weed seeds and pathogens

Cons:

- Is labor intensive
- Requires careful control of moisture and C/N ratio
- Must be built all at once, requiring storage of kitchen wastes until it's time to start a new pile
- Conserves less nitrogen
- Produces compost with reduced ability to suppress soilborne diseases

COOL

Pros:

- Needs little maintenance
- Spares disease-suppressing microbes
- "Conserves nitrogen
- Allows materials to be added a little at a time

Cons:

- Allows nutrient loss through extended exposure to elements

- May take 6 months to 2 years to produce finished compost
- Fails to kill pathogens or weed seeds
- Needs balanced carbon and nitrogen, as well as wet and dry materials, as you add to the pile
- Produces compost with more undecomposed bits of high-carbon materials”

MODIFICATIONS:

Another, more substantial, modification of the California method is becoming increasingly popular. As might be anticipated, it is the work of the California method with its frequent back-straining turnings that many gardeners object to. Modifications have focused on reducing or eliminating the need for turning. Some gardeners are able to substitute bottom aeration for turning, by constructing their bins 1 foot off the ground to make use of convection currents. One cornposter claims to have reduced composting time to 6 days using this method, with thorough grinding of materials.

The Raised Bin Method:

Turning a compost pile can be a tedious and strenuous job, especially for a retirement-age gardener. Complaints about the hard work of fast composting will be familiar to anyone who has resisted composting for such reasons.

A solution to this problem is the open-hearth-bottom bin sitting on a cement slab. A grill made of three lengths of 1-inch pipe 1 foot long sits 1 foot above the slab. The grill allows air into the center of the heap for complete composting. The bin itself can be made of salvaged wood or other materials. One gardener has found that hollow concrete blocks lying on their sides, with pipes thrust through the centers of the blocks that are set 10 inches above the ground, also works well.

As the compost in a bottom-aerated bin heats up, air is pulled up and through the compost by natural convection, reducing the need to turn the pile.

The first experimental raised bases were made by US Public Health Service researchers who found that 1 ton of rapidly decomposing compost uses up 18,000 to 20,000 cubic feet of air daily.

The theory behind the raised-bin method is that as the pile heats up, it pulls up the cooler air from the ground. This air percolates through the mass, aerating it as it passes upward. It is believed that forced aeration by convection currents (cool air “air pulled in by heat) is more thorough than aeration through turning.

Dr. Golueke, in Composting, states that the major difficulty of aeration such as that achieved in elevated piles is that it is difficult to diffuse the air through the pile so that all parts of the pile are uniformly aerated. Air channels form and airflow is short-circuited through these channels, causing materials near the channels to dry out—a particular problem when this method is used in municipal composting. There is less of a problem in small-scale operations that don't use high-pathogen materials like sewage sludge and night soil. Weed seeds, however, require high temperatures for destruction, and dryness can be a problem in any compost operation.

It is easy enough for curious composters to experiment with raised-bottom bins. As a cautionary measure, avoid potential pathogen sources with this method.

7) A COMPOST CHECH LIST

Following are several checkpoints to help you gauge the success of your compost. These points will serve as a standard from which you can determine the efficiency of your composting methods.

Structure: The material should be medium loose, not too tight, not packed, and not lumpy. The more crumbly the structure, the better it is.

Color: A black-brown color is best; pure black, if soggy and smelly, denotes anaerobic fermentation with too much moisture and lack of air. A grayish, yellowish color indicates waterlogged conditions.

Odor: The odor should be earthlike, or like good woods 'soil or humus. Any bad smell is a sign that the fermentation has not reached its final goal and that bacteriological breakdown processes are still going on. A musty, cellar like odor indicates the presence of molds, sometimes also a hot fermentation, that has led to losses of nitrogen.

Acidity: A neutral or slightly acidic reaction is best. Slight alkalinity can be tolerated. Remember that too acidic a condition is the result of lack of air and too much moisture. Nitrogen-fixing bacteria and earthworms prefer a neutral to slightly acidic environment. The pH range for a good compost is, therefore, 6.0 to 7.4. Below 6.0 the reaction is too acidic for the development of nitrogen-fixing bacteria."

Mixture of raw materials: The proper mixture and proportion of raw materials is most important! Indeed, it determines the final outcome of a compost fermentation and the fertilizer value of the compost. On average, an organic matter content of from 25 to 50 percent should be present in the final product. If mineralized soil and subsoil are to be used, soil that has frozen over winter secures better results. Ditch scrapings, or soil from the bottom of a pond, should be frozen and exposed to air for a season before being incorporated into compost.

Moisture: Most composting failures result from a failure to maintain the proper moisture conditions. Moisture content should be like that of a wrung-out sponge: No water should drip from a sample squeezed in the hand, yet the compost should never be dry.

8) **COMPOSTING WITH EARTHWORMS**

<u>If you let them, earthworms will do most of your composting work for you</u>, in the garden, on the farm—or even in your basement.

Earthworms are amazing creatures, capable of consuming their own weight in soil and organic matter each day and leaving behind the richest and most productive compost known. The castings of earthworms contain from 5 to 11 times the amount “of available N-P-K as the soil the worms ate to produce those castings. How do earthworms perform this magic? The secretions of their intestinal tracts act chemically to liberate plant nutrients with the aid of soil microorganisms. And what earthworms do for the major plant nutrients, they do for the micronutrients, too. Earthworms literally tunnel through your soil, day and night, liberating plant nutrients wherever they go. Let loose in a compost heap, they will quickly reduce it to the finest of humus. Mulch your garden with organic matter of nearly any kind, and earthworms will never stop working on it until they have reduced the mulch to dark, rich humus. If you encourage earthworms to stay in your soil, or work with them in producing compost, they will virtually ensure that you produce successful compost.

9) **SHREDDERS AND OTHER EQUIPMENT**

Compost can easily be made without mechanical equipment. However, more compost can be made—in a shorter time—when the materials are first shredded or ground. For this reason, the compost shredder has become a standard fixture in many gardens and small farms. Shredder design has been improved over the years, and modern shredders bear little resemblance to those primitive, bulky“and often dangerous models of the past.

There are many advantages to using a shredder as part of a home composting program. The benefits of shredding compostable materials include the following:

• **Speed.** Your compost piles really will heat up and break down within 2 weeks because the shredder chews the compostable materials into small bits, making the job of the decomposers much easier.

• **Quantity**. You'll have plenty of compost when you need it, provided you keep working at the shredder.

- **Quality**. You'll have better, more uniform compost because the shredder breaks up the materials more thoroughly.

• **Mixtures**. You can "mix your own" right at the machine, to ensure a balance of nutrients or to make a compost specially designed to meet the needs of your soil.

10) **USING COMPOST**

Your compost is finished. After carefully following the recommended steps for turning the year's bounty of organic materials into rich, mellow humus, you want to be certain that it's used to best advantage—that it benefits your soil most and helps ensure a natural abundance and health in your coming crops.

It is not possible to stress too heavily the "soil bank account" theory of fertilizing. The real purpose of the organic method is to build permanent fertility into the soil by adding to its natural rock mineral reserves and to its humus content. Practically all the natural fertilizers are carriers of insoluble plant food. They start working quickly, but they don't drop their load of food all at once, as does a soluble fertilizer. An insoluble fertilizer will work for you for months and years.

Beyond building nutrient reserves for plants, your soil improvement program should, most importantly, feed the "micro-herd" that is the real source of fertility and health for your crops. This is the essence of the organic gardener's maxim: "Feed the soil, not the plant.

So, you can see that, as an organic gardener or farmer, you are adding fertilizer not only to supply immediate plant food needs but also to build up the soil microbiome that will nourish future crops.

WHEN TO APPLY COMPOST

The principal factor in determining when to apply compost is its condition. If it is half finished, or noticeably fibrous, it could well be applied in October or November. By spring, it will have completed its decomposition in the soil itself and be ready to supply growth nutrients to the earliest plantings made. Otherwise, for general soil enrichment, the ideal time for applying compost is a month or so before planting. The closer to planting time it is incorporated, the more it should be ground up or worked over thoroughly with a hoe to finely shred it.

If your compost is ready in fall and is not intended to be used until spring, keep it in a protected place. If it is kept for a long period during summer, water the finished compost from time to time.

For organic farmers and gardeners, it’s not a bad idea to make applications of compost either in fall or winter or in early spring. The big advantage here is that application at such a time helps equalize the workload. Usually this time of year is the least crowded with busy schedules, and the farmer or gardener can devote more time to doing a good job without interfering with the rest“matter can be worked down into the soil to supply food for the organisms that give life to spring soil. They become active and start to grow at about freezing temperatures. However, soil temperatures must rise to 50°F (10°C) before they really take on the dynamic action that characterizes a living organic soil. In early spring, the temperature is just about to rise to the level where the vital soil organisms can make use of it.

In summer, plants pull more nutrients from the soil than they do in any other season. But perhaps you didn’t realize that in summer the soil has more nutrients available to give to plants than at any other time of the year. During summer, the increased activity of bacteria, fungi, and other soil microorganisms is primarily responsible for the abundance of plant food. These same microorganisms are one of the primary forces that act on organic matter and natural rock fertilizers to make them available to plants. The beauty of this system is that microbes are releasing nutrients to plants most quickly at just the time when plants are growing most rapidly.

GENERAL RULES FOR APPLYING COMPOST

Apply at least ½ inch to 3 inches of well-finished compost over your garden each year. There is little if any danger of burning due to overuse, as is the case with chemical fertilizers. You can apply compost either once or twice a year. The amount would depend, of course, on the fertility of your soil and on what and how much has been grown in it.

For most applications, it is important that compost be well finished—that is, aged long enough so that the decomposition process has stabilized. Unfinished compost has been found to retard germination and growth of certain plants. Some plants, such as corn and squash, seem to thrive on partly finished compost, however. In general, be most careful when applying compost shortly before planting or in seeding mixes. Fall soil preparation and mulching applications are less critical.

If you want to be certain that your compost is aged well enough, you can perform a germination test. Soak a few seeds, such as lettuce or radish, in a tea made with your compost, and soak an equal number from the same packet in distilled water. Lay each batch on a paper towel and keep them warm and moist for a few days, until they start to sprout. If the distilled-water-treated seeds germinate better, you know you must let your compost age longer.

Compost can be added to the soil at any time, and can either be incorporated into the top 4 inches as you prepare your garden beds for planting or added to transplant holes or furrows. A broad fork or similar tool that loosens the soil but keeps its structure intact is a better choice than a rotary tiller. Larger areas can be rotary-tilled before"“spreading a thin layer of compost, then quickly sown to a cover crop. A light sprinkling of mulch—hay, straw, leaves, or similar dry material—will conserve moisture for the cover crop to germinate and meanwhile protect soil from the weather. Crops such as corn can be seeded directly into a newly seeded cover crop such as clover, which will then form a “living mulch” between the crop rows.

THE VEGETABLE GARDEN

Your vegetable garden will thrive if you give it liberal amounts of compost. Dig it in during fall, bury it in trenches, put it in the furrows when you plant and in the holes when transplanting seedlings. When the plants begin to grow rapidly, mix compost with equal amounts of soil and use it as a top-dressing; or mulch the plants heavily with partially rotted compost or with such raw compost materials as hay, straw, sawdust, grass clippings, or shredded leaves.

There is one rule to remember when mulching: The finer the material, the thinner the layer you will need. Remember that compost used at planting time should be well finished, especially for potatoes, which are prone to become scabby when in contact with incompletely decomposed manure. You may safely use partially finished compost only on heavy feeders like corn and squash.

For sowing seeds indoors or in a cold frame, put your compost through a sieve made of hardware cloth mounted on a wooden frame, then shred it with a hoe or even roll it with a rolling pin to make it very fine. The ideal seeding mixture is fine textured and crumbly and tends to fall apart after being squeezed in your hand.

11) EQUIPMENT AND TOOL SOURCES

BioCycle Equipment and Systems Directory

https://www.biocycle.net/buyers-guide/biocycle-equipment-and-systems-directory/

Current listings of sources for any and all equipment and supplies to help establish and maintain“larger-scale municipal or farm composting operations. Tools needed for home or small local composting are readily available at local garden and hardware stores, including chains such as Home Depot, Lowe’s, and Tractor Supply. Several good sources of composting tools and supplies, including bins, tumblers, totes, aerators, and thermometers, can be found online, along with helpful advice on how to use them. These are some websites that offer a full range of home composting tools and supplies as well as more ideas for innovative home- and community-scale technologies:

Compost Junkie

http://www.compostjunkie.com

Gardeners Supply Company

https://www.gardeners.com/

Hayneedle, Inc.

https://www.hayneedle.com/stylists/green-living_22/styleboards/composting-containers-accessories_833”

Johnson-Su Bioreactor Instructions

http://regenerationinternational.org/bioreactor/

Information on the advantage of this simple technology for producing high-fungal compost and detailed instructions on how to build one yourself

Planet Natural

https://www.planetnatural.com/product-category/organic-gardening/composting/”