MASTER COMPOSTER

Home Study Course

Lessons on How to Effectively Manage
Yard Trimmings and Other Organic Materials
Generated at Home

University of Wisconsin-Extension

Master Composter

Table of Contents

Welcome to the Master Composter Course!

This series of lessons will teach you how to become more proficient at managing yard trimmings and other organic materials that you generate at home.

Lesson 1. Managing Yard Trimmings and Organic Wastes at Home 1
- Why Manage Organic Materials at Home? 1
- How Much Organic Material Can be Composted? 3
- Are There Certain Regulations I Should be Aware Of? 3

Lesson 2. The Composting Process 8
- History of Composting 8
- The Science of Composting 9
- Key Factors Affecting the Composting Process 14

Lesson 3. Materials and Methods for Composting 20
- What to Compost 20
- Composting Methods 25

Lesson 4. Making and Maintaining a Compost Pile 32
- When to Start a Compost Pile 32
- Where to Compost 33
- Making a Compost Pile 34
- Troubleshooting: Problems and Solutions 37
- Compost Pile pH 39
- Health Considerations 39

Lesson 5. Using Compost 42
- Benefits of Compost 42
- Finished Compost 44
- Compost Application 45

Lesson 6. Other Options for Managing Yard Trimmings & Food Scraps 49
- Vermicomposting 49
- Grasscycling 56
- Mulching 59
- Resource Saving Landscape Design 61

Appendix Study Question Answers 66

Master Composter

MANAGING YARD TRIMMINGS AND ORGANIC WASTES AT HOME
Lesson One

What's ahead

In lesson 1 of the home study course, you'll learn:

- why it is beneficial to manage yard trimmings and kitchen scraps at home;
- how much organic material you can expect to compost and mulch;
- state and local regulations related to managing yard trimmings and other organics; and
- different options available to households for handling yard trimmings

Why manage organic materials at home?

In our society, we spend considerable time, energy, and resources stopping, controlling, and ignoring decay. We spray produce and add chemicals to food to inhibit it. Garbage trucks come by weekly to remove our decay, taking it to landfills so it can rot elsewhere.

At the same time we are investing our energies into disposing of decay, we are also depriving the land of valuable nutrients. All that rotting organic material has the potential to significantly improve soil health and plant growth — right a home. Every fall, many folks go to great lengths to bag up dead leaves and garden cuttings that get hauled away to a composting or land-spreading site. They pay fees either directly or through taxes to have someone else make the decay go away. In the spring, they rush to stores to buy fertilizers and other amendments to put onto their yards.

The words associated with the natural process of decomposition seem to have unpleasant connotations: rot, decay, putrefaction, spoilage, waste. This may explain why some people are hesitant to get involved with composting and mulching. Composting is a process that facilitates rot and decay.

> *Yard trimmings*: this is a term, which has the same meaning as yard waste. Many people involved in composting and recycling across the U.S. feel that the word "waste" makes it harder for the public to appreciate the value of compost and mulch produced from leaves, grass clippings, brush and garden debris. Most professionals now use the term "yard trimmings" in place of "yard waste".

Through education and subtle peer pressure, the "ick" factor associated with composting and mulching is slowly disappearing. Home composting is becoming "eco-chic" in some neighborhoods — a backyard is not complete unless it features a compost bin. More and more people are talking about composting with neighbors, at parties and in workplace lunchrooms.

There are a number of reasons for this growing interest in backyard composting

and mulching. Children learn about recycling, composting and other environmental issues at school and they take the information home to their parents. Communities are expanding education efforts associated with recycling programs to include backyard composting. More importantly, people are starting to realize that personal actions can make a difference in our environment. As stewards of the planet, one of the most powerful things we can do is to care for the small patches of land surrounding our homes. Instead of packing up excess organic materials to send to a distant destination, we can turn them into a valuable amendment that makes soil healthy, vibrant and living. We can reap benefits, which include a more beautiful yard with reduced water and fertilizer bills. In addition, our actions will reduce costs for transporting and managing yard materials off-site, and save landfill space.

Reduce, reuse and recycle

Many folks find it easier to understand the concepts of backyard composting and mulching when they are explained using recycling and waste reduction terminology. We can reduce, reuse, and recycle a sizable quantity of our yard trimmings and in many communities, a considerable amount of food wastes. With a small amount of planning and effort, we can make a significant dent in the amount of material put out at the curb and/or brought to centralized composting sites.

Reduce - One of the easiest ways to reduce yard trimmings is to leave grass clippings right where they fall. Clippings work their way into the ground within days of cutting, improving the soil and feeding the lawn. Another way to reduce yard trimmings is to develop and maintain home landscapes so they mimic natural systems. Consider reducing your lawn area by planting more groundcovers and creating small beds around trees and shrubs. By analyzing your current yard layout and making some modifications, you can reduce the amount of yard trimmings generated.

Reuse - Many organic materials are being put back to use in yards and gardens with very little effort. You can mulch with yard trimmings such as shredded leaves, grass clippings, and chipped wood (from branches). Mulching offers numerous benefits such as protecting the soil, conserving moisture and suppressing weeds.

Recycle - Two forms of organic recycling are backyard composting and vermicomposting (worm composting). Home composting recycles yard trimmings and certain types of food scraps into a valuable soil amendment. Vermicomposting is another method for recycling a wide variety of food wastes into nutrient rich worm castings. You can use these soil amendments, compost and worm castings, in potting soil mixtures, for making compost tea, in gardens, on lawns, and around shrubs and trees. Redworms used for vermicomposting can also be used for fishing bait. In addition, you can recycle your Christmas tree into a bird feeding station, potpourri, mulch for acid loving plants, and fireplace logs (tree trunk).

Almost all households in Wisconsin are recycling a significant portion of their wastes — cardboard, metal cans, plastic containers, glass jars and bottles, newspapers and more. By reducing, reusing, and recycling your yard trimmings and food scraps, you move closer towards zero waste generation and improve your yard at the same time.

How much organic material can be composted?

You may be saying, "OK, if I reduce, reuse, and recycle my organic materials – just how big a dent can I make in my household waste stream?"

Most people don't know how much waste they generate. In 2009, the average Wisconsin resident generated 4.5 lbs of trash per day or 1,643 lbs per year. An average four-person household would then generate about 6,572 lbs of trash per year.

It is estimated that the average composting household recycles about 650 lbs per year (Economic Cost-Benefit Analysis of Home Composting Programs in the United States, The US Composting Council, 1995). This compares with other studies that have shown averages of 550 to 750 pounds of yard trimmings and food waste were composted in households.

A recent WI DNR study sorted and weighed a range of materials delivered to different landfills in the state. Even though most yard materials were banned from WI landfills in 2010, they found that about 161,000 tons of yard materials was still being landfilled. If we composted these materials along with food scraps the amount of waste sent to landfills from residents would be reduced by up to 25%.

For each household that starts composting, there is the potential to divert an additional 650 lbs of material from landfills and municipal collection/curbside programs. Expanding existing home composting helps too. Increasing the number of households that compost can extend the life of expensive landfills and reduces cost to municipalities and residents.

Home compost piles, however, should not include meat and oily foods due to the possibility of creating odors and attracting pests. Yet, many food scraps can be composted along with yard materials, human hair, natural dryer lint, lake weeds, waxed cardboard and more. (See lists of acceptable and non-acceptable items to compost in Lesson 3.)

Perhaps the best part about reducing, reusing and recycling organic materials, is that your yard will directly profit from your efforts. The compost produced from these materials is a great soil amendment. In addition to providing nutrients for the plants compost helps to improve soil texture, suppress certain plant diseases, and improves soil health.

Are there certain regulations I should be aware of?

Wisconsin is one of many U.S. states that have passed yard trimmings legislation. In addition, some communities within Wisconsin have ordinances related to home composting or burning leaves and brush. These regulations are sometimes confusing for residents and businesses. Many people are aware of the statewide ban on

landfilling yard waste, but they may have questions on exactly what materials are banned and what their options are for handling them.

Wisconsin's recycling law

According to Wisconsin's recycling law, yard trimmings are banned from landfills and incinerators that don't recover energy (since January 3, 1993). Yard trimmings, defined as "yard waste" under Wisconsin's recycling law, consist of the following materials:

- leaves,
- grass clippings,
- yard and garden debris, and
- brush including clean, woody vegetative materials no greater than six inches in diameter

This law applies to yard waste produced from either residential or non-residential sources, with some exemptions for brush. The legal definition of yard waste does not include:

- stumps,
- roots,
- shrubs with intact root balls,
- Christmas trees,
- wreaths or garlands,
- floral arrangements

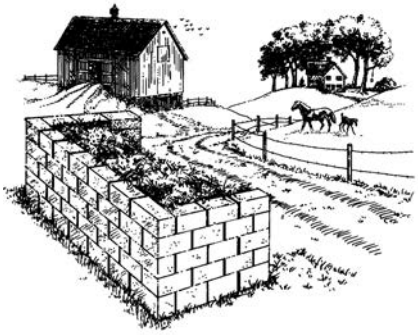
It should be noted that the landfill ban applies only to brush generated in "yards and gardens". The term "yards and gardens" has a fairly broad definition. It applies to any dwelling, including private residences and apartments, or any business, institution, or government that generates brush on building grounds, in parks, or in yards and/or gardens. Brush generated in these locations must be managed to comply with the recycling law. The Wisconsin DNR exempts brush generated by:

- farms,
- commercial orchards and nurseries,
- public and private forests,
- road maintenance and construction,
- utility or railroad right of-way clearing, and
- prescribed burns done to create or maintain wildlife habitat by private, public, or non-profit organizations or individuals

Exempted brush generators must comply with local and state burning restrictions imposed for reasons of fire safety, air pollution control, and prevention of public nuisances.

Options for managing yard trimmings

The options available for residents to manage their yard trimmings will vary with their location. According to Wisconsin's recycling law, recycling programs operated by towns, villages, cities and counties must inform residents of their options for handling yard trimmings, but they are not obligated to provide a community management program.



One option is **on-site management** or backyard composting, which is the focus of this home study course and the Master Composter Training Program. Municipalities can encourage use of this option by publicizing its benefits, providing

residents with educational materials and programs, as well as by offering bin distribution programs. Master Composters can help promote on-site management to a variety of audiences such as residents and youth through outreach activities.

Another option for some residents is a **community management program**. A number of Wisconsin communities and counties offer such a program. With this option, the community oversees collection, transportation, and processing of yard trimmings. Variations for community management programs include:

- Contracting for services. The municipality contracts with haulers, nurseries, landscape firms, or farmers to collect and/or process yard trimmings. Yard trimmings are composted in a centralized facility or land spread on agricultural fields.

- Operating a composting facility. Municipalities handle the processing of yard trimmings and marketing of finished compost. Collection and transportation may be the responsibility of the generator, the responsible unit, or it may be a contracted service.

A number of local governments successfully utilize both options of on-site management and a community management program. They develop educational programs for home composting and other on-site management methods and promote them as the preferred option for handling yard trimmings. The community management option is utilized for yard trimmings that are difficult to manage on-site due to space constraints, physical disabilities, and/or storms. By encouraging a large number of generators to manage yard trimmings on-site, local governments can save on collection, transportation and processing costs. Residents also save money – either directly or through decreased taxes.

A third, but less preferable, option for residents is to **burn brush** and other yard trimmings in their own backyards. The ban in Wisconsin's recycling law does not prohibit backyard burning, but it is highly discouraged by the WI Dept. of Natural Resources. Burning may, however, be prohibited in some municipalities by local ordinances. Burning is also restricted by state fire control and air quality rules.

Leaf burning can cause serious health problems, especially in urbanized areas. The open burning of leaves produces particulate matter, carbon dioxide and hydrocarbons. Particulate matter is comprised of microscopic particles that can reach into the deepest regions of the lung and stay there for months or years. Inhaling particulate matter can increase the chance of respiratory infection and trigger asthma attacks. High levels of hydrocarbons are produced when moist leaves are burned without proper air circulation. Some of these hydrocarbons, such as aldehydes and ketones, cause irritation of the eyes, nose, throat and lungs. A substantial portion of the hydrocarbons in leaf smoke consist of aromatic hydrocarbons, some of which

are known carcinogens. Carbon monoxide is an invisible gas that results from incomplete combustion. Burning leaf piles are ideal for creating carbon monoxide emissions. Carbon monoxide is absorbed into the bloodstream through the lungs and combines with red blood cells. This reduces the amount of oxygen the red blood cells can absorb and supply to body tissues. Unborn children, infants, smokers, elderly, and persons with heart and lung disease are especially vulnerable to problems with carbon monoxide.

Compared with backyard burning, composting and mulching are much better ways to manage yard trimmings because they return nutrients to the soil, they keep air clean, and they pose significantly less health risk.

Wisconsin DNR Administrative Code Chapter 502 – large scale compost facilities

In addition to the disposal ban on yard waste, Wisconsin has regulations governing composting facility design and operation under DNR Chapter NR 502.

Facilities for composting solid waste from a single family or household are exempt from the regulations and licensing requirements provided the facility is operated in a nuisance-free and environmentally sound manner. In addition, Chapter NR 502 provides an exemption for yard and vegetable food waste composting facilities with a capacity of 50 cubic yards or less on-site at any time. Facilities can also compost clean chipped wood waste and manure. These sites must also be operated in a nuisance-free and environmentally sound manner.

If you or someone you know of is interested in developing and operating a larger composting site, you can obtain a copy of Chapter NR 502 from your DNR district office.

Local ordinances affecting composting activities

Some communities in Wisconsin have passed ordinances regulating household composting activities. Ordinances vary, but may include specific setbacks from lot lines, require bin enclosures or there may be restrictions on incorporating food wastes into a pile. Before building your own compost pile or conducting Master Composter outreach activities in your community, it would be wise to check with officials in your community to see if there applicable local ordinances.

Summary

In this lesson, you've learned about reasons for managing organic materials at home and how much you can potentially compost or mulch. You've also become familiar with state regulations that relate to yard trimmings and different options for handling them. Now try to answer the **study questions**. They will help you remember what you've learned. The **study activities** will assist you in further expanding your knowledge. In the next lesson, Lesson 2, you'll learn about the history of composting and how the composting process works.

Study questions
Lesson 1

1. Name three reasons for managing organic materials at home.

2. Describe the concepts of backyard composting and mulching using recycling and waste reduction terminology.
3. What is the number of pounds of yard materials and food scraps that an average household composts?
4. List three items that are not included in the Wisconsin legal definition of yard waste.
5. Name three byproducts from the open burning of leaves.

Answers can be found in the back of the study guide.

Study activities
Lesson 1

Local ordinances affecting composting activities

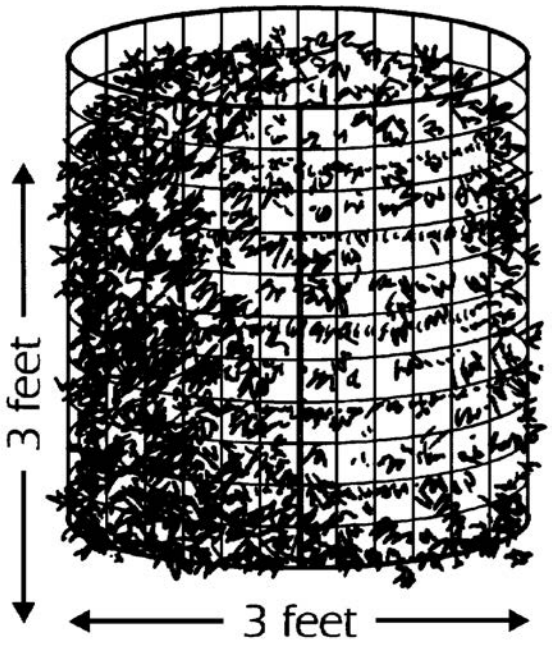
Contact the clerk for your city, village or town. Inquire whether there are any ordinances regulating household composting activities. If there is an ordinance, try to obtain a copy of it. Study the ordinance to see if there are lot line setbacks, policies on incorporating food scraps or other restrictions. Pass this information onto others you know that are involved in composting activities.

Local options for managing yard trimmings

Research the options available in your community or county for managing yard trimmings. What level of government is responsible for recycling where you live? Do they sponsor a community collection or management program? If so, do they provide house-to-house collection of grass, leaves or brush? How often are yard trimmings collected e.g. weekly, seasonally? Is a drop-off site available for residents to bring yard trimmings? Where do the yard trimmings go? Are they composted or land spreads on agricultural fields? Who pays for these services?

You may want to find out if your community sponsors a backyard composting education program. What types of educational activities are being done e.g. workshops, fair exhibits, etc.? Do they unit send out mailings or other educational materials about home yard trimmings management options?

If your community has the information readily available, ask them how money is spent on yard trimmings management – for community management programs and backyard composting education programs. Note that some communities may not spend any money on yard trimmings management.



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THE COMPOSTING PROCESS
Lesson Two

What's ahead

In lesson 2 of the home study course, you'll learn:

- what composting is;
- the history of composting;
- how microorganisms decompose organic matter;
- the role of macroorganisms in decomposition; and
- key factors that affect the composting process.

Introduction

Composting is the biological decomposition of organic material in the presence of oxygen into a humus-like substance called compost. The process occurs naturally, but can be accelerated and improved by controlling environmental factors. People may wonder, "why bother composting if everything organic decomposes eventually anyway?" If raw wastes are put directly into the soil, the decomposition process will rob the soil of nitrogen, an important nutrient for plants. (Soil incorporation is one method of composting, but requires leaving the area fallow – see Chapter Three.) Finished compost from a pile is typically a more uniform product with a better balance of nutrients. It can be used throughout the growing season in many different types of applications. With a pile, composters have more control over adding and mixing the amount of carbon and nitrogen rich materials used to make the end product. In addition, a properly controlled composting environment can ensure production of high temperatures needed for killing weed seeds, diseased plant tissue and pathogenic organisms.

History of composting

Occasionally, curious individuals want to know the origins of composting. It is difficult to attribute the birth of composting to a specific individual or even one society. The ancient Akkadian Empire in the Mesopotamian Valley referred to the use of manure in agriculture on clay tablets over 4300 years ago. There is evidence that Romans, Greeks and the Tribes of Israel knew about compost. The Bible and Talmud both contain numerous references to the use of rotted manure, straw and organic materials on agricultural fields. Other references to compost are contained in tenth and twelfth century Arab writings, in medieval Church texts, and in Renaissance literature. Notable writers such as William Shakespeare, Sir Francis Bacon, Sir Walter Raleigh all mentioned the use of compost.

On the North American continent, both Native Americans and early European founders of America enjoyed the benefits of compost. Many New England farmers made compost using a recipe of 10 parts muck to 1 part fish, periodically turning their compost heaps until the fish disintegrated (except the bones). One Connecticut farm, Stephen Hoyt and Sons, used 220,000 fish in one season of compost production. Other famous individuals that produced and promoted the uses of compost include George Washington, Thomas Jefferson, James Madison and Dr. George Washington Carver.

The early 20th century saw the development of a new "scientific" method of farming. Work done in 1840 by a well-known German scientist, Justus von Liebig, proved that plants obtained nourishment from certain chemicals in solution. Liebig dismissed the significance of humus, because it was insoluble in water. After that discovery, agricultural practices became increasingly chemical in nature. Combinations of manure and dead fish did not look very effective beside a bag of fertilizer. For farmers in many areas of the world, chemical fertilizers replaced compost.

Sir Albert Howard, a British agronomist, went to India in 1905 and spent almost thirty years experimenting with organic gardening and farming. He found that the best compost consisted of three times as much plant matter as manure, with materials initially layered in sandwich fashion, and then turned during decomposition (known as the Indore method). In 1943, Sir Howard published a book, *An Agriculture Testament*, based on his work. The book renewed interest in organic methods of agriculture and earned him recognition as the modern day father of the organic farming and gardening.

J.I. Rodale carried Sir Howard's work further and introduced American gardeners to the value of composting for improving soil quality. He established a farming research center in Pennsylvania and the monthly *Organic Gardening* magazine. Now, organic methods in gardening and farming are becoming increasingly popular. A growing number of farmers and gardeners are realizing the value of compost for plant growth and restoring depleted soil.

The science of composting

While our ancestors realized that compost was helpful for growing plants and improving soil health, they did not know how or why it worked. Our knowledge about the science of composting comes from research conducted during the past 50 years – relatively recent compared to the 2000 plus years that humans have been composting.

Backyard composting speeds up the natural process of decomposition – providing optimum conditions so that organic matter can break down more quickly. As you dig, turn, layer and water your compost pile, you may feel as if you are doing the composting, but the bulk of the work is actually done by numerous types of decomposer organisms.

Microorganisms in a compost pile

Microorganisms such as bacteria, fungi and actinomycetes account for most of the decomposition that takes place in a pile. They are considered chemical decomposers because they change the chemistry of organic wastes. The larger decomposers, or macroorganisms, in a compost pile include mites, centipedes, sow bugs, snails, millipedes, springtails, spiders, slugs, beetles, ants, flies, nematodes, flatworms, rotifers, and earthworms. They are considered to be physical decomposers because they grind, bite, suck, tear, and chew materials into smaller pieces.

Of all these organisms, aerobic bacteria are the most important decomposers. They are very abundant – there may be millions in a gram of soil or decaying organic matter.

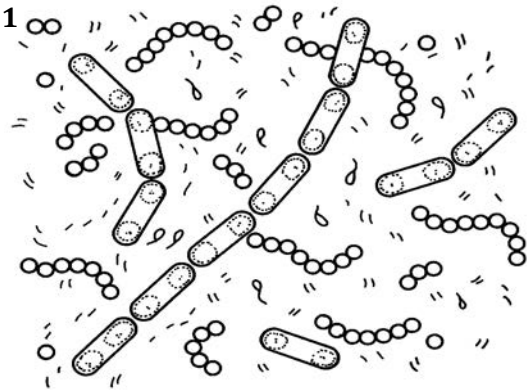
You would need 25,000 of them laid end to end on a ruler to make an inch. They are the most nutritionally diverse of all organisms and can eat nearly anything. Bacteria utilize carbon as a source of energy (to keep on eating) and nitrogen to build protein in their bodies (so they can grow and reproduce). They obtain energy by oxidizing organic material, especially the carbon fraction. This oxidation process heats up the compost pile from ambient air temperature. If proper conditions are present, the pile will heat up fairly rapidly (within days) due to bacteria consuming readily decomposable materials.

While bacteria can eat a wide variety of organic compounds, they have difficulty escaping unfavorable environments due to their size and lack of complexity. Changes in oxygen, moisture, temperature, and acidity can cause bacteria to die or become inactive. Aerobic bacteria need oxygen levels greater than five percent. They are the preferred organisms because they provide the most rapid and effective composting. They also liberate plant nutrients such as nitrogen, phosphorus and magnesium. When oxygen levels fall below five percent, the aerobes die and decomposition slows by as much as 90 percent. Anaerobic microorganisms take over and in the process, produce organic acids and amines (ammonia-like substances), which are smelly, contain unavailable nitrogen and in some cases, are toxic to plants. In addition, anaerobes produce hydrogen sulfide (smells like rotten eggs), cadaverine, and putrescine (other sources of offensive odors.).

There are different types of aerobic bacteria (fig.1), that work in composting piles. Their populations will vary according to the pile temperature.

Psychrophilic bacteria work in the lowest temperature range. They are most

Figure 1



active at 55°F and will work in the pile if the initial pile temperature is less than 70°F. They give off a small amount of heat in comparison to other types of bacteria. The heat they produce is enough however, to help build the pile temperature to the

point where another set of bacteria – **mesophilic** bacteria – start to take over.

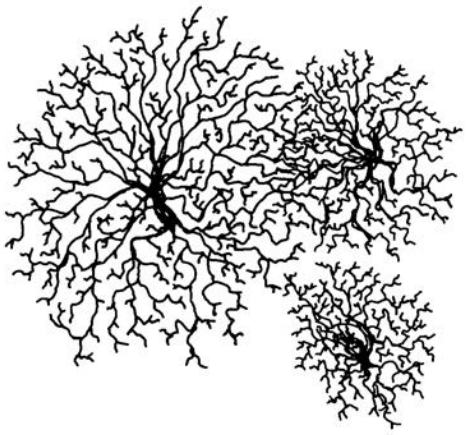
Mesophilic bacteria rapidly decompose organic matter, producing acids, carbon dioxide and heat. Their working temperature range is generally between 70 and 100°F. When the pile temperature rises above 100°F, the mesophilic bacteria begin to die off or move to the outer part of the heap. They are replaced by heat-loving **thermophilic** bacteria.

Thermophilic bacteria thrive at temperatures ranging from 113°F to 160°F. Thermophilic bacteria continue the decomposition process, raising the pile temperature to 130-160°F, where it usually stabilizes. Unless a pile is constantly fed new materials and turned at strategic times, the high range temperatures typically last no more than three to five days. Thermophilic bacteria use up too much of the degradable materials to sustain their population for any length of time. As the thermophilic bacteria decline and the pile of the temperature gradually cools off, the mesophilic bacteria again become dominant. The mesophilic bacteria consume remaining organic material with the help of other organisms.

The drop in compost pile temperature is not a sign that composting is complete, but rather an indication that the compost pile is entering another phase of the composting process. While high temperatures (above 140°F) have the advantage of killing pathogenic organisms and weed seeds, it is unnecessary to achieve those temperatures unless there is a specific concern about killing disease organisms and seeds. (You can greatly reduce the possibility of pathogens in a pile by excluding pet waste, diseased plants and manure from plant eating animals.) However, manures are good compost materials but must be composted with thermophilic temperatures to kill virulent stains of salmonella and E.coli. Many decomposers are killed or become inactive when pile temperatures rise above 140°F.

If the pile temperature exceeds 160°F, composters may want to take action and cool their pile buy turning it. A number of research projects have shown that compost amended soil can help fight fungal infestations. If the compost pile temperature goes above 160°F, the composting materials may become sterile and lose its disease fighting properties.

Figure 2



While the various types of bacteria are at work, other microorganisms are also contributing to the degradation process. Actinomycetes (Fig. 2), a higher-form bacteria similar to fungi and molds, are responsible for the pleasant earthy smell of compost. Grayish in appearance, actinomycetes work in the moderate heat zones of a compost pile. They decompose some of the more resistant materials in the pile such as lignin, cellulose, starches

and proteins. As they reduce materials, they liberate carbon, nitrogen and ammonia, making nutrients available for higher plants. Actinomycetes occur in large clusters and become most evident during the later stages of decomposition.

Like bacteria and actinomycetes, fungi are also responsible for organic matter decay in a compost pile. Fungi are primitive plants that can be either single celled or many celled and filamentous. They lack a photosynthetic pigment. Their main contribution to a compost pile is to break down cellulose and lignin, after faster acting bacteria make inroads on them. They prefer cooler temperatures (70 to 75°F) and easily digested food sources. As a result, they also tend to take over during the final stages of composting.

Macroorganisms

As mentioned earlier, larger organisms are involved in physically transforming organic material into compost. They are active during the later stages of composting – digging, chewing, sucking, digesting and mixing compostable materials. In addition to mixing materials, they break it into smaller pieces, and transform it into more digestible forms for microorganisms. Their excrement is also digested by bacteria, causing more nutrients to be released.

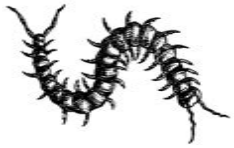
Micro- and macroorganisms are part of a complex food chain. This food chain consists of organisms classified as first-, second-, or third-level consumers. The categories are based on what they eat and who they are eaten by. First level consumers become the food for second level consumers, which in turn, are eaten by third level consumers. Soil ecologist Dr. Daniel L. Dindal gives an example of how the food chain works *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 an overview of some of the larger macroorganisms you are likely to find a in a compost pile.

Ants – Ants feed on a variety of materials including fungi, seeds, sweets and other insects. They help the composting process by bringing fungi and other organisms into their nests. Ants can make compost richer in phosphorus and potassium by moving minerals around as they work.

Millipedes – Millipedes have worm-like segmented bodies, with each segment having two pairs of walking legs (except the front few segments). Millipedes help break down plant material by eating soft decaying vegetation. They will roll up in a ball when in danger.



Centipedes – Centipedes are flat, segmented worms with one pair of legs in each

segment. They are third-level consumers that feed on soil invertebrates, especially insects and spiders.

Sow bugs – Sow bugs have a flat and oval body with distinct segments and ten pairs of legs. They are first-level consumers that feed on rotting woody materials and other decaying vegetation. Pill bugs look similar to sow bugs, but roll up in a ball when disturbed.

Springtails – Springtails are small insects distinguished by their ability to jump when disturbed. They rarely exceed ¼ inch in length and vary in color from white to blue to black. Springtails are principally fungi feeders, although they also eat molds and chew on decomposing plants.

Flies – Flies are two winged insects that feed on almost and kind of organic material. They also act as airborne carriers of bacteria, depositing it wherever they land. Although flies are not often a problem with compost piles, you can control their numbers by keeping a layer of dry leaves or dry grass clippings on top of the pile. Also, bury food scraps at least eight to twelve inches deep into the pile. Thermophilic temperatures kill fly larvae and mites help to keep fly larvae reduced in numbers.

Beetles – Beetles are insects with two pairs of wings. Types commonly found in compost piles include the rove beetle, ground beetle, and feather-winged beetle. The feather-winged beetle feeds on fungal spores. Immature grubs feed on decaying vegetables. Adult rove and ground beetles prey on snails, slugs, and other small animals.

Snails and slugs – Snails and slugs are mollusks that travel in a creeping movement. Snails have a spiral shell with a distinct head and retractable foot. Slugs do not have a shell and are somewhat bullet shaped with antennae on their front section. They feed primarily on living plant material, but they will also attack plant debris. Look for them in finished compost before using it as they could do damage to your garden if they move in.

Spiders – Spiders are eight-legged creatures and third-level consumers that feed on insects and small invertebrates. They can be very helpful for controlling garden pests.

Earthworms – Earthworms are the most important of the large physical decomposers in compost pile. Earthworms ingest organic matter and digest it with the help of tiny stones in their gizzards. Their intestinal juices are rich in hormones, enzymes and other fermenting substances that continue the breakdown process. The worms leave dark, fertile castings behind. A worm can produce its weight in castings each day. These castings are rich in plant nutrients such as nitrogen, calcium, magnesium and phosphorus that might otherwise be unavailable to plants.

Earthworms thrive on compost and contribute greatly to its quality. The presence of earthworms in either compost or soil is evidence of good microbial activity.

Key factors affecting the composting process

There are certain key environmental factors which affect the speed of composting. The organisms that make compost need food (carbon and nitrogen), air and water. When provided with a favorable balance, they will produce compost quickly. Other factors affecting the speed of composting include surface area/particle size, volume and temperature.

Food

Organic material provides food for organisms in the form of carbon and nitrogen. As described earlier, bacteria use carbon for energy and protein to grow and reproduce. Carbon and nitrogen levels vary with each organic material. Carbon-rich materials tend to be dry and brown such as leaves, straw and wood chips. Nitrogen materials tend to be wet and green such as fresh grass clippings and food waste. A tip for estimating an organic material's carbon/nitrogen content is to remember that fresh, juicy materials are usually higher in nitrogen and will decompose more quickly than older, drier, and woodier tissues that are high in carbon.

A Carbon:Nitrogen (C:N) ratio ranging between 25:1 and 35:1 is the optimum combination for rapid decomposition. If there is more than 35:1 carbon, heat production drops and decomposition slows. You may have noticed that a pile of leaves or wood chips will sit for a year or more without much apparent decay. When there is too much nitrogen, your pile will likely release the excess nitrogen as smelly ammonia gas. Too much nitrogen can also cause a rise in the pH level, which is toxic to some microorganisms.

The C:N ratio does not need to be exact. Values in Table 1 are calculated on a dry-weight basis. It is difficult to determine an exact C:N ratio without knowing the moisture content of the materials being used. Home composters seldom have the equipment or inclination to measure moisture content or worry about numbers. Blending materials to achieve a satisfactory C:N ration is part of the art of composting. A simple rule of thumb is to develop a volume based recipe using 3 parts carbon rich materials (Browns) to 1 part Nitrogen materials (Greens). A sample recipe would be three 30 gal bags of leaves with one 30 gal bag of green weeds and grass clippings.

TABLE 1
Carbon/Nitrogen ratios for selected composting materials

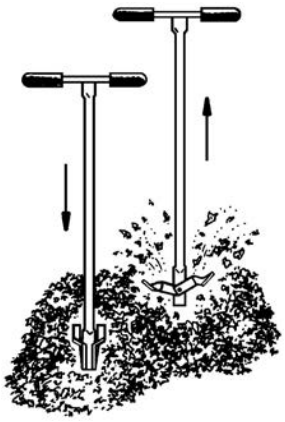
MATERIAL	C:N RATIO
Corn stalks	50-100:1
Fruit waste	35:1
Grass clippings	12-25:1
Hay, green	25:1
Leaves, ash, black elder and elm	21-28:1
Leaves, oak	47-50:1
Leaves, pine	60-100:1
Leaves, other	30-80:1
Manure, horse and cow	20-25:1
Paper	170-200:1
Sawdust	200-500:1
Seaweed	19:1
Straw	40-100:1
Vegetable waste	12-25:1
Weeds	25:1
Wood chips	500-700:1

Materials with a C:N ratio greater than 30:1 can be considered "Browns" while materials with a C:N ratio below 25:1 are considered "Greens."

Air

Proper aeration is a key environmental factor. Many microorganisms, including aerobic bacteria, need oxygen. They need oxygen to produce energy, grow quickly, and consume more materials. Aeration involves the replacement of oxygen deficient air in a compost pile with fresh air. Natural aeration occurs when air warmed by the composting process rises through the pile, bringing in fresh air from the surroundings. Aeration can also be affected by wind, moisture content, and porosity (spaces between particles in the compost pile). Compacting the pile reduces the pile's porosity and decreases air circulation. Porosity can be negatively affected if large quantities of finely sized materials such as pine needles, grass clippings, or sawdust are used. In addition, air circulation can be impeded if materials become water saturated.

Figure 3



Air movement in the pile can be improved with a few simple techniques. The easiest way to aerate a pile is to regularly turn it with a pitchfork or shovel. Turning will fluff up the pile and increase its porosity. Another option is to add coarse materials such as leaves, straw or corn stalks. Other options include using a compost aeration tool (Fig. 3 available from garden supply companies), or a ventilator stack (Fig. 4). Stacks can be made out of perforated plastic pipes, chicken wire wrapped in a circle or bundles of twigs. Ventilator stacks may be useful for large piles and should stick out of top or sides.

Moisture

Decomposer organisms need water to live. Microbial activity occurs most rapidly in thin water films on the surface of organic materials. Microorganisms can only utilize organic molecules that are dissolved in water. The optimum moisture content for a compost pile should range from 40 to 60 percent. If there is less than 40 percent moisture, bacteria slow down and may become dormant. If there is more than 60 percent, the water will block pore spaces stopping the movement of oxygen into the pile and suffocating the aerobic bacteria. Anaerobic bacteria will take over, resulting unpleasant odors.

The ideal percentage of moisture will depend on the organic material's structure. Straw and corn stalks will need more moisture than leaves, while food waste or grass clippings are not likely to need additional moisture. Since most homeowners do not have access to laboratory equipment used to measure moisture, a general rule of thumb is to add water to and mix materials so they are about as moist as a wrung-out sponge. Material should feel damp to the touch, with just a drop or two of liquid expelled when squeezed in your hand.

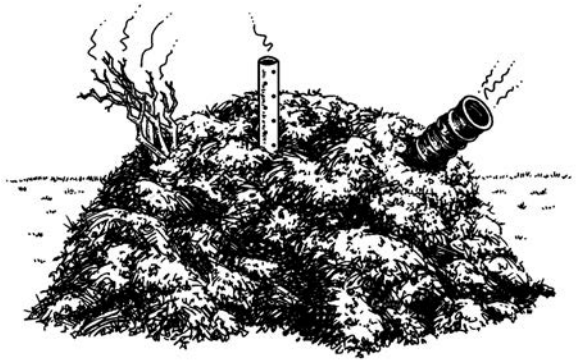
If a compost pile is too dry, it should be watered as the pile is being turned or with a trickling hose. Certain materials such as dead leaves, hay, straw, and sawdust should be gradually moistened until they glisten. These types of materials have a tendency to shed water or adsorb it only on the surface. If a pile is saturated with water, turn it so that materials are restacked. It may also help to add dry, carbon rich material.

Temperature

Temperature is another important factor in the composting process and is related to proper air and moisture levels. As the microorganisms work to decompose the compost, they give off heat, which in turn increases pile temperatures. Temperatures between 90° and 140°F indicate rapid decomposition. Lower temperatures signal a slowing in the composting process. High temperatures greater than 140°F reduce the activity of most organisms.

Outside air temperatures can impact the decomposition process. Warmer outside temperatures in late spring, summer and early fall stimulate bacteria and speed up decomposition. Low winter temperatures will slow or temporarily stop the composting process. As air temperatures warm up in the spring, microbial activity will resume. During winter months, compost piles can be covered with a tarp to help retain heat longer, but it is not necessary.

Figure 4



Novice composters and people interested in making a fast compost may want to track temperatures. The most accurate readings will come from a compost thermometer or temperature probe. Compost thermometers are

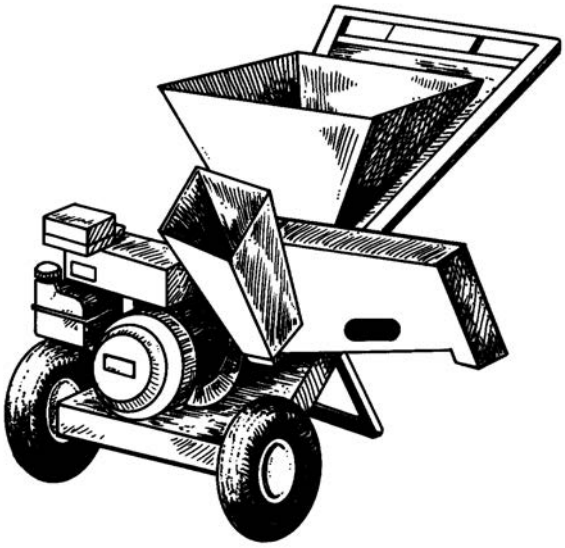
available from many garden supply companies. Another method for monitoring temperature is to stick your fist into the pile. You can also place a metal pipe or iron bar in the middle of the pile, periodically pulling it out and feeling it. If the bar or the interior of the pile feels uncomfortably warm or hot during the first few weeks of compositing, you'll know everything is fine. If the temperature inside the pile is the same as outside, it is an indication that the composting process is slow. You can increase activity by adding nitrogen rich materials and turning the pile.

Particle size

Particle size affects the rate of organic matter breakdown. The more "surface area" available, the easier it is for microorganisms to work because activity occurs at the interface of particle surfaces and air. Microorganisms are able to digest more, generate more heat and multiply faster with smaller pieces of materials. Although it is not required, reducing materials into smaller pieces will definitely speed decomposition. Organic materials can be chopped, shredded, split bruised or punctured to increase their surface area. Don't "powder" materials because they will compact and impede air movement in the pile.

For many yard trimmings, cutting materials with a knife, pruning shear, or machete is adequate. An easy way to shred leaves is to mow them before raking. You can collect them at the same time if your mower has a bag attachment. Another option is to use a lawn trimmer to shred leaves in a garbage can. Several different models of shredders (Fig. 5), and chippers are available for sale or rental to use in shredding woody materials and leaves. It is a good idea to wear safety goggles when doing any type of shredding or chopping activity.

Figure 5



Kitchen scraps can be chopped up with a knife. Some ambitious people use meat grinders and blenders to make "garbage soup" from their food scraps and water. They pour the mixture into their heaps.

Volume

Volume is a factor in retaining compost pile heat. In order to become self-insulating and retain heat, piles made in Wisconsin should ideally be about one cubic yard. The one cubic yard size retains heat and moisture, but is not too large that the material will become unwieldy for turning. Homes located on lakes or in windy areas may want to consider slightly larger piles e.g. 4'x4'x4'. Smaller compost piles will still decompose material, but they may not heat up as well, and decomposition is likely to take longer.

Summary

In this lesson, you've learned about the history of composting and the science of how it works. Now try to answer the **study questions**. They will help you remember what you've learned. The **study activities** will aid you in applying your knowledge. In the next lesson, Lesson 3, you will learn what materials can be composted and different methods that can be used.

Study questions
Lesson 2

1. Define what composting is.
2. Name at least three famous individuals living during the past five hundred years that recognized the value of compost as a soil amendment.
3. What microorganism is considered the most important of all decomposers and why?
4. What macroorganism is noted as the most beneficial one for your compost pile and why?
5. List six key factors that affect the composting process.

Answers can be found in the back of the study guide.

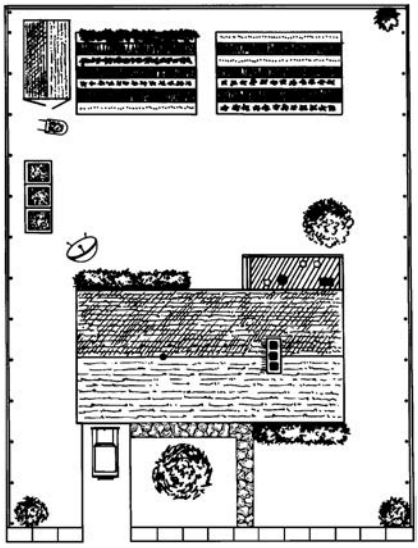
Study activities
Lesson 2

Decomposer hunt

If you have an existing compost pile, turn it with a shovel or pitchfork. Sift through the pile to look for macroorganisms. See how many you can find and identify based on the descriptions and drawings in this lesson. If you do not have a pile, you can try this exercise in a friend's compost pile, or you can look in your yard and garden under large rocks or items such as birdbaths, trashcans, etc.

Compost pile temperature monitoring

Consider starting a seasonal project to monitor temperatures in your compost pile. If you do this, you may be able to see the corresponding temperature and physical appearance changes that occur as you modify environmental factors such as food, air and water. You will need to purchase or borrow a compost thermometer. Use the chart provided on the next page to develop your own. You can start with an existing pile or build a new one. If the pile was constructed previous to winter, you can record changes in pile temperature as the weather warms up and you add new material. If you start this project with a new pile, you may want to initially record the pile temperature two or three times per week for first three weeks.



Lesson 2
Compost pile temperature monitoring
Record temperatures and other information about your pile on a weekly basis to see first hand, how your actions affect the composting phase. Make multiple copies of this sheet if necessary.

Week	**Date**	**Temperature**	**Pile height**	**Compost activity** **(Note materials used, turn, watering)**	**Notes on appearance**
Week 1 (sample)	*May 1*	*65°*	*3'*	*Built new pile of leaves, garden debris, food scraps, straw, added water*	*Leaves and garden debris mushy from overwintering*
Week					
Week					
Week					
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Master Composter

MATERIALS AND METHODS FOR COMPOSTING
Lesson Three

What's ahead
in lesson 3 of the home study course, you'll learn:

- about materials that can be added to compost piles;
- why some materials do not belong in your bin or heap;
- what compost additives can and cannot do for compost piles; and
- different methods that can be used for home composting.

What to compost

The materials you put into your compost pile have a major impact on how well the composting process works and the quality of the final compost. The key to good composting is to have a variety of materials and a balanced carbon to nitrogen ratio. Variety increases the types of microorganisms at work in your pile and your chances of obtaining nutrient rich compost. Some people think they don't have enough organic material to build and maintain a compost pile, but in addition to the leaves and grass clippings that we usually think of composting, there are numerous other suitable organic materials. Most of these materials are easy to find at home and as you read this chapter you will learn about the many materials that can be safely composted in your backyard. Many people who have had success making compost will seek out free or cheap local sources of materials to add to their pile to produce more compost.

In contrast to those who worry about having enough materials, some folks want to put almost any type of organic material into their pile. While anything organic will eventually decompose, it may not belong in a backyard composting pile. It is important to be aware of these materials and the reasons they should be avoided. New and potential composters often have questions about what materials can be composted. A list of some commonly available materials is included in Table 2. Compostable materials that need special handling are mentioned in Table 3. Materials that should be avoided are named in Table 4. (Note: The term "organic" as it is used here and throughout this manual refers to materials derived from living organisms.)

Commonly used compostable materials

As you are collecting materials around your yard and home, it may not be easy to determine if materials are higher in carbon or in nitrogen. Tables showing carbon to nitrogen ratios for particular materials are helpful but they usually only show a limited number of materials. A simple method (also described earlier in Lesson 2) for differentiating between materials is to remember that fresh, juicy materials are usually higher in nitrogen.

In addition, materials of animal origin (such as feathers, manure, blood meal) are typically higher in nitrogen. Drier, older, or woody vegetable and plant tissues are usually higher in carbon. The following table helps to illustrate this point. 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). Materials designated as other (O) do not affect the C/N ratio.

Before adding food scraps and lake weeds to our composting pile, check with your municipality to make sure that there are no restrictions on their use.

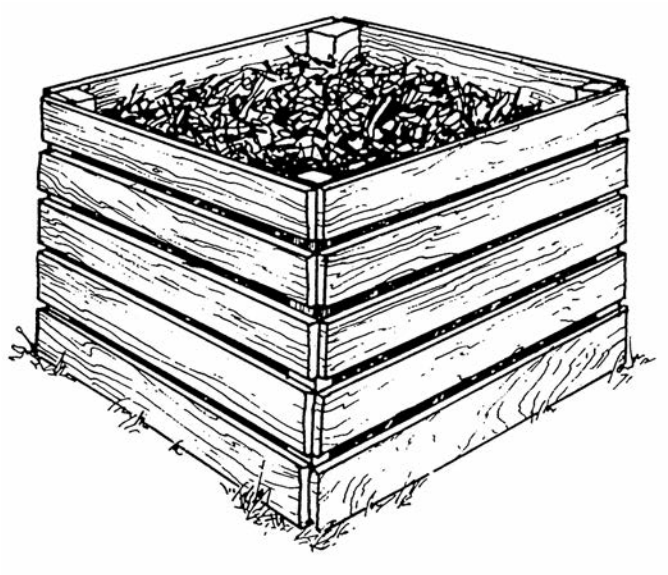


TABLE 2
Partial listing of compostable materials

MATERIAL	C/N	MATERIAL	C/N
Bedding, herbivorous Pets (except birds)	C & N	Hair	N
Blood meal	N	Hay	C
Bone meal	N	Lake weeds	N
Coffee grounds	N	Leaves	C
Crushed egg shells	O, alkalizer	Lint	N
Feathers	N	Manure	N
Fruit	N	Paper (non-recyclable)	C
Fruit peels and rinds	N	Peanut shells	C
Garden debris, fresh	C & N	Pumpkins	N
Garden debris, dried	C	Straw	C
Grass clippings, fresh	N	Tea grounds and leaves	N
Grass clippings, dried	C	Vegetable scraps	N

Compostable materials that require special handling

There are number of compostable materials that require a little special handling before they are put into a backyard pile. Some of the materials listed below may require extra preparation or they may need to be added in layers or small quantities. Other materials listed in Table 3 may cause difficulties with the composting process or negatively affect the final product. The comments are intended to help you decide whether to include these particular materials in your own pile.

TABLE 3
Compostable materials requiring special handling

MATERIAL	C/N	Comment
Apple pomace	N	High moisture content – spread on pile in thin layers
Cardboard (non-recyclable)	C	Slow to decompose – shred into small pieces.
Corn cobs and stalks	C	Slow to decompose – run through shredder or chop into very small pieces, mix with nitrogen rich material
Citrus rinds	N	Slow to decompose – chop into small pieces
Diseased plants	C or N	Diseases may be hard to eliminate. Sun bake plants in black plastic bag until thoroughly cooked, or leave in hot pile (131-140°F) for 2 to 4 weeks or omit from pile
Grass clippings with chemicals	N	Most pesticides degrade in 3-12 months. Leave clippings on lawn for 2-3 weeks (best) or add direct to pile if materials composts for at least 12 months. Do not use grass or weeds treated with Clopyralid or Picloram, such as Confront, Stinger, Hornet, Tordon or others with these chemicals. Very low levels remain in compost that damages certain plants. (Do not use clippings as garden mulch for 2-3 weeks after treatment.)
Hedge trimmings	C or N	Slow to decompose – thin layers of hedge trimmings can be used occasionally to increase pore space; chop twigs and branches into small pieces
Lime	O, alkalizer	Changes pile chemistry, causes nitrogen loss in the form of ammonia, too much lime hurts bacteria and other microorganisms – omit from pile or use very sparingly in thin layers if pile is going anaerobic (do not mix with manure)
Nut shells – walnut, pecan	C	Slow to decompose – pulverize with shredder
Paper, glossy colored	C	It is better to put glossy magazines and inserts into your paper recycling bin. But if added to the compost bin remember glossy paper is typically coated with clay and may be slow to decompose
Peat moss	C, low in nutrients	Highly moisture absorbent, slow to decompose – mix thoroughly with other materials, add in small quantities. If possible, soak peat moss in warm water before adding to pile
Pine cones	C	Slow to decompose – shred or chop into very small pieces
Pine needles	C	Slow to decompose – mix thoroughly with other materials, add in small quantities: 5-10% of materials
Quackgrass	N	Omit from pile unless Quack is sun baked in black plastic bag until thoroughly cooked
Rhubarb leaves	N	Contains oxalic acid but since compost piles are typically well buffered minimal impact occurs – add in small quantities, mix thoroughly with other materials

TABLE 3
Compostable materials requiring special handling (continued)

MATERIAL	C/N	Comment
Sawdust	C	Slow to decompose, can negatively affect aeration – work into pile in thin sprinklings; mix with nitrogen rich materials; omit any treated lumber sawdust
Soil	O, activator source	Can make finished compost heavy – add small quantities in thin layers as soil activator or omit from pile (finished compost produces the same results and typically weighs less)
Sod	N	Slow to decompose – break into small clumps, mix thoroughly with other materials or cover top of the pile with roots up, grass down (better in fall) or compost separately with roots side up, water thoroughly, cover with a dark tarp
Walnut leaves	C	Contain juglone which can be toxic to plants – mix thoroughly with other materials, toxin will biodegrade in two to four weeks according to an Ohio State University study
Weeds, pernicious	C	Rhizomatous root system hard to kill – sun bake in plastic bag until thoroughly dried or omit from pile
Weeds, other	N	Weed seeds hard to kill – best to use when green and no see heads present or leave in hot pile (131-140°F) at least 1 week
Wood chips	C	Slow to decompose can improve aeration, shred or chop into smaller pieces if possible; mix with nitrogen rich materials; omit any treated lumber chips – landfill instead

Organic materials to avoid

Someday when your compost pile has shrunk and looks disappointedly small, you may scour your yard and home for organics to add to it. Some of those materials do not belong in your backyard compost pile. Table 4 lists materials to avoid along with the reasons for omitting them.

TABLE 4
Materials to avoid putting in a home compost pile

MATERIAL	Comment
Bones	Very slow to decompose, can attract pests
Cat Litter	May contain pathogens harmful to humans *Toxoplasma gandi* or *Toxocara cati*, may also contain chemicals to perfume litter
Charcoal and briquettes	Contain sulfur oxides and other chemicals (to assist ignition) that are toxic to soil and plants
Cooked food waste	May contain fats which can attract animals
Dairy products	May smell, and attract pests (butter, cheese mayonnaise, salad dressing, milk, yogurt, sour cream)
Dishwater	May contain grease, perfume and sodium from dish soap and food residue
Fatty, oily, greasy foods	May putrefy and smell bad, attract pests
Fish scraps	Can attract pests, smells bad during decomposition
Meat	Can attract pests, smells bad during decomposition
Peanut butter	Can attract pests, slow to decompose

TABLE 4
Materials to avoid putting in a home compost pile (continued)

MATERIAL	Comment
Pet wastes, human excrement	May contain pathogenic bacteria, viruses, and parasites that require prolonged high temperatures to be destroyed
Treated woodchips & sawdust	Landfill, do not compost or use as mulch
Wood ashes	Changes pile chemistry, can cause nutrient imbalance - omit from pile

Compost additives

There is a wide array of compost inoculants, starters and activators sold in stores and mail order catalogs. Some types of activators can also be found at home. Sorting out the claims and benefits of compost additives can be a little overwhelming for first-time composters. Fortunately, compost additives are not required for successful composting. In some situations, certain additives can be helpful.

Inoculants generally contain special cultures of dormant bacteria and fungi. The theory behind using them is that they are supposed to introduce microorganisms, hasten the breakdown of materials in a compost pile and produce a better product. They are rarely needed because leaves, kitchen scraps, finished compost and other organic materials already contain ample bacteria that work readily on their own.

Commercial "starters" or accelerators are supposed to help the decomposition process by adding nitrogen, enzymes, and bacteria to a pile. Some people feel better putting these products in their piles, but independent tests conducted to date have not shown significant benefits. Tests conducted at University of Wisconsin-Stevens Point and Rodale Research Center showed that the best compost additives are finished compost or topsoil from your yard. (Store bought soil is sometimes sterilized so it does not always add microorganisms.)

Activators contain a nitrogen source. Activators include organic types (manure, blood meal, finished compost, soil) and artificial types (chemically synthesized compounds such as commercial nitrogen fertilizers). While activators are not necessary for successful composting, they can sometimes help if a pile is made from materials low in nitrogen. Nitrogen is usually the limiting nutrient in a pile that doesn't heat up or decay quickly enough. Some purists do not recommend using commercial nitrogen fertilizers as an activator, but if you have some readily available, it may be helpful. Avoid using ammonium sulfate as it may be toxic to earthworms. Keep in mind that chemical fertilizers are not as effective as organic sources because they contain no protein (which micro-organisms use). Organic sources are better sources of nitrogen if you need to add an activator.

If additional nitrogen is needed, apply approximately 0.15 pounds actual nitrogen per 3 bushels (3 3/4 cubic feet) of carbon rich materials such as leaves. Table 5 lists estimated amounts of various nitrogen sources to add. For example, 7 ounces (about 1 cup) of ammonium nitrate is equivalent to 0.15 pounds. Authors of *The Rodale Book of*

Composting recommend adding 2 to 3 pounds of organic nitrogen supplement (blood meal, manure, bone meal, alfalfa meal) per 100 pounds of low nitrogen materials (e.g. straw, sawdust).

TABLE 5
Amounts of various nitrogen sources needed to apply 0.15 pounds (2.4 oz) Nitrogen

NITROGEN SOURCE	% NITROGEN	OUNCES TO APPLY
Ammonium	33	7.0
nitrate	15	16.0
Calcium	46	5.2
nitrate	12	20.0
Urea	10	24.0
Dried blood		
Fish meal		

Source: Dickson, et. al. 1991

Composting methods

Answering the question, "How should I make compost?" is rather like answering the question, "How can I bake a cake?" It depends on what your objectives are, what materials and equipment you have to work with, and how much effort you are willing to put in. Source: Stuart B. Hill, Ecological Agricultural Projects

The secret to successful composting is to select an approach and technique that suits your needs and lifestyle. Your choice will depend on a number of factors such as how much space you have available, what materials you have, what you want the compost for, how much time you want to spend, and how neat you want your compost pile to look. For example, if you only need a little compost, want to expend minimal effort, and have a small area to do it in; your best choice might be a commercially available bin. If you have plenty of space, and want large quantities of compost quickly, you may want to build a deluxe three-bin unit. If you want to compost food waste separately, you may find it easiest to directly incorporate them into the soil. This lesson will cover five methods of composting: holding units, turning units, heaps, sheet composting, and soil incorporation. Other composting alternatives such as leaving grass clippings on the lawn, mulching, and vermicomposting (worm composting) are discussed in a later lesson.

You can make compost above the ground in bins, boxes, garbage can, bags, barrels or piles. You can make compost on the ground in rows. You can make compost below the ground in pits, trenches, or holes. You can make compost inside, outside, on a balcony, a deck or in a garage.
Source: Mark Cullen and Lorraine Johnson, Urban/Suburban Composter: The Complete Guide to Backyard, Balcony, and Apartment Composting

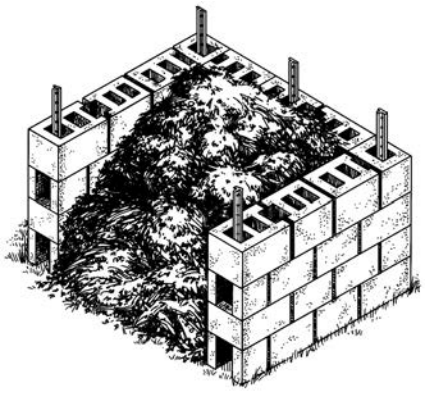
Holding units

Holding units are bins used to hold yard and kitchen materials until composting is complete. They need relatively little maintenance and some models can be used by apartment dwellers for composting on balconies. Non-woody materials can be added to a holding unit as they are generated. (Many of the commercial one-bin systems sold in stores and mail-order/internet catalogs are holding units.) Using a holding unit is one of the easiest ways to compost, but is generally slower. This type of enclosure makes it difficult to turn the heap as a way of getting oxygen in. No turning is required, but the lack of aeration causes the composting process to take up to two years.

The process can be hastened by using portable bins. Some lightweight units are designed to be taken apart and easily moved. These units can be removed from an existing heap and transferred to an adjacent location. The heap is then turned back over into the unit, mixing and aerating materials. Portable units can be purchased (usually plastic) or constructed from circles of wire fencing or hardware cloth, snow fencing, or wire framed in wood.

Other folks attempt to improve aeration in holding units by adding one or more ventilating stacks, by poking holes into the pile or by moving the bin to the side and transferring materials to the empty moved bin. Ventilating stacks need to be placed into the center of the bin prior to making a pile. Stacks can be made of perforated pipe, a cylinder of wire mesh or even a bunch of twigs loosely tied together. PVC pipes should be at least 1 inch in diameter with holes drilled randomly along the length. They can be inserted vertically or horizontally. Another alternative to improve aeration is to place the holding unit on a wood pallet or a bed of small branches.

In holding units, stages of decomposition will vary from the top to the bottom of the heap since yard trimmings and other organics are added continuously. Typically, the more finished compost will be found near the bottom of a pile. Finished compost at the bottom can be removed and used. How easily one gets to the finished compost depends on the type of bin used. Some holding units are designed with a removable front or small doors at the bottom of the bin. With portable bins, finished and unfinished compost can be separated using a similar method to the one described above. The portable bin should be removed and set nearby. Less decomposed materials from the top of the pile can be put into the empty unit until finished compost is uncovered. More effort is required for heavy or permanent holding units without removable doors. Unfinished compost must be removed and placed in an adjoining unit or temporary storage container. If you have room, it is helpful to have two or three stationary units. One bin can be used for fresh organics, another for maturing materials, and possibly, a third for finished compost.



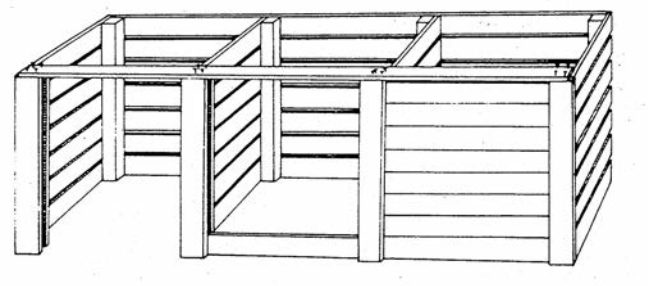
In addition to the portable bins mentioned earlier, there are numerous other types of commercial and home-built units. Stores and mail order catalogs typically sell units made from plastic and occasionally, wood. Home-built units can be constructed from pallets, lumber, hardware cloth, tires and plastic or metal barrels, among other materials. Some people like the appearance of permanent

structures, which can be made from landscape timbers, concrete blocks, rocks or bricks. Descriptions of commercially available bins and detailed plans for building composting units are available in a series of fact sheets available per the listing at the end of this lesson.

If you plan to build a wood composting unit, avoid using lumber treated with chromated copper arsenate (CCA), alkaline copper quant (ACQ), creosote and other rot inhibiting treatments. (You should also avoid using treated lumber around vegetable gardens.) Toxic compounds from the wood preservatives could leach into your compost. The compounds are harmful to humans and pets. They have been shown to cause cancer and skin and eye irritations. Use wood that is naturally resistant to decay such as cedar or untreated pine. Structures built from pine will probably have to be replaced within a few years. By then, you may be ready for a multiple bin unit or a new design.

Turning units

Turning units are systems designed to turn or aerate. These units make compost faster than unturned holding units because the aerobic bacteria multiply with more oxygen and can breakdown more organic materials. One type of turning unit is a bin that can be taken apart, moved empty, so that the composting material can be transferred back to the empty bin. Other types are a series of bins, a rotating drum or rolling ball. Compost can be made in 3 months (including aging time) when organic materials have a good C:N ratio, proper moisture and are turned on a regular basis (every 5-7 days). Frequent turning not only makes compost faster, but it also yield higher temperatures (130-140°F) that kill major disease organisms, fly larvae and weed seeds. These higher temperatures also provide a good environment for the most effective decomposer organisms.



Turning systems typically cost more than holding units. Home built units may also take more effort to build. Turning units may be difficult for people with back and limited strength issues. However, some barrel units are designed for easier turning and maintenance. These systems may actually be easier to use than holding units for older or physically challenged composters. Barrel units tend to have smaller capacities than most other bins, which make them better suited for people with small amounts of yard trimmings and food scraps.

Materials need to be carefully prepared and added to turning units in stockpiled batches. Materials should be saved until there is enough to fill one bin of a multiple unit, or to fill a barrel unit to the prescribed level. Food wastes can be accumulated in a pest-proof container such as a plastic, five-gallon bucket. If necessary, sawdust can be added to the top of each day's scraps to reduce odor.

Heaps

Heap composting is similar to composting with holding and turning units except that it does not require a structure. Recommended dimensions for

a heap are 5 feet wide by 3 feet high. Length can vary depending on the amount of materials used. Heaps take more space due to gravity. The wider width will help the pile retain heat better. Materials can be added as they are generated or they can be sorted until enough are available to make a good sized heap. During fall months, making a good sized heap will help the composting process work longer into the winter season. Ideally, two heaps are better than one. When the first heap is large enough, it should be allowed to compost undisturbed. A second heap can be started with new materials.

Turning a heap is optional. The composting process will obviously take longer if the pile is not turned. Food scraps should not be thrown on an unturned pile because pests are likely to be attracted. Woody materials may also pose a problem. If woody materials are not cut up into small pieces, the pile may tend to become more of a brush pile than a composting pile. A woody pile decomposes extremely slowly, usually over a period of several years, and can become huge quickly.

Sheet composting

Sheet composting is a way to obtain the benefits of decayed organics material without building a composting pile. Sheet composting involves spreading a thin layer of organic materials, such as leaves, over a garden area. The materials are then tilled in with a hoe, spade, garden fork, or rotary tiller. Leaves, garden debris, weeds, grass clippings, and vegetative food scraps are examples of materials that can be easily tilled into the soil. To aid decomposition, materials should be shredded or chopped prior to layering.

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

To ensure adequate decomposition of organic materials before planting, it is best to do sheet composting in the fall. Spread a 2-to 4- inch layer of organic materials on the soil surface and till in. A rotary tiller will do the most thorough job of working materials into a vegetable garden. In a flowerbed containing perennials and bulbs, it may be necessary to carefully work the organic material in with garden fork or hoe.

Soil incorporation

Soil incorporation is also known as pit or trench composting. Organic materials are buried into the soil well below ground surface. With time, materials break down to fertilize future planting in your garden. This method is simple and well suited for composting non-fatty food wastes. The decomposition process uses anaerobic bacteria, so it is generally slower than other methods. Decomposition can take up to a year, depending on the soil

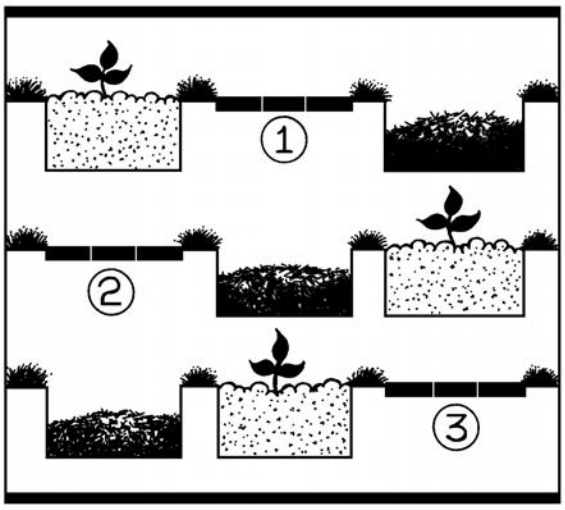
temperature, the number of organisms in the soil, and the carbon content of the materials. Soil incorporation works best for people with large garden areas. It is advisable to wait a year before planting over areas where food scraps or other materials have been dug in to avoid the possibility of nitrogen borrowing from plants and ensure complete decomposition.

There are different ways to do soil incorporation. With all techniques, the hole should be dug at least 8 inches down, preferably 12- to 15- inches deep. Burying to this depth discourages animals from digging up the organic materials should be mixed with soil from the hole. After placing them in the ground the hole should be covered with the soil dug from it.

Some folks like to use a posthole digger to quickly dig a spot for incorporation. Other people like to set up a rotational trench system. A vegetable garden can be organized around a three-row, three-year rotation. As shown in the diagram, initially, you use the first row for planting, the second row is a path, and the third row is for composting. During the second year with this system, the first row becomes the path and the second row becomes the new trench for composting, and the third row becomes the planting area. In the third year, the first row is used for composting, the second for planting, and the third for a path. If this cycle is continued, you'll always be planting in fertile beds.

Summary

In this lesson, you've learned about organic materials that can be used for composting, including some that need special attention. You have also learned why certain materials should not be added to a pile, and about compost additives. The final part of the lesson covered five methods that can be used for home composting. Now answer the **study questions** and do one or more of the **study activities** to apply your new knowledge. In the next lesson, Lesson 4, you will learn about building and maintaining compost piles.



Study questions
Lesson 3

1. Why is it good to use a variety of organic materials in a compost pile?
2. Describe a simple method for determining whether a material is higher in carbon or nitrogen.
3. List four compostable materials that some folks may prefer to leave **out** of a home compost pile because of potential problems they could cause.
4. Describe why cat litter and other pet wastes should not be put into a compost pile.
5. List the five methods of composting covered in the lesson.

6. Which composting method is likely to produce finished compost the most quickly.

Answers can be found in the back of the study guide.

Study activities
Lesson 3

Compost pile candidates

Develop a list of compostable materials that you generate in your yard and home. If you currently have a compost pile, start the list with those materials. See if you can find at least 10 different items to put in your pile. Note if the materials are available seasonally, whether they might be higher in nitrogen or carbon, and estimate potential quantities. Keep this list handy for quick reference throughout the year.

Finding supplemental materials locally

As mentioned in the lesson, occasionally composters may look for free or inexpensive sources of compostables to increase the variety of materials in their pile. Consider using the chart provided on the next page to make a list of materials readily available in your community. Include sources, quantities and costs, if applicable. This information can be shared with others as you perform Master Composter outreach duties.

Compost bin research and field trip

One of the biggest hurdles for people that are thinking about composting is acquisition of a compost bin. People want to know what kinds of bins are available locally and/or through web based orders. They may prefer commercially built bins or they may hope to construct or acquire a home-built bin. You can help make their task easier by doing some research on bins available in your community.

First, if you have not already done so, check to see if your municipality sponsors any type of compost bin distribution program. A growing number of Wisconsin local governments are subsidizing the cost of compost bins for their residents.

Next, make a list of stores in your community that are likely to sell compost bins. Many stores sell bins on a seasonal basis during the spring and summer months. To save time, you may want to first contact the stores by phone to inquire whether they sell one or more types of bins. Visit the stores that sell composting bins, and record information such as the brand, type of bin, size and cost. Use this information as a handy reference when doing outreach activities. You may want to type up the information to use as a handout.

Other Resources

Fact Sheets are available at:
http://learningstore.uwex.edu

- Compost bin plans for:
  - Barrel composter
  - Can composter
  - Concrete-block compost bins(s)
  - Wire mesh compost bin
  - Wood 3-bin compost unit
  - Wood and wire compost bin
- Making and using compost in the garden

Lesson 3

Finding supplemental materials locally

Research different sources of compostable materials available in your community. Consider stores, riding stables, farms, orchards, beauty salons, and sawmills, among numerous other possibilities.

Compostable material	Source(s)	Quantity available	Cost	Availability e.g. always, fall	C/N content

Master Composter

MAKING AND MAINTAINING A COMPOST PILE
Lesson Four

What's ahead

In lesson 4 of the home study course, you'll learn:

- how different seasons affect compost pile construction and activity;
- what factors to consider when selecting a composting site;
- fast and slow methods for making compost;
- common composting problems and possible solutions;
- why compost pH changes during decomposition; and
- about some health considerations associated with home composting.

When to start a compost pile

In Wisconsin, compost piles can be built in spring, summer or fall. Spring and summer are good times to start making compost in earnest because of the wide availability of nitrogen-rich materials such as weeds, prunings, and grass clippings. They can be combined with shredded leaves stored from the fall and other organic materials from spring yard clean-up. Composting activity will be at its height during summer months, especially if care is taken to keep the pile aerated and moist. Depending on the composting method used, piles started in the spring and early summer can yield compost by fall. Fall is an ideal time for using large amounts of compost.

Compost piles can also be successfully started in the fall. The composting process will take longer due to cool temperatures and finished compost is not likely to be ready until the following spring or summer. If large quantities of leaves are used in constructing the pile, nitrogen-rich materials must be added to "jump start" or balance the C:N ratio. Additional options to manage large volumes of leaves include using them as mulch around trees and shrubs or sheet composting them in garden areas. Save fall leaves to cover kitchen scraps in winter each time they are added to the pile and to have as a carbon source in summer. It's hard to find brown leaves in July.

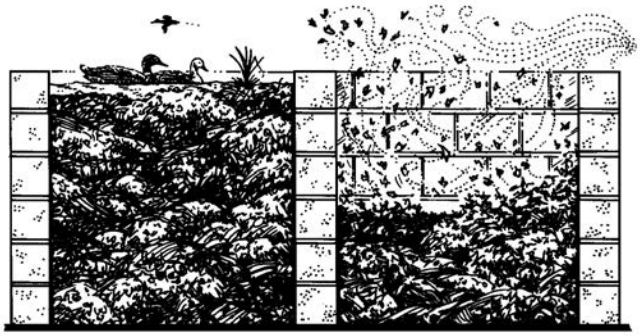
People often wonder what happens to compost piles in the winter. Decomposition slows down and in many piles, it actually stops during very cold temperatures. Some compost piles, particularly smaller ones, will freeze. The freeze/thaw cycle helps to break down the cellular structure of materials. When spring comes, bacteria will have more surface area to work on, and the pile will heat up again, even if it has been

completely frozen during the winter. If desired, you can prolong composting activity during cool months by adding nitrogen-rich materials such as manure and by placing insulating materials around the pile. Bales of straw and hay or layers of leaves can be used around the sides of a bin. The top can be covered with additional straw, leaves or a plastic tarp. Don't aerate your pile in the winter because turning or poking air holes in the pile will allow heat to escape.

Adding food to a compost pile during the winter can be tricky. As mentioned earlier, decomposition occurs at a much slower rate, and the pile may end up partially or totally frozen. If volumes of food scraps are continually added throughout the winter, the pile can turn into a soupy mess by springtime. To avoid problems such as odors and pests, food scraps should only be added to a compost pile during the winter if the pile meets the following guidelines:

- Is at least one cubic yard in size
- Contains plenty of carbon-rich materials to balance the food scraps and to cover the scraps after they are added (maintain C:N)
- Materials will be turned and mixed when warmer weather arrives

If food is added, it should be buried into the pile at least 8 inches deep. It may help to have containers of shredded leaves nearby to use for covering food waste additions during the winter. Vermicomposting (worm composting) provides an alternative method for handling food scraps inside your home during the winter or year round. Vermicomposting is covered in more detail in a later lesson.



Where to compost

A well-chosen composting site can help speed up the composting process, make it easier to care for the pile, and perhaps even motivate neighbors to start composting. There are several factors to consider when selecting a composting site including access to materials and water, sunlight, drainage, convenience, and neighbors, among others.

The first step in selecting a site is to find out if there are local regulations pertaining to composting. Your municipality may have a setback ordinance requiring composting bins to be located a certain distance from lot lines. Next, you should consider the following physical factors:

- Good drainage in the soil below the pile
- Fairly level ground – avoid depressions
- Protection from strong winds
- Convenient access to a water source e.g. reachable with a garden hose
- Space for temporary storage of organic materials
- Adequate room in front of the pile for easy access – room on two or more sides is even better

Compost piles can be put in sunny or shady areas. Direct sunlight in the summer tends to dry piles out, especially in bins made of wire and/or wood. During winter months, however, piles in sunny locations will benefit from the

sun's heat. Although piles in the shade do not benefit from the sun's rays, they will heat up just fine with a well-balanced mix of materials. If possible, locate compost piles in direct contact with bare ground to give microorganisms and earthworms maximum opportunity to find their way into the compost. Some people like to put a pallet that acts as an aeration mat at the bottom of their pile to provide passive airflow from underneath the pile. For better results, place the pallet or mat on bare ground. If composting is done on apartment balconies or patios e.g. in tumblers, it may be wise to put plastic sheeting underneath to prevent compost from staining wood or stone. Finished compost or a few handfuls of soil can be used to increase the number of microorganisms in the compost.

Avoid putting compost piles against wooden building or trees – wood in contact with compost may decay. Other things to avoid include dripping eaves or downspouts which can dump uncontrollable amounts of water. Try to keep your bin away from your neighbor's outdoor entertaining areas. If you run into a problem (hopefully temporary) with odor or flies, your compost pile will be less offensive while you're correcting the problem.

People have different views about the visibility of compost piles. Some folks believe that piles should be "hidden' in out-of-the-way places, while others don't mind having the bin in full view. Give some thought to the aesthetics of the composting system you select and how your neighbors might view it. Hopefully, you will set a good example so that you can educate others about the benefits of composting.

Making a compost pile

Compost piles can be constructed as materials become available or by adding stockpiled material in batches. Many times aspiring composters will ask for a recipe. There are a variety of recipes that will produce excellent compost. Two basic composting recipes are described on the next two pages. The major difference between the recipes is the amount of time and attention required.

Hot and fast compost
This compost should be ready in approximately six to twelve weeks.

Tools:

- Pitchfork or shovel
- Rake
- Equipment for chopping and shredding e.g. hand pruners, machete, loppers, rotary lawn mower, chipper/shredder
- Water hose with spray head
- Tarp for mixing (optional)
- Compost bin unit that allows easy pile turning, ideally 3' x 3' x 3'
- Scrap of black plastic or compost bin lid to help retain moisture
- Compost pile thermometer (optional)

Ingredients:
Assemble enough of the following ingredients to fill your bin.

- 2-3 parts of nitrogen-rich material ("greens")
- 3-4 parts of carbon-rich material ("browns")
- Water
- Compost activator – nitrogen source, preferably organic, if needed

Instructions:

1. Chop or shred coarse materials larger than 1/2" in diameter or 2 inches in size to increase surface area and speed up decomposition. Leaves will break down more quickly if shred with a rotary lawn mower or shredder.
2. If desired, place a pallet or aeration mat on the bottom of the composting bin to help aerate the pile from underneath. Hardware cloth can be nailed to the pallet to keep material from falling through gaps between the pallet boards.
3. Lay a 4 to 6 inch layer of carbon-rich material in the bin or on a tarp.
4. Add a 4 to 6 inch layer of nitrogen-rich material.
5. Mix layers with a garden fork or shovel. Consider the porosity and moisture content of the pile. If dense materials are used such as manure or wet leaves, add dry, bulky items such as straw or chopped corn stalks. Add more water if the pile is not as damp as a wrung out sponge. Squeezing a handful of the material should yield one or two drops of water. If you are using a tarp for mixing layers, empty the materials into your bin after mixing.
6. Repeat steps 3-5 until the pile is 3-4 feet high. Piles larger than 5 feet tall and wide tend to compact and need to be turned to keep their centers from going anaerobic. Food scraps should be added to the third or fourth layers, and should be buried at least 8-12 inches down from the top of the pile. Sawdust, leaves, straw, or compost can be placed on top of the foods scraps to help adsorb odors.
7. If desired, add a small amount (up to 1/2 shovelful) of finished compost or soil to the compost pile to help introduce microorganisms to the pile.
8. Within a few days the pile should begin to heat up. Monitor the temperature carefully. After the pile has heated and starts to cool (about one week), turn it. Move materials from the edge and top of the pile into the middle. Add water if needed. Turn the pile sooner if the temperature goes above 140°F or if some of the inner material looks whitish.
9. During the first few weeks of composting, the pile temperature should continue to be hot. Turn the pile when the temperature surpasses 140°F in order to cool it off. If the pile goes above that temperature, many beneficial microorganisms will die. More nitrogen or water may be needed if the pile does not reach at least 120°F by the second week. At the second turning (about one week after the first), the material should start turning coffee-brown in color and be uniformly moist.
10. Activity in the pile will slow down after microorganisms utilize the easily decomposable material. Less heat will be generated and the pile will begin cooling off. Turn the pile periodically to ensure adequate aeration (no more than once a week). As the composting process continues, the pile will eventually reduce to about 1/3 of its original height. The finished compost should look like dark, crumbly soil mixed with small unrecognizable pieces of organic material. It should have a sweet, earthy smell. The pile temperature should be within 10°F of ambient air temperature.
11. Let the unfinished compost cure for at least three weeks before using, longer for seedlings and transplants. If compost is not cured long enough, it can be toxic to plants, especially young ones. Unfinished compost will also temporarily rob soil of its nitrogen which can harm plants

Cool and easy compost

This compost will be ready in 6 months to 2 years.

Tools:

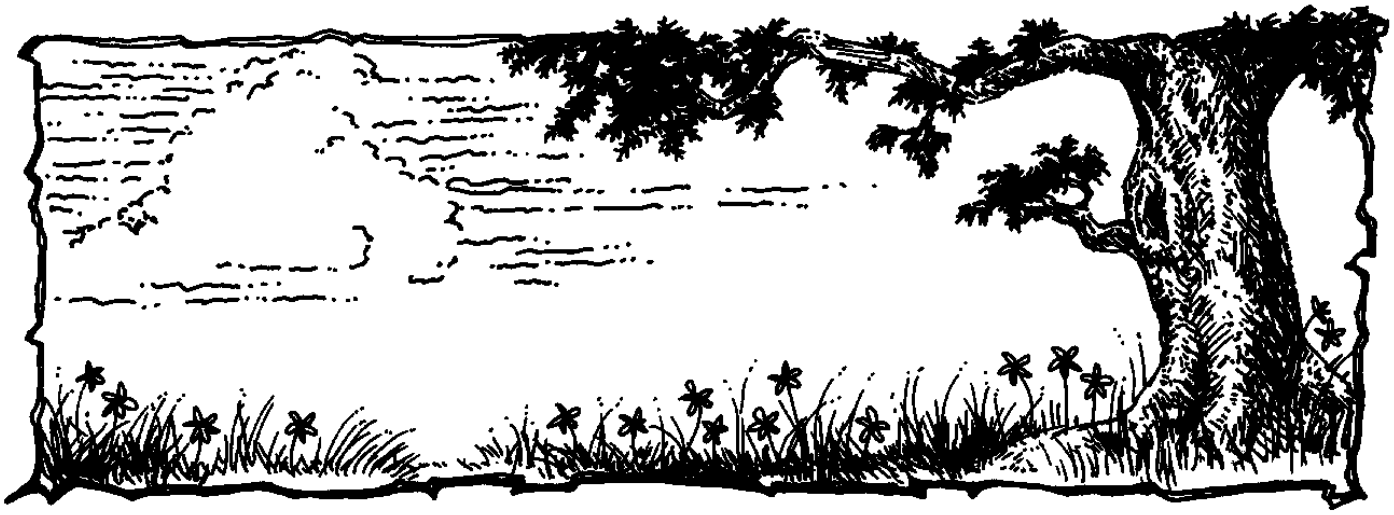
- Pitchfork or shovel
- Equipment for chopping and shredding
- Water hose with spray head
- Compost bin (optional)
- Scrap of black plastic or compost bin lid for covering pile (optional)

Ingredients:

- Mixed yard trimmings as available: leaves, garden debris, weeds without seeds or spreading roots, grass clippings, small pruning
- Vegetable scraps
- Other handy compostable materials that are unlikely to attract pests
- Nitrogen source, preferably organics, if needed

Instructions:

1. Locate compost bin or heap in an area where it will get rained on, preferably out of direct summer sunlight.
2. Place yard trimmings in the bin or pile as collected in yard clean-up or mowing. Moisten dry materials as they are added. Mix grass clippings, pine needles (up to 10 percent) and other similar materials with leaves or composting materials already in the pile.
3. Chop or shred any yard trimmings over 1/2 inch in diameter or 2 inches, in size, especially if adding large amounts.
4. Bury vegetable scraps under 8 to 12 inches of yard trimmings or finished compost.
5. If the pile has tendency to dry out, cover the top with black plastic or a compost bin lid. Add water as needed to keep pile about as damp as a wrung out sponge. Water will infiltrate the pile better if it is added in combination with turning.
6. Periodically check the compost pile to monitor the decomposition process. If possible, turn the pile at least two or three times per season. Material at the bottom of the compost pile will look like dark, rich soil in approximately six months to two years. Time to finished compost depends on the material composted and the amount of pile maintenance done. Removal of finished compost will vary depending on the type of compost unit used, if any. Undecomposed materials should be added to an existing or new compost pile.



Troubleshooting: Problems and solutions

Most composting problems are fairly easy to fix. They tend to fall into three broad categories: slow decomposition problems, odor problems and pest problems. The trick is learning how to read the symptoms and experimenting with solutions. All problems are related to compost process factors such as the size and types of materials you put in your pile, moisture level and aeration. If you are having a problem, it means that one or more of these factors are out of balance and needs to be adjusted. The following tables show symptoms, possible causes and possible solution or alternatives.

TABLE 6
Problem: Slow composting

Symptom	Possible cause	Possible solution/alternative
Compost pile is damp and warm in the middle, but nowhere else	The pile may be too small	Gather enough material to form a pile 3x3x3 and cover the top
Compost pile is not heating up.	If the pile seems damp enough, it may be a lack of nitrogen.	Mix in fresh grass clippings, manure, blood meal or other material high in nitrogen. If it is difficult to turn the pile create holes in the pile and add the nitrogen-rich material.
	Not enough oxygen	Turn or fluff the pile.
	Cool weather	Increase pile size and/or insulate it with straw or a tarp.
	Compost needs more microorganisms	Mix in finished compost (best) or up to a half shovelful of garden soil.
	Compost may be finished	If it looks dark and crumbly, smells earthy (not moldy or rotten), and feels finished—it may be done. Use it?
Compost pile is dry throughout	May be lack of water	Turn the compost and add water. Moisten new materials before adding to the pile. If the pile is out in the open, considering covering it with a tarp or plastic cover. The pile should be damp as a wrung out sponge.
Matted, undecomposed layers of leaves or grass clippings	Compaction, poor aeration	Break up layers with a pitchfork, or shred them and rebuild the pile. Avoid adding heavy layers of leaves, grass clippings, hay or paper unless first shredded.
Large, undecomposed items	Size and composition of materials	Screen out undecomposed items, reduce size if necessary, and use as starter for next pile.

TABLE 7
Problem: Odors

Symptom	Possible cause	Possible solution/alternative
Compost pile has a bad odor like a mixture of rancid butter, vinegar and rotten eggs.	Not enough oxygen—too wet	Turn the pile and add coarse dry materials such as leaves, straw, or chopped corn stalks to soak up excess moisture. Protect the pile from rain.
Compost pile has a bad odor like ammonia.	Pile may contain too much nitrogen.	Add materials high in carbon such as shredded leaves, wood chips, sawdust, or shredded newspaper and aerate.

TABLE 8
Problem: Pests

Symptom	Possible causes	Possible solution/alternative
Compost pile is attracting rats, raccoons, dogs, or other pests.	Inappropriate food scraps may have been added—meat, fat, bones, or other animal wastes	Avoid adding inappropriate materials. Bury non-fatty food scraps 8–12 inches deep in the pile. Cover with sawdust, leaves, or compost to help absorb odors. If problems persist with animals, use a rodent-resistant bin with a top, bottom, and sides. Bins built with side and cover openings less than 2 inches will discourage raccoons, skunks and other large animals. Where rats are a problem, use hardware cloth with openings 1/2 inch or less to enclose the bin.
Compost pile contains flies earwig, slug, and/or other insects.	Pile is composting correctly. Insects are a good sign of a productive compost pile	If there is an over abundance of flies, add a thin layer of soil over food scraps. Flies love damp hay or straw; turn and mix hay or straw with other materials in the pile. Slugs and earwigs are happy in compost piles. If the pile is next to a garden, barriers can be placed between the pile with traps, metal flashing, etc.

Compost pile pH

Occasionally, composters will become concerned about the pH of their compost pile, particularly during the initial stages of decomposition. The term pH" describes the alkalinity or acidity of soil, compost, and other substances and is usually expressed as a number. The pH scale runs from 1, indicating pure acidity, to 14, which is purely alkaline. A neutral substance has a pH of 7, halfway between 1 and 14. The neutral zone is desirable for most plants, except certain acid-loving ones such as azaleas and blueberries.

The pH of decaying compost changes during different stages of composting. During the early stages, organic acids are produced and the pH may drop as low as 4 or 5. As decomposition continues, the pile will neutralize on its own, as long as it is getting enough oxygen. Do not add lime or lime substitutes to adjust the pH unless you have performed a pH test. Adding too much lime can raise the pH to levels where nitrogen will be lost from the pile in the form of ammonia gas, thus creating an odor problem.

If you want to test the pile pH, it is better to do so when the compost is finished. You may also want to test the pH of the soil where you plan to use the compost. Compare the pH findings with the needs of the particular plants you intend to use - and then make adjustments to the soil with lime or peat moss, if needed. Most composters can probably ignore compost pile pH as long as they use a good variety of organic material when building it.

Health considerations

Health considerations related to composting are dependent on the materials being composted and individual sensitivity to organisms in compost. As mentioned earlier, dog, cat, and tropical bird wastes can contain harmful pathogens and should be avoided. For most individuals, contact with composting material should not cause problems if normal sanitary measures are observed (e.g. washing hands after working with the compost pile). Gloves are recommended for pile building and maintenance, especially if you have any cuts or blisters. A sensible health precaution is to make sure your tetanus booster is up-to-date (recommended for both composting and gardening).

A few individuals may be sensitive to some of the organisms in compost piles. The high populations of mold and fungi can cause allergic reactions in some people. One of these fungal species, *Aspergillus fumigatus*, can infect the respiratory system of a sensitive person who is heavily exposed. Aspergillus commonly occurs in nature and is found in basements and many other locations. Home composting piles may contain some Aspergillus organisms, but are not responsible for significant elevations of

background levels. In other words, Aspergillus organisms in your home composts pile will not affect your neighbors. People who have conditions that predispose them to infection or allergic reactions should avoid turning compost piles or take precautions to minimize exposure. Common dust masks can be worn under dry and dusty conditions.

Home composting piles are sometimes blamed as a source of Blastomycosis. Blastomycosis is a fungal lung disease that has symptoms similar to pneumonia. Experts on Blastomycosis do not believe that mycelio spores are likely to form in a composting pile because of the high temperatures generated by bacteria. (This has not been proven conclusively because the Blastomycosis fungus is very difficult to isolate. Conditions have to be just right for it to form.) The mycilio phase (problem phase) occurs at temperatures less than human temperature (98°F). Blastomycosis is typically found around riverbanks, lakes, and streams and is more associated with water drawdown. As a precaution, people living in areas where the incidence of blastomycosis is high could forego composting organic material such as rotting wood taken from banks of rivers, streams, and lakes.

Summary

In this lesson, you've learned how weather affects composting activity, where compost piles should be sited, and two recipes for producing compost. You have also learned about some common composting problems and how to solve them. The last section of the lesson covered compost pile pH and health considerations. Now see how well you can answer the **study questions**. Try at least one of the **study activities** to expand your composting knowledge. In the next lesson, Lesson 5, you will learn about the many benefits of finished compost and how it can be used.

Study questions
Lesson 4

1. List the guidelines for composting food waste during winter months.
2. Name five physical factors to consider when locating a compost pile.
3. What are the key differences between the "Hot and Fast" and "Cool and Easy" compost recipes?
4. What are possible causes of odors in a compost pile and how can they be remedied?
5. True or false, and why? Composters should add lime to their compost pile if the pH falls below 6.0 during the initial stages of composting.
6. Describe two health considerations related to backyard composting.

Answers can be found in the back of the study guide.

Study activities
Lesson 4
Survey of friends and neighbors

Try to get a sense of how people are backyard composting in your community and some of the common problems they experience. Develop a short survey that you can use informally with friends and neighbors. Consider asking your friends what recipe they use to compost including materials, tools, type of bin (if any), and length of time to finished compost. Find out what problems they have experienced while composting and how they solved them. If they have not yet solved their composting problems, you could offer some possible solutions. You may also want to ask your acquaintances how they use their finished compost.

Composting problem lab

If you are adventurous, you can try simulating common composting problems such as odors and slow decomposition in plastic bags or other small, inexpensive containers. The compost problem samples could be made up prior to a workshop and brought for attendees to experience first hand. Give the containers to workshop attendees and have them discuss possible problems and solutions. If possible, bring some extra materials that they could use to add to the containers to "solve" the problems. You may want to first experiment at home on reproducing compost problems in small containers.

For example, to produce a bad odor like rancid butter, vinegar, and rotten eggs, you could mix fresh, juicy fruit and vegetable scraps, grass clippings, and coffee grounds together and place them in an airtight bag or container. Leave for several days before opening. To produce a bad odor like ammonia, you could mix together fresh grass clippings and bone or blood meal. After a couple of days, add a small amount of lime, then leave for another day or two before opening. Slow decomposition could be simulated by mixing together two or more high carbon materials such as leaves, sawdust, and shredded cardboard. Use your imagination.

Other resources

Fact sheet available at:
http://learningstore.uwex.edu

- Making and Using Compost in the Garden (Learning Store item A4021).

Master Composter

USING COMPOST
Lesson Five

What's ahead
in lesson 5 of the home study course, you'll learn:

- how compost benefits soils and plants;
- characteristics of finished compost;
- how to apply compost to plants in your yard, garden and home.

Benefits of compost

Inexpensive to produce and easy to use, homemade compost is an excellent source of organic matter for your soil. Using compost improves the soil's structure and texture, enabling it to better retain nutrients, moisture and air for the support of crops. The joy of working in rich, crumbly soil and tending healthy, robust plants should more than compensate for the effort expended in making the compost and distributing it.

When organic matter is worked into soil, by people or by earthworms, it dramatically improves soil structure. Soil structure refers to how inorganic particles (sand, silt and clay) combine with decayed organic material (also called humus). Soil with a good structure has a crumbly texture, drains well, retains some moisture, and is easy to turn over. Compost helps improve all soil types, especially sandy or heavy clay soils.

Sandy soil feels loose, and has coarse, light particles that won't hold their shape when squeezed in your hand. The looseness of the particles creates so much air space that water and nutrients drain through quickly.

When compost is mixed with sandy soil, it helps to retain moisture and micronutrients. The addition of compost also increases the soil's porosity so that plant roots can more easily penetrate it.

Clay soil looks heavy and dense. It contains fine soil particles with very limited pore space for air or water. It gets very sticky when wet and will form a lump when squeezed in your hand. When compost is mixed with clay soils, it binds with the clay particles to form larger particles, allowing better surface water drainage. The compost portion holds moisture inside the particles for plant uptake. The addition of compost

also helps clay soils resist surface crusting and erosion.

Compost is typically considered a soil amendment or conditioner, rather than a fertilizer. It contains small amounts of nutrients and trace elements that are very beneficial for plants. One of the reasons that compost is so valuable is because it is a composite of different ingredients, some of which rot more rapidly than others. As a result, nutrients are slowly released over a period of time. The nutrient content of each batch of compost is impossible to predict, because it depends on variables such as the raw materials, the carbon to nitrogen ratio of the pile, and whether any amendments are added. The greater the variety of materials used in making it, the greater will be the variety of nutrients in the end product – including minor elements such as iron, cobalt, manganese, boron, zinc, and copper. After it has been stored for several months, compost will lose some nitrogen and potassium, although it will still retain most of the other nutrients. To discourage nutrient leaching, you can cover the compost with plastic or some type of tarp. In contrast to compost, some chemical fertilizers release elements so quickly that rain leaches them away before plants can utilize them.

Compost attracts earthworms and other soil organisms as it provides them with food. These soil organisms can create tunnels in the soil, which aerates the soil, improves drainage, and brings up minerals from the subsoil, making them available to plants. Adding compost to the soil also increases microbial activity. Microorganisms remain in compost, even after decomposition has slowed down. These microorganisms continue to decompose organic matter in the soil, contributing to chemical reactions that benefit plants. They convert nitrogen, potassium, phosphorus and other nutrients in organic materials into a form that plants can absorb. Some types of microorganisms are nitrogen-fixing bacteria, which take nitrogen from the air and make it accessible to plants. Other microbes produce chemical substances that help protect plants from several types of diseases.

Research by plant pathologists indicates that soil amended with compost tends to produce plants with fewer insect and disease problems. Certain types of compost will suppress several soil borne diseases in ornamental and vegetable crops. When used as a mulch around garden plants, compost can help control the spread of fungal diseases by keeping water from splashing disease spores onto plants. For this reason and because studies show that compost-rich soil discourages many diseases, you may want to mix compost into soil around your plants to help protect them. Using either leaf mold, compost made exclusively from dried leaves, can help suppress nematodes. Adding some pine needles to

the leaf mold or leaf-based compost has been found to be particularly potent against nematodes. Research on the use of compost has shown that components of composts improve the ability of plants to resist disease caused by root and foliar pathogens. Studies currently being conducted will likely show additional benefits.

Another value of compost is that it improves soil chemistry. Humus helps plants overcome soil pH levels that are either too low (acidic) or too high (alkaline). It acts as a buffer in the soil and helps keep extreme pH from making nutrients insoluble. Organic matter has a high capacity to fix heavy metals in soils and can neutralize soil toxins. According to Dr. Selman Waksman in his book *Humus: Origin, Chemical Composition, and Importance in Nature*, high salt concentrations are less injurious; and aluminum solubility and its specific injurious action are markedly decreased.

The use of compost aids in moderating soil temperatures. Soil amended with compost typically has a darker color than unamended soil because compost is dark brown. Dark soil absorbs more heat and will tend to heat up faster in the spring, stimulating plants to start growing sooner. During hot weather, soil covered with 1 to 2 inches of compost mulch tends to remain cooler than soil without mulch. The mulch serves as an insulating blanket, helping plants perform better in the summer heat.

Benefits of compost to soil

- Improves soil texture
- Improves soil's water-retention capability
- Improves soil's aeration
- Improves soil's resistance to erosion
- Adds and stores nutrients in the soil
- Discourages some types of plant diseases
- Improves soil's ability to absorb rapid changes in pH
- Neutralizes certain toxins
- Helps keep soil temperature stable

Finished compost

Some novice composters may be unsure as to when their compost is actually finished. Finished compost will be dark, loose and "crumbly". It should smell sweet and earthy; never moldy and rotten. Crumbly compost will be sort of fluffy – it does not need to be decomposed to the point of being powdery. You may see lots of macroorganisms crawling around such as earthworms and sow bugs. Most of the original materials should not be recognizable, although things that take a long time to decompose such as twigs, nutshells, and straw fibers will still be visible. These items can be screened out and put back into a compost pile. The temperature of the finished compost should be the same as the outside air temperature and should not reheat. If it is still warmer than the surrounding air, it needs more decomposition time. Once the compost appears finished, cure it for at least three weeks to make sure that the

decomposition process has stabilized. Unfinished compost has been found to retard germination and growth of some plants. If you plan to use compost as part of a mix for seedlings or transplants, you may want to do a simple test to ensure that the compost is fully aged. The following germination test is recommended in *The Rodale Book of Composting*.

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

Compost should be screened when it is used as a top-dressing for lawns and as a component of container mixes. A simple screen can be made by fastening 1/2" mesh hardware cloth over a wooden frame. Some people prefer to use a 1/4" mesh for screening compost that will be used for starting seeds. Place the screen over a wheelbarrow or box and sift the compost into the collector. Large pieces left behind on the screen could go into another compost pile.

Compost application

Finished compost can be applied in spring, summer and fall. The best time to incorporate large amounts of compost into a garden is in the fall. This can be done after the first killing frost and before the soil becomes frozen hard. Compost can be spread and left on top of the garden soil or it can be turned under with a spade or rototiller. Incorporating compost into the soil helps keep it from drying out and retains some nutrients that might otherwise escape into the atmosphere as gas. If used in the spring, compost should be incorporated into the soil a month or so before planting. During the summer, compost can be applied as either a top-dressing or side-dressing to plants.

If you want to store finished compost for a while, cover it with a plastic or canvas tarp to discourage nutrient leaching. Don't leave a pile of finished compost unused for more than six months. Specific recommendations for applying compost are discussed below.

Annual flower and vegetable beds

In the spring and late fall, 1/2"–1" of compost can be incorporated into garden soil to improve and maintain soil quality. If the garden area is new and has inferior soil, you may need to incorporate 2"–3" of compost into the top 6" of earth to bolster its organic content. During summer months, mulch with screened compost at a rate of 1/2–1" around individual plants (side-dressing) or over the entire bed. Side-dressing is best done in the spring and early summer so plants can derive maximum benefit from the compost. To side-dress a plant, lay a circle of compost on the soil around the plant. Start about an inch from the stem and spread it out to the drip line (imaginary circle beneath the outer edge of the foliage).

For transplants, put a handful of compost into each hole before placing the plant in it. Compost will provide nutritional support throughout the season and improve soil structure around the plants.

Perennials

Compost can be used for all types of perennials. It is particularly valuable for perennial food plants, such as asparagus, rhubarb, strawberries, and raspberries. Before planting, prepare multiple holes or a trench approximately 8" wide and 18" deep. Fill them with compost before adding the perennials. For perennials that are already planted, mix compost with topsoil and apply 1/2"–1" on top as a mulch. If you try to work compost into the soil, you may damage roots.

Trees and shrubs

When planting new trees or shrubs, do ***not*** use compost in the planting hole. Compost-rich soil encourages roots to remain in the planting hole, rather than growing out into the surrounding soil. The roots may grow in a circle and within a few years, the roots can literally strangle the plants, causing it to die. Mulching is a much better way to use compost to benefit trees and shrubs. Spread a 1/2"–1" layer on bare soil as far as the drip line extends (outer edge of the plant's branches). With trees, this band of mulch should start about two feet from the trunk. It may be necessary to remove the grass mat from the tree trunk or shrub base outwards to the dripline. Work compost into the top 2 inches of soil or cover with 2–3 inches of another type of mulch e.g. chopped leaves or wood chips. The top layer of mulch will help keep the compost in place and keep it from drying out.

Lawns

For new lawns, spread 2" of screened compost onto the soil. Incorporate the compost into the top 6"–8" inches of soil. For established lawns, compost can be used as a top-dressing. Use an aerator to punch holes in the sod. Then grind or screen compost until it is fine in order to avoid smothering the lawn. If a screen is used, it should have 1/2" or smaller mesh. Spread or broadcast a 1/4"–1/2" covering of fine compost over the entire lawn. Lightly rake the compost so that it falls into the holes. To renovate patchy lawns, work compost into bare spots about 2" deep, soak with water and plant grass seed.

Containerized plants

Finely screened compost can be used in potting mixes. No more than 1/4–1/3, by volume, of the potting mix should consist of compost—higher levels can result in excess nutrients. Use only well aged compost as fresh compost may contain phytotoxins that can injure the plant. One suggested mix: 2 parts soilless mix (e.g. part moss, perlite, and vermiculite) and 1 part screened compost.

For established plants, use up to 1" of fine compost and apply it as a mulch. As mentioned earlier, another excellent way to provide nutrients to containerized plants is to water them with compost tea.

Compost tea

Another way to apply compost during growing months is by brewing and using compost tea. Compost tea works especially well for providing nutrients to new transplants and young seedlings, which are sensitive to chemicals. It also is a convenient way to supply nutrients to soil in planters, which sometimes lack space for the addition of a solid soil amendment. To make compost tea, place a burlap or cloth bag filled with finished compost in a watering can, tub, or barrel of water. Agitate it for a couple of minutes or let it sit for a few days. Water will leach nutrients from compost and dilute them into a mild tonic the same color as tea. Spray or pour compost tea on and around plants at watering time. The same bag of compost can be used to produce several batches of tea. Afterwards, the remaining compost can be dug into the soil or used as a mulch. Soil bacteria and plants roots will continue to extract valuable nutrients from the compost.

Summary

In this lesson, you learned about the numerous benefits of compost, how to tell when it's finished, and numerous applications for using it. Now try to answer the **study questions** and do one or more **study activities**. In the next lesson, Lesson 6, you'll learn about other methods for managing yard trimmings and food scraps.

Study questions
Lesson 5

1. List at least five benefits of finished compost.
2. What are the characteristics of finished compost?
3. Describe a simple test for determining if compost is adequately aged.
4. What is compost tea?
5. Name the types of compost applications that finely screened compost is recommended for.

Answers can be found in the back of the study guide.

Study activities
Lesson 5
Soil testing

If you have not already done so, consider having your soil tested by a University of Wisconsin soil-testing laboratory. Testing soil can give information on the soil's ability to supply nutrients for plant growth, providing a scientific basis for deciding how much nutrients and lime are needed. A basic soil test will provide data on soil pH, organic matter content, lime requirements, and phosphorus and potassium. The soil test costs approximately $7.00-$15.00. If you wish to have the university test your soil, you can bring a sample into your county Extension office and pay the fee there. The sample (no more than 1 1/2 cups) should be placed in a clean plastic bag or a wax-lined soil sample bag from your Extension office. Test lawn and garden areas separately. UW-Extension Fact Sheet A2166, "*Sampling Lawn and Garden Soils for Soil Testing"* explains how to take a good soil sample. Home soil test kits can also be purchased at garden stores or through mail order catalogs. Test results

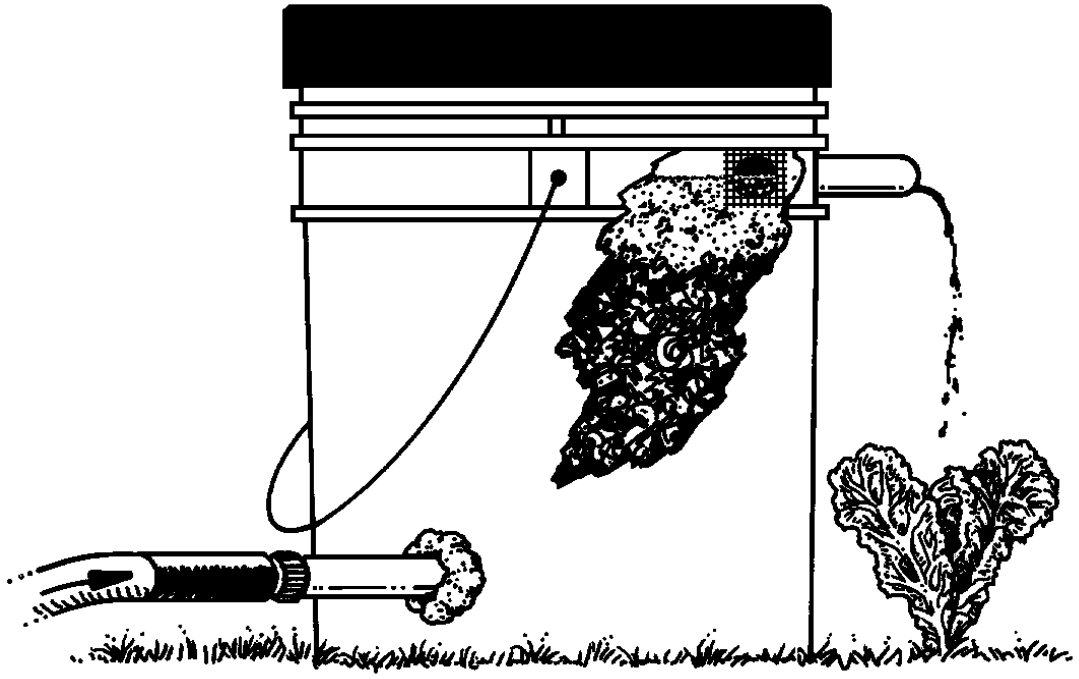
from the home kits may not be as reliable as laboratory testing results.

Compost benefits

Experiment with a few plants in your garden or home to see how your compost affects growth over a period of time. Start with at least six plants of the same species. Use half of the plants as a control with no compost addition. Use finished compost with the other plants. If you do this experiment in the garden, add a handful of compost to the holes while transplanting half of the test plants. If you decide to use containerized plants for the experiment, use 1/4 to 1/3 by volume of compost in the planting mix for half of the plants. A variation of the experiment is to use compost tea rather than finished compost. Monitor the growth of the test plants noting differences in height, color, disease resistance, etc.

Brew compost tea

When you have access to finished compost, try brewing up a batch of compost tea. Use it for container plants in your home and yard. Make note of changes you see in your plants and if it seems to affect some types of plants more than others.



Master Composter

OTHER OPTIONS FOR MANAGING YARD TRIMMINGS & FOOD SCRAPS
Lesson Six

What's ahead
in lesson 6 of the home study course, you'll learn:

- about vermicomposting and how to set up a home system;
- about the benefits of grasscycling and how it can be done to achieve an attractive, healthy lawn;
- why mulches can improve your yard;
- how to modify or create a landscape design for your lot that reduces the amount of yard trimmings generated.

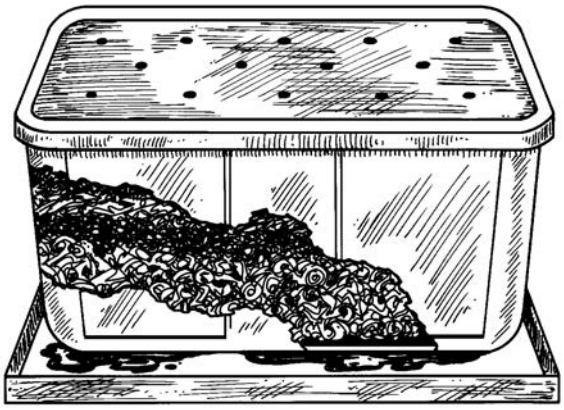
Vermicomposting

Worm composting provides a convenient method for recycling kitchen scraps into valuable resources. It is the process of using redworms and microorganisms (bacteria, protozoa and fungi) to convert organic waste into vermicompost – an excellent soil amendment.

Worm composting can produce compost for plants, worms for fishing or both. The same basic design works for producing worms or compost, but the management strategies differ slightly. In any case, kitchen scraps are recycled into a nutrient rich product. Worm composting, properly managed, has very little smell, and can actually reduce the undesirable smells associated with kitchen scraps mixed in with garbage. Vermicomposting also provides an interesting topic of conversation for dinner guests and has served as a great science project for many school children.

The container (worm box)

Worm composting can take place in several types of containers. Old washtubs, plastic utility tubs, dresser drawers or used shipping crates can be adapted for worm composting. Containers can also be purchased at local stores, through internet sources or built at home.



Two important features of the container are size and construction. If you have a large household or generate a lot of food scraps, consider using more than one container. Larger containers can be heavy to move and hard to clean when the worm castings are ready to harvest.

Sizing the container – There are two methods for selecting worm box dimensions—calculation or estimation. Either method is used for determining the length and width of the container. Since

worms are surface feeders, an 8"–16" depth will allow adequate space to bury scraps regardless of horizontal dimensions. For occasional large volumes of scraps, consider composting these materials outside.

Calculation – Space needed for each pound of scraps – Get out a scale and weigh kitchen scraps each week for several weeks. Try to select a time when usage is at a "normal" level. Then use a ratio often used in sizing worm boxes: allow one square foot of surface for each pound of scraps per week.

Estimation – On the average, studies suggest two square feet of surface area per person. For 1–2 people, a box 4 square feet or 2 feet on each side should do. For 3–6 people, try 2x3 feet. Modify dimensions based upon how often the contributors to the worm box eat out, do large amounts of canning or freezing, or discard leftovers and rotten flood.

Location

Containers should be placed in a convenient location where the worms will not be subjected to temperature extremes. Worms do their best work at temperatures ranging between 55–77°F. Many people store their worm containers in the basement to keep them out of the way. Other common locations include kitchens or heated garages and breezeways.

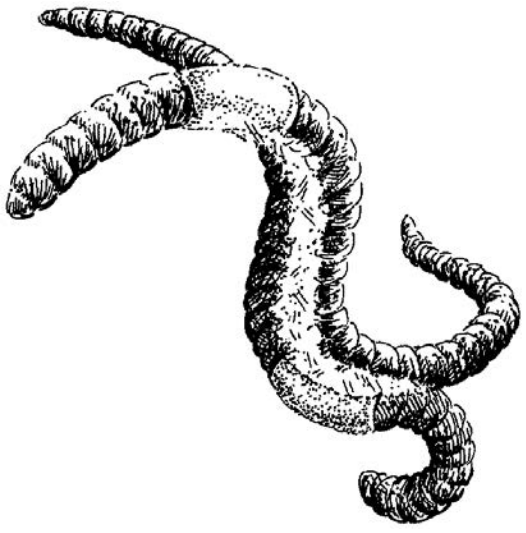
Containers can be placed outside during the summer. Once the daily temperature falls below 50 degrees, the worm bin must be brought indoors. (Worm bins left outside during warm months run the risk of bringing unwanted insects into the house.) The *design* of the worm bin should match its intended location. If it will be in a highly visible site, put more effort into construction aesthetics.

Constructing a container

Worm boxes can be made out of plastic or wood. If recycled materials are used, be certain to avoid containers with possible chemical residues such as pesticides or preservatives. New plastic containers should be scrubbed with strong detergent and rinsed with hot water.

If you select a plastic container, drill 14–20 holes (3/16"–1/4") in the bottom for aeration and drainage. Raise the bin on bricks or wooden blocks for air circulation. Place a try underneath to catch excess liquid.

If you plan on using a home-built container, select 5/8" exterior grade plywood, with the "exterior" side inside. Other wooden boards or scrap lumber may be substituted. Use either nails with a spiral shape, or screws to increase holding power under alternating wet and dry conditions. Avoid using wood treated with preservatives that could leach under acidic composting conditions.



Dimensions for worm box

Container size	Sides	Ends	Bottom and top
A 2-person box (2' x 2' x 10")-up to 4 lbs. scraps/week	23-3/8" x 10" each side	23-3/8" x 10" each end	24" x 24"
3-6 person box (2' x 3' x 12") – up to 6 lb. scraps/week	35-5/8" x 12" each side	23-3/8" x 12" each end	24" x 36"

Additional materials and tools:

- 2"x2" boards for support in the corners and along the bottom edges (optional).
- Four small pieces of wood to put on the bottom to allow ventilation under the bin.
- 1-1/2 – 2" nails or wood screws
- 4" gate hinges for the top
- Tools – a saw, hammer and a drill with a 1/4" bit for ventilation holes.

Assembly – Nail or screw the sides together. Square and secure to the bottom with 5-7 nails for screws per side. Drill 9-12 drainage holes spaced evenly throughout the bottom surface. Add 2" x 2"s to the corners and the bottom edges for support. Nail the wooden blocks to the bottom corners, or place the box on boards or casters for aeration and drainage. Keep a plastic sheet or tray underneath to capture excess moisture, bedding or worm castings.

You may be able to extend the life of your box if you finish it with a waterproof seal and allow it to dry thoroughly after harvesting a batch of worm composting – prior to putting in fresh bedding. A continuously wet untreated box may only last 2-3 years.

Bedding materials

Bedding functions as a home for the worms and kitchen scraps, and helps to retain moisture. Since worms will be living their entire lives in the bedding, be certain it is free from fire retardants, pesticides, etc. Some suggestions for materials:

Machine-shredded newsprint or computer paper is one of the most effective bedding materials. It can be found at recycling centers or available at offices. *Avoid glossy papers.*

Hand-shredded newsprint is prepared by tearing newsprint into strips. While most readily available, it can mat down in layers, making it difficult to bury kitchen scraps, and larger strips may dry out faster than machine-shredded newsprint. *Avoid glossy papers.*

Shredded cardboard, where available, is very desirable and has a high moisture-holding capacity. It can dry out on the tops and sides. *Avoid fire-retardants used in insulations*.

Leaves are natural habitat for worms, but may contain other animals such as centipedes that can eat worms. Leaves can mat together, making it difficult to bury kitchen scraps. *Avoid leaves from heavy-traffic areas because of the potential for heavy metals from motor vehicle emissions*.

Additives – These materials can be mixed in with other bedding, but are not always necessary:

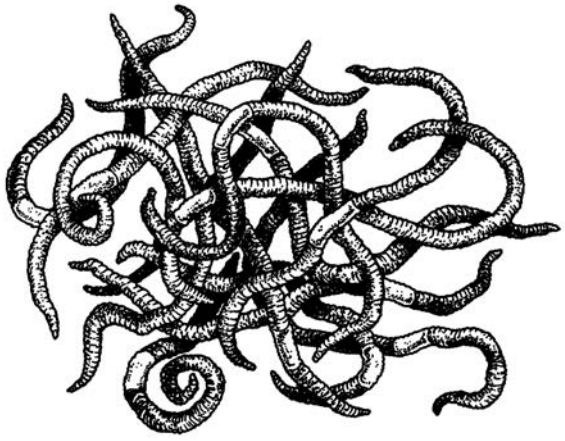
- **Peat moss** will lighten other beddings, break up compaction and absorb excess moisture. Mix in approximately one-third peat moss (by volume) in a container.

- **Soil or sand** will add nutrients, and additional grit, and aid in digestion for worms. Use no more than handful or two when initially preparing bedding.

- **Pulverized egg shells or ground limestone** will add grit and calcium. Add small amounts periodically.

Worms

What kind of worms? – There are several kinds of earthworms. The best type for worm composting are redworms (*Eisenia foetida* or *Lumbricus rubellus*). Also known as red wigglers and manure worms, they consume large amounts of organic material in their natural habitats of manure and decaying leaves. Nightcrawlers and other garden worms are great for the garden soil, but will die in the confined conditions necessary for worm composting.



How many worms? – Worms can reproduce rapidly, so regardless of the starting numbers, worm populations will eventually stabilize based on the amount of food scraps added. To have all garbage consumed from the starting set-up time, some estimation of "average food added" will be necessary.

This calculation is similar to that used in sizing the container, but here the calculation is based upon average pounds of scraps *per day*. Worm suppliers typically measure redworms by the pound because vermicomposters usually want 1000-2000 worms to start with. The number of worms per pound varies depending on the maturity of the worms, but 1 pound consists of roughly 1000 worms. (Imagine counting out that many worms at a time for each customer.)

In general, add 2 pounds of worms per 1 pound of daily scraps, or a 2:1 ratio. The 2'x3'x1' bin is designed for approximately 7 pounds of kitchen scraps per week, or a pound per day – so plan on 2 pounds of worms. For the 2'x2' bin, try about 1 pound of worms. If you are unable to start with this many worms, reduce the amount of food waste put into the bin until the population increases. Redworms mature in 60-90 days and produce cocoons that take 21 days to hatch. Once worms start breeding, they can lay two to three cocoons per week with each cocoon hatching two to three worms. Worm populations usually do not exceed the size of the container because they are limited by the availability of food and room to move and breed.

Where to get worms? – If you're fortunate, you may be able to get some worms from a friend who does vermicomposting. Adventuresome

composters can find them in an old leaf or manure pile. Worm growers are also an excellent source and can be found selling worms on the internet. Redworms are also available through bait dealers, though often at a much higher price than purchasing from growers.

The care and feeding of redworms
filling the container – After setting up the worm box and finding a source for redworms, it's time to prepare their home. Plan on about 5-8 pounds of dry bedding for a 2'x2'x1' box; and 9-13 pounds of dry bedding for the 3'x2'x1' box. Mix 3 pounds of water per pound of dry bedding – a **3:1 ratio**. Remember, one gallon of water weights 8 pounds.

The bedding throughout the container should be damp. Add 1-2 handfuls of soil or sand and mix. Lift and fluff the bedding gently to create air spaces. Leave space on top for a piece of black plastic or 2-3 newspapers as a cover to retain moisture and keep out light. If you use a plastic container with a lid, you may want to leave the lid ajar to keep the container from getting too wet inside. Sprinkle redworms over the surface, breaking up any clumps. Place under a bright light and the worms will burrow into the bedding.

Putting food scraps into the worm box – There are a number of alternatives, but the general idea is to bury food scraps under a few inches of bedding, then replace the cover. If done on a rotational basis digging into unfinished material is avoided. Divide the bin into four or more imaginary sections and bury successive loads in different locations in the bin.

It can be helpful to have a temporary container (e.g., and ice cream bucket) for food scraps, to periodically empty into a part of the worm bin. Keeping a record of your contributions can be a fun task for a curious adult or an interested child.

How much is too much? – A given quantity of worms can only eat so much. When "overloaded", the system may go anaerobic and start to smell. During canning or holiday times, when the volume of scraps exceeds worm box capacity, plan on setting up an interim bin or finding another method to handle the material.

How little is not enough? – While relatively easy to care for, worms will expire if neglected too long. Skipping one or two weeks is possible without any problems, but if you plan to be gone for a month or more, you may want to find a friend to feed and look after your worms.

Guide for adding kitchen scraps and other materials to your worm bin

	Examples and suggestions
Types of food to add	Vegetable and fruit scraps generated during food preparation; coffee grounds; spoiled food from fridge e.g. baked beans, leftover casserole; plate scrapings e.g. pasta, vegetables, gravy; cheese; deviled eggs; crushed egg shells (do not break down during composting, but provide calcium for worms)
Caution food items	Large amounts of bones, fat or other material may putrefy. If small amounts of these items are added, grind or chop first so worms can recycle it more easily. Consider mixing this type of food with sawdust to reduce potential for odors.
Do not add these materials	Cat litter; plastic bags; metal caps; or other non-organic materials.

Keeping redworms happy – Preventive measures can most readily be taken by careful observation each time material is added to the worm box. Some things to watch for:

Strong smell – If too much material is added over a short time span, anaerobic conditions can develop. If so, recover the worm box and allow the worms to work on the contents until further broken down.

Worms climbing up sides of container, or the population is declining – May indicate dying worms, check the following and correct:

Too hot – shade the box or move to a cooler location

Too wet – add fresh bedding and ventilation holes

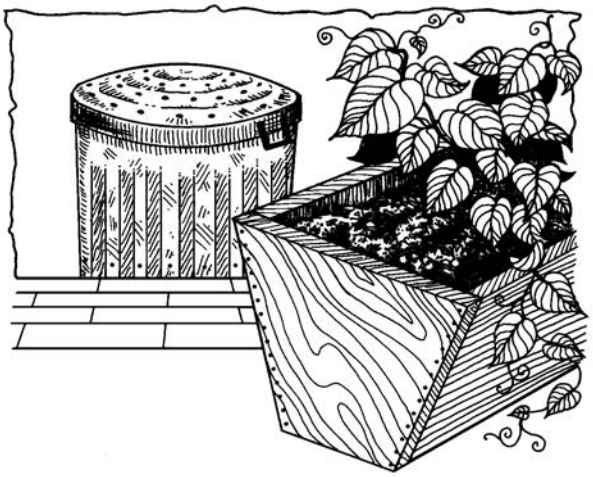
Too acid or salty – add fresh bedding and ventilation holes. Dead worms quickly decompose and are cleaned up by other organisms in the box. You may not be able to recognize any dead worms.

Fruit flies – Try one or more of the following solutions to control fruit fly populations:

- **Cover:** be sure you are maintaining a 2-3 inch layer of bedding material over food scraps
  - **Remove** banana peels and citrus materials from the bin (until fruit fly populations declines)
- **Change** bedding material
- **Build** a trap using a small jar, plastic bag, beer and a rubber band. Pour beer into the jar. Make a small hole in the corner of the plastic bag and insert the bag into the jar. Fasten the bag to the jar with the rubber band. Fruit flies will be attracted to the beer and will not be able to find their way out.
- **Place** a piece of remay or interfacing fabric on the top of the bedding material

Harvesting worms and compost

How often you harvest worm castings will depend on your goals for vermicomposting - whether you are more interested in worms, the worm castings, or having a continuous system. Generally, if your main goal is to use worms for fishing, you may want to harvest the bin every 2-3 months and transfer the worms to fresh bedding. The amount of finished compost will be less. If your goal is to produce worm castings for plants, bury food scraps for 4 months, then leave the box alone for 2-3 months. The result will be a box of rich, black homogeneous castings. Consider using a second box for vermicomposting during this time period.) If you want continuous worms and compost, harvest compost and prepare fresh bedding every 3-4 months.



Harvesting alternatives

Worms move *away from* light, and from temperature and moisture extremes. They will also move *toward* a source of fresh food. Combine these factors with personal style, time, and product priorities from above, to select a preferred harvesting method. Some options:

Dump and hand sort – Dump the entire contents of finished vermicompost onto a large sheet of plastic. Sort the material into cone-shaped mounds. Use a bright light above the mounds to drive the worms toward the interior and bottom of each mound. Wait 5-10 minutes and then gently scrape off layers of vermicompost until all you have left is a mass of worms. Place the worms into a temporary storage container or a worm box with fresh bedding. Watch out for tiny, lemon-shaped worm cocoons that contain baby worms. You may want to throw them in with your fresh bedding. *To prolong the life of a wooden worm box, rinse it out and set it aside to dry during the sorting process*.

Divide and harvest - Move all the material to one side of the box, adding fresh bedding to the other side. Add fresh scraps to the new bedding for several weeks, covering only the new side to allow the other to dry out. Soon, most all worms will have migrated to the new side, and the old compost can be harvested. Save the finished vermicompost for garden and houseplants.

Putting worm compost to use

Worms are very effective at turning kitchen scraps into material high in available plant nutrients. Place it sparingly where plants can use the nutrients right away.

Where to use worm compost

Seed beds – Sprinkle a layer down a row where seeds are to be planted.

Transplants – When starting plants in the garden from potted plants or flats, work a handful or more of worm compost into the hole before planting.

Top dressing – For house or garden plants, put a thin layer of worm compost around the plants. The nutrients will work down for the roots with next rains or watering. Avoid placing against plant stems.

Potting soil – A fine mix for potting soil would be about 1/4 worm compost, and the other 3/4 a favorite potting mix. Equal amounts of peat moss, perlite and sand or garden soil work well.

Broadcasting – Simply scatter it over the garden and incorporate it into the soil.

How much to use?

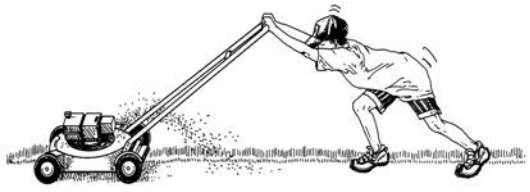
In general, worm compost is preferably mixed with garden or potting soil mixes. 100% worm compost may contain salt concentrations, which inhibit plant growth.

Grasscycling

Grasscycling refers to the natural recycling of grass clippings by leaving them on the lawn after mowing. When grass clippings are allowed to decompose on the lawn, they release valuable plant nutrients such as nitrogen, phosphorus and potassium. Clippings also help shade the soil surface and reduce moisture loss due to evaporation. Residents who grasscycle enjoy greener, healthier lawns. In addition, grasscycling saves time, work and money. A study was conducted in Fort Worth, Texas with 147 homeowners who quit bagging their clippings. The homeowners mowed their lawns 5.4 times per month versus 4.1 times by homeowners who bagged their grass. However, the grasscyclers spent an average of seven hours less during the grass cutting season on yard work because they did not have to spend time bagging grass for disposal.[1] Savings in money can be realized from reduced fertilization requirements reduced need for trash bags and less wear and tear on mowers by not having a bag attachment full of heavy clippings.

Contrary to what some folks believe, grass clippings will not damage lawns. As long as the lawn is mowed regularly and the mower height is set correctly, lawns are improved by grasscycling. In the 1960s, it was commonly believed that grass clippings were a major component of thatch and that removing clippings would dramatically slow thatch development. Although thick amounts of thatch (over 1/2") can damage lawns by hampering air and water from reaching grass roots, small amounts of thatch are actually beneficial to a lawn. A small amount of thatch provides insulation to roots and serves as a mulch to prevent excessive water evaporation and soil compaction. An 11-year study at the USDA research station in Beltsville, Maryland, found that on an annual basis, grasscycling contributes only .03 inches to the thatch layer.

Grasscycling does not spread lawn disease. Disease spores are present whether clippings are grasscycled or disposed of. Turf grass disease occurs when disease-causing spores contact susceptible grasses under certain environmental conditions.



[1] Knoop, Bill. "Don't Bag It: An Urban Educational Program", Texas A&M University System.

Mowing

Most all lawn mowers can grasscycle. No special equipment is necessary to grasscycle. Owners of older rear or side discharge mowers can remove the catching bag and cover the discharge chute with a plate/cover that can be purchased at a local hardware store. Many manufacturers also have attachments that are supposed to improve the mower's grasscycling performance. Most new mowers are designed for improved grasscycling with decks that are shaped to cut clippings into smaller pieces so they will fall below the tops of the grass blades – helping to prevent clumping. Proper mowing will increase lawn quality. For the best results, observe the following practices:

- Set your lawn mower to cut at the proper height. Raise the mowing height of the lawn mower during the spring and summer. The higher mowing height encourages deeper root growth during the spring and reduces heat stress in the summer. See the mowing chart for recommended heights.

- Keep your mower blade sharp. A dull mower blade tears grass, which increases the chance of disease infestations.

- Cut your lawn when the grass is dry. Wet grass is difficult to cut evenly, dulls blades and tends to form clumps.

- Mow often enough so that no more than 1/3 of the lawn height or 1" is cut at one time.

- Clean the mower deck periodically. Wet clippings can become matted on the underside of the mower deck, resulting in clumping of clippings or mechanical failures.

Recommended mowing heights

Grass	Let lawn grow to:	Recommended height of mowed lawn
Bent grass	2"	1.5"
Fescue Chewing Fine Tall	 3" 3" 4"	 2" 2" 3"
Kentucky blue-grass	3 ½"	2 ½"
Rye grass	3 ½"	2 ½"

Grasscycling is not appropriate in every situation. Prolonged wet weather, mechanical breakdown of mowers, or infrequent mowing are situations where clippings should be bagged or collected. The clippings can be used in backyard compost pile. They can also be used as a mulch to provide weed control and prevent moisture loss around flowerbeds, trees and shrubs. Mulching with clippings should be avoided if herbicides have been applied to the lawn within the previous three weeks.

Watering

In addition to receiving natural rainfall, established lawns need irrigations. In hot weather, lawns may need as much as one inch of water every seven to ten days. Avoid daily watering, as lawns watered too frequently tend to develop shallow root systems that make them more susceptible to stress and disease. Deep, infrequent watering produces deeper, extensive root systems that enable turf to resist disease and stress. The best time to water is early morning, as less water is lost due to evaporation. Try to avoid watering in the evenings because it may promote the development of disease.

There are several techniques you can use to identify whether your lawn needs watering:

- Footprinting-Walk across the lawn and examine the lawn behind you to see if your steps left any footprints. If the lawn has low levels of water, then footprints will appear on the lawn.

- Screwdriver Test—Press a screwdriver into the lawn. If it is difficult to push the screwdriver into the ground, then the soil is very dry and needs to be watered.

- Evapotranspiration – Some water utilities provide customers with daily or weekly estimates of lawn watering requirements based on weather conditions.

- Consult County Extension Agents or Master Gardeners for advice on appropriate lawn watering in your area.

An exception to the rule of heavy and infrequent watering applies to newly seeded, plugged or sodded lawns. These lawns need to be watered daily for about ten days.

To determine how much water is being applied from your sprinkler during a given time frame, set a straight-sided can out on your lawn underneath the path of the sprinkler. After one hour, measure the amount of water in the can with a ruler or tape measure. For example, one inch of water in a can means that one-inch of water has fallen on your lawn.

Fertilizing

Proper fertilization should be done in conjunction with grasscycling. In order to become dense and green, lawns need properly timed fertilizer applications. Over fertilization weakens lawns and causes excessive and succulent top growth. Fall is the best time to apply fertilizers to cool-season grasses such as

Kentucky Bluegrass, and tall fescues. Application of fertilizer in the fall will improve lawn quality, and maximize root growth and the storage of food reserves. Applying fertilizer to cool-season grasses in the spring can:

- Encourage the growth of summer annual weeds and crab-grass plants.
- Stimulate top growth which depletes food reserves and slows root growth in grass.
- Makes lawns more susceptible to diseases, insect infestations, and injury when stressed during dryer summer months.
- Increase the frequency of mowing for a fast growing lawn.

Soil samples should be taken periodically to determine the amount and types of nutrients in the soil. (County Extension offices will test soils for a minimal fee.) By leaving grass clippings on the lawn, nitrogen is added to the soil, reducing the amount of fertilizer needed. For moderate even growth, and to reduce leaching of nitrogen into the ground water, avoid the uses of large quantities of fast acting fertilizers (ammonium nitrate, ammonium sulfate, or urea). Fertilizers should include slow release nitrogen sources such as sulfur-coated urea, urea formaldehyde, IBDU or organic fertilizers.

Mulching

Using organic mulch is a simple way to recycle yard trimmings and improve gardens and planting beds. Common organic mulches include materials such as wood chips, leaves, grass clippings or compost. Mulches have numerous benefits and are used for a variety of reasons.

- Mulch reduces evaporation from the soil surface.
- Mulch keeps weed seeds from germinating.
- Mulch insulates the roots of plants from temperature extremes and helps protect plant crowns from winter cold.
- Mulch decreases soil erosion, particularly on sloped areas.
- Mulch helps ease soil compaction when a mulched area is hit with heavy rains.
- Mulches provide ideal environmental conditions for earthworms and other soil organisms that are necessary for a healthy soil.
- As mulches break down on the surface, they add valuable nutrients.
- A properly mulched bed around the base of a tree can protect the trunk from being damaged by a lawn mower.

Mulching guidelines

Large leaves and small twigs should be shredded before they are used as a mulch. A simple way to accomplish this it to place them in small piles, six to eight inches high and two feet wide, on the lawn. Then, with a lawn mower set for the highest cutting height, run over the row once or twice. A grass catcher attached to the mower is handy for catching leaves.

A grinder, shredder or chipper is necessary for large branches and limbs. A few avid gardeners own this type of equipment and may be willing to provide assistance to neighbors. Many rental companies have this equipment for rent on an hourly or daily basis.

A few guidelines for mulching are listed below:

- Mulches should be applied after annuals and perennials are well established (four to six inches tall).

- Annuals and perennials (both flowers and vegetables) should be mulched with a material that breaks down in a relatively short time, such as grass clippings or partially composted leaves. Grass clippings can be spread in thin layers over vegetable and flowerbeds, or mixed with partially composted leaves and spread in a thicker layer. As mentioned in the previous section, do not mulch with grass clippings that have been treated with an herbicide for at least three weeks. During the growing season, it is better to mulch with finished compost, grass clippings or materials of a lower carbon content.

- Spread healthy leaves, grass clippings or shredded garden trimmings on winter-fallow gardens to protect the soil. Heavy layers of mulch on flower and vegetable gardens should be removed in the spring about three weeks before the last spring frost is expected. This will expose the soil to the sun so beds will warm up properly for spring planting – otherwise, the soil may stay cold longer in the spring. Light layers of mulch can be turned into the soil on annual beds in the spring.

- Care needs to be exercised when using whole leaves for insulating hardy plants during northern winters because they tend to form ice sheets and mat down, but well shredded leaves can be used for mulching flowering perennials, raspberries and grapes. Leaf mulch is best applied after the ground is frozen. If done earlier, rodents may burrow in leaves and damage growing plants.

- Certain types of leaves contain substances that can be harmful to plants. These types include rhubarb, red cedar, walnut and butternut. Fresh walnut or butternut leaves should not be used as a mulching material in gardens or left on the lawn because they contain juglone, a chemical toxic to several plant species. All of the above leaves can be safety composted. The composting process breaks down the harmful chemicals.

- Pine needles have the advantage of decaying slowing. They tend to acidify the soil, making them ideal as a mulch for acid loving plants such as azalea, rhododendron, holly, viburnum, blueberry, and strawberry. Do not use them in areas of the yard or garden

where neutral or alkaline soils are desired.

- Woody plants should be mulched with a two to three inch layer of shredded or chipped wood. Do not make the layer too thick as a settled mulch more than 4 inches thick restricts the access of oxygen to the soil and to plant roots. Allow freshly chipped wood to dry out before applying. On newly planted ornamental trees and shrubs, extend the mulched area at least six inches beyond the canopy spread. Then gradually expand the mulched area as the plant grows. Once in place, pull back the mulch away from the main trunk (two to three inches) to avoid possible wood decay and deter rodents from gnawing on the bark.

- Paths can also be covered with shredded or chipped wood, making it as thick as practical to wear longer and to keep down weeds.

- Weed the area to be mulched prior to applying the mulch. The soil should be moist before applying mulch since mulch slows rainwater infiltration. The mulch can also be moistened after application to help settle it and prevent it from flying away.

Be creative when using mulches. In addition to the above suggestions, consider using mulches in animal pens, along fencerows and on the surface of containerized ornamental plants.

Resource saving landscape design

The key to establishing an attractive, low maintenance, resource saving yard is planning. Homeowners can easily achieve this type of yard if they are willing to invest a small amount time in developing an overall plan.

The first step is to conduct a survey of the yard and existing planting (if any). While you can take mental notes, it may be more helpful to prepare a simple diagram of the yard showing the location of the house and existing plants. Graph paper is readily available in store stationary departments and can be used to develop a scale drawing. Consider making notes about the following topics:

- Take into consideration the surrounding area. Plan views, visualize it and screen out what might be considered undesirable views. At the same time, think about areas of the home and yard that could be emphasized and enhanced with plants such as entryways and back patio/deck areas.

- Consider the formation of the land and its combination of shady areas, sunny areas, low areas, damp areas, slopes, etc. Also, check soils in different location of the yard to determine soil type and presence of plant nutrients. County Extension offices offer soil tests for a minimal fee. This

information will useful when selecting proper plant varieties for each area.

- Look for areas where grass does not (or will not) grow well. Low maintenance ground covers, shrubs and trees will probably do better in these areas. Perennials, shrubs and trees generate fewer trimmings and require less fertilizer, water, labor and other resources than turf.

- Consider if there are areas under trees that could be allowed to naturalize. This would mean that no cultivated plants, with the possible exception of spring flowering bulbs or native shrubs, would be planted and the leaf cover would be allowed to remain.

- Look at possibilities for creating mulched beds around existing trees and shrubs. Mulched beds will save time mowing grass and help the plants. Lawn areas compete with trees and shrubs for water. Using mulch to separate planting areas from lawn is better for both grass and ornamental plants. Consider planting beds that connect existing trees or shrubs isolated in lawns.

- Look for turf areas that are worn by heavy foot traffic and consider whether they might be replaced by tough, low maintenance surfaces. Examples of surfaces include wood chip paths, low wood decks, gravel, or concrete or brick pavers.

The next step is to consult with county Extension agents, Extension master gardeners, landscape designers and/or garden stores about desirable plants for your location. In addition, there are a number of garden references and Cooperative Extension publications with plant listings. After identifying possible plants for your yard, review their environmental requirements (e.g. sun or shade, moist or dry soil) and what their mature size is. You may also want to check on disease resistance and other characteristics such attractiveness to wildlife type of flowers, and winter hardiness. Make a master list of plants that appeal to you and are suitable for your yard. Use this master list when working on a diagram plan for your yard. The following is a list of suggestions to consider when creating or modifying your landscape design.

- Whenever possible, use native plants. Plants that have adapted to local climates and soils will thrive much better than some of the imported species. Plant slower growing varieties rather than the fast growing-hybrids that will require much more pruning.

- Work with the directional layout of the landscape. Plants that do well in the sun should be placed in an area that will not be shaded over in a few years. Wind-tender plants should not be placed in an unprotected area

where they could be damaged with cold winds. Healthy plants usually require less maintenance than unhealthy plants. They do not lose as much foliage, twigs, branches, etc. In addition, they require less pruning.

- Naturalize as much of the landscape as possible. It isn't necessary to rake up all leaves—only those on turf grass, ground covers and gardens. If there is only a thin layer of leaves, it can be mulched down below the top of the grass with a mulching lawnmower. Many areas do very well with the natural leaves left by the shrubs and trees. Naturalized areas have a less manicured look, but can be just as aesthetically pleasing. More importantly, this practice requires less maintenance and reduces yard waste.

- Plant for the future. Think how the yard will look in 10 to 15 years and space plants accordingly. Instant landscapes will be jungles in a short time.

- If you have larger lawn areas, you may want to investigate wildflower mixes that can create "attractive" meadows requiring little water. These meadows typically only need to be mowed once or twice each summer after planting.

Another way to reduce generation of yard trimmings is to think about your current shrub and tree maintenance practices.

- Does your landscape have many shrubs that are sheared for tight hedges or rounded globes? If so, consideration should be given to changing this look to a more natural free-form appearance in order to reduce the amount of pruning. Some types of hedges can be left unsheared to assume an attractive natural form. Shearing hedges generates large amounts of woody or evergreen trimmings that are difficult to compost at home or use as mulch unless shredded. Some hedge plants produce attractive flowers or fruit that attract birds if they are left unsheared.

- Are the trees and shrubs on an annual fertilizing schedule? Most trees and shrubs receive nutrients from the surrounding lawn area. If trees and shrubs are showing reasonable growth and appear healthy, fertilizer is not necessary. Fertilizing promotes growth and additional growth will produce more leaves in the fall and may require more pruning.

- Are trees and shrubs showing signs of stress, disease, insect damage or poor growth? As mentioned earlier, have the soil tested by the local Cooperative Extension Service to determine what nutrients are necessary for the health of the plant.

- Are trees being topped when they are pruned? This practice injures the tree and leads to excessive growth. Selective removal of branches is better for the tree and produces less waste.

Summary

In this lesson, you've learned about three additional methods for reducing and recycling yard trimmings. Grasscycling produces a healthier lawn while saving time and money. Mulching with organic materials is a way to reuse yard trimmings and improve gardens and planting beds. With a small investment in planning, resource saving landscape design helps create an attractive yard that generates fewer trimmings.

You have also learned how vermicomposting can be used to manage food scraps and produce valuable products such as fertile worm casting for plants and worms for fishing. Now see how well you can answer the **study questions** and consider trying one or more of the **study activities**.

Study questions
Lesson 6

1. List five benefits of grasscycling.
2. True or false? Leaving clippings on the lawn contributes to the build-up of thatch.
3. Explain five benefits of mulching with organic materials.
4. Describe how to develop a resource saving landscape design.
5. True or false? Any type of earthworm can be used for vermicomposting.
6. Describe two ways to harvest the worm castings.

Answers can be found in the back of the study guide.

Study activities
Lesson 6
Grasscycling demonstration

Conduct a grasscycling demonstration in your front yard so you and your neighbors can observe first-hand any differences between areas of lawn where clippings are collected and where they are left on the lawn. If possible divide your front lawn area in half perpendicular to the street so that pedestrians and motorists passing by can also benefit from your demonstration. For best results, try the demonstration for a minimum of 2-3 months. Consider placing one or two signs in your front yard to inform passersby of your experiment.

The demonstration will be easiest to do if you own a convertible mower with a removable bagging attachment. If you own a mulching mower that does not allow bagging, you may need to rake the clippings in one-half of the front yard, and the bag them. An alternative would be to trade lawn mowers with a neighbor or friend for a few months if they own a mower with a bagging attachment.

The grasscycling demonstration will be most successful if you follow the guidelines for cutting, watering and fertilizing your lawn outlined in this lesson.

Vermicomposting bin

Teaching about a particular subject is always easier when you have first-hand knowledge about the topic. If you do not already have a vermicomposting bin, consider starting one using the information provided in this lesson. A 10-gallon Rubbermaid type bin with holes drilled in for drainage is a nice size if you think you might use it for demonstrations. It may not be large enough to handle all of

your food scraps in which case, you might want to utilize two 10-gallon bins.

Other resources

Applehof, Mary, 1998. Worms Eat My Garbage, Flower Press, Kalamazoo MI 49002, www.wormwoman.com

Appendix – Study Question Answers

Study question answers
Lesson 1

1. Reasons for managing organic materials at home include producing a valuable soil amendment, reducing the need for water and commercial fertilizers, saving money on collecting and managing organic materials off-site, and saving landfill space (food scraps and other non-recyclable organics).
2. You can *reduce* yard trimmings by leaving grass clippings on the lawn, reducing your lawn area, and developing home landscapes that mimic natural systems. You can *reuse* organic materials by mulching with items such as shredded leaves, grass clippings and wood chips. Organic *recycling* can be accomplished using backyard composting and/or vermicomposting
3. Approximately 24 percent of the residential waste stream in Wisconsin is made up of yard trimmings and food scraps. Past studies of backyard composting has shown the average composter will compost 550 to 750 pounds of material per year.
4. Items not included in the legal definition of yard waste include stumps, roots, shrubs with intact root balls, Christmas trees, wreaths or garlands, and floral arrangements.
5. Three byproducts from the open burning of leaves include particulate matter, carbon dioxide and hydrocarbons.

Study question answers
Lesson 2

1. Composting is the biological decomposition of organic material in the presence of oxygen into a humus-like substance called compost. The natural decomposition process is accelerated and improved by controlling environmental factors.
2. Famous individual that made mention of or used compost during the last five hundred years include William Shakespeare, Sir Francis Bacon, Sir Walter Raleigh, Stephen Hoyt, George Washington, Thomas Jefferson, James Madison, Dr. George Washington Carver, Sir Albert Howard, and J.I. Rodale.
3. Aerobic bacteria are considered the most important decomposer because they are very abundant, and provide the most rapid and effective composting.
4. Earthworms ingest organic material and leave behind dark fertile castings. The castings are rich in nutrients that can be readily used by plants.
5. Six key factors that affect the composting process include food (carbon and nitrogen sources), air, moisture, temperature, particle size and volume.

Study question answers
Lesson 3

1. Variety increases the types of microorganisms at work in your pile and your chances of obtaining nutrient rich compost.
2. Fresh, juicy materials and materials of animal origin (e.g. feathers, hair, manure, blood meal) are typically higher in nitrogen. Drier, older, or woody vegetable and plant tissues are usually higher in carbon.
3. Diseased plants, grass clippings treated with pesticides, lime, pernicious weeds and wood ashes.
4. Cat litter and pet wastes may contain pathogenic bacteria, viruses and parasites that require prolonged high temperatures to be destroyed. Avoid droppings from tropical birds as they too may contain harmful pathogens. Bedding from gerbils, hamsters, rabbits and other herbivorous pets is O.K. to add to a compost pile because their digestive systems do not contain enzymes likely to be harmful to humans.
5. Holding units, turning units, heaps, sheet composting, and soil incorporation.
6. Turning units.

Study question answers
Lesson 4

1. Food scraps should be buried at least 8 inches deep in a high carbon material such as leaves. Only add food scraps to a compost pile during the winter if it contains plenty of carbon-rich material and is at least one cubic yard in size. In addition, the pile should be turned in the spring as soon as it thaws out.
2. Physical factors to consider when choosing a composting site include good drainage, fairly level ground, protection from strong winds, convenient access to water, temporary storage space and adequate room in front of the pile for easy access. Avoid putting a compost pile against buildings or underneath dripping eaves and downspouts.
3. The following are unique to the “Hot and fast” compost recipe: use of a compost bin that facilitates turning, collecting materials to fill the bin before starting the pile, mixing layers of carbon-and nitrogen-rich materials, close monitoring of temperatures, and regular turning.
4. A compost pile odor that smells like a mixture of rancid butter, vinegar, and rotten eggs is probably caused by the pile being too wet with not enough oxygen. This problem can be remedied by turning the pile and adding dry coarse materials such as shredded leaves, straw or chopped corn stalks. A compost pile odor that smells like ammonia may be caused by too much nitrogen. The solution to this problem is to add materials high in carbon such as shredded leaves, wood chips, or shredded newspaper. In addition, the pile should be aerated.
5. False, during the initial stages of composting, the pH of the pile is likely to be slightly acidic. The pile will neutralize on its own as long as it gets enough oxygen. It is better to leave lime out of compost piles and add it to soil, if needed.
6. Health considerations related to backyard composting included possible pathogens generated by pet wastes (avoid putting dog, cat, and pet bird, wastes into a pile).

Individuals who are allergic to *Aspergillus fumigatus* and other molds and fungal organisms should take protective measures to minimize exposure.

Study question answers
Lesson 5

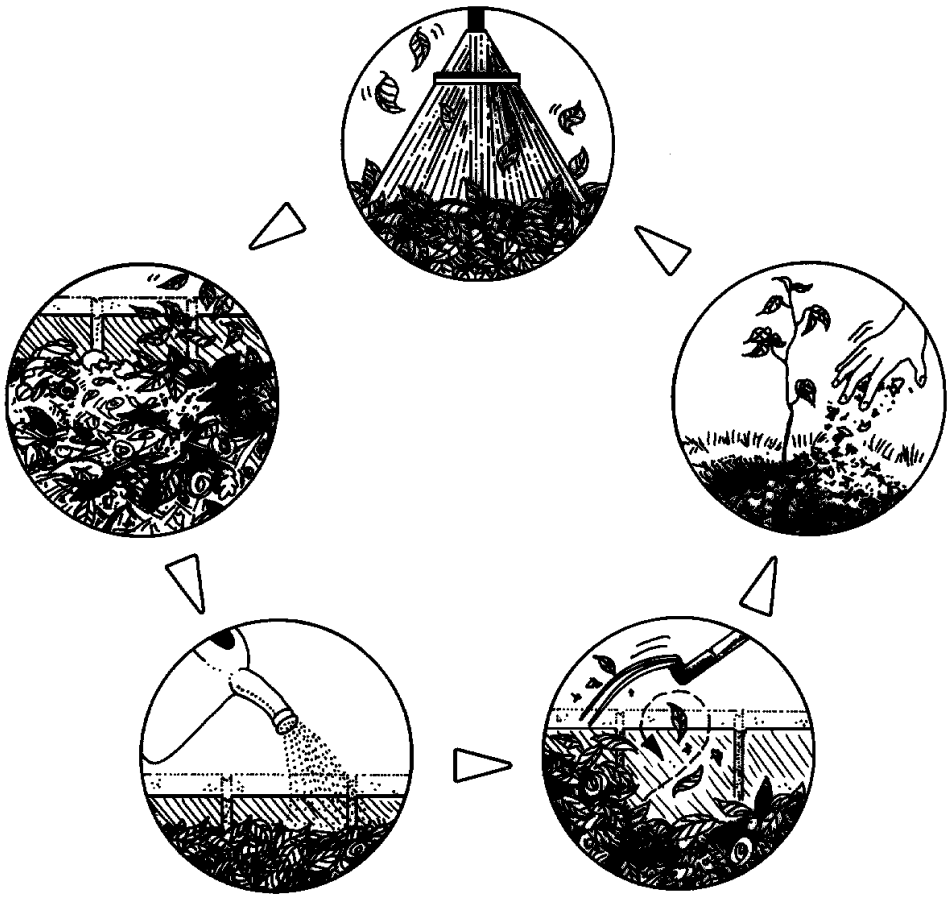
1. Compost greatly improves oil texture while also improving soil's water-retention capability, soil aeration, and resistance to erosion. Other benefits of compost include adding and storing nutrients in the soil, improving soil's ability to buffer rapid changes in pH, and neutralize certain toxins. Compost can also help keep soil temperatures stable.
2. Finished compost is dark, loose and crumbly. It has a sweet and earthy smell. Most of the original materials will not be recognizable. The temperature of finished compost will be approximately the same as the outside air temperature and it should not reheat. You may also find lots of macroorganisms in it such as earthworms and sow bugs.
3. A germination test can be conducted with a few lettuce or radish seeds. The seeds should be soaked in a tea made with compost. An equal number of the same type of seeds soaked in distilled water. The batches of seeds should be laid on a paper towel and kept warm and moist for a few days, until they germinate. If the distilled-water-treated seeds germinate better, the compost needs to be aged longer.
4. Compost tea is made from a bag of compost soaked in water. Nutrients from the compost leach into the water, producing a mild tonic the same color as tea. The tea is an excellent way to provide nutrients to plants and can be applied at watering time.
5. Finely screened compost is recommended for top-dressing lawns and when making container planting mixes.

Study question answers
Lesson 6

1. Grass clippings release valuable plant nutrients such as nitrogen, phosphorus, and potassium. They also help reduce moisture loss due to evaporation. In addition, grasscycling saves time, work and money.
2. False. Grass clippings are not a major component of thatch. A small amount of thatch—less than 1/2 inch—provides insulation to the roots and serves as mulch to prevent excessive water evaporation.
3. Mulch reduces evaporation from the soil surface, keeps weeds down by suppressing the germination of seeds, and it insulates the roots of plants from temperature extremes. Other benefits of mulches include decreasing soil erosion, easing soil compaction, and the addition of valuable soil nutrients as decomposition occurs. Mulches can also help protect tree trunks from being damaged by lawn mowers.
4. The first step for developing a resource saving landscape design is to survey the yard and existing plantings. Look at surrounding views, sunlight patterns, slopes, soils, areas of heavy foot traffic and how well existing turf and plants grow. Next, consult publications and/or experts such as Extension agents, Master Gardeners, landscape designers, and garden store personnel to research locally available plants

for the desired location. Consider using native plants and placing them in naturalized areas and mulched beds. Select appropriate plants for different locations on the property using information obtained during the site survey.

5. False. The best type of worms to use for composting are redworms (Eisenia foetida or Lumbricus rubellus). Nightcrawlers and other garden worms will die in the confined conditions necessary for worm composting.
6. Two methods for harvesting worm compost include the dump and hand sort method and the divide and harvest method. The first method involves dumping the contents of a worm bin onto to plastic, forming the material into mounds, and scraping off the vermicompost until a mass of worms is left. The worms are then placed into the bin with fresh bedding and the vermicompost can be used for plants. With the divide and harvest method, the finished vermicompost is moved to one side of the worm bin. Fresh bedding is added to the other side. Food scraps should be added to the new bedding and within three to four weeks, the worms should migrate to the fresh bedding.



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Master Composter Home Study Course (G4107) I-11-2015