

COMPOSTING

Easy Methods
for Every Gardener



Improve Your Soil
Recycle Kitchen and Yard Wastes
Grow Healthier Plants
Create an Earth-Safe Garden

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. Composting is the result of the activities of a succession of organisms, each group paving the way for the next group by breaking down or converting a complex biodegradable material into a simpler or more usable material that can be utilized by its successor in the chain of breakdown. Generally speaking, the more "simple" the molecular structure of the material, the more resistant it becomes to bacterial attack and, hence, the more biologically stable it becomes. Whether the decomposition process takes place on the forest floor or in a gardener's compost heap, the biochemical systems at work are the same, and humus is always the result.

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.

As we saw in chapter 2, the advantages of humus are twofold. First, when it is mixed with the soil, the resulting combination becomes a heterogeneous, loosely structured soil mixture allowing air and water to penetrate to soil organisms and growing plants. Because of its loose texture, humus-rich soil soaks up water in its pores so that less runoff occurs. Second, humus contains a number of chemical elements that enrich the soil with which it is mixed, providing nutrients for growing plants.

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 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.

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.

Decomposition of compost is accomplished by enzymatic digestion of plant and animal material by soil microorganisms. Simultaneously, the chemical processes of oxidation, reduction, and hydrolysis are going on in the pile, and their products at various stages are used by microorganisms for further breakdown.

Bacteria use these products for two purposes: (1) to provide energy to carry on their life processes and (2) to obtain the nutrients they need to grow and reproduce. The energy is obtained by oxidation of the products, especially the carbon fraction. The heat in a compost pile is the result of this biological "burning," or oxidation. Some materials can be broken down and oxidized more rapidly than others. This explains why a pile heats up fairly rapidly at the start. It is because the readily decomposed material is being attacked and bacterial activity is at its peak. If all goes well, this material is soon used up, and so bacterial activity slows down—and the pile begins to cool. Of course,

if the mass of the material is big enough, it acts as an insulator to prevent heat loss, and the high temperature may thus persist for some time after the active period is over, especially if the pile is not turned. Persistent high temperatures are the result of uneven breakdown.

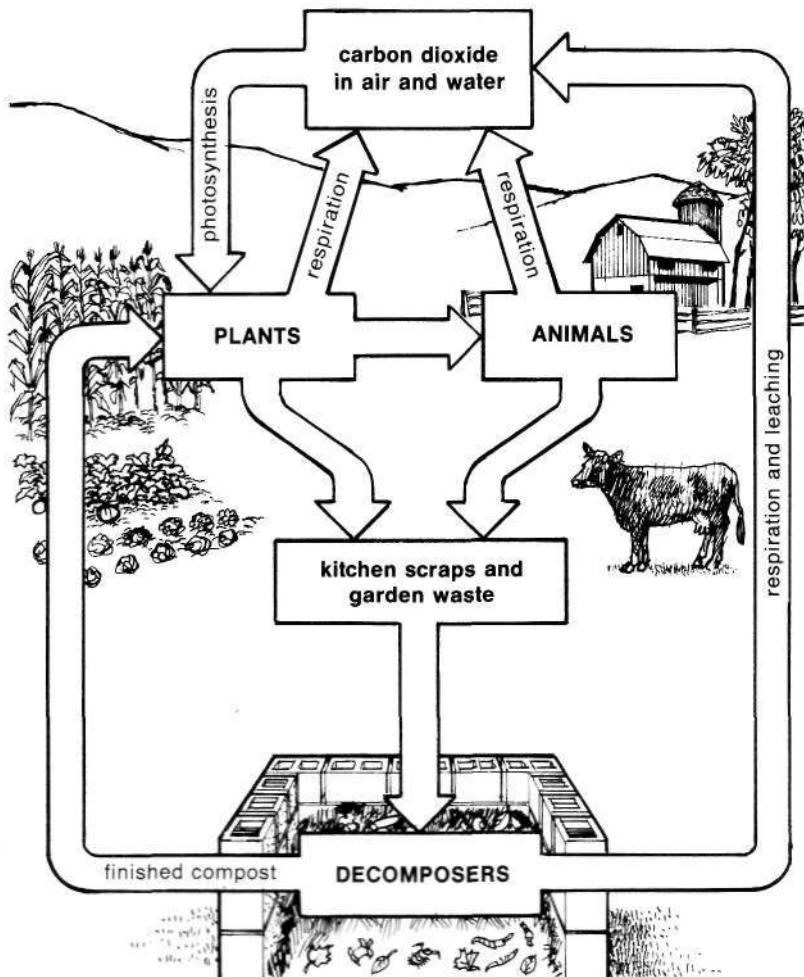
The raw materials that you add to your compost heap will have to be of biological origin in order to decompose down to finished compost. Wood, paper, kitchen trimmings, crop leavings, weeds, and manure can all be included in the heap. As compost is broken down from these raw materials to simpler forms 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.

Carbohydrates (starches and sugars) break down in a fairly rapid process to simple sugars, organic acids, and carbon dioxide that are released in the soil. When proteins decompose, they readily break down into peptides and amino acids, and then to available ammonium compounds and atmospheric nitrogen. Finally, species of "nitrifying" bacteria change the ammonium compounds to nitrates, in which form they are available to plants.

At this stage of decomposition, the heap is near to becoming finished compost, with the exception of a few substances that still resist breakdown. 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. In order 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). Minor elements are needed in minute quantities.

These chemicals in the compost pile are not in their pure form, and certainly not all in the same form at the same time. For example, at any given moment, nitrogen may be found in the heap in the form of nitrates and nitrites, in ammonium compounds, in the complex molecules of undigested or partly digested cellulose, and in the complex protein of microorganism protoplasm. There are many stages of breakdown and many combinations of elements. What's more, microorganisms can make use of nitrogen and other elements only when they occur in specific forms and ratios to one another.



The carbon cycle. Green plants use carbon dioxide gas, water, and sunlight to make sugars and other carbon-containing compounds that animals use as food. Carbon compounds in plant and animal wastes provide food for decomposers in the compost pile. Materials that have passed through the decomposers' bodies and the microbial bodies themselves contain nutrients used by plants to continue the carbon cycle.

Nutrients must be present in the correct ratio in your compost heap. 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

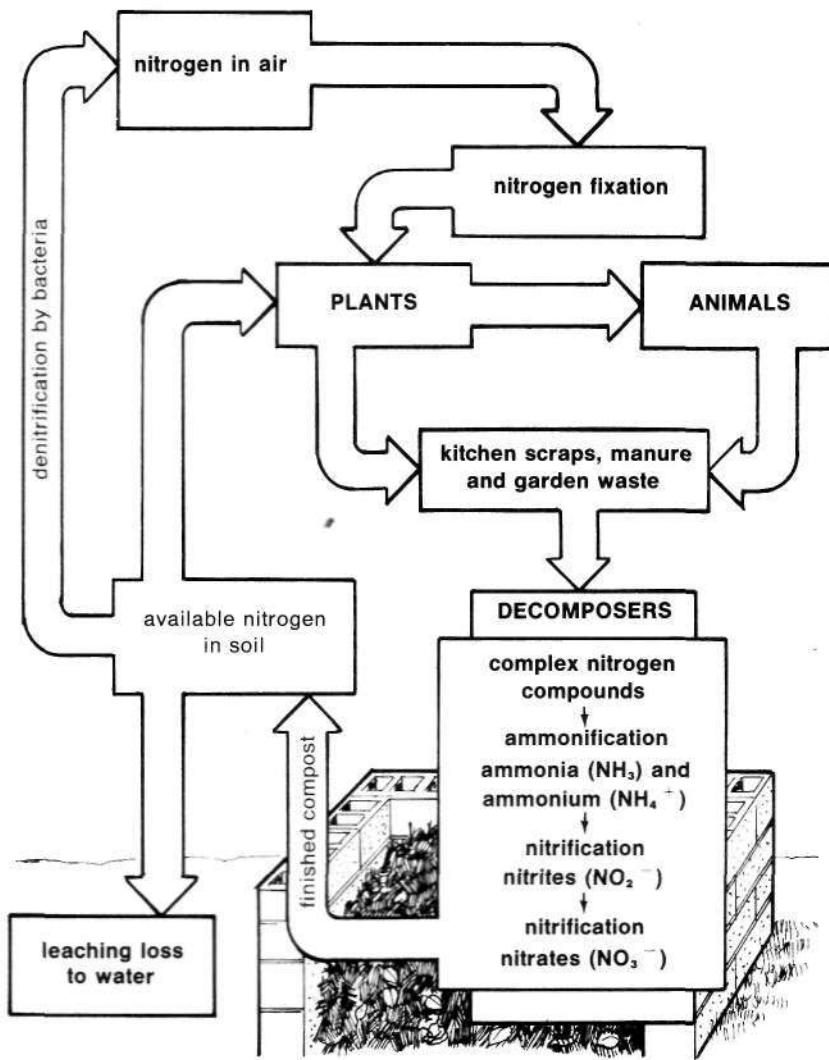
to the plants that would benefit by its presence in humus. Unpleasant odors from the compost heap are most often caused by nitrogen being released as ammonia. Materials too high in carbon for the amount of nitrogen present (C/N too high) make composting inefficient, so more time is needed to complete the process. When added to the soil, high-carbon compost uses nitrogen from the soil to continue decomposition, making it unavailable to growing plants. See chapter 6 for more on balancing the C/N ratio.

Affecting the interwoven chemical and microbial breakdown of the compost heap are environmental factors that need to be mentioned here.

Composting can be defined in the 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 availability of nutrients limit and determine how much oxygen your 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, "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 an important factor in the biology of a compost heap. Low outside temperatures during the 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 fall into basically two categories: mesophilic, those that live and grow in temperatures of 50°



The nitrogen cycle. Shortage of available nitrogen is often a limiting factor in plant growth, since plants can't make use of abundant atmospheric nitrogen gas. (So-called nitrogen-fixing plants rely on symbiotic bacteria.) Composting plant and animal wastes exposes the nitrogen they contain to nitrogen-fixing microorganisms and decomposers that break it down into forms available to plants.

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, 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

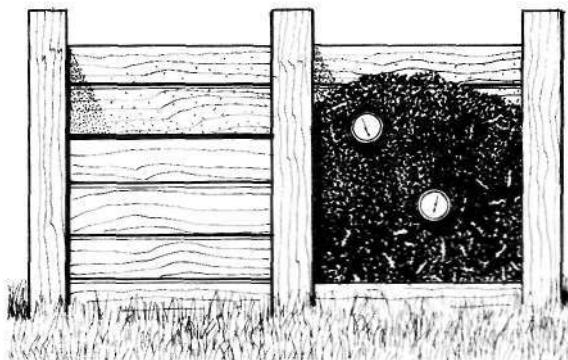
that could be detrimental to a planted garden.

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 acid (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.

Compost Organisms

Since decomposition is the crux of the composting process, let's take a look at the various organisms involved in this vital function of the working compost heap. Most are microscopic, some are large enough to be observed with the unaided eye, but nearly all are beneficial, each having a role in breaking down raw organic matter into finished compost. They are known as decomposers.



You can gauge the progress of your compost by regularly checking the temperature inside the heap. Mesophilic decomposers work best at temperatures of 50° to 113°F (10° to 45°C); as decomposition progresses, temperatures increase to 113° to 158°F (45° to 70°C) and thermophilic microorganisms continue the breakdown process.

Microscopic Decomposers

By far the most important microscopic decomposers are bacteria, which do the lion's share of decomposition in the compost heap. But there are other microscopic creatures, such as actinomycetes, protozoa, and fungi, that also play important roles. Together, these microscopic decomposers change the chemistry of the organic wastes; they carry the name of chemical decomposers.

The larger fauna in the heap include mites, millipedes, centipedes, sow bugs, snails, slugs, spiders, springtails, beetles, ants, flies, nematodes, flatworms, rotifers, and most important, earthworms. Collectively, these are called the physical decomposers since they bite, grind, suck, tear, and chew the materials into smaller pieces, making them more suitable for the chemical work of the microscopic decomposers.

Bacteria. The bacteria likely to be found in a compost heap are those that specialize in breaking down organic compounds, those that thrive in temperatures ranging up to 170°F (77°C) in the thermophilic range, and those that are aerobic, needing air to survive. Bacterial populations differ from pile to pile, depending upon the raw materials of the compost, degree of heat, amount of air present, moisture level, geographic location of the pile, and other considerations.

Bacteria are single-celled and can be shaped like spheres, rods, or spiral twists. They are so small that it would take 25,000 bacteria laid end to end to take up 1 inch on a ruler, and an amount of garden soil the size of a pea may contain up to a billion bacteria. Most bacteria are colorless and cannot make carbohydrates from sunshine, water, and carbon dioxide the way green plants can. Some bacteria produce colonies; others are free-living. All reproduce by means of binary fission.

Bacteria are the most nutritionally diverse of all organisms, which is to say, as a group, they can eat nearly anything. Most compost bacteria, similar to fungi and animals, can use living or dead organic materials. Some are so adaptable they can use more than 100 different organic compounds as their source of carbon because of their ability to produce a variety of enzymes. Usually, they can produce the appropriate enzyme to digest whatever material they find themselves on. In addition, respiratory enzymes in the cell membrane make aerobic respiration possible.

Since bacteria are smaller, less mobile, and less complexly organized than most organisms, they are less able to escape an environment that becomes unfavorable. A decrease in the temperature of the pile or a sharp change in its acidity can render bacteria inactive or kill them.

When the environment of a heap begins to change, bacteria that formerly dominated may be decimated by another species.

At the beginning of the composting process, mesophilic (medium-temperature) bacteria and fungi predominate. They gradually give way to thermophilic (high-temperature) bacteria as the pile becomes hotter; the more thermophilic bacteria that are present, breaking down compounds and releasing heat as a by-product, the hotter the pile becomes. As stability approaches, actinomycetes and fungi that have so far been confined to the cooler edges of the pile begin to dominate the compost and hasten it toward further stability.

Actinomycetes. The characteristically earthy smell of newly plowed soil in the spring is caused by actinomycetes, higher-form bacteria similar to fungi and molds. Actinomycetes are especially important in the formation of humus. While most bacteria are found in the top foot or so of topsoil, actinomycetes may work many feet below the surface. Deep under the roots they convert dead plant matter to a peatlike substance.

While they are decomposing animal and vegetable matter, actinomycetes liberate carbon, nitrogen, and ammonia, making nutrients available for higher plants. They are found on every natural substrate, and the majority are aerobic and mesophilic. Five percent or more of the soil's bacterial population is comprised of actinomycetes.

The reason that other bacteria tend to die rapidly as actinomycete populations grow in the compost pile is that actinomycetes have the ability to produce antibiotics, chemical substances that inhibit bacterial growth.

Protozoa. Protozoa are the simplest form of animal organism. Even though they are single celled and microscopic in size, they are larger and more complex in their activities than most bacteria. A gram of soil can contain as many as a million protozoa, but compost has far fewer, especially during the thermophilic stage. Protozoa obtain their food from organic matter in the same way bacteria do. In fact, they are so much like bacteria and so much less important to composting that they need only brief mention in the compost biological census.

Fungi. Fungi are primitive plants that are single celled or are many celled and filamentous. Unlike more complex, green plants, they lack chlorophyll and therefore lack the ability to make their own carbohydrates. Most of them are classified as saprophytes because they live on dead or dying material and obtain energy by breaking down organic matter in dead plants and animals.

Like the actinomycetes, fungi take over during the final stages of

the pile when the compost has been changed to a more easily digested form. The best temperature for active fungi in the compost heap is around 70° to 75°F (21° to 24°C), though some thermophilic forms prefer much greater heat and survive to 120°F (49°C).

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. They can be categorized as first-, second-, and third-level consumers, depending upon what they eat and by what they are eaten. First-level consumers attract and become the food of second-level consumers, which in turn are consumed by third-level consumers. The organisms comprising each level of the food chain serve to keep the populations of the next lower level in check, so a balance can be maintained throughout the compost. Soil ecologist Dr. Daniel L. Dindal gives an example in *Ecology of Compost*:

Mites and springtails eat fungi. Tiny feather-winged beetles feed on fungal spores. Nematodes ingest bacteria. Protozoa and rotifers present in water films feed on bacteria and plant particles. Predaceous mites and pseudoscorpions prey upon nematodes, fly larvae, other mites and collembolans. Free-living flatworms ingest gastropods, earthworms, nematodes and rotifers. Third-level consumers such as centipedes, rove beetles, ground beetles, and ants prey on second-level consumers.

The following is a rundown of some of the larger physical decomposers that you may find in nearly any compost heap. Most of these creatures function best at medium or mesophilic temperatures, so they will not be in the pile at all times.

Mites. Mites are related to ticks, spiders, and horseshoe crabs because they have in common eight leglike, jointed appendages. They can be free-living or parasitic, sometimes both at once. Some mites are small enough to be invisible to the naked eye, while some tropical species are up to 1/2 inch in length.

Mites reproduce very rapidly, moving through larval, nymph,

adult, and dormant stages. They attack plant matter, but some are also second-level consumers, ingesting nematodes, fly larvae, other mites, and springtails.

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

The life cycles are not well understood, except that eggs are laid in the soil in springtime, hatching into small worms. Young millipedes molt several times before gaining their full complement of legs. When they reach maturity, adult millipedes can grow to a length of 1 to 2 inches. They help break down plant material by feeding directly on it.

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. It is well, therefore, to look for them when you spread your compost, for if they move into your garden, they can do damage to crops.

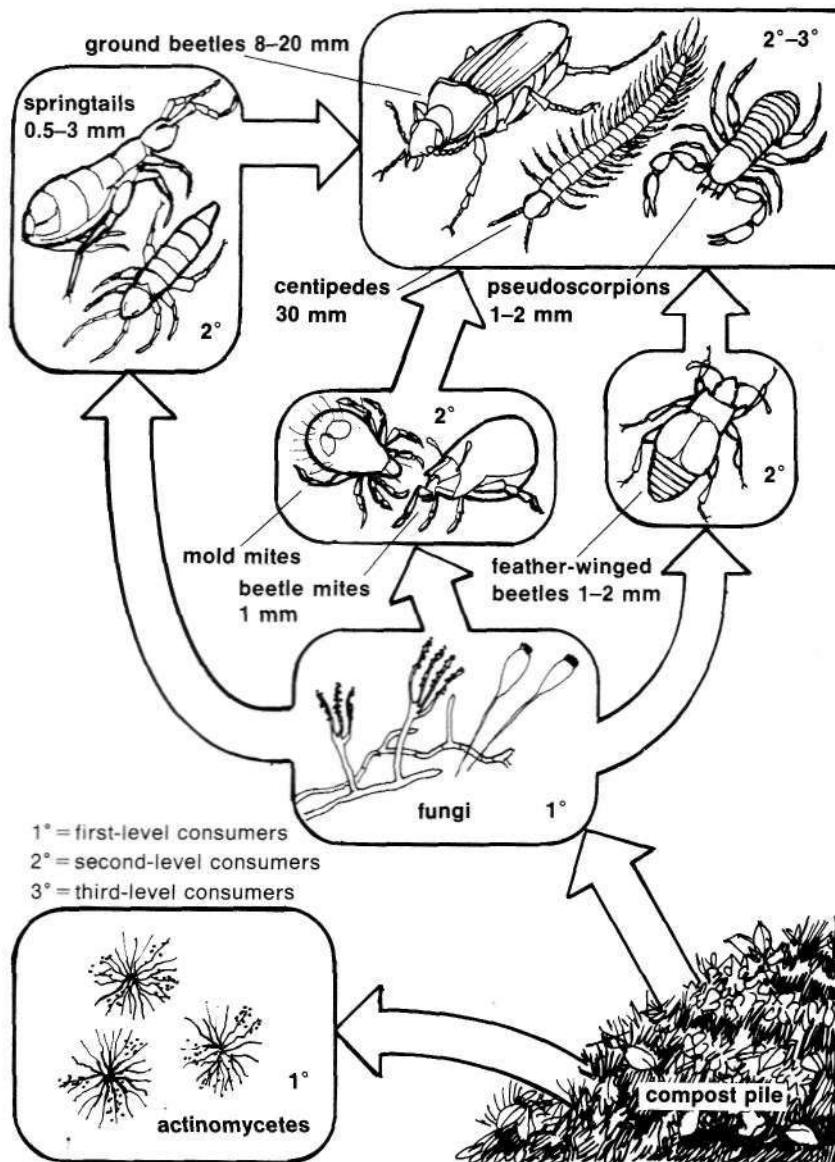
Spiders. Spiders, which are related to mites, are one of the least appreciated animals in the garden. These eight-legged creatures are third-level consumers that feed on insects and small invertebrates, and they can help control garden pests.

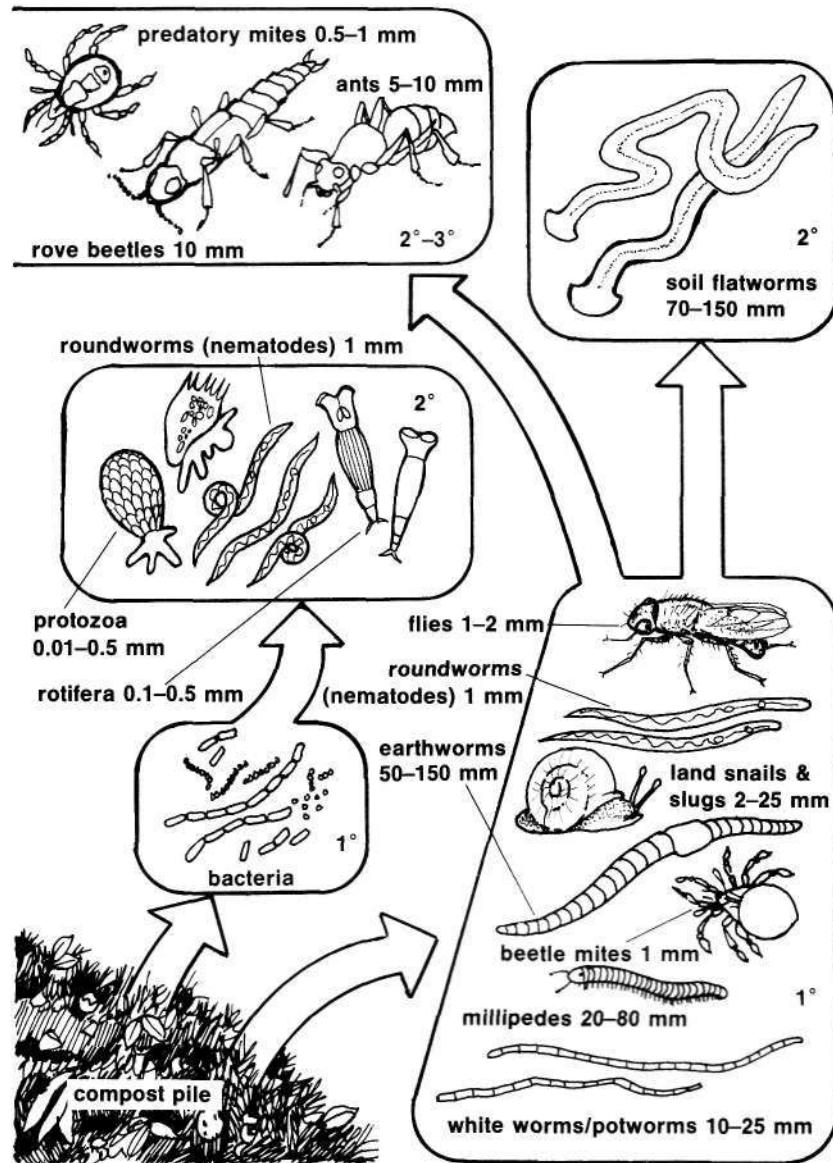
Springtails. Springtails are very small insects, rarely exceeding 1/4 inch in length. They vary in color from white to blue-grey or metallic and are mostly distinguished by their ability to jump when disturbed. They feed by chewing decomposing plants, pollen, grains, and fungi.

Beetles. The rove beetle, ground beetle, and feather-winged beetle are the most common beetles in compost. Feather-winged beetles feed

THE COMPOST FOOD WEB

Energy flows in the direction of the arrows.





on fungal spores, while the larger rove and ground beetles prey on other insects as third-level consumers.

Beetles are easily visible insects with two pairs of wings, the more forward-placed of these serving as a cover or shield for the folded and thinner back-set ones that are used for flying.

A beetle's immature stage is as a grub that feeds and grows during the warm months. Once grubs are full grown, they pass through a resting or pupal stage and change into hard-bodied, winged adults.

Most adult beetles, like the larval grubs of their species, feed on decaying vegetables, while some, like the rove and ground beetles, prey on snails, insects, and other small animals. The black rove beetle is an acknowledged predator of snails and slugs. Some people import them to their gardens when slugs become a problem.

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. They 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. The work of ants can make compost richer in phosphorus and potassium by moving minerals from one place to another.

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. Mites and other organisms in the pile also keep fly larvae reduced in number. Though many flies die with the coming of frost, the rate of reproduction is so rapid that a few survivors can repopulate an area before the warm season has progressed very far.

Nematodes, Flatworms, and Rotifers. Nematodes, or eelworms, plus free-living flatworms and rotifers all can be found in compost.

Nematodes are microscopic creatures that can be classified into three categories: (1) those that live on decaying organic matter; (2) those that are predators on other nematodes, bacteria, algae, protozoa, and so on; and (3) those that can be serious pests in gardens, where they attack the roots of plants.

Flatworms, as their name implies, are flattened organisms that are usually quite small in their free-living form. Most flatworms are carnivorous. They live in films of water within the compost structure.

Rotifers are small, multicellular animals that live freely or in tubes attached to a substrate. Their bodies are round and divisible into three parts: head, trunk, and tail. They are generally found in films of water, and many forms are aquatic. The rotifers in compost are found in water that adheres to plant substances where they feed on microorganisms.

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. 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.

Both male and female reproductive systems are in one earthworm, but fertilization can occur only between two separate individuals during copulation. The fertilized eggs are deposited and contained in a cocoon, out of which the young worms emerge after 8 to 10 days.

Since earthworms are willing and able to take on such a large part in compost making, wise gardeners adjust their composting methods to take full advantage of the earthworm's talents. The earthworm's contributions to the compost heap will be discussed more fully in chapter 9.

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, vacuum cleaner accumulations—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 begin to 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. Even a friend with one horse and no garden can supply all the manure you'll need for a backyard pile.

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.

But you don't have to stop with manure expeditions. In town, you can scavenge at grocery stores, city agencies, factories and mills, restaurants, and many retail operations. Ranging farther into the country, you can find materials in fields and along roadsides, streams, and ponds, at farms and orchards, at sawmills and canneries. Nearly any

organic gardener can find ample composting materials by going no further than 5 miles from home. The farmer, of course, must make composting an integral part of his or her soil management plan, utilizing every scrap of home material and adding green manure crops as necessary. Even the organic farmer—especially one who has few animals or cultivates a small but intensive area—might need to look for supplementary materials. The materials listed in this chapter can be of use to both gardeners and organic farmers seeking to enhance their composting operations.

Where to Begin

Begin, of course, at home. Are you discarding *any* organic matter at all? Newspapers? Tea bags? Clippings from the children's haircuts? Dishwater? With the exception of human and pet excreta (addressed later in this chapter), you can use everything. Before foraging, be sure that your home recovery program is 100 percent effective.

Once you venture outside your own yard, the best place to start is with friends, neighbors, and relatives. Some diligent composters offer to cart away kitchen scraps after every social call. This is often a valuable community service for people who would like to compost their wastes but for one reason or another are not able to do so. Recycled plastic pails with tight-fitting lids, such as those used for wallboard compound, make excellent containers for storing a week's worth or more of goodies. A layer of peat moss or sawdust on the bottom helps absorb moisture and odors. You can offer to pick up the full pail regularly, and leave a fresh, empty one in its place.

Your expeditions away from home can continue with a trip through the business directory of the phone book. *Go* through it slowly, listing all possible sources of materials. Your search might end when you find that you can pick up manure at the local riding stable every Saturday morning and vegetable trimmings from the neighborhood supermarket every Tuesday and Friday afternoon. After your routine is established, it usually operates like clockwork.

Here is a partial list of away-from-home materials. You will come across others in your expeditions—but do consider these for starters.

Farms and Orchards. These can provide you with spoiled hay, corn silage, eggshells, manure of every kind, feathers, barnyard litter, spoiled fruit, spent mushroom soil, whey from dairy operations, and orchard litter.

Factories and Mills. Apple pomace is available from cider mills.



The search for a variety of composting materials should begin at home-

Other available compostables include cannery wastes of all kinds, shredded bark, sawdust, and wood shavings from lumber mills and carpentry shops; botanical drug wastes from pharmaceutical firms; cement dust; cocoa bean hulls (good mulch); coffee chaff from coffee wholesalers; cottonseed meal; excelsior from receiving departments; felt wastes; fly ash from incinerators; agricultural frit from glass factories; grape pomace from wineries and spent hops from breweries; granite dust from cutting operations; leather dust; lignin from paper mills; spoiled meal from flour mills; peanut shells; slag from steel plants; spice marc (spent) from spice packers; tanbark from tanneries; tankage from meat-processing plants and slaughterhouses.

City Agencies. You may be able to acquire dried sewage sludge, leaf mold from parks department leaf depositories, fly ash from incin-

erators, aquatic weeds, and pulverized wood from tree trimming operations.

Stables and Feedlots. Manure and stable litter of all kinds are valuable compostables.

Retail Stores. You can get vegetable trimmings from supermarkets and shops, hair from barbers and salons, pet hair from grooming parlors, food wastes from restaurants, excelsior from gift shops (used for packing breakables), plant wastes from florists, and sawdust from carpentry shops and lumber supply houses.

Roadsides, Fields, and Waterways. Old leaves, weeds, and water plants from streams, lakes, and ponds may be plentiful. A note of caution: Many native plants, even those viewed as weeds, are endangered species that are protected by law. This is especially true of plants growing near oceans or in wetlands; such areas often contain fragile ecosystems that should not be disturbed. In gathering materials in fields and wild areas, be aware of your ecological responsibility to avoid robbing natural areas of their native plants.

Regional Materials

Gardeners in certain parts of the country can avail themselves of materials abundant only in their regions. New Englanders can look for wool and felt wastes from mills, leather dust, and maple syrup wastes. Those along seacoasts can find greensand, fish scraps, and seaweed. Southwestern gardeners should look for cannery wastes, mesquite, olive residues, grape pomace from wineries, and citrus wastes. Southerners may have access to cotton gin trash, Spanish moss, peanut shell ashes, tung oil pomace, sugarcane trash, molasses residue, castor pomace, tobacco stems, rice hulls, and water hyacinth plants.

In collecting materials for your heap, not only will you be adding to your own soil's fertility and structure, but you will also be contributing to the recycling of wastes that might otherwise become pollutants in the environment. Many communities now have or are planning composting facilities for at least part of their trash. If yours is one of them, they probably make finished compost available free or at low cost to gardeners. Chapter 13 has more information about using municipal compost. If your town has not yet pursued this option, it may offer free delivery of leaves, shredded tree trimmings, and other compostable municipal wastes. A large poultry farm might be paying to have manure and litter hauled away. Their trash can be your treasure.

Supermarkets and restaurants will be more than happy to contribute their organic wastes to you, since it lowers their disposal costs. Most important, however, these materials, instead of being dumped, buried, or burned, will find their way back to the soil.

Materials to Avoid

Although nearly any organic material can contribute to good compost, there are some that should be avoided, and others to 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 common sense 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 the use of such material dubious at best for the home gardener. **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.

Large amounts of highly acid materials such as pine needles and oak leaves should not be used without the addition of enough limestone to neutralize the acid. For acid-loving crops, however, you might wish to build acidic compost by the deliberate use of these materials.

Be very careful about diseased plants—you may be better off burning them and adding the ashes to your compost than risking inoculating your whole garden with them. Weeds can generally be composted, but be careful to ensure hot composting temperatures if they have produced seed. A few species, such as quack grass and Canada thistle, reproduce readily from the tiniest bit of surviving rhizome and should be avoided entirely.

Don't use large amounts of grease and oil, since they not only attract animal pests but also inhibit the biochemical processes necessary to successful composting. The amount of grease and oil from a normal household will cause no problem. However, carting home tubs of spent grease from the local potato chip factory is unwise.

Do not use toxic materials. There is little sense in trying to build an organic soil by including pesticide-treated wastes in the compost heap. Plant debris from roadsides might have been subject to a broad, potent, and persistent herbicide applied by the highway department; or, if the highway is a busy one, plants might be coated with lead emissions from passing traffic. Be careful in choosing materials.

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, dried blood, bonemeal, 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. All will be considered later in this book.

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Many people add lime to their compost in order 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 as well. Bonemeal 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 acid peat instead of soil in your heap.

Rock or colloidal phosphates are excellent materials for enriching the mineral content of your compost. Microbial action makes their nutrients more readily available than they would be if added directly to the soil. They also contain significant amounts of calcium and micronutrients. Other rock powders such as granite dust and greensand, both sources of potassium and micronutrients, are similarly made more available to plants when first consumed by compost organisms.

Specific nutrients can also be added by using plants that are especially rich in those elements in your compost. Seaweeds, such as the kelps, are rich in potassium and are also good sources of such elements as iodine, boron, copper, magnesium, calcium, and phosphorus. If available locally, seaweed should certainly be added to the compost heap. **The water hyacinths that grow** so abundantly in the rivers of the South **are especially rich in many** of the elements that are more apt to **be deficient in the** soil. Leaves, discussed more thoroughly later in this **chapter, are** a teeming source of micronutrients that are not found in upper layers of soil; use them in compost whenever possible.

Refer to the lists beginning on page 111 for other materials that are particularly high in nitrogen, phosphorus, and potassium.

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 com-

pounds 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.

Those who follow the practices of biodynamic agriculture consider certain activators, made according to precise instructions, to be essential for producing the highest-quality compost. These preparations are used in minute quantities, as part of a holistic approach to working with soil, plants, and the energies of nature. The biodynamic method is explained more fully in chapter 8.

Claims have sometimes been made that special cultures of bacteria will hasten the breakdown of material in a compost heap and also produce a better quality of finished compost. Products are manufactured that are reported to be effective in improving the action of a compost heap.

Most independent tests, however—including those conducted at the Rodale Research Center—indicate that there is no benefit to be gained from the use of an activator that relies solely on the introduction of microorganisms. It seems that microorganisms will quickly multiply to the limit that their environment will permit. Since all the necessary microorganisms are already present in manure, soil, and other composting materials, there is no benefit to be gained from introducing strains in the form of an activator product. The best activator is a layer of finished compost from the previous heap or a generous amount of healthy topsoil.

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 which 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 Research Center, 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 include not only blood meal (which is expensive when purchased commercially at garden centers), but tankage, manure, bonemeal, 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 Materials

Here is a list of the more common—and some not-so-common—materials that can be used in composting.

ALFALFA

Alfalfa is a perennial herbaceous legume grown as livestock feed and as a green manure or cover crop. Alfalfa grows almost everywhere in the United States and is widely available as hay, meal, or dehydrated feed pellets. Its nitrogen content and absorbency make it an excellent addition **to the compost pile**.

In combination with leaves and/or household garbage, alfalfa serves as a good compost stimulant and activator; its 12:1 carbon/nitrogen (C/N) ratio helps bring the pile's overall C/N ratio into the desired 25:1 to 30:1 range. While expensive when sold as hay, alfalfa is moderately priced in the form of dehydrated pellets or meal, and these products can be purchased at most feed stores. Farmers and feed stores may also have rotted or spoiled bales, unsuitable as animal feed, that they will gladly give you.

APPLE POMACE

Anyone who presses his or her own cider produces heaps of this sweet pulp. Yellow jackets, hornets, and bees love to zero in on the residues, so it's best to get the pomace into a working compost heap as soon as possible. Fresh pomace is wet and heavy and should be mixed well with dry leaves, hay, or other absorbent matter.

While low in nitrogen, pomace does contain valuable amounts of

phosphoric acid and potash. Large numbers of seeds are also present in pomace; these storage organs contain reserves of phosphorus and nitrogen, adding to the nutrient value of the pomace.

If you collect pomace from commercial presses, look into the source of their apples and the pesticides applied to the fruit. Apple skins may contain residues of metallic sprays, especially if such sprays are used heavily. Spray residues can build up to toxic levels when large amounts of pomace are used.

BAGASSE

Bagasse is the waste plant residue left from the milling of sugarcane. Gardeners in the Deep South may have access to quantities of this valuable addition to the compost heap. (See also "Sugar Wastes" on page 106.)

BANANA RESIDUE

The skins and stalks of this tropical fruit contain abundant amounts of phosphoric acid and potash. Banana skins also 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.

BASIC SLAG

This is an industrial by-product formed when iron ore is smelted to make pig iron. The smelting process uses large amounts of limestone and dolomite that combine with impurities in the ore, rising as a sludge that coats the surface of the molten metal. Skimmed off, cooled, and hardened, the resultant slag contains numerous minerals also found in the soil—lime, magnesium, silicon, aluminum, manganese, sulfur, and iron. It also contains trace amounts of boron, chromium, copper, molybdenum, potassium, sodium, strontium, tin, vanadium, zinc, and zirconium. The exact percentage of these minerals depends on variations in the smelting process. The "Composition of Slag" table on page 84 shows the main elements found in slag, the compounds in which they most often occur, and the average range of each mineral.

Packaged slag has been pulverized into a fine black powder so it can be used as a soil builder in gardening and farming. The material is alkaline and is popular as a liming agent. Tests show that slag is better for this purpose than lime because of its greater store of minerals.

Since slag is made up of finely pulverized but insoluble particles, it can be applied liberally to soil or compost heap with no fear of overuse. It won't burn plants or roots. Beans, peas, clover, vetches, alfalfa, and other leguminous crops will benefit from its application. Slags vary in content, so check the analysis before using them. Avoid slags with low or nonexistent amounts of nutrients and minor elements. Don't use slags containing excessive amounts of sulfur.

BEET WASTES

Residues from sugar beet processing are commonly used for livestock feed, though they will compost readily. The nitrogen content averages 0.4 percent, potassium content varies from 0.7 to 4.1 percent, and phosphoric acid content ranges from 0.1 to 0.6 percent. Dried beet pulp is also available at many feed stores.

BONEMEAL

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

Composition of Slag

Material	Compound	Percentage
Lime	CaO	38-45
Magnesia	MgO	4-9
Silica	SiO ₂	33-39
Alumina	Al ₂ O ₃	10-14
Manganese oxide	MnO	0.2-1.5
Iron oxide	FeO	0.2-0.7
Sulfur	S	1.0-2.0

Bone black is charred bone that has been used as a filter for sugar refining. Bone black contains about 1.5 percent nitrogen, 30 percent phosphoric acid, and many micronutrients.

Bonemeals are most effective when mixed with other organic matter and added to well-aerated soils. They will also exert an alkalizing effect because of their lime content, so match their use to your soil's pH characteristics. Use them moderately in composting to avoid the volatilization of nitrogen to ammonia.

BUCKWHEAT HULLS

Buckwheat is a cereal crop grown mainly in the northeastern United States and in Canada. Popular among organic farmers and gardeners as a green manure and bee forage crop, it grows well on even marginal soils. Buckwheat hulls, left after processing of the grain, are lightweight and disk shaped. They make good additions to the compost heap, though many gardeners prefer to use them as mulch. The hulls absorb water easily, stay in place once applied (a layer 1 1/2 inches thick will suffice), and look like a crumbly loam.

CASTOR POMACE

Castor pomace is the residue left after the oil has been extracted from the castor bean. It is widely used as an organic fertilizer in place of cottonseed meal, because the latter is a valuable feed. The nitrogen analysis of castor bean varies from 4 to 6.6 percent, while phosphoric acid and potash have been found to be 1 to 2 percent, with greater variation occurring in the phosphorus content.

Where animal matter is unavailable, compost can easily be made with castor pomace and other plant matter. Moisten the pomace and spread it over the green matter in semiliquid form. The finer the plant matter, the quicker the bacterial action.

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 according to the type of fruit and the density of the skin. The thicker the peel, the more nitrogen contained.

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 also 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-sized 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.

COCOA BEAN SHELLS

These residues from chocolate factories are available in bulk from garden supply houses, but because they make such an attractive mulch, cocoa bean shells rarely find their way into the compost heap. They are rich in nutrients, though, and benefit the soil however they're used. Cocoa shell dust has 1.5 percent phosphorus, about 1.7 percent potassium, and 1 percent nitrogen—a high analysis of the latter considering the woody nature of cocoa.

If the shells themselves have been treated to extract caffeine and theobromine, the residues will have about 2.7 percent nitrogen, 0.7 percent phosphoric acid, and 2.6 percent potassium. Untreated raw shells show a higher nutrient content. Pressed cocoa cake has also been offered as fertilizer. It's higher in nitrogen, has less potassium than shells, and has a phosphorus content of nearly 0.9 percent. The nitrogen content of cake will vary according to its processing.

If you can locate a source of oil-free and theobromine-free cocoa wastes, you'll have a useful product for mulching acidic soils. The extraction process uses lime, so the shells will help raise the pH while adding moisture-retentive organic matter. Cocoa shells are also weed free and odorless.

To use them as mulch, spread the shells in a layer 1 inch deep. They are light brown, look nice around shrubs, evergreens, and flower beds, and offer excellent drought-proofing and insulative properties. Shells used in compost piles should be shredded or pulverized.

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.

CORNCOBS

These residues used to be available in large amounts from mills, but modern combines now shred the stalks and expel the cobs right back into the field. Cobs contain two-thirds of the nutrients found in the corn kernel, but they must be shredded before composting or their decay will take years. Let the cobs age in open piles for several months, then grind them with a shredder or lawn mower.

Cobs have superior moisture retention and make effective mulches when spread 3 to 4 inches deep. Shredded cobs may also be used as a seed-starting medium. In long-standing, no-turn piles, unshredded cobs mixed with leaves and other dense materials will provide aeration and discourage caking and matting.

COTTONSEED MEAL

Cottonseed meal is made from cottonseed that has been freed from lints and hulls and deprived of its oil. Since cottonseed cake is one of the richest protein foods for animal feeding, relatively little is available for use as fertilizer. Although it is a rich source of nitrogen, most organic certification programs prohibit the use of cottonseed meal as a fertilizer. This is because cotton, as a nonfood crop, receives heavy applications of pesticides, some of which may accumulate in the seeds. Unless you have access to meal from organically grown cotton, you may choose to avoid cottonseed meal in favor of another nitrogen source for your compost pile.

Cottonseed meal is also commonly used to increase soil acidity for acid-loving specialty crops, but other materials, such as pine needles and peat moss, will serve the same purpose. Cottonseed meal has a nitrogen content of around 7 percent. Its phosphoric acid content is between 2 and 3 percent, while potash is usually 1.5 percent.

DRIED BLOOD

Dried blood is a slaughterhouse by-product. It is high in nitrogen, about 12 percent, but its phosphorus content varies from 1 to 5 percent. Dried blood is used mainly as an animal feed, though most garden shops carry it for use as a fertilizer. The cost per pound can be quite high because it is tied to the price of meat. Dried blood can be applied directly to the soil around plants, but it should be kept several inches away from the stems to avoid burning. Dried blood may also be used in compost heaps. Sprinkled over layers of moist organic matter, its high nitrogen content stimulates decay organisms, especially when added to carbon-rich materials.

FELT WASTES

Check hat factories for discarded hair, wool, and felt. These materials may contain up to 14 percent nitrogen and will aid in making rapid, high-heat compost. Such wastes are quite dry, however, and will decompose slowly or pack down unless they are thoroughly moistened and mixed with bacteria-rich ingredients like manure or green matter.

FISH SCRAP

Gardeners near oceans or fish-processing plants can usually truck home loads of this smelly stuff. It is well supplied with nitrogen and phosphorus (7 percent or above for each nutrient) and also contains valuable micronutrients like iodine. But, like all fresh residues, fish scraps easily turn anaerobic and are highly attractive to rodents, flies, and other scavengers.

Fish scraps must be handled carefully in the garden, either buried (covered with at least 4 inches of soil) or composted in properly built heaps enclosed by sturdy bins or pens. The trick is to use generous amounts of bulky, high-carbon materials such as shredded brush, straw, or sawdust to balance the high nitrogen and moisture of the fish, to increase aeration, and to discourage packing down.

Composting fish scraps in a pit is somewhat easier (once you've dug the pit, of course). Mix them with organic matter or soil, and cover them with enough dirt to discourage flies. The pit must also be en-

closed by a sturdy fence or wall and topped with a scavenger-proof frame or lid.

Fish scrap presents difficult challenges to the composter on any scale, but it offers ample benefits when used with reasonable care and attention to providing adequate carbon and air. William F. Brinton, of Woods End Research Laboratory in Maine, has successfully demonstrated fish waste composting, with minimal odor problems, using a farm- or industrial-scale windrow method.

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 (see "Trench and Posthole Composting" on page 161). 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. Do not use meat scraps, fat, or bones in compost piles, for these materials take too long to fully break down and are most attractive to scavenging animals.

GIN TRASH

Gin trash is another by-product of the cotton industry. Once burned and discarded, these leaf and stem wastes are now being composted and returned to the soil. While cotton wastes contain many valuable nutrients and fibrous organic matter, their effect on soil health may not always be beneficial, depending on the type of cotton and the state in which it was produced. In some states, including Texas and Oklahoma, arsenic acid is applied as a defoliant and desiccant. Signifi-

cant residues of this carcinogen are left in the gin trash, making it an undesirable addition to the compost pile. Normal arsenic levels in the soil run about 5 parts per million, but gin wastes may contain 40 times that amount.

Arsenic acid is no longer used in cotton production in California. Home composters who have access to gin trash should consider its source and the production methods used in their state before making gin trash a part of their composting program. Because of the timing of arsenic acid applications, contamination of the seeds does not occur; arsenic residue is not a concern with cottonseed meal. (See "Cottonseed Meal" on page 87.)

GRANITE DUST

Granite dust is a natural source of potash that is superior to the chemically treated potash sold as commercial fertilizer. Granite dust or granite meal has a potassium content of between 3 and 5 percent, contains micronutrients, is inexpensive, and will leave no harmful chemical residues. Unlike chemically treated sources of potash, granite dust is slow acting, releasing its nutrients over a period of years. It may be used in the compost pile or added to soil or sheet compost. Use it liberally directly on the soil, applying 10 pounds to 100 square feet when spreading. Choose a windless day for application, and wear a dust mask.

GRAPE WASTES

Wineries produce these residues of skins, seeds, and stalks by the ton during the pressing season. Vineyards also accumulate large amounts of grapevine pieces after annual pruning. While the nutrient content of grape wastes isn't that high, the sheer bulk of organic materials involved benefits the soil by promoting aeration and microbial activity.

The residues of pressing will be wet and mushy and should be mixed with absorbent plant matter. Additional nitrogen in the form of manure or high-protein green matter may also be necessary if you desire rapid, hot compost. The prunings are tough and must be chopped into pieces 3 to 6 inches long, or shredded, if they are to break down in a season.

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; 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 also 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 also profitably mix 2 parts grass clippings with 1 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 also 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 immediately, along with 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. You can also 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 preemergent 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

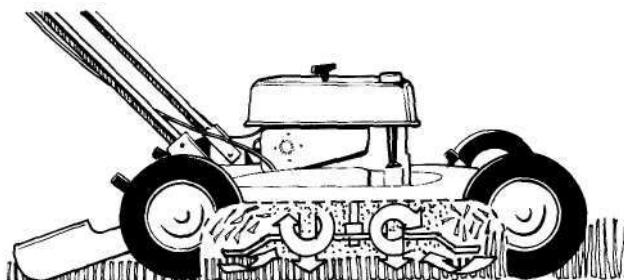
LETTING THE CLIPPINGS FALL

Leaving grass clippings on your lawn some of the time provides the grass with natural fertilizer and saves work. It is recommended in Grasscycling, a lawn care plan promoted by the Professional Lawn Care Association of America. The low-maintenance lawn care plan is based on the highly successful Don't Bag It program originally developed in Texas. Leaving clippings does not cause thatch buildup as was once believed. Thatch is made up of dead roots, leaf sheaths, and rhizomes, not clippings. If you mow with a regu-

lawn mower, don't let the grass grow more than 1 1/2 inches between mowings, and mow the grass only when it is dry. Even so, the clippings can be messy.

Mulching mowers eliminate the mess by chopping the clippings into fine fragments after they cut the grass. The fragments fall down into the lawn, where they decompose rapidly and release nutrients. Mulching mowers can also shred a few fallen leaves on the lawn while you are mowing and can be used to prepare piles of leaves for composting.

Mulching lawn
mowers chop
grass clippings
into fine bits that
break down
quickly to return
nutrients to the
lawn.



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. Incorporating greensand into your compost improves the availability of its potassium and micronutrients. Good glauconite deposits also contain 50 percent silica, 18 to 23 percent iron oxides, 3 to 7.5 percent magnesia, small amounts of lime and phosphoric acid, and traces of more than 30 other elements useful to higher plant life. Unlike wood ashes, another frequently used source of potash, greensand does not have an alkalinizing effect.

HAIR

Between 6 and 7 pounds of hair contain as much nitrogen as 100 to 200 pounds of manure. Like feathers, hair will decompose rapidly in a compost pile but only if well moistened and thoroughly mixed with an aerating material. Hair tends to pack down and shed water, so chopping or turning the pile regularly will hasten decay. Most barbershops or hair salons will be happy to supply you with bags of hair (though they may think your request is strange unless you explain).

HAY

Farmers often have spoiled hay available free or at low cost to gardeners. Hay is an excellent source of carbon for compost and also contains significant amounts of potassium, especially if it includes legumes such as alfalfa, clover, or vetch.

Hay is sometimes best used as mulch, especially around fruit trees. However, unless it was cut early, before seed heads began to form, it

poses the hazard of introducing weed seeds into your garden. High-temperature composting will kill most weed seeds. In order to ensure that high enough temperatures (above 140°F, or 60°C) are reached, you should chop or shred the hay first, especially if it has matted in the bales. This can be done by spreading out the sections and running a lawn mower back and forth over them. You should alternate layers of nitrogenous materials such as manure with the shredded hay, to stimulate rapid heating. Make sure the materials are moist enough by giving each layer a good sprinkling. If high enough temperatures are not reached within a couple of days, the pile should be turned and relayed with an additional nitrogen source.

HOOF AND HORN MEAL

There are many grades of hoof and horn meal. The granular form breaks down with some difficulty unless kept moist and well covered; it also tends to encourage the growth of maggots because it attracts flies. Finely ground horn dust, which gardeners use for potting mixtures, is quite easily dissolved. The nitrogen content is from 10 to 16 pounds per 100-pound bag, or as much as a ton or more of manure, while the phosphoric acid value is usually around 2 percent. If available, this is a very handy source of nitrogen for gardeners with small compost heaps, because it can be easily stored, is pleasant to handle, and is less costly than other forms of bagged organic nitrogen.

HOPS

Hops are viny plants grown and used for making beer. (Hops impart the characteristic bitter flavor.) Spent hops, the wastes left after the brewing process, are an excellent garden fertilizer, containing (when dry) 2.5 to 3.5 percent nitrogen and 1 percent phosphoric acid. They do have a strong odor when wet and fresh, but this dissipates rapidly.

Wet hops may be spread directly on the garden in fall or spring just as you would apply manure. Turn the matter under, mixing it with the top 4 to 5 inches of soil. Wet hops heat up rapidly, so keep them several inches away from plant stems to avoid burning. This tendency to heat up is, of course, desirable in making compost. Be sure to balance the sogginess of spent hops with absorbent matter.

Spent hops make a good mulch when dry. They resist blowing away and will not easily ignite if a lighted match or cigarette is tossed onto a pile. Many other mulch materials burn easily. A layer of dry, spent hops will break down slowly, staying put for 3 years or more.

Another brewery waste to inquire about is the grain left over from the mashing process. When wet, this material contains almost 1 percent nitrogen and decays rapidly.

INCINERATOR ASH

Incinerator ash, if available, can be a fine source of phosphorus and potash for the compost heap. Its phosphorus content depends upon what was burned but averages 5 or 6 percent; its potassium content is from 2 to 3 percent. As with many compostable materials, the source of the ash should be considered before it is added to the compost pile. Ash from apartment building incinerators may be acceptable, depending on the materials burned. It is best to avoid municipal incinerator ash, most of which is considered hazardous waste because the heavy metals and other toxic substances found in municipal solid waste often become more concentrated and soluble when burned.

LEATHER DUST

Available as a by-product of leather processing and as a commercial fertilizer from garden shops, leather dust contains from 5.5 to 12 percent nitrogen. Phosphorus is also present in considerable amounts. Use as a soil amendment, as a side-dressing around plants, or as a dusting over successive layers in the compost heap.

Leather dust is often contaminated with the heavy metal chromium, used in the tanning process. While one producer of leather dust fertilizer points out that the chromium in their product is in an immobile form, studies have not addressed the long-term effects of this material in the soil. Some organic certification programs prohibit the use of leather dust for this reason. Unless you have a source that produces leather dust with low or no levels of heavy-metal contaminants, it is best to refrain from using it on your compost or on soil in which food crops will be grown.

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. (See the table "Composition of Fallen Leaves" on page 97.) 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 bonemeal 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.

If you don't have a shredder, there are various other devices you can adapt to leaf shredding. Many people use a rotary mower for shredding. A mower that is not self-propelled is best and easiest to control. Two people can work together very nicely, one piling up leaves in front of the mower and the other running it back and forth over the pile. A leaf-mulching attachment on the blade will cut the leaves finer, but sometimes it is not necessary. You will be surprised how many leaves you can shred this way in 30 minutes or so.

Of course, some people use a mower with a mulching attachment to cut up leaves right on the lawn. This does not make them available for compost or mulch somewhere else—like the garden—where they are more essential.

If you have so many leaves that you can't compost all of them—or if you don't have the time to make compost—you can make leaf mold. Leaf mold is not as rich a fertilizer as composted leaves, but it's easier to make and is especially useful as mulch.

A length of snow fencing or woven wire fencing placed in a circle makes the best kind of enclosure for making leaf mold. Gather leaves in the fall and wet them thoroughly; then tamp them down in the

enclosure. Leaves are slightly acid. If your plants don't need an acid mulch, add some limestone to the leaves before tamping them down.

These leaves will not break down over the winter into the kind of black, powdery leaf mold found on the forest floor. By spring or summer they will be broken up enough to serve as a fine mulch. Some people, including nursery operators who require fine potting soil, keep leaves "in cold storage" for several years. When they come for their leaves, they find black, crumbly humus.

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.

If you keep poultry or livestock, use your supply of leaves for litter or bedding along with straw or hay. Leaf mold thus enriched with

Composition of Fallen Leaves

Name	Cal-cium	Mag-nesium	Potas-sium	Phos-phorus	Nitrogen	Ash	pH
Ash, white	2.37	0.27	0.54	0.15	0.63	10.26	6.80
Beech, American	0.99	0.22	0.65	0.10	0.67	7.37	5.08
Fir, balsam	1.12	0.16	0.12	0.09	1.25	3.08	5.50
Hemlock, eastern	0.68	0.14	0.27	0.07	1.05	—	5.50
Maple, red	1.29	0.40	0.40	0.09	0.52	10.97	4.70
Maple, sugar	1.81	0.24	0.75	0.11	0.67	11.85	4.30
Oak, white	1.36	0.24	0.52	0.13	0.65	5.71	4.40

extra nitrogen may later be mixed directly with soil or added to the compost pile.

A lawn sweeper is a good tool to use for collecting leaves. It is easier than raking and often does a better job. Hand-held leaf vacuums are also available at most lawn and garden stores.

Many municipalities are now composting leaves and yard wastes instead of dumping them into landfills. If your community has such a program, you can send in your surplus leaves with a good conscience and probably pick up finished compost in return.

LIMESTONE

Limestone is an important source of calcium and, when dolomitic limestone is used, magnesium. It is commonly used to raise the pH of acid 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 lose some of the valuable nitrogen.

If your soil is acid, 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 acid 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 acid conditions. As mentioned in chapter 2, organic matter in the soil tends to buffer the effects of pH extremes by making nutrients available to plants regardless of soil pH. Lime, therefore, should be used to supplement soil improvement through the addition of compost.

MANURE

Manure is the most valuable ingredient in the compost pile. For a full discussion of using manure in composting, see chapter 7.

MOLASSES RESIDUES

The wastes from sugar refining are obviously rich in carbohydrates, but they also contain some mineral nutrients. Naturally occurring yeasts in the compost will ferment these sugars rapidly. Dry molasses is also available from feed stores.

OLIVE WASTES

Olive pits contain phosphorus, nitrogen, and some lignin (a woody substance related to cellulose). But the pits must be ground or chopped before composting, or they'll take years to decay. Pulpy olive wastes vary in nutrient density. One analysis showed the pomace (what's left after oil extraction) having 1.15 percent nitrogen, 0.78 percent phosphoric acid, and 1.26 percent potassium. The pulp is oily and should be well mixed with other organic matter.

PAPER

Many kinds of paper, even those with colored inks, can be used for compost or mulch. You can save a lot on trash collection costs, and keep the valuable carbon for your soil, by recycling paper through your compost. Although the colored inks contain various heavy metals, one study found that their concentration is low enough to be negligible, even when glossy magazines are used as a garden mulch. If only a few colored-ink items are mixed in with newsprint, there should be no cause for concern.

The secret to using paper successfully is to shred or chop it as finely as possible. Matted layers of newspaper, like hay and grass clippings, will halt the composting organisms in their tracks. Various tools will work for this process, including shredders used for brush. If you don't have a lot of paper, a sharp machete will chop it adequately. And don't forget the office paper shredder—you may even be able to recycle preshredded office paper from local businesses. Dairy farmers in various regions are being encouraged to use newspaper, which they shred using silage-making equipment, as bedding for their animals. The newspaper is very absorbent and makes an excellent compost medium when mixed with manure.

Shredded paper should be incorporated into your compost in layers, alternating with garbage or other wet materials. Because it is almost pure cellulose, it requires a concentrated nitrogen source to stimulate decomposition, but once broken down it creates a high-quality humus that will improve the tilth of any soil.

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 acid compost is needed for certain plants, substitute peat for the soil in your compost pile. (See "Soil" on page 104.) Peat compost is beneficial for camellia, rhododendron, azalea, blueberry, sweet potato, watermelon, eggplant, potato, and tomato plants—all of which prefer acidic soil conditions.

PEA WASTES

Feeding pea shells and vines to livestock and getting the waste back as manure is an excellent recycling method. Otherwise, pea wastes can be rapidly composted since they are rich in nitrogen when green. Dry vines should be shredded or chopped before or during composting, to hasten decay. Diseased vines should be burned and the ashes returned to the soil. (Pea ash contains almost 3 percent phosphoric acid and 27 percent potassium.)

PET WASTES

As discussed earlier in this chapter, the wastes of dogs, cats, and birds are potential carriers of organisms that may cause disease in humans. Such materials should not be included in the home compost pile. Wastewater from aquariums, however, contains a certain amount of algae and organic matter that can be beneficial to plants. Use aquarium water to add moisture to your compost heap or for watering plants.

PHOSPHATE ROCK

Phosphate rock is a mainstay in organic gardens and farms because of its value as a soil and compost pile amendment. While its chemical composition varies according to the source, phosphate rock generally contains 65 percent calcium phosphate or bone phosphate of lime. A diversity of other compounds and micronutrients important to plant development is also present.

Phosphate rock is a naturally occurring mineral, however; don't confuse it with superphosphate. The latter has been treated with sulfuric acid to increase its solubility. But many micronutrients are lost due to this processing, and the increase in the availability of sulfur stimulates the presence of sulfur-reducing bacteria in the soil. These organisms attack sulfur and also ingest a fungus that normally breaks down cellulose in the soil. Besides encouraging this microbial imbalance, superphosphate can also leave harmful salts in the soil. Furthermore, within a few days superphosphate will react chemically with calcium and other soil nutrients to become indistinguishable from the less-soluble rock powder.

Phosphate rock creates no such problems. It's slow acting, which makes nutrients available to plants for many years after a single application. Applied alone to vegetable or flower gardens, 1 pound to every 10 square feet of growing area will suffice for 3 to 5 years. It may also be sprinkled lightly over succeeding layers in a compost heap to add nutrients to the finished product. It is valuable when combined with manure and other nitrogenous materials, since it prevents loss of nitrogen in the form of ammonia. The nutrients in rock phosphate are more readily available to plants when it is added via compost, having first been incorporated into the bodies of countless microorganisms.

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* spp., 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 also worthwhile compost pile additions. The tubers contain about 2.5 percent potash, plus other minerals. Use the potato vines, too; they can be either composted or dug back into the soil. The vines, when dry, contain approximately 1.6 percent potash, 4 percent calcium, and 1.1 percent magnesium, plus sulfur and other minerals.

RICE HULLS

Often considered a waste product, rice hulls have been found to be very rich in potash and to decompose readily, increasing humus content, when worked into the soil. The hulls make an excellent soil conditioner and a worthwhile addition to the compost heap. They also make a good, long-lasting mulch that does not blow away.

Gardeners in the Texas-Louisiana Gulf Coast area can often get ample amounts of this material from rice mills; occasionally it is free. Some mills make a practice of burning the hulls, and the residue from this operation contains a high percentage of potash, making it especially valuable as a composting material.

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 acid. A very comprehensive study made from 1949 to 1954 by the Connecticut Agricultural Experiment Station of sawdust and wood chips reported no instance of sawdust making the soil more acid. It is possible, though, that sawdust used on the highly alkaline soils of the western United States would help to make the soil neutral, a welcome effect.

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.

SEAWEED

Coastal gardeners can gather different types of seaweed by wandering the shoreline. Look for kelp (*laminaria*), bladder wrack (also called *fucus*), sea lettuce (*ulva*), and other varieties. Gardeners elsewhere can buy dried, granulated seaweed (kelp meal) or liquid concentrate. All these seaweed variants are rich in many types of micronutrients and are a boon to plants, soil health, and the compost pile.

Compared with barnyard manure, seaweed in general has a similar organic content. The proportions, however, vary—seaweed has more potassium than manure but has less nitrogen and phosphorus. Seaweed is perhaps most valued for its micronutrient content. An analysis of the seaweed most commonly used in seaweed meals and extracts identified the presence of some 60 elements, including all those important for plant, animal, and human health.

Use wet, fresh seaweed quickly because it deteriorates rapidly when piled haphazardly. Exposure to the elements will quickly leach out many of seaweed's soluble minerals. Dig the seaweed under, or mix it with nitrogenous and absorbent materials for rapid composting. Bacteria feast on the alginic acid found in the leaves, which makes seaweed an excellent compost pile activator. If composted with manure that is rich in litter, seaweed aids the speedy decay of the straw; very little nitrogen is lost, and all the other elements are preserved. Decay occurs rapidly.

If you have only a small amount of seaweed, chop it and soak it overnight in a gallon of hot water (160° to 180°F, or 71° to 82°C). Sprinkle this mixture over successive layers of the compost pile. The liquid can also be used as a fertilizer and as a seed-soaking solution.

Kelp meal can be used as an activator in compost, since its rich micronutrient composition stimulates microbial growth. Seaweed extract can be used to feed plants directly through their leaves, and may also be applied to compost in the course of moistening the layers. When used as a foliar feed, plant growth is also stimulated by seaweed's content of cytokinins and other plant growth hormones.

SEWAGE SLUDGE

Sewage sludge is the solid residue left after organic wastes and wastewater have been chemically, bacterially, or physically processed. Depending on how it is processed, sludge may contain up to 6 percent nitrogen and from 3 to 6 percent phosphorus.

Activated sludge is produced when sewage is agitated by air rap-

idly bubbling through it. Certain types of very active bacteria coagulate the organic matter, which settles out, leaving a clear liquid that can be discharged with a minimum amount of pollution. The resulting sludge is usually heat-treated before being offered as a soil amendment.

Digested sludge is formed when the solid matter in sewage is allowed to settle without air agitation, the liquid is drained off, and the sludge is fermented anaerobically. The conventional anaerobic digestion system takes from 15 to 30 days at 99°F (37°C) from the time the sewage reaches the sedimentation tank until the digested solids are pumped into filter beds for drying. The dried material is either incinerated or used for soil improvement.

Until recently, most sewage sludge was incinerated, buried in landfills, or dumped offshore. Now there's an increasing interest in using this potentially valuable material as a soil conditioner. This would be ideal if the residue were composed solely of the remains of human waste, but that isn't the case. Since industrial wastes are often treated in the same sewage plants as household wastes, sewage sludges are often contaminated with heavy metals that, when regularly incorporated into the soil, can build up to toxic levels.

All municipal sludge must be composted at high temperatures before it can be safely used as a garden fertilizer. Even then, avoid using it for edible crops, especially roots and leafy greens, since some viruses can survive hot composting temperatures. Any municipal solid waste composting operation should provide information on metals and other toxic compounds in its products if it offers them for sale to the public; most states prohibit distribution of uncompested sludge to the public.

As restrictions on sewage waste disposal make it more difficult and costly, an increasing number of cities are establishing sludge composting programs. Gardeners who have access to the products of such programs should ask questions and get detailed answers about the content of the sludge, its chemical analysis, and how it has been processed. Unless you're absolutely sure of the chemical content of your community's sludge, don't apply it near or on food crops or anywhere that runoff might contaminate a garden, an orchard, or a well. See chapter 13 for more information about municipal sludge composting.

SOIL

While not a necessity, soil is a valuable component in compost making. The thin (1/8-inch) layer called for in Indore heaps contains billions of soil organisms that consume plant, animal, and mineral matter, converting it to humus. Soil also contains minerals and organic

matter, so it acts like an activator when added to compostables. You can achieve much the same results using finished compost saved from a previous batch.

Thin layers of dirt in the compost heap work to absorb unstable substances produced by fermentation, thereby slowing their loss to the atmosphere. And when the pile is built, a topping of several inches of topsoil will stop heat and water from leaving the pile. Don't add too much soil, however, or the finished compost will be quite heavy.

Other than your own property, sources for soil include nearby woods, fields, building excavations, and mud from streams and ponds free of industrial or agricultural pollution. Don't use pond or stream mud directly in your soil; it will have the same effect as adding raw manure. Mud is also easier to handle if you dry it before composting, by mixing it with layers of absorbent plant wastes.

STRAW

Although straw will add few nutrients to the compost heap, it is widely used because it is readily available and adds considerable organic material. It is also unsurpassed as an aerating medium, as each straw acts as a conduit for air to circulate throughout the pile.

The fertilizer value of straw is, like that of all organic matter, twofold; it adds carbon material and plant food to the compost. The carbon serves the soil bacteria as energy food, while the plant food becomes released for growing crops. Where much straw is used, incorporate considerable amounts of nitrogen (preferably in the form of manures) so that the bacteria that break down the straw into humus do not deplete the soil of the nitrogen needed by growing plants.

If used in quantity, the straw should be cut up. Long pieces of straw mixed with other materials that hold water or composted with ample amounts of barnyard manure offer no trouble, though heaps cannot be turned easily. Straw compost must therefore be allowed to stand longer. For quicker compost, weigh down the material with a thicker layer of earth. This also preserves the moisture inside the heap.

If a large straw pile is allowed to stay outside in the field, it will eventually decay at the bottom into a crumbly substance. Such material is excellent for compost making and mulching. Some of the fungi it contains are of the types that form mycorrhizal relations with the roots of fruit trees, evergreens, grapes, roses, and so on, and a straw mulch will therefore benefit these plants not only as a moisture preserver but as an inoculant for mycorrhizae.

The nitrogen value of straw is so small that it need not be ac-

counted for in composting. The mineral value of straw depends on the soils where the crops were grown. (See the table "Typical Analyses of Straws" below.)

SUGAR WASTES

The most plentiful sugar-processing residue is burned bone, or bone charcoal, which is used as a filtration medium. Called "bone black" when saturated with sugar residues, this substance contains 2 percent nitrogen, more than 30 percent phosphorus, and a variable potassium content. Raw sugar residues, also known as bagasse, have over 1 percent nitrogen and over 8 percent phosphoric acid.

TANBARK

Tanbark is plant waste that remains following the tanning of leather. Its residues are shredded, heaped, and inoculated with decay-promoting bacteria. Thus composted, tanbark is sold in bulk as mulching material. Analysis shows nitrogen at 1.7 percent, phosphorus at 0.9 percent, and potassium at 0.2 percent; minor amounts of aluminum, calcium, cobalt, copper, iron, lead, magnesium, molybdenum, zinc, and boron are also present. Like peat, tanbark makes an excellent mulch but is generally too expensive to use extensively in compost.

Typical Analyses of Straws (%)

Straw	Cal-cium	Potash	Mag-nesium	Phos-phorus	Sulfur
Barley	0.4	1.0	0.1	0.1-0.5	0.1
Buckwheat	2.0	2.0	0.3	0.4	?
Corn stover	0.3	0.8	0.2	0.2	0.2
Millet	1.0	3.2	0.4	0.2	0.2
Oats	0.2	1.5	0.2	0.1	0.2
Rye	0.3	1.0	0.07	0.1	0.1
Sorghum	0.2	1.0	0.1	0.1	0.2
Wheat	0.2	0.8	0.1	0.08	0.1

SOURCE: Kenneth C. Beeson, U.S. Department of Agriculture.

TANKAGE

Tankage is the refuse from slaughterhouses and butcher shops, except blood freed from the fats by processing. Depending on the amount of bone present, the phosphorus content varies greatly. The nitrogen content varies usually between 5 and 12.5 percent; the phosphoric acid content is usually around 2 percent, but may be much higher.

Tankage, because it is usually rich in nutrient value, is especially valuable to the compost pile. However, it is also in demand as a feed additive and so is available only sporadically. Because it is an animal waste, tankage does require some special care in composting. Your compost must be kept in a secure, enclosed container, safe from four-legged scavengers. Use a good supply of high-carbon materials such as leaves, hay, or sawdust to absorb odors, with a layer of soil over each layer of tankage.

TEA GROUNDS

Useful as a mulch or for adding to the compost heap, one analysis of tea leaves showed the relatively high content of 4.15 percent nitrogen, which seems exceptional. Both phosphorus and potash were present in amounts below 1 percent.

TOBACCO WASTES

Tobacco stems, leaf waste, and dust are good organic fertilizer, especially high in potash. The nutrients contained in 100 pounds of tobacco wastes are 2.5 to 3.7 pounds of nitrogen, almost 1 pound of phosphoric acid, and from 4.5 to 7 pounds of potassium.

Tobacco leaves are "stripped" for market in late fall, leaving thousands of stalks. Some farmers use their stalks to fertilize their own fields, chopping up the stalks and disk them into the soil. Some stalks are available for gardeners, however, and tobacco processing plants bale further wastes for home use.

These wastes can be used anywhere barnyard manure is recommended, except on tobacco, tomatoes, potatoes, and peppers because they may carry some of the virus diseases of these crops, especially tobacco mosaic virus.

Compost tobacco wastes, or use them in moderation in mulching or sheet composting mixed with other organic materials. They should not be applied alone in concentrated amounts as a mulch—the nicotine will eliminate beneficial insects, earthworms, and other soil organisms as well as harmful ones.

WATER HYACINTH

Southerners who lack sufficient green matter for compost can often find quantities of the water hyacinth (*Eichhornia crassipes*) growing in profusion in southern streams. This plant is considered a serious menace to agriculture, fisheries, sanitation, and health in the South and other parts of the world where it grows with remarkable rankness. For best results, shred and mix it with partially decomposed "starter material" such as soil or manure.

WEEDS

Weeds can be put to use in the compost pile. Their nitrogen, phosphorus, and potash content is similar to other plant residues, and large quantities can provide much humus for the soil. Weed seeds will be killed by the high temperatures in the compost pile, and any weeds that sprout from the top of the heap can be turned under. Be careful not to allow weeds to grow and set seed on your finished compost. Weeds can even be used for green manure, as long as they will not be stealing needed plant food and moisture. Some produce creditable amounts of humus, make minerals available, and conserve nitrogen.

There are some weeds that you are better off burning or piling separately from your garden compost, since they are extremely vigorous and hard to kill. This applies primarily to weeds that reproduce through underground stems or rhizomes, such as quack grass, johnson-grass, bittersweet, and bishop's-weed.

WOOD ASH

Wood ash is a valuable source of potash for the compost heap. Hardwood ashes generally contain from 1 to 10 percent potash, in addition to 35 percent calcium and 1.5 percent phosphorus. Wood ashes should never be allowed to stand in the rain, as the potash would leach away. Wood ashes should be used very cautiously—it is not uncommon for home gardeners to create difficult nutrient imbalance problems by applying too much wood ash. It is a strong alkalinizing agent and also increases soil salinity. You should use it in the garden only if a soil test indicates acid soil and a lack of potassium.

Wood ashes can be mixed with other fertilizing materials or side-dressed around growing plants. Apply no more than 2 pounds per 100 square feet. Avoid contact between freshly spread ashes and germinating seeds or new plant roots by spreading ashes a few inches from plants. Be similarly sparing with wood ashes in your compost—use no more than a dusting on each layer, if you must. Manure and hay are also rich in potassium, and they do not pose the dangers of wood ashes.

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 also make a fine mulch for ornamentals.

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: (1) as bedding in the barn, followed by field application of the manure; (2) as a mulch on row crops, with the partially decomposed material eventually worked into the soil; and (3) adequately composted with other organic materials. Well-rotted chips or sawdust are safe materials to use under almost any condition.

WOOL WASTES

Wool wastes, also known as shoddy, have been used by British farmers living in the vicinity of wool textile mills since the industrial revolution in the early nineteenth century. The wool fiber decomposes when in contact with moisture in the soil and, in the process, produces available nitrogen for plant growth. Generally, the moisture content of the wool wastes is between 15 and 20 percent. It contains from 3.5 to 6 percent nitrogen, 2 to 4 percent phosphoric acid, and 1 to 3.5 percent potash.

C/N Ratios and Nutrient Analyses

The following tables and lists provide information about the carbon/nitrogen ratios and nutrient contents of a variety of organic materials. The presence of a material in this section does not necessarily mean it is ideal for composting; neither does exclusion of a material mean that it cannot be composted. As mentioned at the beginning of this chapter, the best materials for composting may be those that are in close proximity to the compost pile.

Many items are listed as ash; since it is not always desirable or possible to reduce organic matter to ash, be aware that these materials are valuable compost pile additions in their natural conditions. Burning organic matter eliminates moisture, so nutrients are much more

concentrated in ashed materials than in fresh. However, the significant advantages of adding fresh materials (moisture, microorganisms, and so on) and the restrictions most municipalities place on burning make ashed materials unlikely additions to most compost piles.

Since nearly all organic material contains some amount of nitrogen, phosphorus, potassium, and micronutrients, you don't need to worry a great deal about including all the plant nutrients in your compost pile. If you incorporate a good variety of materials into your

Carbon/Nitrogen Ratios of Bulky Organic Materials

Material	Ratio
Vegetable wastes	12 1
Alfalfa hay	13 1
Seaweed	19 1
Rotted manure	20 1
Apple pomace	21 1
Legume shells (peas, soybeans, etc.)	30 1
Leaves	40-80 1
Sugarcane trash	50 1
Cornstalks	60 1
Oat straw	74 1
Chaff & hulls (various grains)	80 1
Straw	80 1
Timothy hay	80 1
Paper	170 1
Sugarcane fiber (bagasse)	200 1
Sawdust	400 1

compost, the necessary nutrients will be there. As mentioned in chapter 4, compost not only provides nutrients, it also makes soil nutrients more available to plants. Only in instances where soil analysis indicates a significant nutrient deficiency should much effort be given to boosting levels of a certain nutrient in your compost.

NATURAL SOURCES OF NITROGEN

The materials listed below are grouped into representative classifications of organic matter; each group is ordered from highest nitrogen concentration to lowest. For specific nitrogen analyses, see the table "Percentage Composition of Various Materials" starting on page

Manure

Rabbit manure
Sewage sludge
Chicken manure
Human urine
Swine manure
Sheep manure
Horse manure
Cattle manure

Animal Wastes (other than manures)

Feathers
Felt wastes
Dried blood
Crabs (dried, ground)
Silkworm cocoons
Tankage
Fish (dried, ground)
Silk wastes
Shrimp heads (dried)
Crabs (fresh)
Fish scrap (fresh)
Wool wastes
Jellyfish (dried)

Lobster refuse

Shrimp wastes
Eggshells
Mussels
Milk
Oyster shells

Meal

Cottonseed meal
Gluten meal
Bonemeal (raw)
Wheat bran
Bonemeal (steamed)
Bone black
Oats (green fodder)
Corn silage

Plant Wastes

Tung oil pomace
Castor pomace
Tea grounds
Peanut shells
Tobacco stems
Coffee grounds
Sugar wastes
Seaweed (dried)

Plant Wastes	Grape leaves
Olive pomace	Pea (garden) vines
Brewery wastes	Grasses
Cocoa shell dust	Cowpea hay
Grape pomace	Vetch hay
Potato skins (raw)	Soybean hay
Pine needles	Pea forage
Beet wastes	Alfalfa
Seaweed (fresh)	Red clover
Leaves	Clover
Raspberry leaves	Millet hay
Apple leaves	Timothy hay
Peach leaves	Salt marsh hay
Oak leaves	Kentucky bluegrass hay
Pear leaves	Immature grass
Cherry leaves	

**NATURAL SOURCES OF PHOSPHATE
(OTHER THAN PHOSPHATE ROCK OR BONEMEAL)**

The following phosphate sources are listed in order from highest phosphorus content to lowest. For specific phosphorus analyses, see the table "Percentage Composition of Various Materials" starting on

Shrimp wastes	Tankage
Sugar wastes (raw)	Castor pomace
Fish (dried, ground)	Rapeseed meal
Sludge (activated)	Wood ashes
Lobster refuse	Cocoa shell dust
Wool wastes	Chicken manure
Dried blood	Rabbit manure
Banana residues (ash)	Silk mill wastes
Apple skins (ash)	Sheep and goat manure
Orange skins (ash)	Swine manure
Pea pods (ash)	Horse manure
Cottonseed meal	Cattle manure
Hoof and horn meal	

NATURAL SOURCES OF POTASH

The materials in each group below are listed in order from highest potassium content to lowest. For specific potash analyses, see the table "Percentage Composition of Various Materials" starting on

Natural Minerals	
Greensand	Grape leaves
Granite dust	Pear leaves
Basalt rock	Oak leaves
Hay Materials	Manure
Millet hay	Pigeon manure
Cowpea hay	Chicken manure
Vetch hay	Duck manure
Soybean hay	Rabbit manure
Alfalfa hay	Swine manure
Red clover hay	Horse manure
Kentucky bluegrass hay	Sheep or goat manure
Pea forage	Cattle manure
Timothy hay	Miscellaneous
Winter rye	Banana residues (ash)
Immature grass	Pea pods (ash)
Salt marsh hay	Cantaloupe rinds (ash)
Pea (garden) vines	Wood ash
Straw	Tobacco stems
Buckwheat straw	Cattail reeds or water lily stems
Oat straw	Molasses wastes
Barley straw	Cocoa shell dust
Rye straw	Potato tubers
Sorghum straw	Wool wastes
Cornstalks	Rapeseed meal
Wheat straw	Beet wastes
Leaves	Castor pomace
Cherry leaves	Cottonseed meal
Peach leaves	Potato vines (dried)
Raspberry leaves	Vegetable wastes
Apple leaves	Olive pomace
	Silk mill wastes

Percentage Composition of Various Materials

The presence of a C, N, or O in the C/N column indicates whether a material's effect on compost would be carbonaceous (C), nitrogenous (N), or other (O). Rock powders, for example, do not affect the C/N ratio and are designated O. C/N ratios of ashed materials represent their effects when fresh; when ashed, they are similar to rock powders.

Material	Nitrogen	Phosphoric Acid	Potash	C/N
Alfalfa hay	2.45	0.5	2.1	N
Apple fruit	0.05	0.02	0.1	N
Apple leaves	1.0	0.15	0.4	N
Apple pomace	0.2	0.02	0.15	N
Apple skins (ash)	—	3.0	11.74	N
Banana residues (ash)	—	2.3-3.3	41.0-50.0	N
Barley (grain)	1.75	0.75	0.5	N
Barley straw	—	—	1.0	C
Basalt rock	—	—	1.5	O
Bat guano	5.0-8.0	4.0-5.0	1.0	N
Beans, garden (seed and pods)	0.25	0.08	0.3	N
Beet wastes	0.4	0.4	0.7-4.1	N
Blood meal	15.0	1.3	0.7	N
Bone black	1.5	—	—	O
Bonemeal (raw)	3.3-4.1	21.0	0.2	O
Bonemeal (steamed)	1.6-2.5	21.0	0.2	O
Brewery wastes (wet)	1.0	0.5	0.05	N
Buckwheat straw	—	—	2.0	C
Cantaloupe rinds (ash)	—	9.77	12.0	C
Castor pomace	4.0-6.6	1.0-2.0	1.0-2.0	N

Material	Nitrogen	Phosphoric Acid	Potash	C/N
Cattail reeds and water lily stems	2.0	0.8	3.4	O
Cattail seed	0.98	0.39	1.7	C
Cattle manure (fresh)*	0.29	0.25	0.1	N
Cherry leaves	0.6	—	0.7	N
Chicken manure (fresh)*	1.6	1.0-1.5	0.6-1.0	N
Clover	2.0	—	—	N
Cocoa shell dust	1.0	1.5	1.7	C
Coffee grounds	2.0	0.36	0.67	N
Corn (grain)	1.65	0.65	0.4	N
Corn (green forage)	0.4	0.13	0.33	N
Corncobs (ground, charred)	—	—	2.0	C
Corn silage	0.42	—	—	N
Cornstalks (green)	0.75	—	0.8	C
Cottonseed hulls (ash)	—	8.7	23.9	C
Cottonseed meal	7.0	2.0-3.0	1.8	N
Cotton wastes (factory)	1.32	0.45	0.36	C
Cowpea hay	3.0	—	2.3	N
Cowpeas (green forage)	0.45	0.12	0.45	N
Cowpeas (seed)	3.1	1.0	1.2	N
Crabgrass (green)	0.66	0.19	0.71	N
Crabs (dried, ground)	10.0	—	—	N

Percentage Composition of Materials—*Continued*

Material	Nitrogen	Phosphoric Acid	Potash	C/N
Crabs (fresh)	5.0	3.6	0.2	N
Cucumber skins (ash)	—	11.28	27.2	N
Dried blood	10.0-14.0	1.0-5.0	—	N
Duck manure (fresh)*	1.12	1.44	0.6	N
Eggs	2.25	0.4	0.15	N
Eggshells	1.19	0.38	0.14	O
Feathers	15.3	—	—	N
Felt wastes	14.0	—	1.0	N
Field beans (seed)	4.0	1.2	1.3	N
Field beans (shells)	1.7	0.3	1.3	C
Fish (dried, ground)	8.0	7.0	—	N
Fish scrap (fresh)	6.5	3.75	—	N
Gluten meal	6.4	—	—	N
Granite dust	—	—	3.0-5.5	O
Grapefruit skins (ash)	—	3.6	30.6	O
Grape leaves	0.45	0.1	0.4	N
Grape pomace	1.0	0.07	0.3	N
Grass (immature)	1.0	—	1.2	N
Greensand	—	1.5	7.0	O
Hair	14.0	—	—	N
Hoof and horn meal	12.5	2.0	—	N
Horse manure (fresh)*	0.44	0.35	0.3	N
Incinerator ash	0.24	5.15	2.33	O

Material	Nitrogen	Phosphoric Acid	Potash	C/N
Jellyfish (dried)	4.6			N
Kentucky bluegrass (green)	0.66	0.19	0.71	N
Kentucky bluegrass hay	1.2	0.4	2.0	C
Leather dust	11.0			N
Lemon culls	0.15	0.06	0.26	N
Lemon skins (ash)		6.33	1.0	O
Lobster refuse	4.5	3.5		N
Milk	0.5	0.3	0.18	N
Millet hay	1.2		3.2	C
Molasses residue from alcohol manufacture	0.7	—	5.32	N
Molasses waste from sugar refining			3.0-4.0	N
Mud, fresh water	1.37	0.26	0.22	N
Mud, harbor	• 0.99	0.77	0.05	N
Mud, salt	0.4	—	—	N
Mussels	1.0	0.12	0.13	N
Nutshells	2.5	—	—	C
Oak leaves	0.8	0.35	0.2	N
Oats (grain)	2.0	0.8	0.6	N
Oats (green fodder)	0.49			N
Oat straw			1.5	C
Olive pomace	1.15	0.78	1.3	N
Orange culls	0.2	0.13	0.21	N

Percentage Composition of Materials—Continued

Material	Nitrogen	Phosphoric Acid	Potash	C/N
Orange skins (ash)		3.0	27.0	O
Oyster shells	0.36			O
Peach leaves	0.9	0.15	0.6	N
Pea forage	1.5-2.5	—	1.4	N
Peanuts (seed/kernels)	3.6	0.7	0.45	N
Peanut shells	3.6	0.15	0.5	C
Pea pods (ash)		3.0	9.0	N
Peas, garden (vines)	0.25		0.7	N
Pear leaves	0.7	—	0.4	N
Pigeon manure (fresh)*	4.19	2.24	1.0	N
Pigweed (rough)	0.6	0.16		N
Pine needles	0.5	0.12	0.03	C
Potato skins (ash)	—	5.18	27.5	N
Potato tubers	0.35	0.15	2.5	N
Potato vines (dried)	0.6	0.16	1.6	C
Powder works wastes	2.5		17.0	O
Prune refuse	0.18	0.07	0.31	N
Pumpkins (fresh)	0.16	0.07	0.26	N
Rabbitbrush (ash)			13.04	C
Rabbit manure	2.4	1.4	0.6	N
Ragweed	0.76	0.26		N
Rapeseed meal		1.0-2.0	1.0-3.0	N
Raspberry leaves	1.45		0.6	N
Red clover hay	2.1	0.5	2.1	N
Redtop hay	1.2	0.35	1.0	C

Material	Nitrogen	Phosphoric Acid	Potash	C/N
Rock and mussel deposits from sea	0.22	0.09	1.78	O
Roses (flowers)	0.3	0.1	0.4	N
Rye straw	—	—	1.0	C
Salt marsh hay	1.1	0.25	0.75	C
Sardine scrap	8.0	7.1	—	N
Seaweed (dried)	1.1-1.5	0.75	4.9	N
Seaweed (fresh)	0.2-0.4	—	—	N
Sheep and goat manure (fresh)*	0.55	0.6	0.3	N
Shoddy and felt	8.0	—	—	N
Shrimp heads (dried)	7.8	4.2	—	N
Shrimp wastes	2.9	10.0	—	N
Siftings from oyster shell mounds	0.36	10.38	0.09	O
Silk mill wastes	8.0	1.14	1.0	N
Silkworm cocoons	10.0	1.82	1.08	N
Sludge	2.0	1.9	0.3	N
Sludge, activated	5.0	2.5-4.0	0.6	N
Smokehouse fire-pit ash	—	—	4.96	O
Sorghum straw	—	—	1.0	C
Soybean hay	1.5-3.0	—	1.2-2.3	N
Starfish	1.8	0.2	0.25	N
String bean strings and stems (ash)	—	4.99	18.0	C

Percentage Composition of Materials—Continued

Material	Nitrogen	Phosphoric Acid	Potash	C/N
Sugar wastes (raw)	2.0	8.0	—	C
Sweet potatoes	0.25	0.1	0.5	N
Swine manure (fresh)*	0.6	0.45	0.5	N
Tanbark ash	—	0.34	3.8	C
Tanbark ash, spent	—	1.75	2.0	C
Tankage	3.0-11.0	2.0-5.0	—	N
Tea grounds	4.15	0.62	0.4	N
Timothy hay	1.2	0.55	1.4	C
Tobacco leaves	4.0	0.5	6.0	N
Tobacco stems	2.5-3.7	0.6-0.9	4.5-7.0	C
Tomato fruit	0.2	0.07	0.35	N
Tomato leaves	0.35	0.1	0.4	N
Tomato stalks	0.35	0.1	0.5	C
Tung oil pomace	6.1	—	—	N
Urine, human	0.6	—	—	N
Vetch hay	2.8	—	2.3	N
Waste silt	9.5	—	—	N
Wheat bran	2.4	2.9	1.6	C
Wheat (grain)	2.0	0.85	0.5	N
Wheat straw	0.5	0.15	0.8	C
White clover (green)	0.5	0.2	0.3	N
Winter rye hay	—	—	1.0	C
Wood ash	—	1.0-2.0	6.0-10.0	O
Wool wastes	3.5-6.0	2.0-4.0	1.0-3.5	N

*Dried manures are up to 5 times higher in nitrogen, phosphoric acid, and potassium.

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 proportion, 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. (See the table "Solving a Heap of Problems" on page 165.)

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 also 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 will 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.

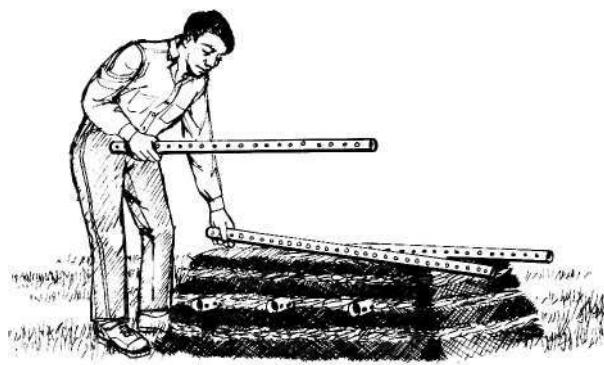
Commercially available and homemade barrel composters are discussed more fully in chapter 10.

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.

Another time-honored trick for good aeration involves layering poles into the heap and withdrawing a few every day or so during the major heat buildup. You can also stick the pile with the tines of a pitchfork to open air channels. There is even a tool on the market that has a small umbrellalike mechanism. You insert it into the pile, open the blades, and twirl it around to make an air pocket.

Sunflower stalks have soft centers that rot out quickly to create organic "pipes" for aerating a compost pile. A well-ventilated heap can be formed by using a 2- to 4-inch layer of sunflower stalks as a base, then topping that with 12 inches of compostable materials, followed by 1/4 inch of soil. Add a few more stalks, another layer of moistened compostables, and another 1/4 inch of soil. Continue this layering



Lengths of
perforated pipe,
placed at
intervals within
the compost
heap, allow air to
reach the pile's
interior and
reduce or
eliminate the
need to turn the
pile.

until the pile is about 4 feet high, finishing it with a 2-inch layer of soil.

Jerusalem artichoke stalks are also effective aerators, but cornstalks do not rot out easily and cannot be used for air channeling.

If you are in no hurry, a static pile built on a base of brush or other coarse materials will have enough aeration to allow materials to gradually decompose. In this case it is especially important to layer in materials that are fluffy enough to allow air to penetrate. Shredding, grinding, or chopping ingredients such as leaves, hay, or paper will prevent the formation of impermeable mats. The finer the materials can be cut, the more quickly they will decompose, since small pieces are more accessible to microbial colonization.

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.

A pile containing a great deal of hay can also be a problem. Country folks know how a haystack sheds water—a well-made haystack keeps the bulk of the hay dry through winter rains. If you are using hay, counter this water-resistant tendency by limiting the hay layers to 6 or 8 inches and wetting each layer thoroughly as you build the pile. Hay that is shredded is less of a problem, especially when combined with wet materials such as cow manure or kitchen scraps. To control the moisture in an exposed heap, cover it with a few inches of hay, which should help shed rain. Some gardeners cover their compost with black plastic and remove it during selected rains.

Be especially careful to check the moisture content when turning the pile—the turning process itself releases moisture. If the pile is

soggy, you can add more absorbent materials such as leaves or dried grass clippings. If it is dry, give it a good sprinkling every 6 to 8 inches.

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. The ideal C/N ratio for composting is between 25:1 and 30:1, with carbon being the higher number. 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. You can find information about the C/N ratios of various materials in the tables at the end of chapter 6.

The carbon materials contribute mass to the pile and give rise to the organic gums abundant in humus. Nitrogen is necessary to stimulate microbes to reproduce as rapidly as possible. However, even materials that contain very little nitrogen will break down over time, but they will never reach the temperatures needed for hot composting. If there is too much nitrogen in relation to carbon, nitrogen will be lost as ammonia, easily detected by its smell. This generally lasts only a day or two, until the material stabilizes. In the worst case, excess nitrogen may cause the pile to become putrefied and anaerobic, usually because carbonaceous materials also contribute to proper aeration.

Some composting guides recommend adding synthetic nitrogen carriers such as urea or sodium nitrate as activators. This is never necessary and is a bad idea because these materials can disrupt microbe populations. Moreover, their manufacture consumes vast quantities of natural gas. If you need a concentrated nitrogen source, there are many naturally derived alternatives available commercially—refer to chapter 6 for a listing.

Warmth and Critical Mass

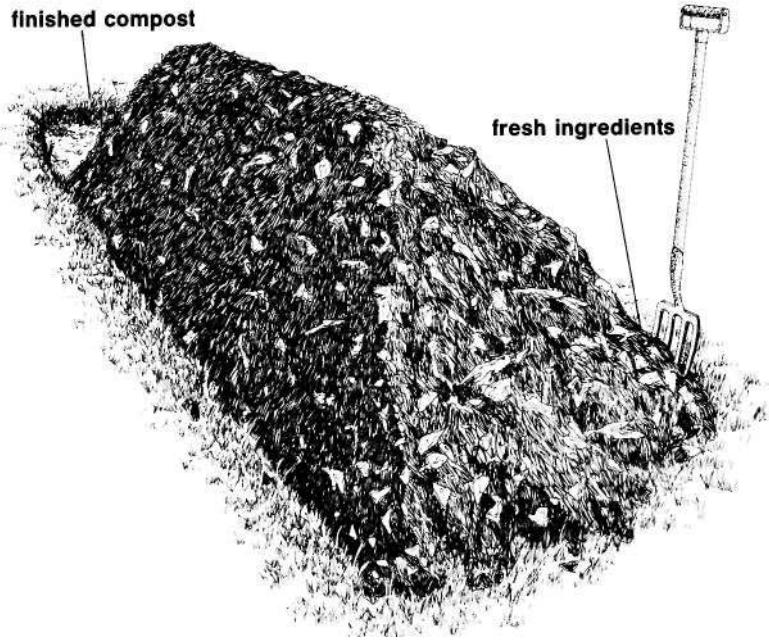
Bacteria become dormant when the temperature drops below 55°F(13°C). If properly built, a compost pile's interior will stay well above that temperature even in freezing weather. Northern composters sometimes insulate their piles with leaves, straw, or hay, even to the point of building an enclosure of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

To achieve optimum hot-composting temperatures (140°F, or 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. Dr. Clarence Golueke, author of *Biological Reclamation of Solid Wastes*, says that in a pile this size, less than half the material (that part right in the middle) is exposed to the highest temperatures. 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.

For continuously composting household, yard, and garden waste while maintaining optimum pile size, a "wandering compost pile" is effective. Starting with minimum dimensions of 3 feet high by 3 feet wide by 3 feet deep, this type of heap "wanders" as fresh ingredients, such as kitchen refuse (minus meat or animal fat), are tossed onto the sloping front face and finished compost is sliced from the back. By screening the finished compost as it is removed and using the larger particles to cover additions to the front of the pile, newly added materials are seeded with the necessary microorganisms.

Inoculation

Bacteria are certain to be among the unseen inhabitants of whatever materials you include in your compost, but they may not be the right mix of the right types for optimal composting. The more diverse your compost ingredients, the more likely you are to include a good balance of bacteria. The best way to inoculate your pile with the right cultures is simply to sprinkle a thin coating of good topsoil or finished compost, saved from a previous batch, over each layer of materials that you add.



While continuously composting household, yard, and garden waste, a "wandering" compost pile moves as new materials are added to the sloping front face and finished compost is sliced from the other end.

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. (See the table "Hot vs. Cool: Compost Pros and Cons" on

the opposite page.) 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. This speed is achieved by keeping aeration levels high, either by passing air through a static pile or, more commonly, by frequent turning. If we liken composting to a combustion process, it is clear that the more air there is available, the hotter will be the compost. 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 vs. Cool: Compost Pros and Cons

	Pros	Cons
Hot	<ul style="list-style-type: none">• Produces finished compost quickly• Uses space efficiently• Builds fertility quickly for new garden locations• Kills most weed seeds and pathogens	<ul style="list-style-type: none">• 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 new pile• Conserves less nitrogen• Produces compost with reduced ability to suppress soil-borne diseases
Cool	<ul style="list-style-type: none">• Needs little maintenance• Spares disease-suppressing microbes• Conserves nitrogen• Allows materials to be added little at a time	<ul style="list-style-type: none">• 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 pile• Produces compost with more undecomposed bits of high-carbon materials

Hot composting conserves less nitrogen than cooler methods, since extra nitrogen is required to stimulate fast bacterial growth and some inevitably drifts off in the form of ammonia. However, a cool pile that sits in the rain for over a year also loses much of its nitrogen content. Finally, studies at the Ohio Agricultural Research and Development Center have shown that compost produced at high temperatures has less ability to suppress soil-borne diseases than does cool compost. This is because the beneficial bacteria and fungi that attack pathogens cannot survive the higher temperatures.

A Cool Alternative

Some compost professionals tend to turn up their noses at slow, cool methods, deriding them as "let it happen" compost. However, if you have the space but not the time or stamina to work with your compost, this is the easiest approach to take. Compost made in this manner will still heat up at first, but not to the levels of hot compost—120°F (49°C) is a maximum. The mesophilic organisms will carry most of the burden of humus making, which will occur in 6 months to 2 years, depending on climate, materials used, and aeration conditions.

The advantages and disadvantages of cool composting mirror those of hot composting: It involves less work but longer lag time until

A SPECTRUM OF METHODS BY TEMPERATURE

The composting methods described in this chapter cover the range of temperatures from hot (thermophilic) to cool (mostly mesophilic) and beyond. The list below shows the methods in temperature order from hot to cool, along with page numbers indicating where each method is discussed.

California method (page 141)
(hot)

City people's method (page 148) (hot)

Compost tumblers (page 151)
(hot)

Raised bins (page 151) (cool
end of hot spectrum)

Movable compost for raised
beds (page 154) (hot or
cool)

Windrows and piles (page
155) (hot or cool)

Biodynamic composting (page
145) (cool or hot)

Indore method (page 139)
(cool)

Ogden's step-by-step
composting (page 152)
(cool)

Pit composting (page 154)
(cool)

Mulch and sheet composting
(page 157) (beyond the cool
end)

Trench and posthole
composting (page 161)
(beyond the cool end)

Anaerobic composting (page
162) (beyond the cool end)

the compost is finished. It fails to kill pathogens or weeds but spares disease-suppressing microbes. It conserves nitrogen but must be protected from the elements longer. It has the advantage of allowing you to add materials a little at a time until you have a critical mass. The drawback to this is that you must be careful to balance carbon and nitrogen as well as wet and dry materials as you go. Otherwise, you can create anaerobic conditions or unpleasant smells. It's often helpful to keep a supply of dry high-carbon materials on hand to layer in when you spread household garbage; remember to sprinkle some soil on top each time you add fresh materials.

There is fierce debate regarding which method produces humus of a higher quality. Although cool compost generally results in more undecomposed bits of high-carbon materials, these can easily be screened out and added into the next pile. Whichever method you choose, the process is really a variation of Sir Albert Howard's Indore method.

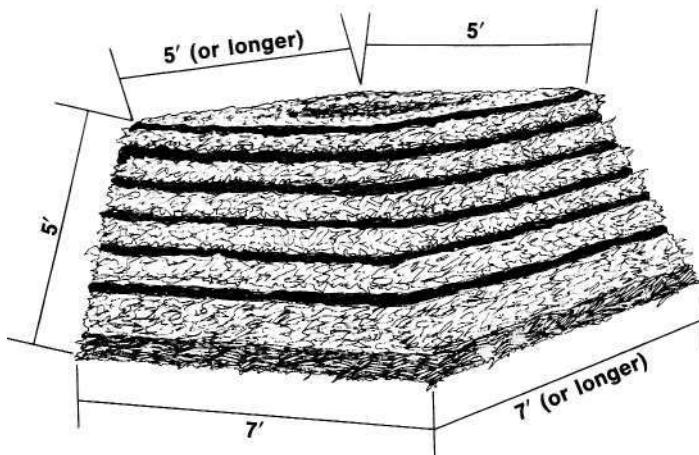
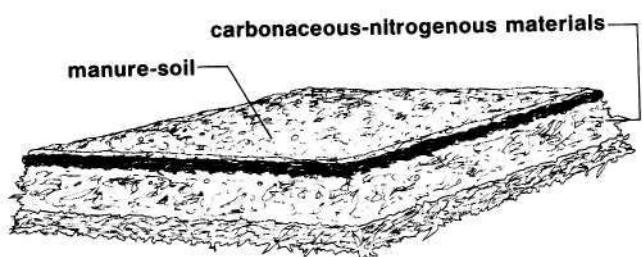
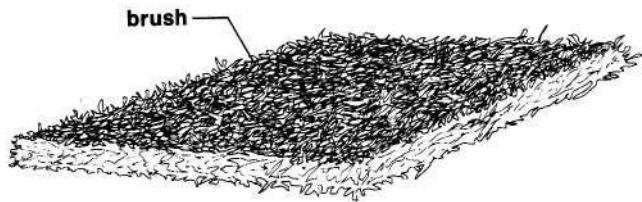
The Indore Method

The Indore process consists of a systematic use of traditional procedures. When Howard first put the system into practice, he used only animal manures, brush, leaves, straw or hay, and sprinklings of chalk or earth. The material was piled in alternating layers to make a 5-foot-high stack, or it was placed in a pit 2 or 3 feet deep. The original procedure was to use a layer of brush as a base and to heap green or dry vegetable material over it in a 6-inch layer, followed by a 2-inch layer of manure and a sprinkling of soil. The order of layers was repeated until the desired height of 5 feet was reached.

The general proportions were, by volume, 3 to 4 parts of vegetable matter to 1 part of animal manure. Sir Albert advised spreading limestone or chalk between layers along with earth. In his work with village or large farm-scale projects, he suggested 5-foot-high piles, measuring 10 by 5 feet, or windrows of any practical length, 10 feet wide.

Later in the history of the Indore method, composting with night soil (mixed human urine and feces), garbage, and sewage sludge was done. These materials were layered with high-carbon organic material such as straw, leaves, animal litter, and municipal trash.

The piles were turned, usually after 6 weeks, and again after 12 weeks. Two turnings were the general practice, but the exact timing of these turnings varied. Occasionally, additional turnings were given to



In the Indore method, a layer of brush forms the base of the pile. It is followed by a layer of green or dry vegetable matter, then a layer of manure and a sprinkling of soil. The layers are repeated until the pile is 5 feet high.

control flies, though the more common practice was to cover the pile with a 2-inch layer of compacted soil when flies or odors were a problem. The liquor draining from the composting mass was, in some variations of the early Indore process, recirculated to moisten the pile.

Harold B. Gotaas, in *Composting: Sanitary Disposal and Reclamation of Organic Wastes*, suggests that the early Indore process stacks were aerobic for a short period after piling and after each turn, but anaerobic otherwise.

The chief advantage to the Indore method as originally practiced is that it can be practiced on a fairly large scale without the need for either mechanization or a great amount of labor. According to Dr. Golueke, although many successful large-scale modified Indore composting efforts use windrows, composting of garden and kitchen waste by the Indore method is done best in bins or pits.

Modifications

The Indore process has been used widely in India where it is most frequently seen today in a modification called the Bangalore method. The process is also employed in Malaya, China, Sri Lanka, South Africa, Costa Rica, East Africa, and other parts of the world. In general, Indore modifications have emphasized the use of night soil, sewage sludge, garbage, or green matter as substitutes for manure. They have also sought higher temperatures through increased frequency of turning and by substituting turning for covering as a means to fly control. Mechanized Indore windrows are now used in some countries.

Another adaptation of the Indore method uses only animal bedding and fresh green plant matter. A sheet of black plastic covers and confines the pile to increase heat and reduce leaching. The total process takes about 3 weeks, and no turning is necessary.

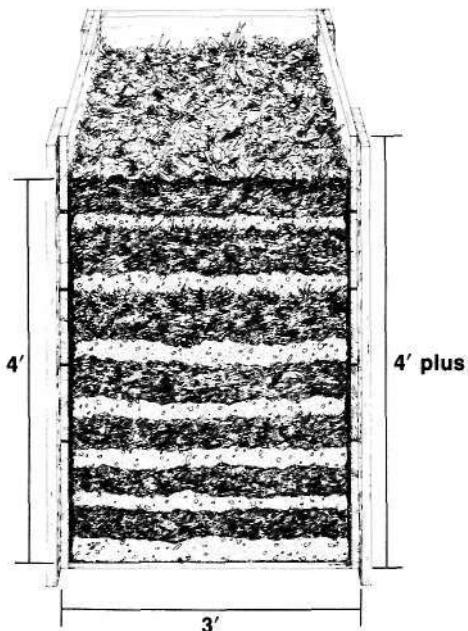
The University of California Method

The composting method developed at the University of California in the early 1950s is probably the best known and the most clearly articulated of the rapid-return or quick methods. It is similar to earlier methods recommended by modifiers of the Indore method, to those practiced in mechanical digester units in Europe and America, and to those described and advocated by Harold B. Gotaas of the World Health Organization in his 1935 book *Composting*. Whereas the Indore

method may be described as falling on the cool end of the compost spectrum, the California method aims for more heat and faster decomposition. The California method has been used in the windrow composting of municipal wastes where shredding of materials, planned adjustment of the C/N ratio, regular and frequent turning for aeration, and control of moisture content are practiced. Municipal composting differs from garden composting in the nature of its materials and in the quantity of its product. Paper and ash that are present in municipal compost require specific adjustments, and so do factors resulting from the bulk of the material, such as compaction and overheating due to self-insulation.

The California method as it applies to the home gardener's individual needs may be summarized this way: (1) raw material of proper composition and in a suitable condition must be provided, and the pile should be built all at one time; (2) a bin is needed to contain the material; and (3) a set procedure must be followed in setting up the contents of the bin.

According to Dr. Golueke, the C/N ratio of the material should be 25 to 30 parts of carbon to 1 of nitrogen. The home gardener may achieve this by using green garden debris or garbage for the nitrogen and dry garden debris for the carbon matter. A high C/N ratio can be



The minimum dimensions of a bin for the California method should be 3 feet by 3 feet, with a height of 4 to 6 feet.

lowered (in favor of nitrogen) through the use of manures. See chapter 6 for more information about the C/N ratios of various materials.

For home gardeners who wish to adjust the C/N ratio of their piles, Dr. Golueke recommends "trial and error, coupled with good judgment." He suggests layering dry and green materials in 2-to-4-inch-deep layers. Paper, he says, is an ineffective absorbent, while high-cellulose or woody materials offer carbon in a resistant form and therefore require additional nitrogen material to balance them at the early stages of the process. High-carbon material acts as an absorbent in the pile and gives it structure.

A minimum volume of 1 cubic yard will usually ensure self-insulation, but greater volume may be required in cold weather. The minimum floor dimensions of the bin should be 3 feet square, and the height of material inside the bin should not exceed 6 feet or be less than 4 feet. A bin may be constructed from wood and hardware cloth, wood alone, or concrete. It may be covered with a screen to discourage flies. Although not essential, a double-bin system allows you to turn the pile by transferring the materials from one bin to the other. (Bins are discussed in more detail in chapter 10.)

Material to be composted should be reduced in size to pieces of 6 to 8 inches, though in garden composting all you really need to do is chop any thick flower stalks and vegetable vines. Shredding with a power shredder is ideal but not essential. Ground material composts faster than coarse, high-cellulose material.

Turning is essential to the California method, for it provides aeration and prevents the development of anaerobic conditions. The more frequent the turning (so long as it is not done more than once a day), the more rapidly the method works. If you have a single bin, turning the pile requires you to remove the front of the bin and fork out the contents, beginning with the top layer and keeping track of the original location of the material. When you return the contents, make sure that the material from the outer layers (top and sides) of the pile ends up in the interior of the new pile. The same result can be achieved in a single operation if you construct a double bin. The material should be fluffed as it is forked, and it should be so thoroughly mixed that the original layers are indistinguishable. In the course of the composting process, every particle of the pile should at one time or another have been exposed to the interior heat of the pile.

Turning schedules are not absolute, and by varying the turning frequency, the compost-making process may be extended to a month or even more, or reduced to as little as 12 days. The suggested schedule

for 12-day compost is this: (1) turn on the 3d day after starting the pile; (2) turn again on the 3d day after the first turning (skip a day); and (3) make the third and final turn on the 9th day after setting up the pile.

On the 12th day, following this schedule, the compost will be complete and ready for use, although it can benefit from further ripening.

The best way to monitor the decomposition process is by noting the course of the temperature changes in the heap. This may be done with a hotbed thermometer placed inside the pile about 12 inches from the surface. (A string on the end of it will aid in retrieval, for if the pile is working, it will be too hot to dig around in.) The temperature will rise from 110° to 120°F (43° to 49°C) within 24 to 48 hours after the process begins and to 130°F (54°C) or higher within 3 to 4 days. When the temperature sinks back to 110°F (43°C), the compost will be ready for use.

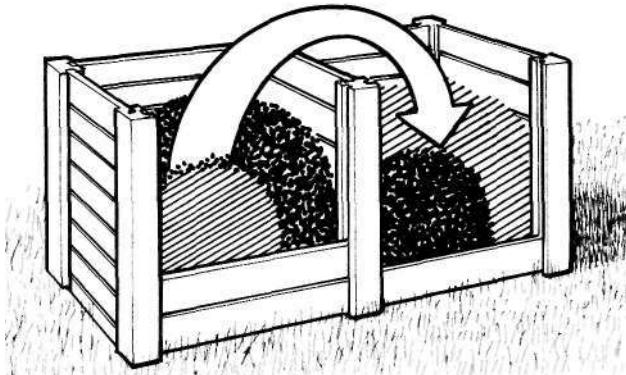
Over the years, we have found that home composters tend to be either too casual or too compulsively pseudoscientific and precise in their composting operations. The most important human ingredients in the process are good judgment and common sense. Use your nose and eyes to determine the cause of any failures you have, and be intelligent about making adjustments of C/N ratio, moisture, and aeration until you achieve satisfactory results.

Modifications

Most of the common modifications of the California system are easily anticipated within the system itself. Schedules, as we have noted, can be adjusted. An experiment performed at the Rodale Research Center, for example, followed a 14-day schedule with turnings on the 4th, 7th, and 14th days. This experiment started with proportioned but thoroughly mixed ingredients (the mixing was done during the grinding). All material was ground. Sprinklings of dried blood or cottonseed meal were used for nitrogen when manure was scarce or absent.

One variation of the California method emphasizes a second shredding after the 2d week in a 2-week process, when a thorough turning has been given after 1 week. The second shredding is followed by sifting. Residue is removed to be used as mulch.

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



Turning the compost properly is essential to the California method. Transfer the materials from one bin to the next, so that the outer layers are moved to the middle of the heap after turning.

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 composter claims to have reduced composting time to 6 days using this method, with thorough grinding of materials. We will examine this approach in more detail later in this chapter.

The Biodynamic Method

The biodynamic method of farming and gardening was developed by a group of people surrounding or influenced by Rudolph Steiner, an Austrian social philosopher who died in 1925. He, in turn, was influenced by the German poet and dramatist Johann von Goethe. The biodynamic method is part of a wider philosophical world view called anthroposophy, a world view with both scientific and humanistic roots that aims at the creation of a new culture based on the unity of all life processes. An excellent, clearly written reference on the principles of biodynamic gardening is Wolf Storl's book *Culture and Horticulture*.

In his book *Bio-Dynamic Farming and Gardening*, Dr. Ehrenfried Pfeiffer, who served as the director of the Biochemical Research Laboratory at the Goetheanum Dornach, Switzerland, and who was a disciple of Rudolph Steiner, explains the biodynamic composting system: "The setting up of the compost heap is carried out as follows: The first step is to dig a pit for the pile from 5 to 10 inches deep. . . . This should be covered, when possible, with a thin layer of manure or compost already rotted. . . . The structure and consistency of the compost should be moist, but not wet."

The biodynamic compost pile is trapezoidal in shape with a base width of 13 to 15 feet and a top width of 6 feet. It is 5 to 6 feet high. Alternate layers of compost material (any organic material) and earth are used with lime or other rock powders sprinkled between layers. When complete, the pile is entirely covered with soil.

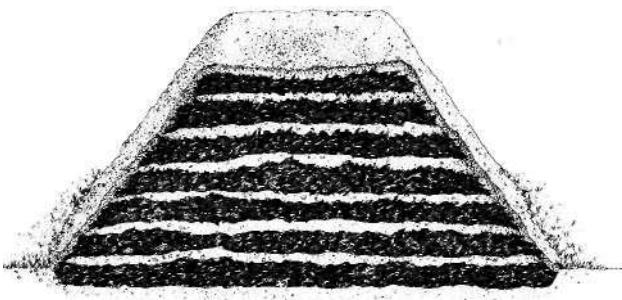
When manure is composted, bedding straw, leaves, or sawdust are layered with it. Piles are moistened with sprinkled or pumped liquid manure or rainwater. Brushwood or drainage tiles in the bottom of the shallow pit provide drainage. Only freshly fallen leaves, those that have not dried or "washed out," are used. When garbage is used, it can be covered temporarily with matting or evergreen branches.

So far, the biodynamic method is not much different from the Indore method or any partly anaerobic slow-acting method of composting. The "trademark" of the biodynamic method comes with the next step.

When the pile is about a yard high, special biodynamic "preparations" are added to the pile. These preparations are known by numbers and are obtainable only from specially designated and certified biodynamic farmers of standing who alone know how to make them. These preparations are not to be sold for profit.

The preparations are made from various plants that have traditionally been employed as medicinal herbs. Among them are chamomile, valerian, nettle, yarrow, dandelion, and horsetail. These plants are themselves composted by the farmers and given a long fermentation process. They are buried at certain depths in the earth in contact with certain parts of animal organs. The biodynamic farmers believe

A cross section
of a biodynamic
heap shows
layers of
compost
materials
alternated with
layers of soil.
Each layer is
sprinkled with
lime or other
rock powders,
and the
completed pile is
covered with soil.



that the scientific basis for the changes that occur during the fermentation of compost has to do with hormone influence. They believe they can direct the composting process in the garden through predetermined use of these plant preparations. The humuslike mass resulting from the composting of the special herbs is distributed as a compost activator or inoculant. Each compost pile needs only a tiny amount of these preparations; the prescribed quantities treat 7 to 16 tons of compost.

In 3 to 5 months, the biodynamic pile is turned and mixed. More preparations are added at this time, if necessary. The turning is important for aeration and to expose all weed seeds to the inner part of the pile. Pfeiffer says that it is the lack of air in the middle of the pile that, coupled with the conditions of fermentation, destroys the seeds.

Biodynamic gardeners believe that everything in nature is there for a purpose. All substances are related dynamically. Weather and the phases of the moon, they say, should be studied so the farmer can work in harmony with them by intention, just as the early peasant once used them through instinct or superstitious tradition.

Through experiment and observation, a biodynamic gardener seeks materials with the qualities most helpful to specific plants. These materials can then be used in custom-blending compost for each plant. This sometimes involves particular minerals known to be needed by that plant. Tomatoes, for example, do well in compost made from their own discarded leaves and vines, while sugar beets need a boron-rich compost made with such substances as seaweed, and potatoes do well in a calcium-rich horseradish compost. Stinging nettles aid in the rapid decomposition of other weeds and organic matter and are an essential ingredient of biodynamic compost.

Evaluation of the biodynamic method is made difficult by its ties to philosophical intangibles and by its adherents' claims of scientific precision. The experiments carried on by Dr. Pfeiffer's laboratory and at other centers show that seeds and plants treated with biodynamic preparations grow faster and are healthier than those grown in control experiments. However, most of the reasons used to explain this phenomenon are still speculative. Other studies have shown higher reproductive vigor among animals fed biodynamically grown hay, as compared with those fed hay fertilized conventionally. One study in Germany demonstrated that vegetables produced biodynamically had superior storage qualities.

Some modern composting experts, such as those who developed the California method, have found that activating preparations in gen-

eral neither aid nor hinder the properly managed composting operation. It is possible that the biodynamic preparations, all made from plants rich in micronutrients or natural acids, bring anaerobic processes closer to the chemical state of aerobic processes than they would otherwise be, but this has not been proved conclusively. Modern scientific composters cannot, of course, measure the effects of inner attitudes on composting. These remain an article of faith to the followers of the biodynamic method and anthroposophy.

On one point at least, evidence indicates that the early biodynamic theory is in error. It is high temperature, not lack of air, that causes weed seeds to be destroyed in the center of the heap. Turning the pile more often than is called for in the biodynamic method is required for the destruction of weed seeds.

However, gardeners who wish to explore the secrets of the most highly regarded farmers in Europe may learn much from biodynamic methods. Beyond tips for fine-tuning your composting techniques, by studying biodynamics you can gain a greater appreciation of the subtleties of compost and its importance in restoring health to ravaged soils.

The City People's Method

Helga and Bill Olkowski, coauthors of *The City People's Book of Raising Food*, produce much of their own vegetable supply on a comparatively small plot of land in a city.

The composting method they practice and recommend to the urban gardener is a "fast" aerobic process. One reason for their recommendation comes from the special need urbanites have to avoid offending neighbors through foul smells and the nuisances, such as stray dogs, rats, and flies, these smells may bring. By maintaining an aerobic pile through frequent turnings, unpleasant odors are avoided.

In a time of increased incidence of often expensive litigation resulting from neighborhood friction, gardeners must be careful to keep composting operations inoffensive. Many modern city dwellers, not understanding the need for or importance of composting, associate it with offenses to public health like leaving garbage exposed on the street. Public education about composting is needed; so are definitive court rulings on the side of careful composters, and sound municipal ordinances.

The Olkowskis, in outlining their method, suggest putting a sturdy, covered bin in a shady place, such as the north side of a garage,

so that the contents will not dry out too rapidly. Three bins are ideal to facilitate turning.

About use and timing, they say the following:

Usually it takes us about a week or so to use up the compost once it is made, as we don't have much time to devote to gardening generally. Since it takes about three weeks for a batch to be ready for use, this means we end up making one every month or so. However there are times during the summer when both our garden needs and garden wastes demand a more rigorous attention to the system.

During this period, they explain, they make compost every 2 weeks, using a three-bin "assembly line" that has one batch cooking and one being used at all times.

City people, the Olkowskis remind us, have an additional reason to balance high-nitrogen and high-carbon materials in their piles. If high-nitrogen materials like chicken manure are added to the pile "in such quantity that there is more than one part of nitrogen to approximately 30 parts carbon, the excess nitrogen will be respired by the microorganisms as ammonia." Ammonia odor, though less distressing than the odors of putrefaction found in an anaerobic pile that has not heated up, still upsets neighbors.

The Olkowskis recommend human urine as an excellent nitrogen source. Urine, since it is liquid, is easy to apply and can be substituted for some or all of the moisture added to the pile.

Recent studies at the Rodale Research Center have concluded that human urine contains enough nitrogen to be effective as a compost activator. It is relatively disease free and is less likely to lose potency than some animal manures because it is easier to apply soon after it is excreted. As a liquid, it can be stored in a closed container. Perhaps the only drawback to using urine as a compost nitrogen source is that of public perception. Give careful consideration to the advantages and disadvantages of adding urine to your compost pile. The urine of sick people should not be used.

Helga and Bill Olkowski recommend using a layering technique to build the pile. They use sawdust as a bottom layer and then alternately layer green and dry material, sprinkling urine or another easily sprinkled nitrogen source, like dried blood or alfalfa meal, over each layer as they build. Although they abandoned the use of a grinder because of its fuel consumption, they still chop large or tough dry materials with a cleaver. "After the pile is built," they continue, "you may need to water it. If you have been adding urine every other layer or so, it may be wet enough."

They turn the pile after a day or so by forking it into an adjacent bin. The same procedure is followed in subsequent turnings every 3 days. As city dwellers, the Olkowskis particularly wish to avoid the odors of an improperly aerated pile that has gone anaerobic. On the other hand, they advise against using side vents in a bin because, they claim, it will increase the heat loss and encourage fly breeding around the cover edges. Neighbors object to flies as much as they do to offensive odors.

COMPOST IN A BAG

Even if you live in an apartment and have absolutely no space for composting, this recipe for compost in a bag can help you recycle some of your kitchen wastes into fertilizer for your houseplants. It's also a great way to teach children about composting.

Start with a medium-sized plastic bag and a twist-tie. Watertight, self-sealing bags also work well.

Place 1 cup of shredded organic matter in the bag. Use your imagination and your available resources here—try coffee grounds, tea leaves, fruit peels, leaves, grass clippings, apple cores without seeds, carrot or potato peels, wood ashes, and so on—any kind of organic material you might normally throw away. The more finely you can chop up or tear these items, the more effective your mini-compost bag will be.

Add 1/2 cup of garden soil to your bag. This is important for

providing the microorganisms that will do the composting "work." Well-decomposed leaf mold or finished compost will work here, too. Don't substitute sterile potting soil; all its microorganisms have been sterilized away.

Add 1 tablespoon of alfalfa meal or alfalfa pellets (available as Litter Green cat box filler or as rabbit or hamster foods).

Pour in 1 ounce of water, and seal the bag. Shake the bag to mix all the contents thoroughly. Squeeze the bag daily to mix your compost (the equivalent of turning a compost pile).

Every other day, leave the bag open for the day to let air in. Without air, your organic matter will decompose improperly and will smell bad. If the contents of your bag smell, they may be too wet or in need of more mixing. In 4 to 6 weeks your compost should be finished and ready to use.

Compost Tumblers

There are a number of manufactured composters on the market that use a cabinet or barrel form, mounted on a stand to make turning easy. Some are even motorized for turning. Plans for building a barrel composter appear in chapter 10. Such structures are best suited to urban composters and small gardens where space is at a premium.

Compost tumblers have many advantages if you need only small amounts of compost or want an easy, foolproof method for composting kitchen wastes. Some people who don't even garden use them as waste recycling systems and give the finished compost to friends who can use it. The main drawback is that once the drum has reached capacity, you have to wait 2 weeks until that batch is finished before adding fresh materials. Several plastic buckets with tight-fitting lids can be used to store kitchen wastes during this time, using sawdust or a similarly absorbent material to keep odors at a minimum.

In order for the compost to be finished as quickly as possible, you should provide adequate moisture and try to balance the carbon/nitrogen ratio as you fill the tumbler. You can compost meat scraps without fear of invasion by vermin, and coarser materials can be screened out and returned to the drum for another go-round. Gardeners who use tumblers report minimal odor problems. This system offers many of the benefits of hot composting while virtually eliminating the effort of turning.

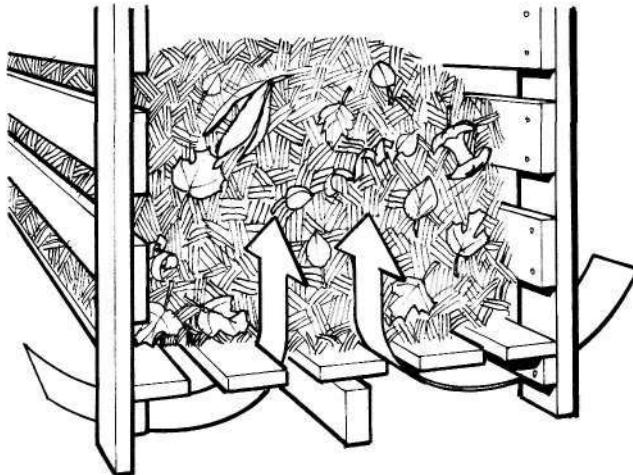
The Raised-Bin Method

Turning a compost pile can be a tedious and strenuous job, especially for a retirement-aged 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.

The first experimental raised bases were made by U.S. Public Health Service researchers who found that 1 ton of rapidly decompos-

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.



ing 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 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.

Ogden's Step-by-Step Method

Sam Ogden, in his book *Step-by-Step to Organic Vegetable Growing*, gives detailed instructions on how to start a compost pile using his cool, partly anaerobic method:

I started in the spring by laying out on a level piece of well-drained ground a rectangle about 5 feet by 12 feet, marking the corners with stakes. Then I lay up an outside wall of one or two thicknesses of sod or cement blocks. My system requires the maintenance of two compost piles, one of which ages for a year while the other one is being built, so in preparing for current use of the pile which has stood a year, I strip off all outside material, much of which is only partly decomposed, and place it within the borders of my sod strips as the first layer in my new compost pile. From now on, all decomposable garbage from our house, and from our neighbors' as well, if I can get them to sort their waste, is spread on the pile and covered with a thin layer of topsoil before it has a chance to become nasty.

This method allows you to add materials gradually over the spring and summer, and it involves no turning. It does, however, require patience, since the compost is not ready to use until a year from the following spring. "By that time," says Mr. Ogden, "the pile is 2 years old . . . having taken 6 months to build and 18 months to cure."

The drawbacks of this method, according to Mr. Ogden, are the following: (1) it requires at least two piles and space for a third; (2) it takes over a year to get started; (3) it won't handle materials that are hard to decompose, unless they are chopped up; and (4) it is not foolproof. Sometimes garbage added to such piles in large quantities putrifies without oxygen and turns into a black, slimy mess instead of crumbly compost. Mr. Ogden avoids the problem by spreading garbage thinly and covering it with soil.

Sam Ogden is frank about the shortcomings of his method, but he feels its near effortlessness compensates for them. He suggests using a rapid method, like the California method, to supplement his system during the first year, when it is getting started.

Mr. Ogden advises his readers against using leaves or grass clippings in the step-by-step method, instead suggesting these materials be piled separately because of their tendency to create anaerobic conditions. Fresh grass clippings are especially problematic in this type of system, since without plentiful aeration they will form a slimy mass instead of breaking down quickly. They pose less of a problem in hot composting systems where air is plentiful. Leaves, on the other hand, can be used if they are spread thinly or shredded first.

Mr. Ogden's sensible step-by-step method is particularly recommended (1) where large quantities of compost are not needed to replenish the land and there is no need for haste; (2) where human energy and machines for grinding are lacking; (3) where supplemental materials for

fertilizing and enriching the soil can be used (that is, animal manures, quick-method compost, or broadcast alfalfa, soybean, or blood meal); and (4) where winters are severe and compost is needed early in the spring.

It is quite easy to have two of Mr. Ogden's piles going for early-season use in successive years, while at the same time practicing quick methods for making compost to use during the growing season and for fall enrichment.

Pit Composting

Ever since some primitive cave dwellers dug a hole to bury their fish bones, garbage pits, in one form or another, have been with us. In most compost literature the word *pit* is used interchangeably with bin to refer to a masonry-enclosed, box-like structure sitting either on ground level or slightly under it. We will use *pit* only for compost-holding containers that actually go down into the ground at least a foot or so. Most compost made in these structures is partially anaerobic. Bins, pits, and the special methods they require are discussed in chapter 10.

The Movable Compost Pile for Raised Beds

Recently there has been much interest in the raised-bed method of intensive gardening, a method commonly used in France and in Japan. In this country, the system has been practiced for many years on the West Coast and is now being adopted by gardeners with small plots all over the United States.

In raised-bed gardening, plants are tightly grouped in small beds. Since more nutrient demand is made on soil by closely grouped plants, beds are dug about 24 inches deep, and the soil in the beds is carefully prepared and contains large quantities of compost and/or manure. Root systems develop vertically instead of horizontally in the beds, which reduces the need for watering and heavy fertilization during the growing season. Mulch is not needed, for the plants themselves shade the soil and form a living mulch.

Beds in the raised system are about a foot higher than ground level. In such enriched and carefully drained beds, crops can be planted

at intervals closer than normal, and complete accessibility allows for staggered spacing and interesting and beneficial interplantings. Interplanting not only conserves space, but promotes growth and guards against pests. Rock powders are also frequently used in preparing raised beds.

One gardener has devised a special composting system for use with intensive raised beds. He writes:

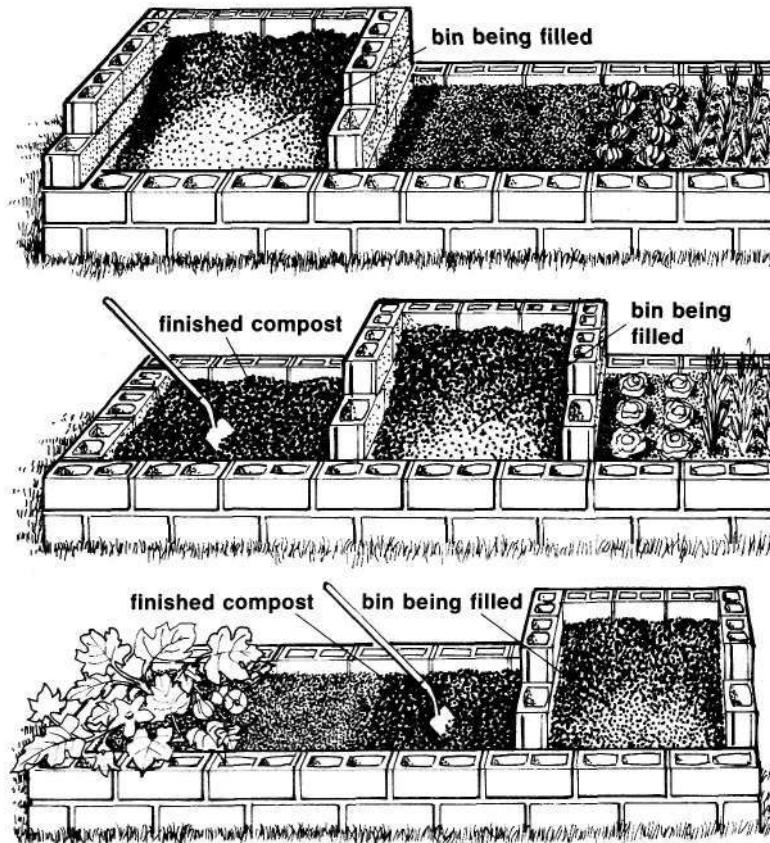
My aim was to take the compost pile with its lively earthworm colony out of its isolated site away from the garden, and make it instead a part of the garden where it is most needed—in my raised beds. . . . The beds are 6 feet wide by 50 long and two cement blocks or 16 inches high, while the soil level in the beds is about 8 inches high.

This gardener scooped out the soil at one end of the raised garden bed and built a three-sided structure with cement blocks. Grass clippings, hedge cuttings, and the remains of an old compost heap were placed in the structure. Grass, soil, manure, and ashes were layered until the pile reached 4 feet in height. When the compost was finished, it was shoveled down to the level of the bed, for use in other parts of the garden. The top and left-hand blocks were moved down the line to form another bin alongside the first, hopscotching up the row with a minimum of work.

To anyone who has discovered that no plant or weed grows better than the one accidentally "planted" where an open-bottomed compost pile once stood, this on-site method makes good sense. Its chief advantage is its handiness for use, both as a receptacle for weeds and debris and, later, as a source of finished compost. Even in intensive gardening, where every inch of land counts, enough room for a bin can generally be found, and in fast-method composting you only need spare the space for 14 days. The land repays its use by allowing even more intensive planting of the next crops. If space is not an issue, move the pile up the bed only once or twice in a season, as adjoining crops are harvested. You can then use the compost to prepare the whole bed the following spring.

Windrows and Piles

Piles and windrows are both heaps for open composting. The systems are used in the open, on the ground, with no confining structure like a bin, pit, or pen. Windrows are elongated piles that require



Combining a compost pile with raised garden beds creates a convenient and efficient way to nourish intensively grown crops. The pile is located nearby for easy disposal of garden wastes; as it "moves" down the bed, it leaves enriched soil where new crops will thrive. As each pile is finished, the rear and left wall of the bin are hopscotched over the remaining wall and rebuilt to form a new bin. When the pile reaches the end of the bed, the process is reversed.

periodic turning to expose all particles of the mass to similar conditions within the windrows. They are often used in large-scale agricultural or municipal composting operations and may be anywhere in the spectrum of hot to cool, depending on how often they are turned.

Even in the far northern parts of the United States, windrowing can be practiced on any drained land. Some people set shed-type roofs

over windrows to protect them from heavy rains. In severe weather, shed sides may also be added to protect active piles. Windrows may be of any convenient length. Regarding their height, Dr. Golueke in *Composting* explains, in speaking of municipal composting, that height is critical because too shallow a pile loses heat too rapidly and too high a pile can become compressed by its own weight, with a resulting loss of pore space that can lead to anaerobic conditions.

Dr. Golueke recommends a maximum height of 5 or 6 feet for freshly ground municipal refuse. This will shrink during decomposition and then be reformed to the recommended size when the pile is turned. The width at the base should be 8 to 10 feet. In dry climates you should shape the pile so it is flattened on top, like a trapezoid, to trap moisture. In rainy climates or wet weather, mound the top to shed water. A layer of hay or straw will also protect the windrow from the weather while preventing moisture loss through evaporation.

Mulch and Sheet Composting

Although not ordinarily considered a composting system, simply spreading organic materials in a thin layer directly in the garden to decompose offers many of the benefits of compost with less need to handle and move materials. This approach is referred to as "sheet composting." It includes such practices as mulching, which performs several functions in addition to contributing organic matter to the soil. Green manuring is another form of sheet composting, in which certain crops or even weeds are grown and incorporated into the soil to add organic matter that doesn't have to be carried to the garden and spread around. Several variations on this theme follow.

In its simplest form, sheet composting consists of spreading any raw organic wastes, such as manure and weeds, over a piece of land and tilling them in. This method is more often associated with farm-scale applications, using power equipment. It can be done on a smaller scale but generally requires taking the treated area out of production for at least a season.

The danger of sheet composting as a compost-making method is that the carbon-containing residues you use will call upon the nitrogen reserves of the soil for their decomposition. The high-nitrogen materials, on the other hand, may release their nitrogen too quickly or in the wrong form. What can be accomplished in a pile in a matter of weeks, given confined and thermophilic conditions, may take a full season in the soil.

Green manuring—the growing of cover crops to be turned under—is the most practical way to add substantial amounts of organic matter to a large garden or homestead field. A green manure crop, often legumes like clover, indigo, winter peas, cowpeas, soybeans, lespedeza, fenugreek, or vetch, is planted after a food crop is harvested. Even weeds may be used; as you know, they plant themselves. The cover crop is then tilled or plowed under at least 2 weeks before the next crop is to be planted. The type of crop used as a green manure and its stage of growth when tilled under are factors that can moderate possible short-term nitrogen depletion. Legumes such as vetch and clover will contribute more nitrogen than will nonlegumes such as rye or buckwheat. Young, succulent growth provides more nitrogen and decomposes more quickly than does coarser, more mature growth. However, the higher C/N ratio of mature growth gives it greater value for improving overall soil structure.

Green manuring may be combined with sheet composting. In fact, it is a good idea to add natural rock powders when you till under, because the decay of the organic matter will facilitate the release of the nutrients locked up in these relatively insoluble fertilizers. Some farmers spread finished compost when turning under green manure, claiming this accelerates its decomposition.

In the sort of ideal circumstances few of us enjoy, green manuring and sheet composting go on in one garden plot while food crops are rotated onto another plot. Rotation and cover cropping are also effective ways of foiling pests and diseases.

"No-Work" Mulching

Ruth Stout popularized her "no-work" deep-mulch gardening system in the 1950s. Her answer to just about every garden chore is a permanent layer of deep mulch covering the entire garden. This requires a relatively fertile soil to begin with in order to work. Once established, the mulch eliminates the need to till, hoe, cultivate, weed, and fertilize. You only need to pull back the mulch to plant seeds or pop in seedlings, and it will serve to retain moisture, moderate soil temperatures, and prevent the growth of weed seedlings. Earthworms and other beneficial organisms are encouraged by mulch—however, so are mice and slugs, which are definitely unwelcome garden visitors.

Ruth Stout convinced a whole generation of gardeners to mulch as a way of saving labor through such testimonials as this:

I am not a particularly vigorous woman, but I do all the work in a garden 40 by 60 feet, raising enough vegetables for my husband, my sister, myself, and many guests. I freeze every variety, from early asparagus to late turnips. We never buy a vegetable. I also do my housework, raise quite a few flowers, rarely do any work after 1:00 P.M. I'm scarcely ever more than just pleasantly tired.

It would be hard to find a more convincing testimony to the labor-saving advantages of mulch than Ruth Stout's description of her own good life. If you are an urban or suburban gardener, however, you may find that the time you save in hoeing is spent in traffic jams, as you chase all over the county looking for hay for sale, or spent vacuuming the messy hay residue out of the back seat of your car once the hay has been found. Labor economy is not the only kind of saving, either, and when you add the price of hay or straw to the cost of the gasoline used in looking for it, you may be fully ready to return to the cheap old hoe.

When compared with composting, mulching is a slow method of adding nutrients to the soil. The process is at least partly anaerobic, for air is sealed off from underlying materials by the top layers. High-nitrogen materials, such as partly rotted manure and garbage, decay rapidly when applied in mulch. High-carbon materials like hay and straw serve better to retain water and retard weeds. Since mulch sits on top of the earth and is not mixed with soil, this high-carbon, decay-resistant material will not tie up large quantities of soil nitrogen all at once like it would if plowed under. However, it will add bulk and nutrients to the soil very slowly; it may be that your soil needs only these slow additions. If so, mulching alone may suffice to keep your garden in shape for several years.

Almost all compostable wastes can be used for mulching. However, it is almost impossible to layer and mix correct proportions of ingredients in mulch form. Rapid decomposition of mulch is impossible because of the lack of self-insulating mass, but even if you could put a 5-foot layer of mulch on your garden and aerate it regularly, the temperatures generated would burn or wilt anything growing there and do damage to the soil and its organisms.

If you need to add large quantities of humus to your garden for building the soil's texture and increasing its productivity, or for modifying the pH level, many experts agree that you would do well to combine the labor-saving advantages of mulch with a seasonal composting program.

Some-Work Mulching

Texas gardener Hank Lyle describes a modification of the Ruth Stout method that is more suitable for building up problem soil. The soil he started with was "red clay, baked by the sun. What wasn't clay was a very hard soil that looked lifeless."

Mr. Lyle plowed under his first garden, then applied a mulch of weeds and other materials 4 inches deep over his 150 by 50-foot patch. After dampening it with a hose, he broadcast 35 pounds of cottonseed meal by hand (he says a lawn fertilizer spreader would have worked better). The cottonseed meal acted as a high-nitrogen layer in the compost.

The next layer consisted of 3 inches of leaf mold. This layer was dampened, and an additional 40 pounds of cottonseed meal was applied over it. The sheet compost settled to a height of 6 inches. Mr. Lyle continues the account:

What we had now was a giant compost pile which was also a mulch. After three days we used a tiller (with the two inside rows of tines removed) to stir and fluff the mulch and mix in what soil the tines could pick up. . . . We dampened the heap again with the spray nozzle.

By the evening of the 4th day, Mr. Lyle reported, the material had begun to heat up under the top layer. More materials (leaves, grass clippings) were added, with 15 pounds of cottonseed meal being sprinkled over each inch of material. Every 4th day the tiller was used to mix the material. The account continues:

By the 20th day, the material had shrunk considerably. We noticed that the soil beneath the compost was beginning to soften and turn dark brown. There were earthworms too. Before we had started the compost, hardly a worm was to be found.

Mr. Lyle continued foraging for organic materials to add to his garden wherever he could, topping it off with a layer of cottonseed hulls from an abandoned gin. This he left for the winter, to absorb the rains and continue decomposing. By spring all that remained was a 3-inch layer of cottonseed hulls. This layer was kept for a year-round mulch.

When compared with rapid bin composting, Mr. Lyle's novel type of sheet composting shows much similarity to the conventional method. It provides moisture through hosing, aeration through tiller turning, a C/N balance of materials through the use of premixing layering techniques and thorough sprinklings of high-nitrogen cotton-

seed meal, and it allows for an aging period (winter) after the initial temperature rise. It would probably be classified as a long-term method, although in its particulars it is most similar to the California method and it is mostly aerobic. Unlike the California method of bin or windrow composting, it involves a maximum "pile" depth of less than 10 inches, so the mass cannot insulate itself enough to achieve thermophilic temperatures long enough to kill weed seeds. No potentially pathogenic raw material was used, so the absence of high temperatures was not a serious drawback to this method.

The important difference between Hank Lyle's and Ruth Stout's methods is that in his, no crop growing went on during the mulch composting period, so the temporary nitrogen drain caused by rapid decomposition didn't threaten crops. The whole plot was used as an oversized compost pile. The chief aim of the process was soil fertility and soil tilth. Weed reduction and water retention were only secondary. At this point, Mr. Lyle probably won't have to repeat the initial fallowing and enriching of his plot for many years. He can now make compost in 'a bin or pit, using the finished compost in the rows he makes in his replenished year-round mulch of hulls.

Trench and Posthole Composting

Burying compost in trenches or holes dug in the garden is a less popular composting method that nonetheless has its staunch adherents. Although it shares some of the disadvantages of both pit composting and sheet composting, some gardeners swear by it for rapid improvement of unusually poor soils.

Nedra Guinn, a gardener in southeast Tennessee, dug trenches 12 inches deep and 18 inches wide, the length of a garden row. These were filled with compost materials including hay, leaves, weeds, tree trimmings, and grass. The materials were then packed down and covered with manure, watered, and mulched. Nedra Guinn planted directly into the mulch and experienced no nitrogen deficiency in crops, but other gardeners who wish to try this method are cautioned either to top the trench with topsoil or to risk nitrogen depletion. The drawbacks of trench composting are the tendency to the formation of pockets of anaerobic activity, the slowness of decomposition, and the possibility of nitrogen-borrowing from plants.

Some gardeners have discovered that the traditional posthole digger is a quick and convenient tool for spot composting. The following

account describes the method used by organic gardener Michael Timchula:

Making compost in postholes can be done from early spring to the latest fall day. If you plan ahead, you can make enough holes in areas where the snow does not pile up too deeply, or in sheltered places, so that you can continue composting throughout the winter.

When cleaning up the garden and yard in early spring, keep the posthole digger handy. As soon as you get a small pile of debris, twigs, leaves, and so on, dig a posthole about 12 to 18 inches deep and bury the debris, topping it off with a handful or two of manure. Cover the hole with the best of the topsoil that was removed and scatter the rest. Watering is usually not necessary, as the hole tends to collect enough moisture to ensure proper composting.

Keep the posthole digger with you at planting time. After planting and laying out your rows and hills, dig holes near a hill, in the center of a row, or between plants and fill them as described. In this way, feeder roots will seek out the fresh compost as the plants grow, and a lush growth will result. The compost holes serve to hold the moisture, and a weak compost tea leaches out to feed the plants.

Cultivating time is when the postholer can be put to good use. In a row that will not need to be disturbed or cultivated for the rest of the summer (next to the carrots or chard or another vegetable that lasts all summer), start digging a row of holes very close together. Pack young weeds, clippings, trimmings, and so on, a handful or two of manure, and the day's garbage and cover lightly with topsoil. Keep one or two holes dug ahead so that you always have a place for making compost. In a large garden, you may need more than one row for the entire season.

Anaerobic Composting

It is possible to make compost without air. In 1968, J. I. Rodale presented this thoughtful and succinct review of the method in the pages of *Organic Gardening and Farming*:

About 19 years ago, I first discussed a process of making compost by the Selby enclosed method which is for the most part anaerobic. Most readers who wrote in about their reactions were in favor of the new idea. But a few were highly critical. They considered it almost irreligious to abolish the aerobic concept of making compost, and said that anaerobic conditions lead to putrefaction.

Those who have criticized the enclosed method of making compost should realize that only in a portion of the period of composting



Covering a compost heap with heavy black plastic allows composting to proceed under anaerobic or semiaerobic conditions.

in the Sir Albert Howard (Indore) process are the conditions aerobic. Let me quote from his *Agricultural Testament*: "After the preliminary fungus stage is completed and the vegetable wastes have broken down sufficiently to be dealt with by bacteria, the synthesis of humus proceeds under anaerobic conditions when no special measures for the aeration of the dense mass are either possible or necessary." About half the period is aerobic and the last half anaerobic.

In addition, two distinct drawbacks exist in the usual form of making compost which permits air to come freely into the heap. First, it causes oxidation which destroys much of the organic nitrogen and carbon dioxide, and releases them into the atmosphere. Second, valuable liquids leach downward and out of the mass into the ground underneath where they are wasted.

The purpose for making compost anaerobically is to prevent or reduce oxidation. Oxidation of nitrogenous substances is always accompanied by the production of a great quantity of free nitrogen compounds. Manure kept in efficient conditions in an open pit loses 40 percent of the nitrogen originally contained. Although this loss is relatively small in comparison with the 80 or 90 percent loss as a result of improper storage, it is also relatively large in contrast to the 10 percent or less obtainable by using closed pits. In them, fermentation takes place out of contact with air. Only a small nitrogen loss occurs.

One difficulty has been finding an efficient and simple way to practice anaerobic composting. One technique is to enclose the compost in a polyethylene wrapping, and gardeners and farmers in all parts of the country have reported highly successful results in covering heaps with heavy black plastic.

Composting without air is not the most popular method used by gardeners, but it does claim some adherents, and it is a useful method in certain situations.

A COMPOST CHECKLIST

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, cellarlike odor indicates the presence of molds, sometimes also a hot fermentation, that has led to losses of nitrogen.
- **Acidity.** A neutral or slightly acid reaction is best. Slight alkalinity can be tolerated. Remember that too acid a condition is the result of lack of air and too much moisture. Nitro-
- gen-fixing bacteria and earthworms prefer a neutral to slightly acid environment. The pH range for a good compost is, therefore, 6.0 to 7.4. Below 6.0 the reaction is too acid 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 the 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.

Solving a Heap of Problems

If you discover problems with your composting process, often-times they can be corrected by turning the pile and adjusting one or more of the conditions required by the compost organisms. Following are some commonly encountered compost problems and some alternatives for remedying or preventing them.

Problem	Remedy
Wet, foul-smelling heap	Turn pile and add high-carbon, absorbent materials. Protect pile from rain.
Dry center and little or no decomposition of materials	Turn pile, thoroughly soaking each layer as it is replaced. Cover with plastic to retain moisture.
Dampness and warmth only in middle	Increase amount of material in pile and moisten.
Damp, sweet-smelling heap but no heat	Add more nitrogenous materials such as blood meal, fresh manure, or urine, and turn or aerate.
Matted, undecomposed layers of leaves or grass clippings	Break up layers with garden fork or shred them, then relayer pile. Avoid adding heavy layers of leaves, grass clippings, hay, or paper unless first shredded.
Large undecomposed items	Screen out undecomposed items and use as starter for next pile.

The small-lot gardener, for instance, might find that composting in a garbage can or plastic leaf bag is the only way to produce compost without offending neighbors' sensitivities. Making anaerobic compost in plastic bags also solves the turning problem. Filled with a mix of organic matter, one of these "compost cases" can be tied shut and placed in any convenient sunny location. The bag can be rolled daily to mix the contents. By keeping a few such bags going at a time, this system provides an ongoing means of composting kitchen garbage and a regular source of small amounts of finished compost.

Compost

Structures



Gardeners have designed a host of imaginative structures for composting. Compost can be made in cages, in block or brick bins, in pits and holes, in revolving drums, in garbage cans, and even in plastic trash bags. A compost structure can be designed to be beautiful, to make compost in the shortest possible time, or to be moved from place to place with the least effort. It can be designed to make compost with no turning required, or to suit the needs of earthworms. Compost structures, in short, are designed to suit the user's needs and resources.

For most home composters, building a bin that makes use of existing or readily available materials is the most practical course. A composter in California constructed a bin using the aluminum sides of an old aboveground swimming pool. Even using bales of spoiled hay to form a temporary structure is a way to make the most of your resources in creating a composting structure, as well as the compost pile itself.

The choice of compost structure is, then, a personal decision, one that should not be made without some prior research and, perhaps even more important, some experimentation. It is experimentation that leads to new structures.

The first decision to be made is whether a structure is needed at all. The gardener or farmer with plenty of room, ample materials, and sufficient time may need no compost enclosure of any kind. In this case the traditional Indore heap is quite suitable.

If yours is a city or suburban lot, however, you might find that the open heap takes up too much room or offends neighbors and family. If space is limited, an enclosure can produce more compost in a smaller land area. It can be more attractive and keep out animals and flies. If you cannot devote a permanent spot to compost making, you will want

to investigate portable structures that can be broken down and moved in minutes. If your garden is located where winter temperatures are severe, a compost pit dug below the frost line can enable you to compost all winter long. If you want to work with earthworms in composting, then you will need to consider some special outdoor structures, and perhaps others for basement composting. Perhaps a commercially built revolving drum suits your needs because age or infirmity prevents you from turning the heap, or simply because the drum produces quick compost and attracts no pests. Perhaps you even prefer to make compost in plastic bags because of its simplicity.

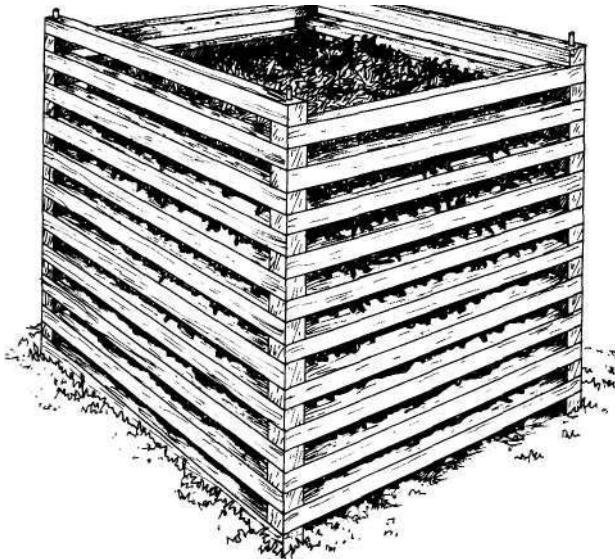
It is certainly true that one compost structure is not best for everyone. It may even be that everyone needs a structure designed especially for him or her. We hope that by describing different structures, we will give you some insight into matching construction with your individual needs. If you are like most gardeners, you will take one of these suggested forms, adapt it to your needs, use it for a year or two, and then make your own adjustments until you have evolved the perfect structure for you.

Pens and Bins

By far the most common compost forms are bins and pens. To simplify, let us call a *bin* any container with concrete, brick, wood, or masonry sides that is fairly substantial and permanent, and *pen* any structure with wire or hardware cloth sides that is a less permanent installation. Not that they're that easy to classify—there are many kinds of structures called bins and pens.

In general, pens have the advantage of allowing for free circulation of air. Their disadvantage is that they also allow for free circulation of flies and four-footed pests. Bins are more stable and protecting structures, but they are often insufficiently ventilated. Neither the bin nor the pen has as great a tendency to go anaerobic as the pit, and both are easier to keep tidy than open composting forms.

A shady, sheltered spot not far from either garden or kitchen is an ideal location for either pen or bin. Often a space between house and garage or garage and shed allows the right amount of room. A three-compartment bin with tight floor and sides and with each compartment measuring a cubic yard in size makes for the neatest and easiest handling of turning. In such a structure there is at all times one batch working and one being used.



The Lehigh bin uses alternating 2 x 4s held together with $\frac{3}{8}$ -inch rods.

An advocate of bottom aeration claims to have made a free compost bin in 1 hour using available cement blocks and some leftover strong iron piping, plus surplus 1 by 2-inch wire mesh. The 4 by 8 by 16-inch cement blocks were laid horizontally with plenty of air between each block. Unlike other composters, this gardener preferred to have his compost bin in a sunny spot, feeling the compost would heat up faster in the sun.

The pipes were thrust across the bin from side to side over the third course of blocks, to provide the pile with a strong bed. On top of the pipes, two lengths of wide wire mesh were laid to hold a bottom layer of coarse garden debris and twigs. This layer and the mesh and pipes held back finer material and allowed for bottom aeration. The gardener never turns his compost but mixes materials together.

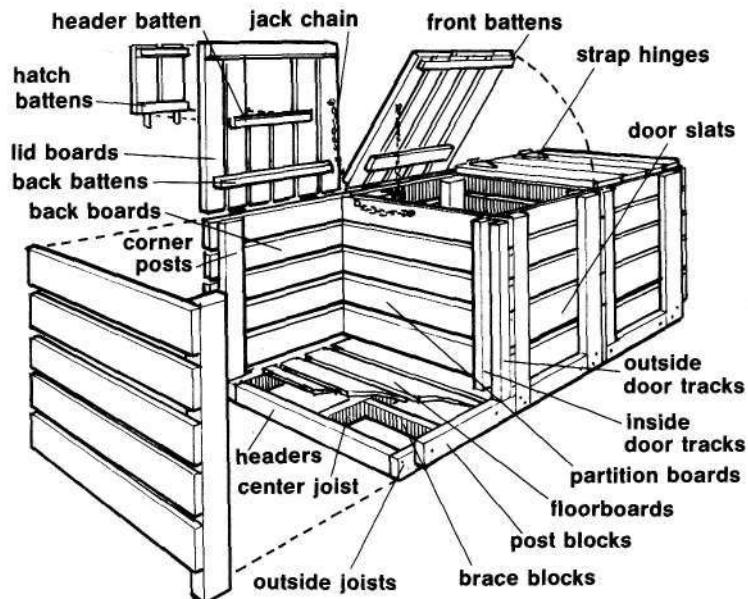
Lehigh-Type Bins

The Lehigh-style bin is easy to erect and disassemble. It is adjustable in size, attractive, portable, long-lasting, and it provides for proper ventilation and protection.

Construction is of alternating 2 x 4s with the corners drilled out and held together with $\frac{3}{8}$ -inch rods. Five 36-inch 2 x 4s to a side will make a bin capable of producing approximately 1 cubic yard of compost at a time.

There have been several variations of the Lehigh bin, some using logs or poles instead of 2 x 4s. This is the type of bin distributed to King County, Washington, residents through their Backyard Com-

MAKING A THREE-BIN COMPOSTER



TOOLS REQUIRED

Electric drill

Saw (circular saw or handsaw)

Hammer

Pliers

MATERIALS

LUMBER—CUT LIST

Cut lumber into the following lengths. Use pressure-treated lumber or untreated pine painted with a preservative or flat black paint. Measure and cut the pieces as you assemble them, to be sure they fit together correctly.

For Bins

1 pc. 2" x 6" x 108" (center joist)

2 pcs. 2" x 6" x 30" (headers)

2 pcs. 2" x 6" x 111" (outside joists)

2 pcs. 2" x 6" x 14 1/4" (brace blocks)

4 pcs. 1" x 6" x 33" (short floor boards)

8 pcs. 2" x 6" x 41 1/2" (corner posts)

24 pcs. 1" x 6" x 36" (partition boards)

6 pcs. 2" x 2" x 34" (inside door tracks)

2 pcs. 2" x 2" x 35 1/2" (outside door tracks)

1 pc. 2" x 6" x 96" (cut to fit for post blocks)

14 pcs. 2" x 6" x 34 1/2" (floorboards)

6 pcs. 1" x 6" x 111" (back boards)

18 pcs. 1" x 6" x 35½" (door slats)

3 pcs. 1" x 3" x 35½" (door slats)

For Lids

18 pcs. 1" x 6" x 37" (lid boards)

3 pcs. 1" x 2" x 36" (front battens)

3 pcs. 1" x 2" x 34" (back battens)

2 pcs. 1" x 2" x 11¼" (hatch battens)

2 pcs. 1" x 2" x 22" (header batten)

HARDWARE

For Bins

22 carriage bolts, ¼ " x 3½", with nuts and washers

1 box 16d galvanized nails

1 box 8d galvanized nails

For Lids

6 strap hinges, 8" (lids)

2 strap hinges, 4" (hatch)

4 lengths jack chain, approximately 36" each

8 heavy screw eyes

4 snap hooks

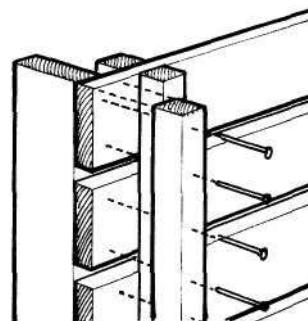
1 box #6 x 1¼" galvanized screws

BUILDING THE BINS

1. Base. Nail a header to each end of the center joist, using 16d nails. Nail the outside joists, front and back, across the ends

of the headers. Nail the brace blocks in place between the joists. Locate and nail the four short floorboards across the joists where the partitions will be located, using 8d nails, as shown.

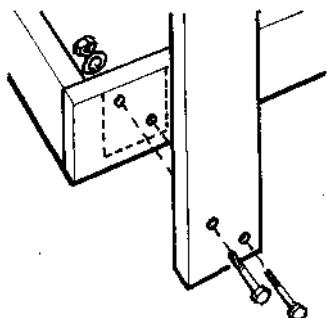
2. Partitions. For each of the four partitions (two outside and two inside), nail six partition boards to connect two corner posts, spacing them evenly. Nail the inside door tracks to the partition boards, 1 inch back from the corner posts.



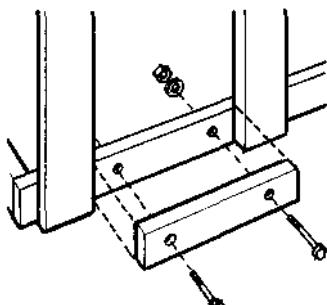
Nail the outside door tracks flush with the front of the two interior partitions. Position the assembled partitions—one on each end of the base and one on each side of the interior compartment; drill and bolt the corner posts to the outside joists.

3. Post Blocks. Cut the 2 by 6 by 96-inch post block board into three pieces, to fit snugly between the bottoms of the front corner

MAKING A THREE-BIN COMPOSTER—*Continued*



posts. Bolt the post blocks in place, flush with the floor surface.



4. Floor. Space the floorboards evenly across the joists and nail them in place. There will be five for each of the two end compartments and four for the middle compartment.

5. Back. Nail the back boards in place, covering the back corner posts.

6. Front. Feed door slats horizontally into the door track.

BUILDING THE LIDS

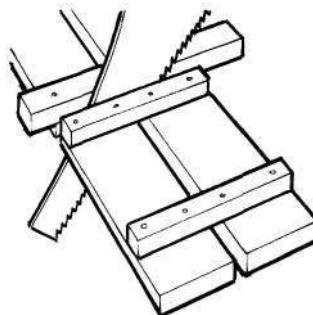
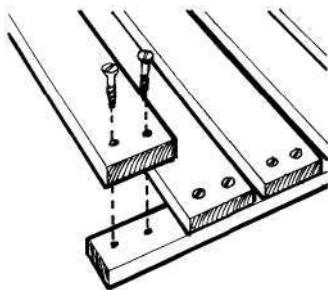
1. Lids. Construct two of the three lids. Using a drill and galvanized screws, fasten six lid boards to the front and back battens; allow about 1/2 inch between boards. Each lid will measure 36 inches across. Construct the third lid in the same manner, but leave out the two middle boards.

posting Program, described in chapter 5. However it is designed, the low cost, effectiveness, and portability of this structure has made it one of the most popular in use today.

Cage-Type Bins

Cage-type bins are simple and inexpensive to build, allow good air circulation, are portable, and allow quick turning of the heap because of a removable front panel. The Lehigh bin lacks this last feature.

There are many variations of cage-type bins, all of which require



2. Hatch. Fasten the hatch battens to the two remaining lid boards, one batten about 2 inches from the end of the boards and one batten 18 inches from the same end. Fasten the header batten to the boards, 20 inches from the end, just behind the back hatch batten. Cut between the header batten and the back hatch batten to separate the hatch. Fasten the two remaining boards and the header batten to the partially constructed lid. Hinge the hatch to the lid.

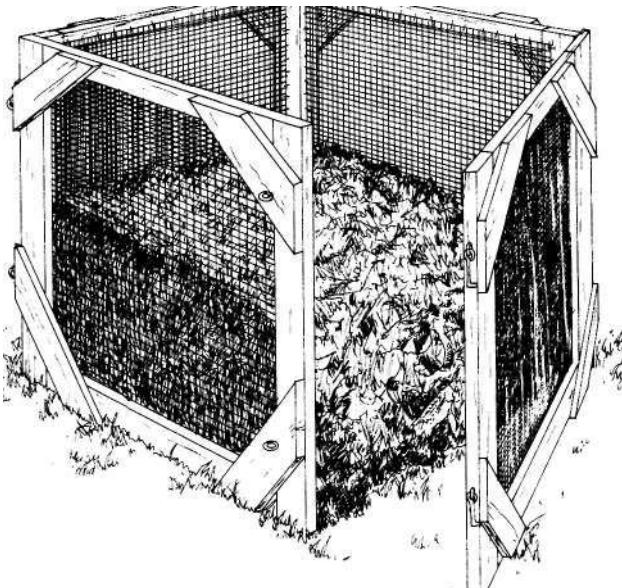
3. Finish. Attach the three lids to the bins with the 8-inch hinges, so that they are centered over the compartments. Use screw eyes to attach a chain to the bottom of the lid for each of the two end bins. Attach the chains on the inside edge at about the middle of the boards, on the side near the center partition. Attach chains underneath both sides of the lid of the middle bin. Mount snap hooks on the ends of the chains. Use pliers to attach screw eyes to the bin partitions.

relatively little lumber, since wire screening forms most of the panels.

The wire-and-wood bin shown on page 186 can be built using scrap 2-inch lumber covered with 1/2 inch chicken wire mesh. The bin is formed by two L-shaped sections held together with screen-door hooks.

To turn the pile, unhook the sides and reassemble the two sections next to the now free-standing pile. Layers can be easily peeled off with a pitchfork and tossed into the empty cage. Keep a hose handy during turning, to add moisture as needed. A properly built and maintained pile in this well-aerated bin can produce 18 to 24 cubic feet of finished compost in 14 days.

The wire-and-wood cage-type bin is inexpensive and portable.



The New Zealand Bin

Perhaps the classic among compost bins is the wooden New Zealand box that was originally designed by the Auckland Humic Club to admit as much air as possible from all sides. It can be used to make several batches of compost in different stages of decomposition, ensuring a continuous supply, and it can be a very attractive structure.

There are several variations of this box, but the simplest one is a wooden structure 4 feet square and 3 feet high or higher with neither top nor bottom. The frame is held together by 2 x 4s. The wooden sides consist of pieces of wood 6 inches wide by 1 inch thick. A 1/2 inch air space is allowed between every two boards so that air may penetrate into the heap from all sides. The boarding in front slides down between two posts so that boards can be removed one by one when complete access to the contents is needed for turning or loading. The open side may also be built up gradually as the pen is filled. Cover the top of the pen with hardware cloth, rolled canvas, burlap, or screen.

If you are using a single bin like the New Zealand box, be sure to allow for a working space in front of the box equal to two or three times the floor area of the box. This much space is needed for turning the pile. You pile up the material outside the bin and then replace it within the bin, mixing so the outside material is placed toward the inside of the new pile.

One variation on the New Zealand box holds four separate bins for compost in different stages. The dividers between the compartments are removable to permit quick and easy shifting of compost from one bin to another.

USING YOUR THREE-BIN COMPOSTER

The following week-by-week schedule will help you get the most from your three-bin composter. The schedule is self-perpetuating. Check moisture content when you transfer compost from bin to bin. Add dry material if it seems soggy; water if it's too dry. To boost microbial activity, mix some soil or active compost into the material from the holding bin when you transfer it to the center bin.

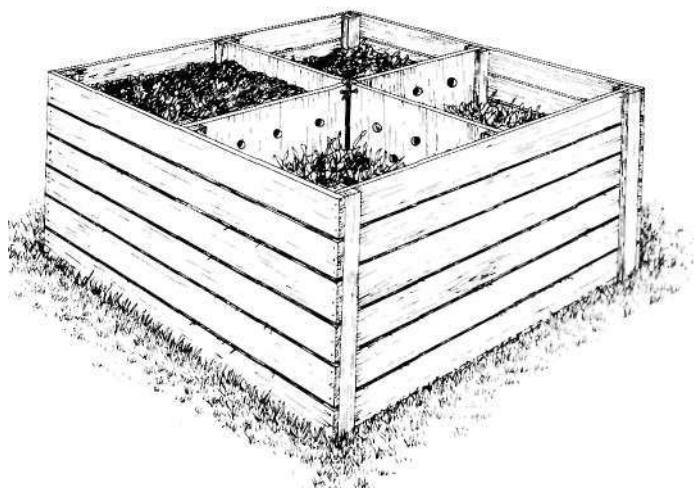
Week 1: In the center bin, build a traditional layered compost heap, including high-nitrogen materials such as manure or bonemeal. Spread a base layer of dry leaves or straw in the holding bin; toss in

kitchen wastes or garden trimmings every day or so.

Weeks 2 and 3: Remove a few front boards from the center bin and stir the compost. Keep adding to the holding bin.

Week 4: Remove all front boards from the center and end bins, and transfer the compost to the end bin to speed the composting process. Then remove the front boards from the holding bin and shovel that material into the center bin. Finally, spread a new layer of dry matter in the holding bin.

Week 5: Check the compost in the end bin. It should be ready to use on your garden.



This variation on the standard New Zealand box is divided to allow production of several successive batches of compost at once.

BUILDING A RODENT-PROOF COMPOSTER

Before rodents discover your compost is a steady supply of kitchen leftovers, you may want to consider building this caged compost bin. Lap-joint construction for the 2x4 framing was chosen for its simplicity and strength. A hardware cloth lining supported by 1 by 3-inch and 1 by 2 1/4-inch stock keeps the pile neatly contained and animals out.

TOOLS REQUIRED

Electric drill
Screwdriver
Saw (circular saw or handsaw)
Hammer
Paintbrush
Wire cutters

4 pcs. $16\frac{1}{2}'' \times 1'' \times 3''$ (corner braces)
11 pcs. $32\frac{3}{4}'' \times 1'' \times 3''$ (top and horizontal large frame sides)
6 pcs. $31\frac{1}{8}'' \times 1'' \times 3''$ (horizontal small frame sides)
4 pcs. $32'' \times 1'' \times 3''$ (vertical large frame sides)
4 pcs. $32'' \times 1'' \times 2\frac{1}{4}''$ (vertical small frame sides)

MATERIALS

LUMBER—CUT LIST

Cut lumber into the following lengths. Use pressure-treated lumber or untreated pine painted with a preservative or flat black paint. Measure and cut the pieces as you assemble them, to be sure they fit together correctly.

2 pcs. $36'' \times 2'' \times 4''$ (frame sides)
2 pcs. $33'' \times 2'' \times 4''$ (frame sides)
4 pcs. $16'' \times 2'' \times 4''$ (legs)
4 pcs. $14\frac{7}{8}'' \times 2'' \times 4''$ (support braces)
5 pcs. $32\frac{3}{4}'' \times 2'' \times 4''$ (bottom frame)

HARDWARE

4 medium hasps
2 hinges, $1\frac{1}{2}'' \times 2\frac{1}{2}''$
36 wood screws, # 10 $\times 1\frac{1}{2}''$
16 pcs. 16d common nails
1 pound 4d common nails
16' \times 36" hardware cloth $\frac{1}{2}'' \times \frac{1}{2}''$
 $\frac{1}{2}''$ staples

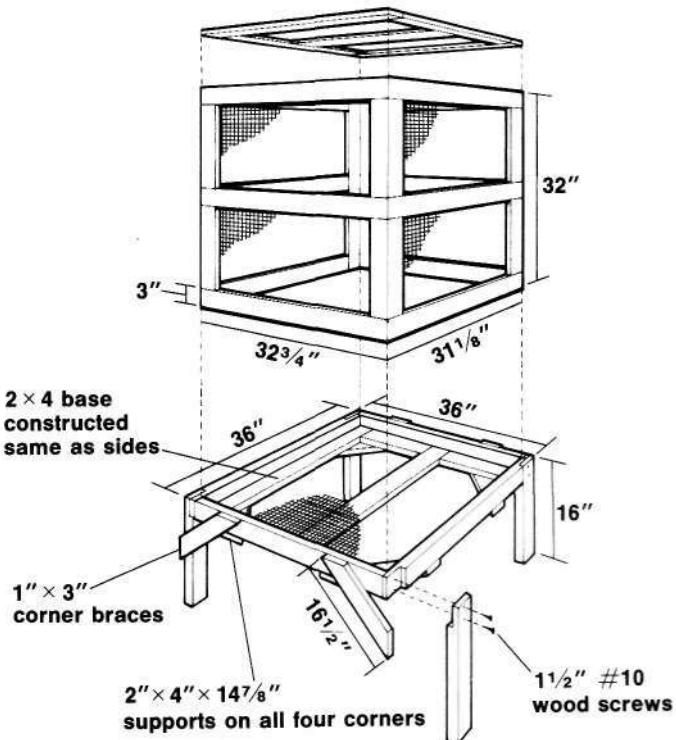
CONSTRUCTION

1. Assemble the base as shown in the illustration using #10 by 1 1/2-inch wood screws at the corners. The 2x4 pieces bearing the load of the compost are cut

at 45-degree angles at both ends and nailed across the corners with four 16d common nails in each piece. The leg braces are also cut at 45-degree angles and fastened with #10 by 1 1/2-inch wood screws as shown.

2. To construct the bottom support frame, remove half the

thickness of the wood on each end to a length that is equal to the width of the 2x4 (usually 3 1/2 inches) on all five pieces. On two pieces, cut a groove (dado) half the thickness of the stock at the center to accommodate the middle support. Use #10 by 1 1/2-inch wood screws for assembly, two per joint.

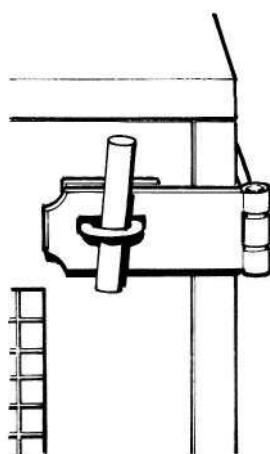


BUILDING A RODENT-PROOF COMPOSTER — *Continued*

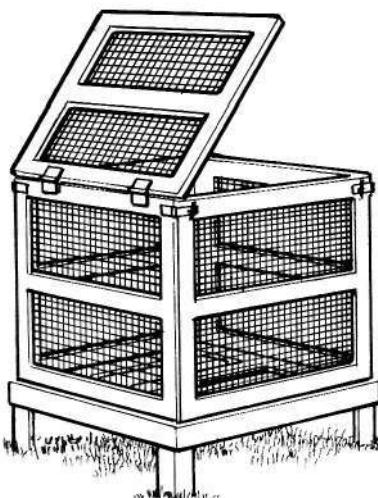
3. The remaining side frames and top are cut and assembled the same way as the base with the exception of using 4d common nails instead of screws at each joint and clinching on the reverse side.

4. For easy access to the compost, hasps are fastened to

the top corners of the side frames, and two 2 1/2 by 1 1/2-inch hinges are attached to the top. Paint the entire unit with a good grade of enamel or a nontoxic wood preserver. After the paint has dried, cut pieces of 1/2 by 1/2-inch hardware cloth to fit the interior of all frames, and attach them with 1/2-inch staples.



The four side frames are joined at their tops with hasps and easily removed pegs.

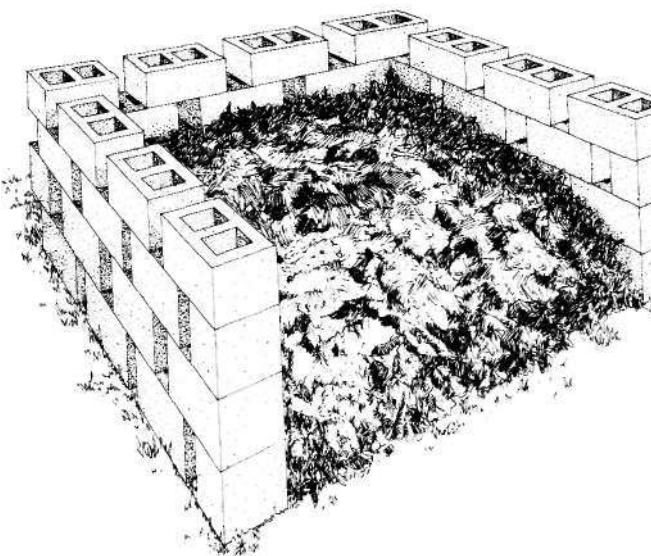


The hinged top frame permits easy access to compost.

Block and Brick Bins

Block and brick bins are permanent if mortared, but cement block bins can be constructed without mortar and can then be moved at will.

The block or brick bin is easily constructed. Usually, blocks are laid to permit plenty of open spaces for air circulation. But they can



A simple block bin looks tidy and may be portable if blocks are not mortared together.

also be closely stacked, set into the ground, and mortared together, or formed into a cylindrical shape with an access gate at the bottom.

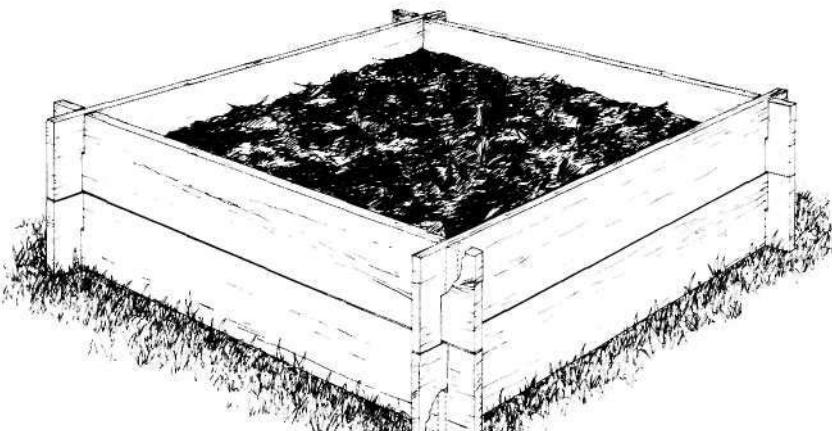
Gardeners who insist on a well-groomed compost area may prefer to have a large, rectangular, brick or block, chimneylike structure with several compartments. Use wooden hinged lids to cover the structure. In a three-bin unit, the first two bins are used in turning while the third stores finished compost. The bottom of the bin, if made of concrete, should slant one way so drainage may be caught in a gutter leading to storage cans. A combination of bricks and boards may be used, with boards set into slots along the front opening. Boards can be removed for access to the compost.

Rough stones laid with or without mortar in an open-fronted, three-fourths cylinder shape (like a larger edition of a state park barbecue pit) make an attractive rustic bin.

The Movable Slat Bin

Another type of portable bin can be constructed of wooden slats. This bin needs no hardware for support—no hooks, nails, or screws.

To make it, cut 10-foot-long 1 by 10-inch boards into 60-inch lengths. Slot each board 4 inches in from the end, $4\frac{5}{8}$ inches across its



This simple bin
is made from
slotted boards
and can be easily
moved.

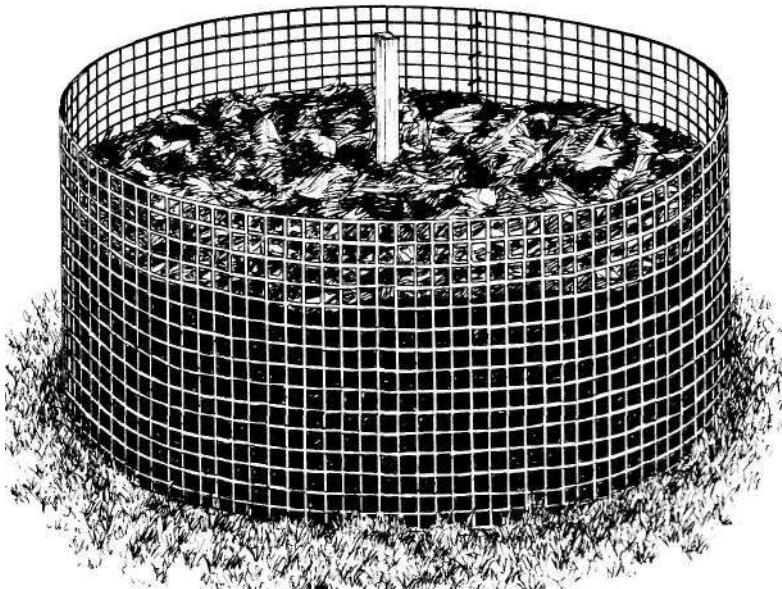
width, so the boards can be nested, as shown. The finished bin is 50 1/4 inches square and 18¹/₄ inches high inside—perfect for even the smallest lot.

Winter Bins

Winter composting does not have to be confined to a pit. An existing compost bin, well insulated with bales of straw or hay and covered for protection from the elements, can continue the composting process during cold temperatures, although at a slower rate than during warmer weather. Structures similar to cold frames can also be used for cold-weather composting, using south-slanting glass lids to catch the rays of the sun and protect the heaps from rain, snow, and drying winds. Manure added to such bins helps to keep temperatures high enough for microbial activity.

Pens

The very simplest pen can hardly be called a structure at all. It is, however, quick to make, neat to use, and it costs little. You just buy a length of woven-wire fencing and, at the site of the compost heap,



A hardware cloth cylinder forms a very simple, movable pen.

bring both ends of the fencing together to form a cylinder large enough to surround the heap. Fasten the ends of the cylinder together with three or four small chain snaps that you can find in a hardware store. Remove the cylinder to a free-standing position, and start building the heap inside the cylinder. When it is half full, drive a stake into the pile. The stake should be as long as the total desired height. You can disassemble the cylinder for easy turning by removing the snaps. You set the cylinder up again and once more turn into it, shifting the ingredients from outside layers to inside, reversing the position of the material. The stake not only helps maintain the shape of the pile, but also aids in directing water into the heap.

A partly anaerobic version of the woven-wire cylinder is lined with a length of roll roofing that is wired to the fencing. The roofing is durable and prevents small bits and pieces from falling out of the bin.

After the bin is full, it is covered with a layer of 6-mil black plastic

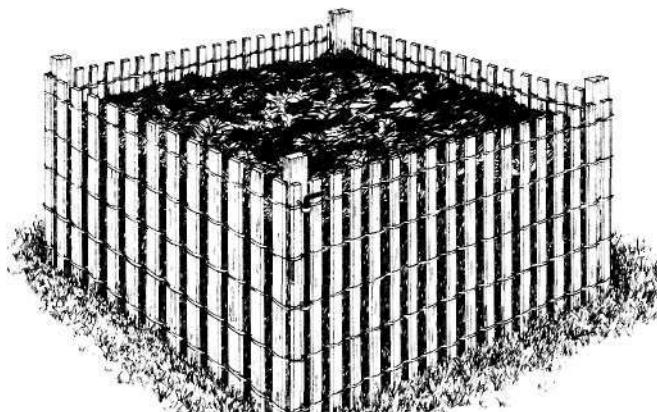
and left to decompose. Turning is not necessary with this system, although composting will take longer and high temperatures will not last long enough to kill weed seeds.

A refinement of the all-wire pen is the wire-and-tomato-stake pen in which 1/2-inch-mesh poultry netting is placed inside an enclosure made by driving 4-foot tomato stakes 1 foot apart in a 10 by 5-foot rectangle and looping baling wire around the top of each stake to weave all stakes together. Small pieces of wire hold the poultry netting to the stakes. Use additional lengths of wire to reinforce the top. These pass from side to side and keep the stakes from spreading apart under the pressure of the compost. These wires are removed when the compost is turned. This type of structure is movable and reusable. However, neither pen will resist large dogs or tunneling rats.

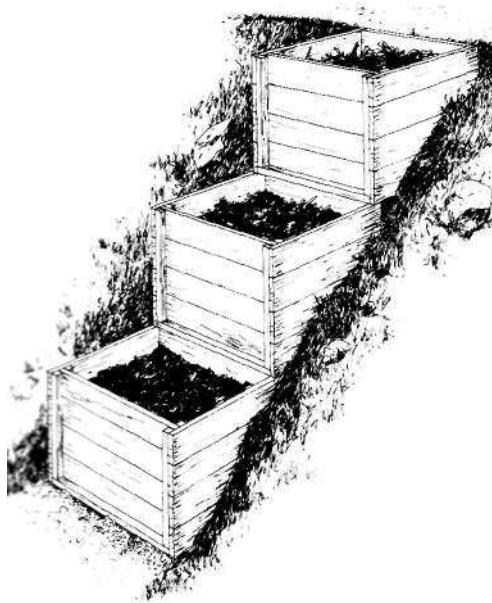
Recycled hardwood pallets make excellent compost bins. They can be quickly assembled by driving in fence posts at the corners. A chicken wire or hardware cloth liner serves as a rodent barrier.

Other materials that can be used to construct pens include snow fences, lattice fencing, steel posts and chicken wire, furring strips, prefabricated picket fence sections, woven-reed or rattan fence sections, heavy window screens, storm windows with hardware cloth replacing glass, and louvered house blinds.

Pens and bins can be made to fit the contours of uneven land. One such structure consists of three bins in stair-step order going up a hill,



Recycled materials, such as snow fence, can be used to construct a compost pen.



Stair-stepped bins make use of a sloped area.

partially cut into the bank. Composting starts in the highest bin. Turning is done by dropping the partially decomposed compost down a step, inverting it in the process. The third box receives the product of the second turning. From it the finished compost is used.

Pits

Pits for composting are dug into the ground and may be partially—or wholly—underground. The chief advantage of the pit form is its stable, secure, insulated structure. A masonry-lined, covered or coverable pit is secure from dogs, rats, clever raccoons, most flies, and wind and rain storms. Pit composting is ideal for severe winter weather because subsurface ground warmth and the heat-retaining properties of concrete enable bacteria to go on working longer. Some northern composters have a pen for summer and a pit for winter.

However, proper composting does not take place in a pit when compost becomes soggy and anaerobic. Provide some drainage to lessen the possibility of anaerobic conditions. Improper aeration and the greater possibility of anaerobic conditions remain, however, the

two greatest drawbacks to pit composting. If you have the time to turn frequently and don't mind the extra strain on your back muscles in raising forkfuls of material from a lower-than-normal position, you may find ways to avoid these problems. Some pits are large and wide enough so that a person can stand at pit-bottom level while turning.

A compost pit can be built of concrete or masonry. Other materials such as tile and pressure-treated wood are also occasionally used as pit liners. A pit must have subsurface walls to prevent drainage water from entering the compost from the soil or the ground surface. Such drainage water would leach nutrients from the compost.

Some experts suggest that a concrete pit bottom is a necessity to prevent leaching, while others prefer a natural dirt bottom that serves as a source for worms and microorganisms. Some concrete-bottom proponents advise using a bottom layer of earth over the concrete, and others say the masonry walls absorb bacteria from manure and help to inoculate new compost materials as they are added.

A useful combination of a composting method and a compost-containing structure is the earthworm pit. Earthworms help aerate and mix the materials, thus eliminating some of the drawbacks of anaerobic pits. The pit, in turn, helps protect the worms from cold weather. More details on earthworm composting are given in chapter 9.

One gardener combined the earthworm pit with the movable-box method. He dug a rectangular hole about 18 inches deep in a flower bed. At earth level over the pit he placed a rectangular, bottomless and topless, wooden box of slightly larger dimensions than the hole. The hole was filled in layer style with kitchen garbage, manure, and green matter. "When the frame was filled, too, the composter placed a board over the top and watered well. In 3 weeks, when the heat of the pile had decreased, earthworms were added.

Another successful pit is the one used by a New York State gardener. It is 4 feet wide, 4 feet deep, and 6 feet long with concrete sides and bottom. The bottom has an inset drainage grid similar to those used in basements and showers. Walls are 8 inches thick and project 18 inches above the ground. The top is made of tongue-and-groove boards nailed to 2 x 4s. A hinged lid provides access. Earthworms do the work of aeration in this pit, and garbage and leaves are the chief materials used.

An inexpensive pit may be made by digging a section of a masonry flue liner into the soil, leaving about 3 inches of it projecting above ground level. A thin layer of concrete poured into the pipe serves as the floor. A small flue liner 2 feet square may not require bottom drainage

if earthworms are used, but check frequently for anaerobic conditions.

Terra cotta tiles are also useful for lining pits. These can be used **for** the sides in combination with a hardware cloth bottom to prevent **rats** from getting in from underneath. Build twin pits to make the **turning** job easier.

Drums

Where space limitations or offending odors are concerns, composting in drums provides an alternative to bins, pens, and pits. A metal or plastic barrel, with drainage holes in the bottom, can be raised off the ground with bricks or blocks to permit aeration. Layering kitchen wastes with absorbent materials like shredded paper or straw can help control odors; without turning or rolling, this method produces compost slowly but does provide a place for waste disposal.

Structures for City Composting

Is there any perfect form of compost making for a city gardener? Helga and Bill Olkowski, in *The City People's Book of Raising Food*, suggest a well-built two- or three-bin brick structure set between two houses. Runoff is caught in sawdust at the bottom of the bin, and the sawdust is turned with the pile. As garbage accumulates on its way to the bin, the Olkowskis layer it with sawdust in 5-gallon cans with tight-fitting lids. Sawdust is added every time fresh garbage is put into the can. The sawdust controls odor and putrefaction. In loading the bins, however, you should remember to compensate for the high-carbon content of the sawdust by using more high-nitrogen wastes.

Other city gardeners, who lack even a small space between houses, have composted successfully in garbage pails and metal drums. The danger with these methods is that they may quite easily become anaerobic and ferment. If you think it is hard enough dealing with garbage in a city, you should try to take care of a huge drum of fermented garbage. If, however, you really need to try these methods, provide aeration and drainage with holes in the bottom and sides of the drum or can. Set it in the basement or another protected area, preferably outdoors or on a flat roof. Elevate the can or drum on bricks or concrete blocks, and set a pan, larger in diameter than the drum, underneath it to catch drainage. Layer garbage with high-carbon-content materials just as you

MAKING A BARREL COMPOSTER

For small composting operations, the barrel composter is ideal. The composter is easy to build and use. The compost is easy to turn by rotating the drum.

TOOLS REQUIRED

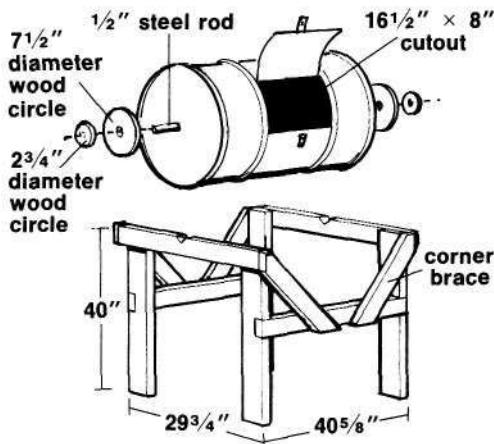
Electric drill
Saws (saber saw with metal-cutting blade and handsaw or circular saw)
Screwdriver
Pliers
Paintbrush

MATERIALS

LUMBER—CUT LIST

Cut lumber into the following lengths. Use pressure-treated lumber or untreated pine painted with a preservative or flat black paint. Measure and cut the pieces as you assemble them, to be sure they fit together correctly.

- 4 pcs. 2" x 4" x 40" (legs)
- 4 pcs. 2" x 4" x 29 $\frac{3}{4}$ " (frame horizontals)
- 2 pcs. 1" x 3" x 40 $\frac{5}{8}$ " (cross braces)
- 4 pcs. 1" x 3" x 23 $\frac{3}{4}$ " (corner braces)
- 2 pcs. $\frac{3}{4}$ " x 7 $\frac{1}{2}$ " diameter wood circles (bearings)
- 2 pcs. $\frac{3}{4}$ " x 2 $\frac{3}{4}$ " diameter wood circles (bearings)



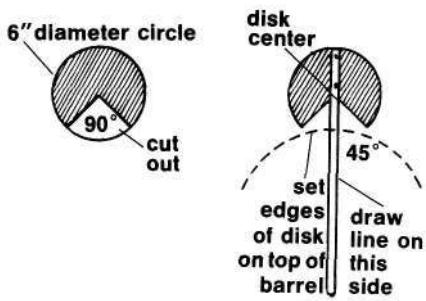
HARDWARE

- 1 55-gallon drum (composter)
- 2 hinges, 1 1/2" x 2"
- 1 small hasp
- 1 steel rod, 1/2" x 40 1/2"
- 8 stove bolts, 1/4" x 1 1/4"
- 12 stove bolts, 1/4" x 1"
- 28 wood screws, #10 x 1 1/2"
- 1 pint black rust-retardant paint

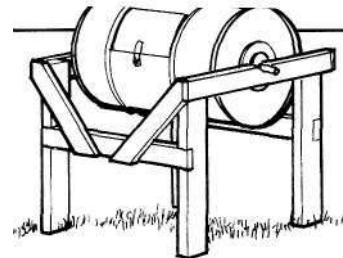
CONSTRUCTION

1. Obtain a 55-gallon drum that has not been used for toxic chemicals. (Paint barrels are ideal.)

2. Drill a 1/2-inch hole in the exact center of each end of the drum, to accommodate the 1/2-inch steel rod. Make a simple gauge to find the center by cutting a 6-inch-diameter circle out of heavy cardboard or wood. Mark the exact center of the circle, and cut out a 90-degree wedge. Attach a piece of wood so that one edge bisects the cut-out wedge. Hold the gauge with the cut-out edge against the edge of the drum. Draw a line where the piece of wood bisects the end of the drum. Move the gauge 90 degrees, and draw another line. The intersection of these lines will be the exact center.



J. Draw the lines for the opening in the barrel, making sure to round the corners slightly. Drill a 1/4-inch hole somewhere along one of the



lines, to start the saber saw. If your barrel has ribs, cut a 1-inch V notch on each rib to facilitate opening the door. Attach the hinges and the hasp to the barrel and lid with 1/4 by 1-inch stove bolts.

4. From $\frac{3}{4}$ -inch pine, cut two 7 1/2-inch-diameter circles (bearings) and two $2\frac{3}{4}$ -inch-diameter circles. Drill a 1/2-inch hole in the center of each, and apply glue to the $2\frac{3}{4}$ -inch circles. Glue each $2\frac{3}{4}$ -inch circle to a 7 1/2-inch one. (It's a good idea to temporarily slip them over the 1/2-inch steel rod and clamp them.) After the glue has dried, remove the bearings, insert the rod through the barrel, and assemble as shown in the illustration. Use four 1/4 by 1-inch stove bolts in each bearing to bolt it to the drum.

5. To build the support frame, use a corner lap joint to fasten the legs to the horizontal pieces. (To make a corner lap joint, simply remove one-half the

MAKING A BARREL COMPOSTER

— *Continued*

thickness of the stock to a length comparable to the width of the stock on the ends of both pieces to be joined.) Use two #10 by 1 1/2-inch wood screws in each joint. Cut grooves (dadoes) on the legs 23 inches from the bottom to fit the 1 by 3-inch cross braces. Cut 45-degree angles at both ends of the 23³/₄-inch-long corner braces, and attach them across corners, as shown, with #10 by 1 1/2-inch

wood screws. Cut a 1/2-inch notch in the center of each top horizontal piece to accommodate the rod.

6. Drill several rows of 14-inch holes along the bottom of the barrel underneath the door opening, to eliminate excess moisture. Paint the barrel unit inside and out with black, rust-retardant paint.

would in a regular pile. Composting is not really an indoor activity, and turning is especially hard to do in a limited space.

Trash cans can be used more readily for outdoor composting by cutting out the bottoms and setting them firmly into the ground to prevent tipping. California composter Helene Cole suggests using several of them and simply waiting 6 to 12 months for the finished product. Chopping your wastes first will speed up the process. A few air holes drilled in the lid will keep the earthworms that do most of the work in this system happy.

Another much more sensible indoor method is the earthworm box discussed in chapter 9. Worms are easily raised in basements where fairly stable temperature conditions can be maintained. Worms do the turning in worm boxes, and the results of their labors are rich worm castings for compost and perhaps a little extra income for you during fishing season. If you live in an apartment, discuss composting or worm-raising plans with your landlord before launching your career.

Commercial Composters

A number of very good commercially produced composting units are now on the market. Generally built on the revolving-drum or upright-cylinder principle, these structures are designed to produce

Use this system to compost kitchen scraps during the winter, or use it year-round to compost all the waste produced by a small yard and garden.

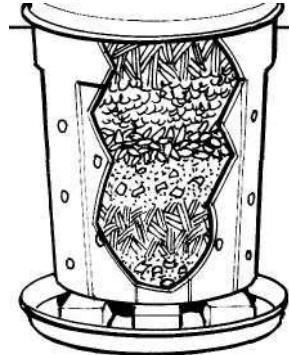
Directions

Use a hammer and a large nail to punch holes in the bottom, sides, and lid of a garbage can. Place the can on a large tray to catch draining liquid if desired.

To start the composting, place a 3-inch layer of finished compost or soil in the bottom of the can. Add finely chopped kitchen scraps followed by an equal amount of shredded newspaper, grass clippings, and/or shredded leaves. Add more material as available until the can is full, then layer new materials into another can and allow the first to finish composting—about 3 to 4 months.

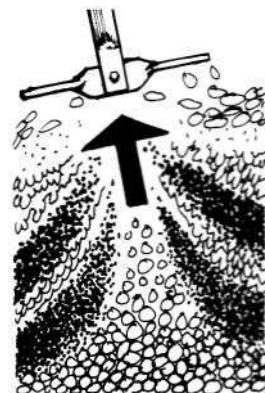
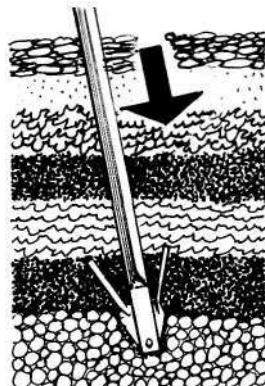
Tips to Make Your Composter Work Its Best

- Protect the composter from freezing temperatures—put it in a garage or cellar.
- Start with soil or finished compost, and add a little more on top of each addition.
- Chop, shred, or even blend all additions as finely as possible.
- Add kitchen scraps before they start to smell.
- Mix the composting material after each addition and every few days. If you don't, it may produce unpleasant odors. Stir

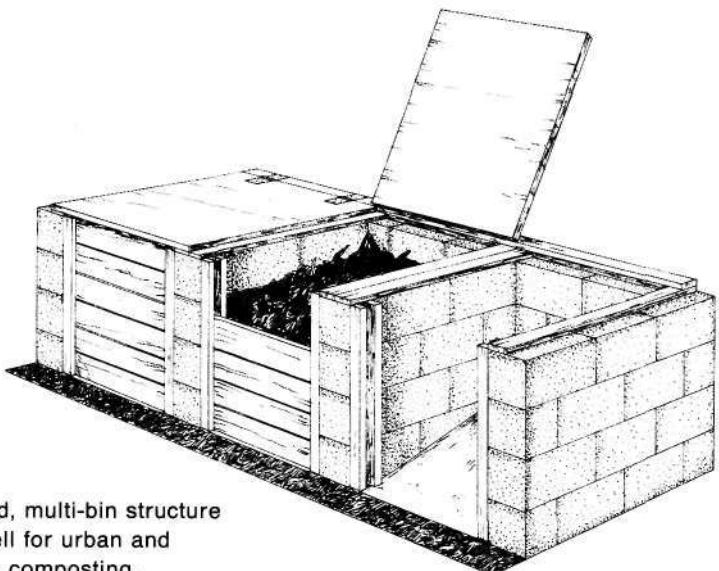


with a stick, roll the can back and forth on its side a few times, or use a "compost-turning tool."

- Add water sparingly and only if your materials are very dry.



COMPOST-TURNING TOOL IN ACTION



A covered, multi-bin structure works well for urban and suburban composting.

high-quality compost quickly and with a minimal effort on the part of the user. Recent articles in the *Wall Street Journal* have noted that commercial composting units represent overkill for most people, since similar composting conditions can be created without a commercial bin. Constraints on space, time, and physical ability, however, will continue to make such products appealing to many home composters.

A relatively recent addition to the commercial composting marketplace is the Green Cone, produced by Eco Atlantic. This closed, sun-heated composter is designed specifically for decomposing kitchen wastes, using a below-ground basket for contact with the soil and a double-walled plastic cone to collect heat from the sun. Small and innocuous looking, the Green Cone can be located close to the kitchen for easy waste disposal, but according to the manufacturer, it is not meant to handle yard wastes and produces very little compost.

A list of known manufacturers of composting units is included in "Equipment Sources" starting on page 263. In general, these composters are designed for small-lot gardeners who want to make compost quickly and without offending the neighbors or attracting animals. Although such conditions can be met with a homemade bin, commercial composters offer valid alternatives to the gardener who is willing to pay \$100 or more for an efficient, attractive composting unit.