new york city master composter manual

nyc compost project:
nyc.gov/wasteless/compostproject

nyc department of sanitation
bureau of waste prevention, reuse & recycling

2/12 ♻ Printed on recycled paper, of course.

nyc compost project

get all the dirt at nyc.gov/wasteless/compostproject

Funded and managed by the NYC Department of Sanitation, Bureau of Waste Prevention, Reuse & Recycling

Sections of this manual have been adapted from:

Cornell Waste Management Institute, "*Master Composter Resource Manual*," 1998.

Trautmann, N. & Krausny, M., "*Composting in the Classroom*," 1998;
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chapter 1:
new york city master composter certificate course

The goal of the NYC Compost Project Master Composter Certificate Course is to cultivate an enthusiastic core of knowledgeable individuals throughout all five boroughs who will expand the public interest, education, and practice of composting in NYC.

The NYC Compost Project Master Composter course and this manual will provide you with a thorough understanding of the composting process, hands-on experience in designing and building compost systems, and a range of techniques for teaching others about composting. You will then be asked to put this knowledge into action!

above: master composters tabling at the new york botanical garden.

below: master composters turning compost at a community compost site on staten island.

what is composting?

Composting is the process of creating the ideal conditions for the rapid decomposition of organic materials. You can think of composting as speeding up the way nature recycles. In nature, when a leaf falls to the forest floor, it is consumed and digested by a host of creatures, from worms and insects to microorganisms such as bacteria and fungi.

When we make a compost pile out of our organic materials, we are creating the conditions (heat and moisture) that decomposer organisms need to thrive. Only organic materials can be composted—and to prevent disease and odors, certain organic materials, such as animal products, shouldn't be included in urban compost bins (see the "What to Compost" Tip Sheet for a complete list of what to compost).

When the decomposer organisms have done their job, what starts out as fruit and vegetable scraps—which would have wound up in your garbage can—becomes a nutrient-rich material called compost, a dark, crumbly material that looks and feels like soil.

When added to gardens, houseplants, street trees, or parklands, compost:

- provides plants with essential nutrients
- protects soil from erosion and compaction
- makes soil healthier without using chemicals
- makes gardening easier and more rewarding

The ingredients for making compost are readily available to all of us—they are in household trash. By composting materials such as food scraps and yard trimmings at home or in community gardens, we also keep this waste out of incinerators —and landfills, and create a valuable resource for our backyards and neighborhoods.

The compost message challenges New Yorkers to rethink their attitude about recycling and composting. But habits change only when the process of composting is understood and carries with it some personal reward. That's why NYC Department of Sanitation's Bureau of Waste Prevention, Reuse and Recycling (DSNY BWPRR) created and maintains the Master Composter Certificate training program, operated through the NYC Compost Project.

nyc compost project workshops fascinate and educate new yorkers of all ages.

nyc compost project

DSNY's **Bureau of Waste Prevention, Reuse and Recycling** created the NYC Compost Project in 1993 to provide compost outreach and education to NYC residents, institutions, and businesses in all five boroughs.

The **NYC Compost Project** develops and conducts innovative programs to encourage composting in different venues. In each borough, the NYC Compost Project maintains a composting **telephone helpline**, hosts a **composting demonstration site**, and offers a variety of **compost-related workshops and classes**, including the Master

Composter Certificate Course. NYC Compost Project staff and volunteers regularly disseminate composting and recycling information at thousands of community events, and offer **compost bins for sale** to NYC residents.

Visit **nyc.gov/wasteless/compost** for all things compost related in NYC including: NYC Compost Project programs, what and how to compost, uses for compost, compost science, NYC composting operations, composting products and services, composting helpful links, and much more.

master composter program requirements

The NYC Compost Project Master Composter program consists of two parts: the first part is instructional, while the second part involves community outreach. Each Master Composter candidate participates in approximately 23 hours of classroom learning (which includes field trips) and 30 hours of volunteer outreach. Fulfillment of these hours will lead to certification as a Master Composter.

Classroom activities consist of lectures on the technical aspects and science of composting, role playing (to practice teaching techniques), hands-on projects (such as building compost piles), and final project proposal presentations. On field trip days, participants tour different NYC composting facilities and demonstration sites. During the Master Composter Certificate Course you will learn a lot about different aspects of composting, and will have the opportunity to develop your own style of teaching. Sharing your composting experiences with classmates is an important part of this course, and will help you determine how you wish to use your new skills.

Volunteer outreach hours can be fulfilled working side-by-side with program coordinators, or on your own. Examples include helping out at NYC Compost Project workshops and events, conducting backyard compost bin check-ups, giving tours of local composting demonstration sites, assisting schools or community gardeners with setting up a compost system, or including composting

above top: nyc compost project staff building a three-bin composting system at a community garden in brooklyn.

above bottom: nyc compost project staff demonstrating how to compost with a worm bin at a school fair in manhattan.

in neighborhood beautification or greening efforts. For some, addressing a civic association meeting is most comfortable.

Work with your program coordinator to determine how best to apply your personal talents and to make sure your presentation is accurate and professional. Master Composters can request BWPRR-produced educational materials on composting, recycling, and waste prevention from their local NYC Compost Project. These materials may also be viewed, downloaded, and ordered on the NYC recycle more, waste less website: **nyc.gov/wasteless.**

above: children learn by doing with nyc compost project staff at snug harbor cultural center and botanical garden on staten island.

more info and feedback

All material contained in this manual is copyrighted by the NYC Department of Sanitation, Bureau of Waste Prevention, Reuse and Recycling (BWPRR) and cannot be reproduced without permission.

Additional copies of this manual, as well as Tip Sheets, compost brochures, and information on recycling and waste prevention in New York City, are available through the BWPRR website, **nyc.gov/wasteless.**

We hope you find this manual informative and helpful in your efforts to educate New Yorkers about the benefits and methods of composting. We welcome your comments on the Master Composter program and encourage you to send us any feedback through the NYC recycle more, waste less website: **nyc.gov/wasteless/contact.**

above: nyc compost project staff conducting an indoor composting workshop.

below: nyc compost project staff assisting with a bin build in brooklyn.

nyc compost project
master composter certificate program

course expectations

The Instructors will:

1. Conduct the program in an informal fashion, where you can take wild guesses, try different things, and make mistakes as you master new information, experiences, skills, and techniques.
2. Ensure that all trainees are given the same opportunities to succeed in the program, regardless of any previous relationships with Department of Sanitation's Bureau of Waste Prevention, Reuse and Recycling, the NYC Compost Project, or the host site.
3. Carefully plan and time out classroom sessions and field trips in order to cover all of the required material.
4. Determine how course time is spent and organized, including whether to continue discussions, extend experiments, answer additional questions, or move on to the next topic.
5. Encourage the expression of varying viewpoints, but when necessary mediate any disagreements.
6. Respond to email or phone requests no later than the end of the next class.
7. Understand that you have work, family, and personal responsibilities beyond this course, so required assignments will be kept to less than two hours per week outside of the course.

As a Master Composter Trainee, I will:

1. Fulfill all the requirements listed on the syllabus.
2. Take full advantage of this opportunity and challenge myself to go to the next level.
3. Join in discussions without worrying about having "the right answer" and try new things even if I'm not sure that I have mastered them yet.
4. Assist with clean-up tasks after classroom sessions, field trips, and site visits.
5. Respect that instructors have work, family, and personal responsibilities beyond the course. Submit questions to instructors via e-mail or voice message if there is not time to address a specific inquiry before, during, or after class.
6. Call the NYC Compost Project office line or cell phone if I will be late to a class, field trip, volunteer opportunity or have an emergency.

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Instructors & Master Composter Trainees agree to:

1. Create a positive experience in the classroom and in the field that links program participants and guests to the people, programs, and activities of the NYC Compost Project and the host sites.
2. Conduct ourselves at all times in a manner that is respectful towards the people, organizations, property, and places that are part of this program. This includes:
    a. Properly representing the policies and views of Department of Sanitation's Bureau of Waste Prevention, Reuse and Recycling, the NYC Compost Project, and the host site.
    b. Arriving on time and being well-prepared for all classes, trips, and volunteer opportunities.
    c. Recognizing that each of us is unique and that all of us have valuable, though different, experiences, viewpoints, and observations to share.
    d. Being open to learning from others in the classroom and out in the field.
    e. Respecting other people's comfort levels when it comes to handling the materials and living organisms that may be encountered in the field or passed around in classroom settings.
3. Show no discrimination or harassment towards others with regard to, but not limited to, such factors as race, color, creed, religion, national or ethnic origin, citizenship, gender or gender identification, sexual orientation, age, veteran or military status, marital status, disability, or other personal characteristics. Harassment includes making derogatory remarks or jokes about such characteristics and other verbal, physical, and visual behavior.

Date: _____

Signature: _____

Print name: _____

Course taken at: (Check the relevant host site.)

- ☐ NYC Compost Project in Brooklyn, hosted at the Brooklyn Botanic Garden
- ☐ NYC Compost Project in the Bronx, hosted at The New York Botanical Garden
- ☐ NYC Compost Project in Manhattan, hosted at the Lower East Side Ecology Center
- ☐ NYC Compost Project in Queens, hosted at Queens Botanical Garden
- ☐ NYC Compost Project on Staten Island, hosted at Snug Harbor Cultural Center & Botanical Garden

nyc compost project
photo/video consent form

subject: **Master Composter Certificate Course and Associated Activities**

location: **Various**

I grant NYC Department of Sanitation's Bureau of Waste Prevention, Reuse and Recycling (BWPRR), its employees, and any of its representatives (including but not limited to NYC Compost Project host sites listed below) the right to take photographs or video of me and my property in connection with the above-identified subject.

I authorize BWPRR, its representatives, and employees to use such photographs and/or video of me with or without my name for any lawful purpose, including for example such purposes as publicity, illustration, and Web content.

I have read and understand the above:

Signature _____

Printed name _____

Organization Name (if applicable) _____

Mailing Address (Optional) _____

_____

Email Address (Optional) _____

Date _____

Signature, parent or guardian (if under age 18) _____

Please check the relevant NYC Compost Project associated with the subject and location indicated above:

- ☐ NYC Compost Project in Brooklyn, hosted at the Brooklyn Botanic Garden
- ☐ NYC Compost Project in the Bronx, hosted at The New York Botanical Garden
- ☐ NYC Compost Project in Manhattan, hosted at the Lower East Side Ecology Center
- ☐ NYC Compost Project in Queens, hosted at Queens Botanical Garden
- ☐ NYC Compost Project on Staten Island, hosted at Snug Harbor Cultural Center & Botanical Garden

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outreach preferences and interests

Tell us more about yourself so we can guide you toward relevant outreach opportunities. Please complete this form and return it before the end of class.

Name _____ Date _____

What audiences are you most interested in reaching? Check all that apply.

- ☐ residents (neighbors, friends, or family)
- ☐ community gardeners
- ☐ nonprofit, community, or greening groups
- ☐ school groups and/or youth organizations
- ☐ educators
- ☐ institutions (hospitals, colleges, etc.)
- ☐ businesses (restaurants, produce stores)
- ☐ religious organizations
- ☐ seniors
- ☐ other

List your connections to particular organizations, gardens, institutions, businesses, or residents where you live, work, or go to school. Please provide at least three connections so that we can help you think through your final project proposal ideas.
(Examples: MS 51, Sixth Street Community Center, Castleton Hill Moravian Church, Van Cortlandt Village CSA, etc.)

_____

_____

_____

Describe any hobbies, talents, or skills that could be incorporated into a compost-related project. Please list at least three.
(Examples: photography, wood-working, gardening, drawing, etc.)

_____

_____

_____

Check the opportunities that most interest you to work alongside certified Master Composters and Compost Project staff.

- ☐ compost site maintenance (turning, sifting)
- ☐ compost site tours
- ☐ construction & repair (compost bins/sifter)
- ☐ horticultural projects (gardening, street tree care)
- ☐ information table at community events
- ☐ indoor and outdoor workshops
- ☐ office workdays
- ☐ outreach & promotional literature distribution
- ☐ technical assistance at compost sites
- ☐ worm bin maintenance

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self-evaluation

This self-evaluation will help you measure your progress in becoming a knowledgeable Master Composter who is comfortable and confident in reaching and teaching others.

Below is a list of activities that Master Composters do on a regular basis. Please check the box that best describes how you would feel if you were asked to do this NOW. (Don't worry, you won't be asked!) Please only check one box per row.

Typical Master Composter Activity	*I'm not ready to try this on my own yet.*	*Somewhat unsure about my abilities, but I would be willing to try.*	*I'm okay with it since I've done it before, but would like to improve.*	*Pretty comfortable; I have some experience.*	*Experienced enough to show someone else how to do this.*
talking one-on-one about composting					
making a batch of compost from scratch					
speaking informally to a small group					
deciding what type of bin works best for a specific situation					
using power tools					
setting up a worm bin					
creating compost-related activities for others					
developing a compost lesson plan					
public speaking or making a presentation					
troubleshooting or solving other people's compost problems					
using compost for horticultural projects					

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final project proposal

Overview

The Final Project Proposal is a great way to apply the skills learned throughout the program to a particular compost education or outreach initiative. Successful proposals weave together all the elements of the Master Composter Certificate Course (clear public speaking, effective use of outreach materials, and solid technical knowledge) into a specific, well-defined effort. Preparation and presentation of your proposal is a good way to share with others what you have learned throughout the program.

Developing a Final Project Proposal is a requirement of the Master Composter Certificate Course. Once the proposal is approved, work on the final project can be credited towards your certification hours.

Check your Master Composter Manual for inspiration and information since it contains examples of presentations, workshops, educational tools, experiments, and games. Please contact the course instructor if you need additional help or resources.

Requirements

(The Final Project Proposal consists of three specific assignments; see course syllabus for due dates.)

1. **Develop an idea for a specific compost-related outreach activity, program, or project.**
   Complete the worksheet on the back to outline your proposal. When completing the worksheet, focus on the people, activities, and areas that spark your interest. The key is to develop an outreach activity that you could actually do as part of your required volunteer hours within the next year. Use these questions to help guide you:

   - What connections do you have to particular organizations, gardens, institutions, businesses, or residents where you live, work, or go to school?
   - What type of hobbies, talents, or skills do you have or enjoy that could be incorporated into a compost-related project?
   - Which Master Composter candidates or other people could you team up with for a joint project?

2. **Submit a written proposal.**
   Proposals must contain details about your project, including your target audience, type of activity, location/venue, goals, and a description of the content and materials that will be included in your activity. See the syllabus to find out when the instructor(s) will provide feedback on your proposals.

3. **Present final project proposal to class.**
   You will practice your public speaking and teaching skills by presenting your final project proposal idea and its details to the other Master Composter candidates during class. Presentations should include actual examples of the content and materials or handouts you plan to use for your project. Time permitting, you will receive and respond to feedback from the class.

nyc compost project
master composter certificate program
final project proposal worksheet

Be S.M.A.R.T. about what you want to accomplish!
Specific – **M**easurable – **A**chievable – **R**elevant – **T**ime Defined

WHY: Describe the goals or outcome you hope to achieve.

WHO: Define your target audience and your connection to them.

WHERE: Determine appropriate location or venue for your project.

WHEN: Devise a proposed timeline.

WHAT: Describe the type of activity, program, or project (workshop, demonstration, tabling, distribution of literature, skit, etc.).

HOW: Describe the content, materials, and methods that you will use.

Master Composter Candidate Name _____ Date Submitted _____

NYC Compost Project Instructor Name _____ Date Reviewed _____

nyc compost project
master composter certification and volunteer hours record

To receive credit towards certification or any available volunteer benefits, all hours must be pre-approved by NYC Compost Project staff AND logged or reported to the NYC Compost Project instructors by the end of the month in which they were completed.

name: _____

Date of Activity	Activity Title	Activity Location, Street Address, City, State, Zip	Activity Type (e-blast, info table, meeting/consultation, tour, technical assistance, workshop)	Primary Attendee Type or Name of Attending Organization(s) (gardeners, general public, K-12 teachers, K-12 staff, K-12 students, master composters, Parks employees)	# of People Interacted with at Event	Volunteer Hours	Running Total	Staff Use

Examples:

2/21	Tabling: MulchFest	Clove Lakes Park, 1150 Clove Rd., SI, NY 10301	info table	general public	42	2.5	2.5	
3/5	Compost Bin Build	Bainbridge Community Garden, 277–279 Bainbridge St, BK, NY, 11233	technical assistance	gardeners	10	3	5.5	

Save for reference-or recycle it!

name: _____

Date of Activity	Activity Title	Activity Location, Street Address, City, State, Zip	Activity Type (e-blast, info table, meeting/consultation, tour, technical assistance, workshop)	Primary Attendee Type or Name of Attending Organization(s) (gardeners, general public, K-12 teachers, K-12 staff, K-12 students, master composters, Parks employees)	# of People Interacted with at Event	Volunteer Hours	Running Total	Staff Use

chapter 2: the science of decomposition

decomposition in nature

what breaks down? an introduction to organic matter

Organic matter is the vast array of carbon compounds in soil. Inclusive of all living organisms and non-living material derived from organisms, organic materials include plants, animals, microbes, animal excrement, shed skins, feathers, and food. Waste generated by plants and animals, or remaining after we use products made from a plant or an animal, is also organic. Figure 2.1 lists some of the common organic materials that we use and dispose of daily.

Organic materials are unique in that they decompose. In nature—think of the forest floor—decomposing organic compounds are integrated into the soil where they play important roles in nutrient, water, and biological cycling. But in the city, where most soil is covered with concrete, organic materials rarely make it back into the ground.

figure 2.1: common organic materials

category	example
food	fruits, vegetables, grains, eggs, dairy products, meats, fish
clothing, textiles, and furnishings	cotton, wool, burlap, leather, feathers, down
paper products	paper, newsprint, cardboard, tissues, packaging material
by-products	food processing wastes, sawdust, blood, bones, fur, paper pulp, shipping pallets
animal wastes	manure, sewage, hair
yard materials	grass clippings, leaves, prunings, weeds, fallen branches

why decomposition is important: properties of soil and plant growth

So, what's the big problem? Our system of disposing things works, doesn't it? In that we no longer walk down streets lined with rotting food and horse manure, yes, our system works. But, in our failure to use the organic materials in our garbage to refortify our soils, we're doing ourselves, and the ecosystems we rely on, a grave disservice.

The growth of all organisms—including humans—is dependent on the availability of mineral nutrients. To fulfill our nutrient needs, we eat plants (usually processed or cooked into a variety of foods). Plants derive the nutrients they need from the soil.

what is soil?

Soil is a mixture of minerals, organic matter, water, and air. The proportions of these elements in a particular soil vary in accordance with use, climate, and regional environment. A moist, subtropical climate, for example, is bound to have wetter soils than a desert.

Soil type or texture—how it looks and feels—depends on the proportion of specific sizes of mineral particles (sand, silt, and clay) present in a particular sample of soil [Figure 2.2]. Soil type varies from one place to another in your backyard.

Some soils are more nutritive than others; some soils are more compact than others. The ways in which soil components interact influence the physical properties attributable to a soil.

figure 2.2; relative sizes of mineral particles

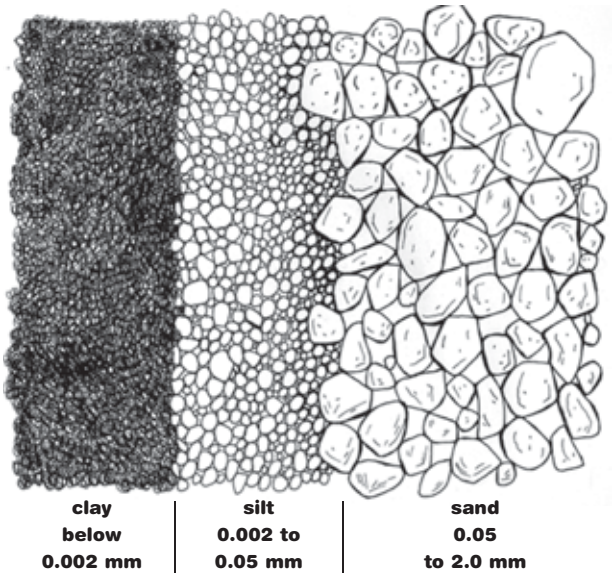
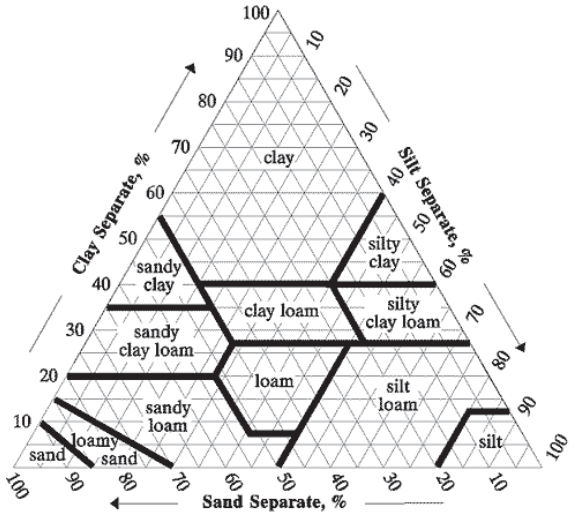


figure 2.3: soil texture



properties of soil

Whether a soil drains well, stores moisture, or provides for the nutritive needs of plants is determined by its texture [figure 2.3], and subsequently, its structure or how the individual mineral particles are arranged. In a well-structured soil, loosely grouped particles called aggregates prevent soil particles from packing tightly together. In between aggregates are many small air pockets like the empty spaces in a jar of marbles. These spaces, or pores, form channels that allow plant roots, excess moisture, and air to move easily through the soil. Smaller pores within the aggregates hold moisture and nutrients until plants need them.

In the absence of aggregates, soil function declines. In sandy soils, for example, the absence of aggregates results in the inability of soil particles to bind together. As a result, the soil cannot hold onto moisture and nutrients. Whatever is not used immediately passes right through.

Deprived of nutrients, soil, like plants and people, becomes weaker and less able to support the organisms (plants, insects, bacteria) that rely on it for sustenance and

shelter. Dry, sandy soils and compacted, clay-rich soils are examples of unhealthy soil types: their soil structures make them incapable of supporting much life.

the function of organic materials in soil

Decomposition is nature's way of recycling organic matter to replenish the soil and nourish plant growth. By encouraging the formation of aggregates, decomposed organic matter—or humus—improves the structure of sand, silt, and clay soils. Enhanced soil structure, in turn, conditions a soil to support healthy plant (and, by extension, animal) life. The following life-sustaining properties characterize humus-enhanced soils:

water and nutrient retention

In loose, sandy soils, humus helps to bind unconsolidated particles together to retain water and nutrients that would normally wash right through.

aeration

Added to a clay or silt soil, humus breaks up the small, tightly bound particles and forms larger aggregates. This allows water to drain and air to penetrate.

nutrient availability

Tiny nutrient particles wash through sandy soils and get trapped (out of the reach of plant roots) in compacted clay soils. The air channels in humus aggregates create vast, plant-accessible nutrient storage chambers. Ionized nutrients from minerals and fertilizers cling to the internal surfaces of aggregate pores until plants want them. The "Cation Exchange Capacity" (CEC) is a measurable indicator of the soil's ability to store important plant nutrients, chiefly: calcium, magnesium, and potassium.

moderation of pH

The availability of nutrients in soil is influenced by pH, a measure of soil acidity or alkalinity. Strongly acidic soils release excess micro-nutrients and lock in phosphorous; strongly alkaline, or basic, soils hold onto valuable minerals. Humus moderates soil pH and makes nutrients already present in the soil more accessible to plants.

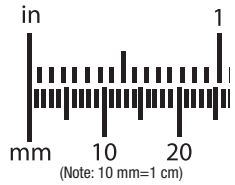
methods of decomposition

Just as photosynthesis describes the transfer of energy from the sun to plants, decomposition describes the transfer of energy from dead, excreted, or outgrown organic matter to living things. Microorganisms including bacteria, nematodes, and actinobacteria form the core of a complex food web that extends from worms and beetles to birds and other predators. By digesting organic residues that range anywhere from plant debris, to feces, to feathers, to bones, microorganisms create a source of energy and nutrients for other organisms. Among leaves and logs on the forest floor, in a steaming pile of hay or manure, or in a compost pile, many of the same organisms are at work. The decomposition food web [Figure 2.4] illustrates the hierarchy of consumption amongst decomposer organisms. This hierarchy is also reflected in the pyramid of functional groups depicted on the "Decomposers in a Compost Pile" Tip Sheet.

figure 2.4: decomposition food web

compost food web identification guide

The compost food web is a way of observing organisms according to what they eat and by whom they are eaten! Follow the guide below to identify organisms in your compost pile and learn who may be eating whom.

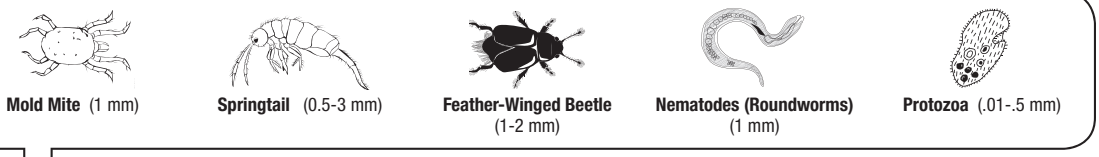


tertiary consumers

Largely macroorganisms that feed on secondary consumers.

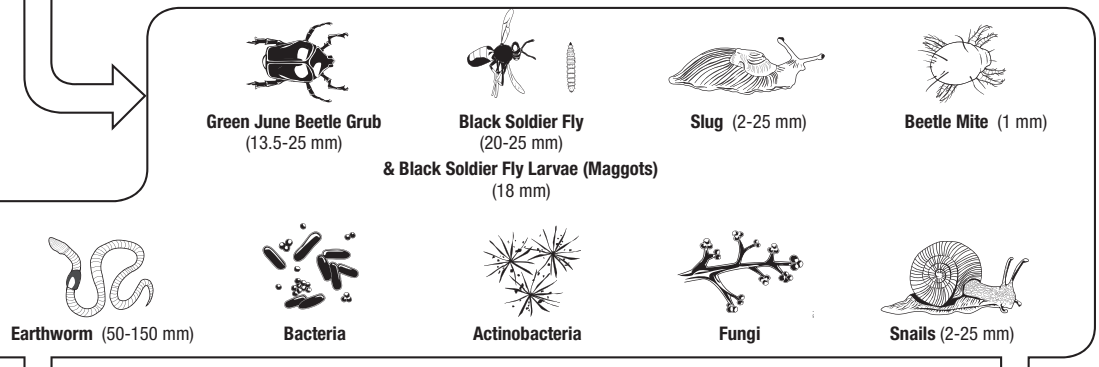
secondary consumers

Largely macroorganisms that mainly feed on primary consumers.



primary consumers

Largely microorganisms that primarily feed directly on dead plants or animals.



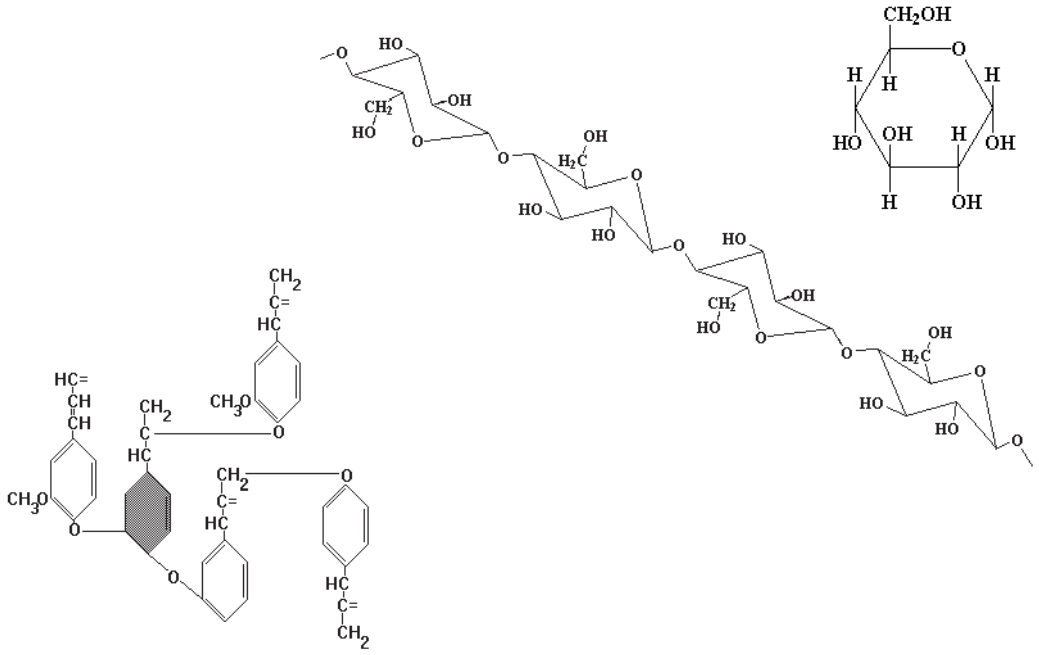
organic residue

Leaves, grass clippings, other plant debris, and food scraps.

Decomposer organisms use enzymes to digest organic matter. Like keys, enzymes are designed only to fit (or react with) particular "locks." In decomposition, these locks are the complex chemical compounds, like lignin and cellulose, which contain such important micronutrients as nitrogen, carbon, phosphorous, and potassium. Because every form of matter has a unique molecular structure, different materials require different amounts of time to decompose. Complex materials—like woody plants, which

contain high quantities of lignin—take longer to break down than simpler, cellulose based, green-leafy plants [Figure 2.5]. Examples of decomposer enzymes include cellulase to break down cellulose, amylase to break down starches, and protease to break down proteins.

figure 2.5: lignin molecule next to less complex cellulose/glucose molecule. Lignin, large polymers that cement cellulose fibers together in wood, are among the slowest compounds to decompose because their complex structure is highly resistant to enzyme attack.



The end result of decomposition is the conversion of organic matter back into its original inorganic nutrient form. Enzymes catalyze reactions in which sugars, starches, proteins, and other organic compounds are metabolized—"burned"—to produce carbon dioxide, water, energy, and compounds resistant to further decomposition. In the process, micronutrients are released in forms that are accessible to plants and other micro-organisms. While some decomposition occurs in the absence of air, most biological breakdown requires oxygen. The specifics of aerobic and anaerobic respiration are described below.

aerobic decomposition

In a forest ecosystem, nothing goes to waste. Aerobic decomposition—the breakdown of organic matter by oxygen breathing decomposer organisms—recycles such organic materials as leaf litter, animal remains, and excrement back into the forest floor. The most common decomposition process in nature, aerobic decomposition is also the most efficient (i.e., the most complete) disintegration process. Because oxygen breathers are able to more fully breakdown—or metabolize—organic matter, aerobic decay releases more energy and generates higher temperatures than the anaerobic process. The ability of aerobic decomposition to yield temperatures high enough to kill pathogens and other invasive pests is a recognized benefit of this process.

Where anaerobic decomposition relies predominantly on bacteria, aerobic decomposition involves a complex web of interacting organisms. Bacteria and fungi initiate the release and recycling of nutrients by secreting specialized enzymes to break down complex organic compounds. As nutrient compounds get passed around the food web, proteins decompose into amino acids such as glycine or cysteine. These nitrogen- and sulfur-containing compounds then further decompose, yielding simple inorganic ions such as ammonium (NH4+), nitrate (N03-), and sulfate (S042-) that become available for uptake by plants and other microorganisms.

In addition to releasing nutritive ions, microbes link some of the chemical breakdown products into long, intricate chemical chains called polymers. Because polymers resist further decomposition, they help to generate another end product of aerobic decomposition: an earthy mixture of organic compounds called humus. Other end products of aerobic decomposition include water and carbon dioxide.

anaerobic decomposition

The decomposition of organic matter in the absence of oxygen, anaerobic decomposition or putrefaction, involves a select group of microorganisms that do not require air to survive. Anaerobic breakdown is the less efficient of the two decomposition reactions. Because breakdown of organic matter is substantially slower and less complete in anaerobic environments, less energy is released as heat and temperatures remain low.

End products realized by anaerobic decomposition include the standard by-products of all decomposition—water, carbon dioxide, and humus—as well as small-molecule alcohols, organic acids, ptomaines, amines, and gaseous substances such as methane and hydrogen sulfide (from which it gets its smelly reputation).

decomposition in a compost pile

In the process of composting, humans have found a way to make the decomposition process work for us. Defined as the controlled process of decomposition, composting allows us to cultivate decomposer ecosystems for the purpose of converting organic materials into humus: a dark, crumbly, nutrient-rich soil amendment.

If a compost pile is an ecosystem, then the key to expediting and enriching the compost process is to create the most favorable environment possible for resident organisms. Maintaining an aerobic system tends to yield the best results. When kept up, these conditions ensure an odorless process that reaches temperatures high enough to kill off pathogens.

Many chemical changes occur during composting, either relatively rapidly in thermophilic systems or more slowly in worm bins or other systems that usually do not heat up. In the course of the three-part cycle that is thermophilic composting, temperatures reach up to 160° Fahrenheit and a rotating brigade of pivotal decomposers lays claim to the pile. For all of the de-construction that ensues, however, the end product offers an unparalleled, chemical free method of re-building depleted soils and remediating contaminated land.

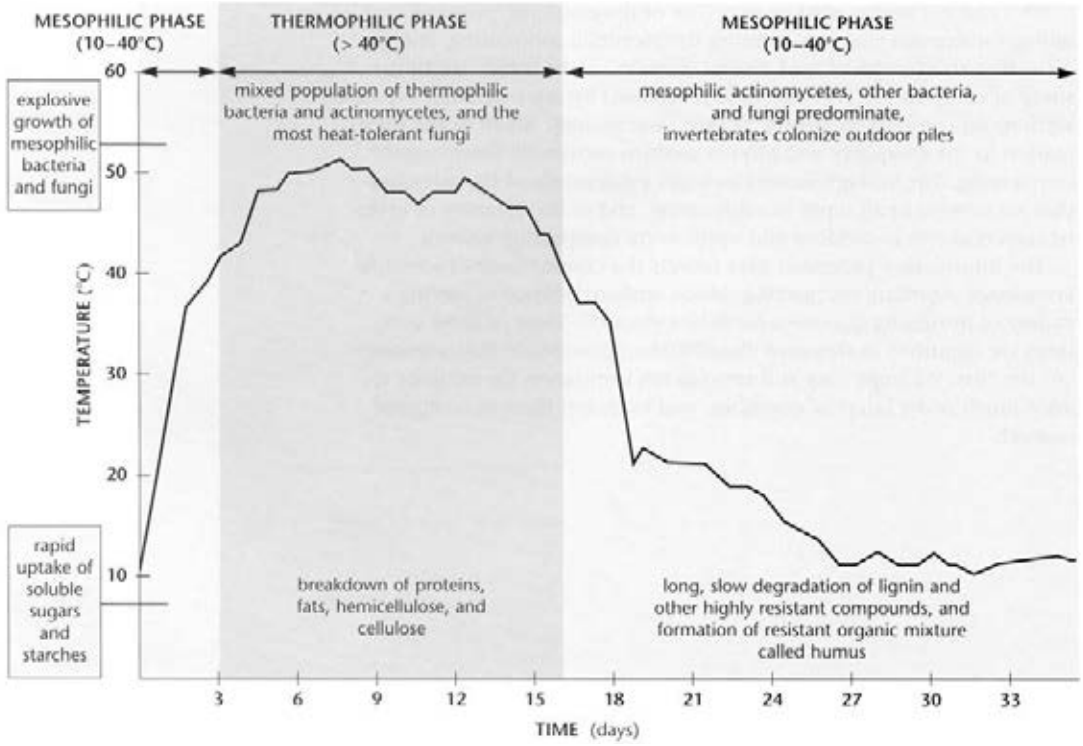
compost chemistry: one HOT pile!

thermophilic composting

Because high temperatures promote rapid decomposition and kill weed seeds and disease-causing organisms, many composting systems are based on providing the optimal conditions for thermophilic, or "hot" composting. Based on the temperature of the pile, thermophilic composting can be divided into three phases:

1. a mesophilic, or moderate-temperature phase (up to 104°F or 40°C), which typically lasts for a couple of days;
2. a thermophilic, or high-temperature phase (over 104°F or 40°C), which can last from a few days to several months depending on the size of the system and the ingredients; and
3. a several-month mesophilic curing or maturation phase.

figure 2.6: the three phases of thermophilic composting



You can map the progress of thermophilic composting by taking periodic temperature measurements and charting a "temperature profile" [Figure 2.6].

High temperatures are a by-product of the intense microbial activity that occurs in thermophilic composting. During the various temperature phases, different communities of microorganisms predominate. Initially, bacteria and other mesophilic microorganisms ingest any soluble sugars in the compost mixture. Thriving at moderate temperatures, these microbes quickly break down readily degradable compounds. The heat that they produce as they digest and reproduce causes the compost temperature to rise.

Once temperatures exceed 104°F (40°C), mesophilic microorganisms become less competitive and are replaced by thermophilic (heat-loving) microbes. During the thermophilic stage, high temperatures accelerate the breakdown of proteins, fats, and complex carbohydrates like cellulose and hemicellulose, the major structural molecules in plants [Figure 2.7]. As the food available to thermophilic organisms becomes depleted, their rate of growth slows and the temperature begins to drop. Turning the pile at this point may produce a new temperature peak (points C and D in Figure 2.8). This is because relatively undecomposed organic matter gets mixed into the center of the pile, where temperature and moisture conditions are optimal for rapid decomposition. At the completion of the thermophilic phase, the compost temperature drops (point E). No amount of turning or mixing will raise the temperature again.

figure 2.7: chemical decomposition during thermophilic composting

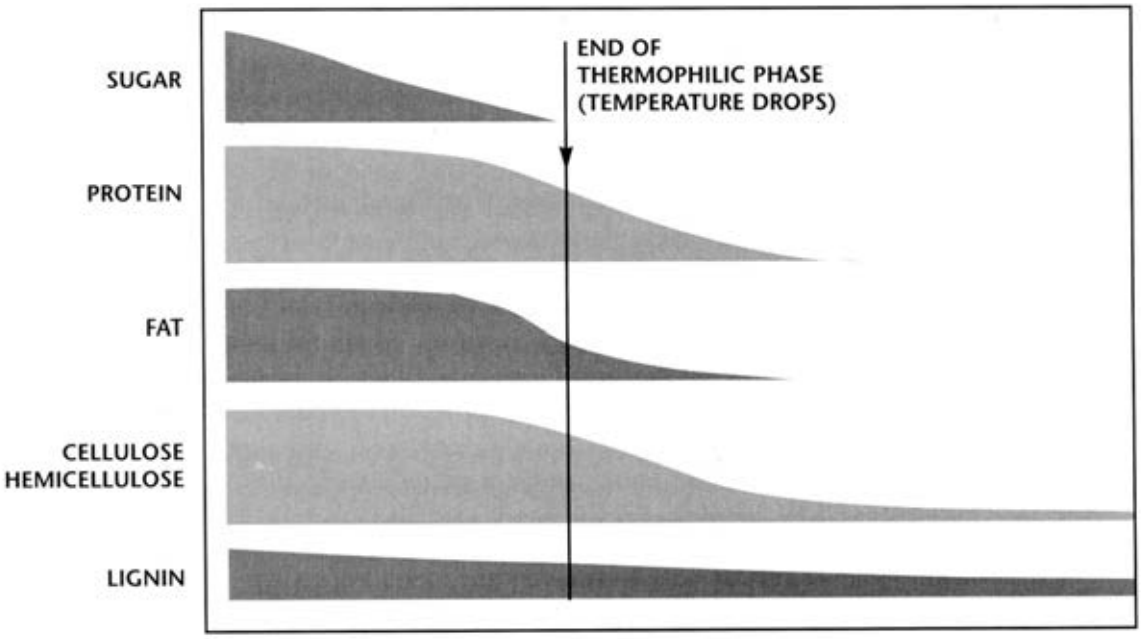
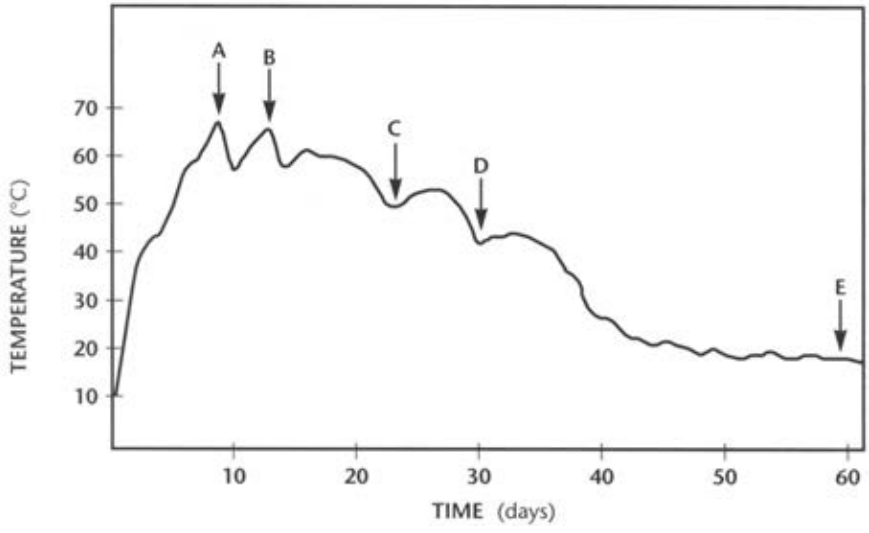


figure 2.8: the effects of turning on composting temperature

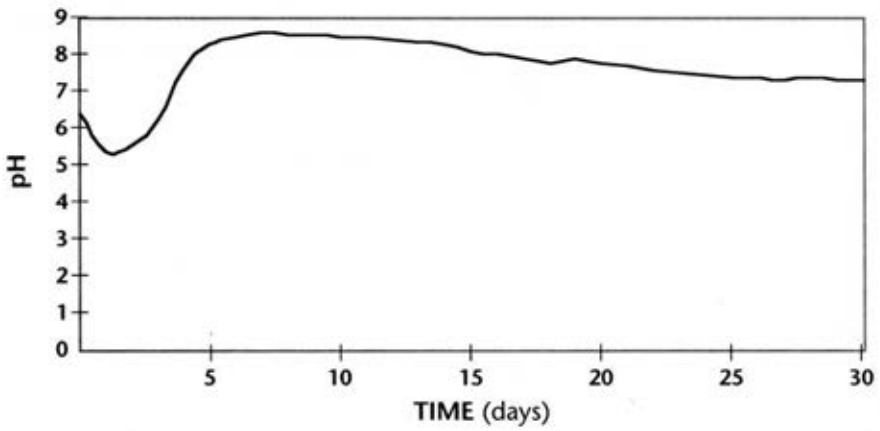


Mesophilic microorganisms take over for the final phase of "curing," or maturation. During this phase, the slow breakdown of complex polymers continues and polymers that are resistant to decay become incorporated into humus. Although the compost temperature is close to ambient, stabilizing reactions continue to occur within the remaining organic matter.

pH

During the course of composting, the pH generally wavers between 5.5 and 8.5 [Figure 2.9]. The initial pH depends on the composition of the ingredients. In the early stages of composting, organic acids may accumulate as a by-product of the digestion of organic matter by bacteria and fungi. The resulting drop in pH encourages the growth of fungi, which are active in the decomposition of lignin and cellulose. Usually, the organic acids break down further during the composting process, and the pH rises. This is caused by two processes that occur during the thermophilic phase: decomposition and volatilization of organic acids, and release of ammonia by microbes as they break down proteins and other organic nitrogen sources. Later in the composting process, the pH tends to become neutral as the ammonia is either lost to the atmosphere or incorporated into new microbial growth. Finished compost generally has a pH between 6 and 8. If the system becomes anaerobic, it will not follow this trend. Instead, acid accumulation may lower the pH to 4.5, severely limiting microbial activity. In such cases, aeration is usually sufficient to return the compost pH to acceptable ranges.

figure 2.9: changes in pH during thermophilic composting



compost ecosystem

Decomposers in a compost pile are part of a complex compost ecosystem in which food, water, air, and shelter are provided for by the organic material within the compost pile. If any of those essential ingredients are missing, the organisms either slow down or stop working all together. It is this web of interdependence that is the driving force behind the production of compost.

Some organisms feed on decomposing plant materials while others feed on other organisms. The two main categories of decomposers are as follows:

Chemical decomposers work by using chemicals in their bodies to break down the organic matter into simple compounds for energy. This is similar to how the acids in our stomachs dissolve the food we eat. Chemical decomposers are mostly microorganisms that cannot be seen without a microscope. Examples of chemical decomposers include bacteria, protozoa, and fungi.

Bacteria are the most abundant of the microorganisms found in a compost pile and perform the majority of the decomposition. An important by-product of their work is the generation of heat, which can warm up the pile and attract other heat-loving organisms to assist with the breakdown process.

Physical decomposers work by feeding on the organic materials in a pile. Similar to how we use our teeth to break up large pieces of food, physical decomposers chew, grind, and squeeze the materials into smaller pieces. After digestion, they excrete waste products which are then broken down even further by the chemical decomposers. Physical decomposers are mostly macroorganisms that can be seen without a microscope. Examples of physical decomposers are worms, mites, flies, and snails.

Earthworms do a large amount of the decomposition work among the macroorganisms. Several species of worms dig tunnels and feed on the decomposing materials in the compost pile. The spaces that the worms create as they move through the compost pile allow air, water, and nutrients to circulate, creating the necessary conditions for many of the other organisms to thrive.

microorganisms

Bacteria, fungi, actinobacteria, and protozoa digest organic matter and convert it into chemical forms that are usable by other microbes, invertebrates, and plants. The "invisible" inhabitants of the pile, microorganisms play an active role within invertebrates' digestive systems, on their excrement, and in layers coating the particles of organic material.

bacteria

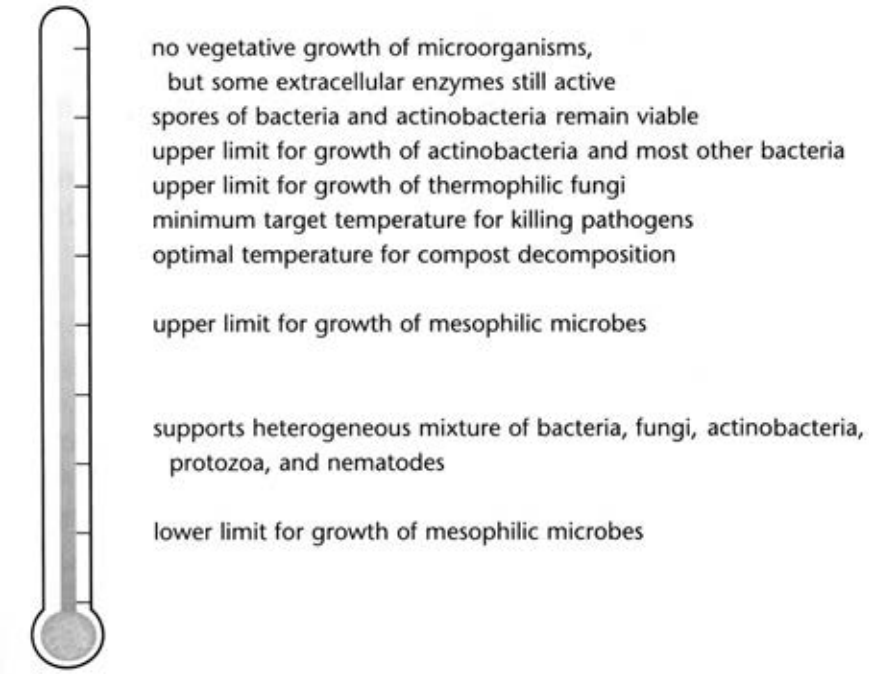
Bacteria, single-celled microorganisms, are responsible for most of the decomposition and heat generated in compost. The most nutritionally diverse group of compost organisms, bacteria use a broad range of enzymes to chemically break down a variety of organic materials. Structured as rod-shaped bacilli, sphere-shaped cocci, or spiral-shaped spirilli, many bacteria are motile, meaning they have the ability to move under their own power. When conditions become unfavorable, bacilli form thick-walled endospores that are highly resistant to heat, cold, and dryness. These spores are ubiquitous in nature and become active whenever environmental conditions are favorable [Figure 2.10].

Mesophilic bacteria, most of which can also be found in topsoil, include hydrogen-oxidizing, sulfur-oxidizing, nitrifying, and nitrogen-fixing bacteria. During the initial stages of composting, mesophilic populations increase exponentially as they devour the readily available simple compounds such as sugars and starches. Mesophilic microbes also inhabit compost piles during the curing, or maturation, phase. The numbers and

types of mesophiles that recolonize compost as it matures depend on what spores and organisms are present in the compost and the immediate environment.

Members of the genus Bacillus dominate the populations of thermophilic bacteria that are active in the "hot" stage of the composting process. The diversity of bacilli species is fairly high at temperatures from 122-131°F (50-55°C), but decreases dramatically above 140°F (60°C). Only bacteria of the genus Thermus—native to hot springs, deep-sea thermal vents, and manure droppings—have been isolated at the highest compost temperatures.

figure 2.10: temperature ranges for compost microorganisms



actinobacteria

actinobacteria

Actinobacteria are a type of primary decomposer that can survive a wide range of temperatures, but are most commonly found in the early stages of the compost pile. They were previously called "actinomycetes," but have recently been reclassified as bacteria.

Actinobacteria are responsible for that characteristic earthy smell of soil, similar to a rotting log. They form long, threadlike branched filaments that look like gray spider webs stretching through compost. These filaments are most commonly seen toward the end of the composting process, in the outer 10 to 15 cm of the pile. Sometimes they appear as circular colonies that gradually expand in diameter.

In the composting process, actinobacteria play an important role in degrading complex organic molecules such as cellulose, lignin, chitin, and proteins. Although they do not compete well for the simple carbohydrates that are plentiful in the initial stages of composting, their enzymes enable them to chemically break down resistant

debris, such as woody stems, bark, and newspaper, that are relatively unavailable to most other forms of bacteria and fungi.

Some species of actinobacteria appear during the thermophilic phase, and others become important during the cooler curing phase, when only the most resistant compounds remain. Actinobacteria thrive under warm, well-aerated conditions and neutral or slightly alkaline pH.

fungi

fungi

Fungi—which include molds and yeasts—are responsible for the decomposition of complex plant polymers in soil and compost. In compost, fungi break down cellulose and other tough debris that are too dry, acidic, or low in nitrogen for bacterial decomposition. Using a process called extracellular digestion, fungi secrete digestive enzymes onto their food; then, they absorb the nutrients released.

Fungi species are predominantly mesophilic. When temperatures are high, most are confined to the outer layers of compost. Compost molds are strict aerobes. They can be microscopic or appear as gray or white fuzzy colonies that are visible on the compost surface. Some fungi form chains of cells called hyphae that look like threads weaving through the organic matter. The mushrooms that you may find growing on compost are the fruiting bodies of some types of fungi. Each is connected to an extensive network of hyphae that reaches through the compost and aids in decomposition.

protozoa

Protozoa are one-celled microscopic organisms. In compost piles, they feed on bacteria and fungi. Protozoa make up only a small proportion of microbial biomass in compost.

invertebrates

Composting can occur with or without the aid of invertebrates. In indoor commercial or industrial composting, invertebrates are often purposely excluded, and the systems are managed to promote thermophilic composting by microorganisms.

figure 2.11: classification of compost organisms according to body width

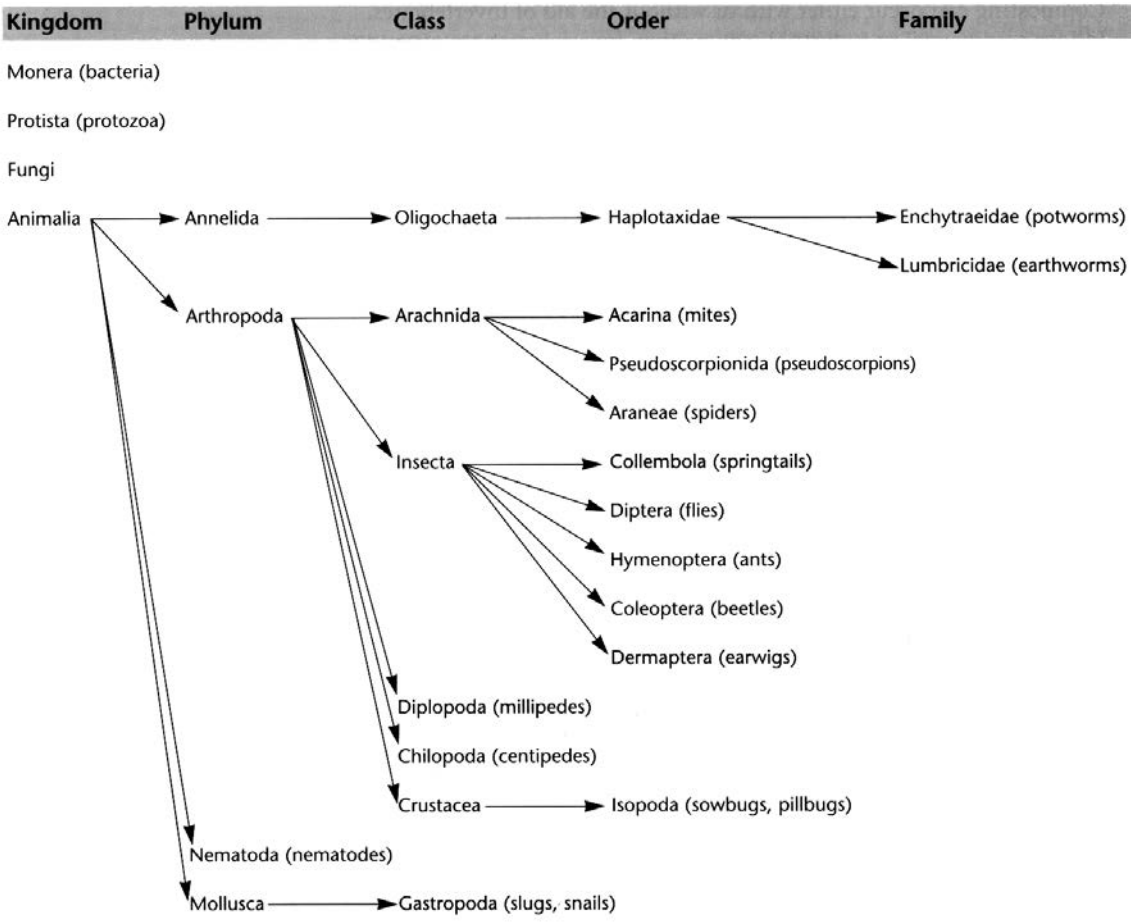
MICROFAUNA live in water films	MESOFAUNA live in air spaces	MACROFAUNA create space by burrowing
← < 0.1 mm →	← 0.1–2 mm →	← 2–60 mm →
Nematodes Protozoa	Mites Pseudoscorpions Springtails Potworms Flies	Earwigs Sowbugs Centipedes Millipedes Earthworms Slugs & Snails

In outdoor piles or bins, however, compost provides an ideal habitat for a vast array of invertebrates common to soil and decaying vegetation. Although most decomposition is still carried out by microorganisms, invertebrates aid in the process by shredding organic matter and changing its chemical form through digestion. Invertebrates are not active at the high temperatures that occur in thermophilic composting. If the compost heats up, the invertebrates may go into a dormant stage or move to the periphery of the pile where the temperatures are cooler.

Scientists use a number of systems for categorizing organisms that live in soil and compost. Different classification schemes provide different "filters" through which we view complex biological communities. The food web is one classification system based on groups of organisms occupying the same trophic level. Another way to classify compost invertebrates is by size [Figure 2.11].

Body width sometimes is used to divide organisms into microfauna (<0.2mm), mesofauna (0.2-10mm), and microfauna (>10mm). Body width is also used to classify invertebrates. Body width is important because it specifies which organisms are small enough to live in the film of water surrounding compost particles, which live in the air-filled pore spaces, and which are large enough to create their own spaces by burrowing. The commonly used taxonomic classification system that divides organisms

figure 2.12: phylogenic classifications of common compost organisms



into kingdom, phylum, class, order, family, genus, and species is based on phylogenic (evolutionary history) relationships among organisms. The following descriptions of common invertebrates found in compost are organized roughly in order of increasing size within the broad phylogenic classifications [Figure 2.12].

annelids: oligochaetes

Potworms (Phylum Annelida, Class Oligochaeta, Order Haplotoxidae, Family Enchytraeidae): Enchytraeids are small (10-25 mm long) segmented worms also known as white worms or potworms. Because they lack hemoglobin, they are white and can thus be distinguished from newly hatched, pink earthworms. Potworms often are found in worm bins and damp compost piles. They feed on mycelia, the thread-like strands produced by fungi. They also eat decomposing vegetation along with its accompanying bacterial populations.

Earthworms (Phylum Annelida, Class Oligochaeta): Because earthworms are key players in vermicomposting, they are described in greater detail later in this chapter.

arthropods

arachnids

mite

Mites (Phylum Arthropoda, Class Arachnida, Order Acarina): There are over 30,000 species of mites worldwide, living in every conceivable habitat. Some are so specialized that they live only on one other species of organism. Like spiders, they have eight legs. They range in size from microscopic to the size of a pin head. Sometimes mites can be seen holding onto larger invertebrates such as sowbugs, millipedes, or beetles. Mites are extremely numerous in compost, and they are found at all levels of the compost food web. Some are primary consumers that eat organic debris, such as leaves and rotten wood. Others are at the secondary level, eating fungi or bacteria that break down organic matter. Still others are predators, preying on nematodes, eggs, insect larvae, springtails, and other mites.

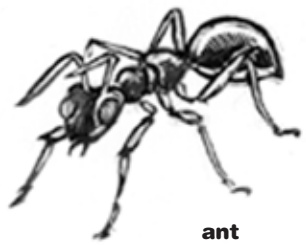
Pseudoscorpions (Phylum Arthropoda, Class Arachnida, Order Pseudoscorpionida): Pseudoscorpions look like tiny scorpions with large claws relative to their body size, but lacking tails and stingers. They range from one to several millimeters in size. Their prey includes nematodes, mites, springtails, and small larvae, and worms. Lacking eyes and ears, pseudoscorpions locate their prey by sensing odors or vibrations. They seize victims with their front claws, then inject poison from glands located at the tips of the claws. A good way to find pseudoscorpions is by peeling apart layers of damp leaves in a compost pile.

Spiders (Phylum Arthropoda, Class Arachnida, Order Araneae): Spiders feed on insects and other small invertebrates in compost piles.

insects


springtail

Springtails (Phylum Arthropoda, Class Insecta, Order Collembola): Springtails are small, wingless insects that are numerous in compost. A tiny, spring-like lever at the base of the abdomen catapults them into the air when they are disturbed. If you pull apart layers of decaying leaves, you are likely to see springtails hopping or scurrying for cover. They feed primarily on fungi, although some species eat nematodes or detritus.


ant

Flies (Phylum Arthropoda, Class Insecta, Order Diptera): Flies spend their larval phase in compost as maggots, which do not survive thermophilic temperatures. Adults are attracted to fresh or rotting food, and they can become a nuisance around worm bins or compost piles if the food scraps are not well covered. Fruit flies and fungus gnats, both of which can become pests in poorly managed compost piles, are in this order.

However, black soldier flies are different in that they do not feed on wastes, bite, or carry disease and their larvae out-compete and deter the breeding of houseflies. The soldier flies deposit their eggs in or near decaying organic matter. Although the adult flies are seldom seen and do not eat, the large off-white larvae (up to 1") often appear by the hundreds in compost bins and are quite voracious. As they consume food scraps or other organic matter, their powerful chewing mouthparts and digestive enzymes liquefy the material and convert it into a fraction of the original volume and weight. As the larvae mature, their bodies darken and become more ridged, with the pupal stage being protected by a tough grey outer shell.

Due to their high protein and fat content, the larvae are highly valued in the bioconversion of manure and other wastes into feedstock for fish, birds, and animals and are being investigated as a potential source of biodiesel.

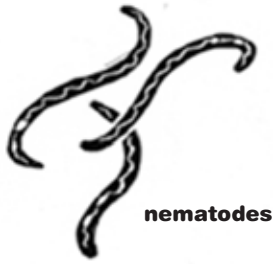
Ants (Phylum Arthropoda, Class Insecta, Order Hymenoptera): Ants eat a wide range of foods, including fungi, food scraps, other insects, and seeds. Ant colonies often can be found in compost piles during the curing stage. Ants benefit the compost process by redistributing materials and aerating the pile, by bringing in fungi and other organisms, and adding minerals especially phosphorus and potassium. Too many ants may be a sign that the compost pile is too dry.

Beetles (Phylum Arthropoda, Class Insecta, Order Coleoptera): The most common beetles in compost are the rove beetle, ground beetle, and feather-winged beetle. Feather-winged beetles feed on fungal spores; the larger rove and ground beetles prey on other insects, snails, slugs, and other small animals.

Earwigs (Phylum Arthropoda, Class Insecta, Order Dermaptera): Earwigs are distinguished by jaw-like pincers on the tail end. Some species are predators, and others eat detritus. They are usually 2-3 cm long.

crustaceans

sowbug



nematodes

Sowbugs and pillbugs (Phylum Arthropoda, Class Crustacea, Order Isopoda): Sowbugs, also called isopods or wood lice, or wood lice, are the only terrestrial crustacean. Because they lack the waxy cuticle common to most insects, they must remain in damp habitats. They move slowly, grazing on decaying wood and resistant tissues such as the veins of leaves. Pillbugs, or rollypolies, are similar to sowbugs, except they roll into a ball when disturbed, whereas sowbugs remain flat.

other arthropods

Millipedes (Phylum Arthropoda, Class Diplopoda): Millipedes have long, cylindrical, segmented bodies, with two pairs of legs per segment. They are slow moving and feed mainly on decaying vegetation. Stink glands along the sides of their bodies provide some protection from predators.

Centipedes (Phylum Arthropoda, Class Chilopoda): Centipedes can be distinguished from millipedes by their flattened bodies and single pair of legs per body segment. They are fast-moving predators found mostly in the surface layers of the compost heap. Their formidable claws possess poison glands used for paralyzing small worms, insect larvae, and adult arthropods, including insects and spiders.

nematodes

Nematodes (Phylum Nematoda): Under a magnifying lens, nematodes, or roundworms, resemble fine human hair. They are cylindrical and often transparent. Nematodes are the most abundant of invertebrate decomposers—a handful of decaying compost probably contains several million. They live in water-filled pores and in the thin films of water surrounding compost particles. Some species scavenge decaying vegetation, some eat bacteria or fungi, and others prey on protozoa and other nematodes.

mollusks

Slugs and snails (Phylum Mollusca, Class Gastropoda): Some species of slugs and snails eat living plant material, whereas others feed on decaying vegetation. Unlike many other invertebrates, some snails and slugs secrete cellulose-digesting enzymes rather than depending on bacteria to carry out this digestion for them.

earthworms

It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures.

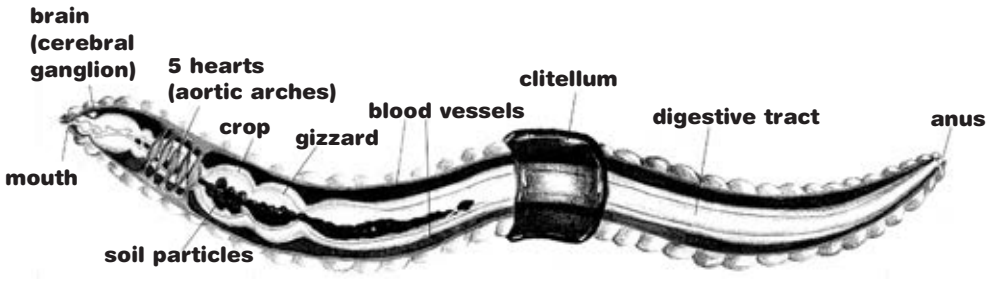
—Charles Darwin 1881

If your only encounter with earthworms has been those shriveled-up specimens that didn't make it back to the grass after a rainstorm, you may not have the same appreciation for these lowly creatures that Charles Darwin did. But if you are a backyard or worm composter, you might have become fascinated by these burrowing invertebrates, and even have some questions about their role in the compost pile. (See figure 2.13 for a simple anatomical depiction of the earthworm.) What are they actually eating, and what comes out the other end? Are worm castings finished compost, or do they get broken down further? How do worms interact with compost microbes during decomposition? Can worm compost enhance the growth of plants?

To answer these questions, it is important to understand that if you've seen one worm, you definitely haven't seen them all. When aquatic forms are included, there are about 3,000 species of earthworms or members of the class Oligochaeta worldwide. Among these species, there is great variety in size, ranging from less than 1/2 inch to 5 feet long (10 mm to 1.5 meters); and weighing from 10 mg to about 1-1/2 lbs (600 g)! Earthworms also exhibit diverse eating habits and ecological and behavioral characteristics. Thus, the answers to the above questions are complicated; what is true for one species is not necessarily true for another. Furthermore, because scientific research has been limited to only about 5% of the total number of worm species, we do not know the answers to many questions for most species of worms.

The information presented below is a synthesis based on many scientific experiments, though there could be exceptions to some of the generalizations for any one species. We also include information specific to the *Lumbricidae*, which is considered one of the most important earthworm families in terms of human welfare, and to one of its members, *Eisenia fetida*, the species most used in vermicomposting. We use the proper genus and species name for the sake of clarity, since the common names for these worms often overlap.

figure 2.13: earthworm cross-section



earthworm feeding and decomposition

Scientists have used several methods to determine the role of worms and other invertebrates in decomposition. In one experiment, organic materials of known weight were placed in mesh bags with different size holes. The bags were then buried in soil. Several months to a year later, the scientists dug out the bags and determined the dry weight of the remaining organic material. It turned out that more decomposition had occurred in bags with holes large enough for earthworms than in those that allowed smaller invertebrates access to the organic materials.

Through these and similar experiments, researchers have determined that much organic matter, particularly the tougher plant leaves, stems, and root material, breaks down more readily after being eaten by soil invertebrates. And, of all the invertebrates who play a role in the initial stage of organic matter decomposition, earthworms are probably the most important.

Worms that are active in compost are feeding primarily on relatively undecomposed plant material. Epigeic species are worms that live and feed in the upper organic or litter layer of soil. *Eisenia fetida*, the species most commonly used for vermicomposting, is one example of this type of worm. Anecic species are another class of worms that live in deep soil burrows and come to the surface to feed on plant residues in the litter layer. By pulling leaves and other food down into their burrows, they mix large amounts of organic matter into the soil. *Lumbricus terrestris*, a worm commonly seen in North American gardens, is typical of this group. A third type of worm is not commonly seen in gardens or compost piles because it rarely comes to the surface. These are endogeic worms. They burrow deep beneath the surface and ingest large quantities of soil containing more highly decomposed plant material.

Anyone who has ever observed earthworm castings will recognize that they contain organic particles that are reduced in size relative to the leaves or other organic matter that the worms ingest. Organic matter passing through a worm gut is transformed chemically as well as physically. However, most worms are able to digest only simple organic compounds such as sugars. A few species, including *Eisenia fetida*, apparently are able to digest cellulose. No species has been found that breaks down lignin.

Worms both influence and depend on microbial populations in soil and compost. They feed on soil microorganisms, including fungi, bacteria, protozoa, amoeba, and nematodes. These organisms are probably a major source of nutrients for worms. Preferential feeding on different microorganisms may alter the microbial populations inhabiting their digestive tract. The mucus found in the worm's intestine provides a favorable substrate for microorganisms, which in turn decompose complex organic compounds into simpler substances that are digestible by the worm. Some of the worm's mucus is excreted along with the casts, and it continues to stimulate microbial growth and activity in the soil or compost. The high levels of ammonia and partially decomposed organic matter in casts provide a favorable substrate for microbial growth. Thus, fresh worm casts generally have high levels of microbial activity and high decomposition rates. This activity decreases rapidly over a period of several weeks as degradable organic matter becomes depleted.

worms and plant growth

Nutrients are transformed during their passage through the worm gut into forms more readily available to plants, such as nitrate, ammonium, biologically available phosphorus, and soluble potassium, calcium, and magnesium. Because of these and other changes in soil and organic matter, physical properties, and biology brought about by worms, plants generally grow faster in soils with worms than in soils without them. Furthermore, studies have shown that extracts from worm tissues enhance plant growth.

Vermicompost is a finely divided material that has the appearance and many of the characteristics of peat. In some studies, it has been shown to enhance soil structure, porosity, aeration, drainage, and moisture-holding capacity. Its nutrient content varies depending on the original organic materials. However, when compared with a commercial plant-growth medium to which inorganic nutrients have been added, vermicompost usually contains higher levels of most mineral elements, with the exception of magnesium. It has a pH of about 7.0, and because most plants prefer slightly acidic conditions, vermicompost should be acidified by mixing with a more acid material such as sphagnum peat prior to use as a growth medium. Another adjustment sometimes made when using vermicompost for plant growth is to add magnesium. Because vermicomposting does not achieve high temperatures, sometimes a thermophilic stage is used prior to adding worms to kill insects and pathogens.

earthworms and water

Earthworms require large amounts of water, which they ingest with food and absorb through their body walls. The water is used to maintain a moist body surface that aids the worm's movement through soil and protects it against toxic substances. A moist body surface is also necessary because worms obtain oxygen by absorption in solution through their cuticle. A soil moisture content of 80-90% by weight is considered optimal for *Eisenia fetida*.

Many worms, including *Lumbricus terrestris*, can tolerate poorly ventilated soils because of the high affinity of their hemoglobin for oxygen. However, under saturated soil conditions, worms will come to the surface, sometimes migrating considerable distances. It is unknown whether low oxygen levels or chemicals in soil solution cause this behavior. Because most water uptake and loss occurs through the thin permeable cuticle, worms are at constant risk of dehydration. Although worms have no shell or waxy cuticle to maintain body moisture, they can survive low moisture conditions. Some species migrate to deeper soil levels when surface soil dries out.

lumbricidae

The family *Lumbricidae* is the dominant family of worms in Europe. As European agricultural practices spread throughout much of the world, so did *Lumbricid* worms. These worms were able to successfully colonize new soils and became dominant, often replacing endemic worm species. They are now the dominant family in most temperate, crop-growing regions around the world, including North America.

Lumbricus terrestris is one of the most common earthworms in northern North America. It lives in a wide range of habitats, including grasslands, agricultural fields, gardens, and forests. It feeds on leaves and other plant materials, dragging them into its burrows in the soil.

eisenia fetida

Eisenia fetida and *Lumbricus rubellus* are the favored species for use in vermicomposting. They are sometimes used together, with *Eisenia fetida* at the surface and *Lumbricus rubellus* further down. *Eisenia fetida* is particularly well suited to composting because it is extremely prolific, thrives in high organic matter habitats, can tolerate a wide range of temperatures and moisture conditions, and can be readily handled. Its natural habitat is probably under the bark of dead tree trunks, but it is most commonly found in animal dung, compost, and other accumulations of decaying plant material. Originally from Europe, it has become established throughout much of the world.

Just how prolific is *Eisenia fetida?* When it is given high-energy and nitrogen-rich food (such as horse manure or activated sewage sludge), adequate moisture, and optimum temperatures (77°F or 25°C), cocoon production in *Eisenia fetida* starts 35 days after the worms hatch, and it reaches its maximum at 70 days. The cocoons, each carrying one to six eggs, are secreted around the clitellum, or swollen region along the worm's body. Between three and four cocoons are produced each week.

Nineteen days later, the young worms, or hatchlings, emerge and the process begins again. Thus, under optimal conditions, a population of *Eisenia fetida* can have four generations and produce 100 times its own weight in one year. Low food quality, overcrowding, or suboptimal temperatures or moisture levels reduce these reproductive rates. For example, growth is 24 times faster at 77°F (25°C) than at 55°F (10°C), and temperatures below 32°F (0°C) and over 95°F (35°C) are considered lethal.

Cocoons of *Eisenia fetida* may survive dryness and possibly other adverse conditions for several years and then hatch when favorable conditions return. In compost piles, adults may move from areas of less favorable conditions to areas with conditions conducive to their growth. For example, in winter months, they may migrate to the warm center of large outdoor pile. Perhaps through these "mini-migrations" or through cocoon survival, *Eisenia fetida* are able to survive winters in regions where temperatures drop well below those that are lethal in the laboratory.

Does the use of *Eisenia fetida* in composting serve to further spread this exotic species, possibly interfering with native earthworm populations? To answer this question, it is useful to consider the fact that populations of earthworms are already much altered throughout the globe. In North America, for example, there are 147 species of worms, 45 of which were probably introduced. In fact, when Europeans first arrived in formerly glaciated parts of North America, they claimed there were no earthworms present. (It is assumed that earthworms in northern North America were wiped out during glaciation.) Thus, the species that are currently in these regions were either introduced in soil from imported plants or spread northward from southern regions of North America. It is thought that *Eisenia fetida* were introduced to North America in organic soils brought in with imported plants. Because it is adapted to compost and other organic substrates, it is unlikely to spread into neighboring soils and compete with soil-inhabiting worms.

benefits of compost: how it all breaks down

Whether a compost pile is quick and hot or slow and cool, the final product is the same: a dark, loose, crumbly material that resembles rich soil. If the decomposer organisms have done their work well—and they undoubtedly will—the transformation will be virtually complete. Few, if any, of the original components of a compost pile will remain recognizable. In the process of biological decay, materials become discolored, disfigured, and depleted. As chemical bonds are broken by hungry decomposers, by-products including water, heat, and carbon dioxide are released. The result is a marked difference between the volume of materials you put into a pile and the volume of compost you get out. Conversion of organic debris into compost is accompanied by a 50 to 70 percent reduction in volume.

What's lost in volume is gained in value. Displaying such soil enhancing properties as moisture retention, particle aggregation, and nutrient-binding, compost enriches plant growth and stimulates thriving micro-biotic communities. Known to many gardeners and farmers as "Black Gold," compost, like naturally derived humus, makes significant contributions to the promotion of healthy ecosystem function. A summary of the most salient of these contributions follows.

7 key functions of compost

1. improves soil structure

The value of compost as a soil amendment is suggested by its appearance. Even a casual observation of soil amended with compost shows that it is made up of many round, irregular aggregates. Adding compost to soil infuses soil with organic aggregates, thereby enhancing water retention, improving air circulation, and making nutrients more available to plants.

2. naturally amends soil

While both synthetic fertilizers and compost can provide plants with the necessary nitrogen, phosphorus, and potassium that they need, compost provides a wider base of nutrients. For example, compost contains trace elements of calcium and magnesium, as well as nitrogen, phosphorus, and potassium. In addition, because synthetic fertilizers are soluble and can easily wash away, they often require several applications to provide an appropriate amount of nutrients throughout a growing season. In contrast, compost binds to the soil and releases nutrients slowly over a longer period of time.

3. moderates soil pH

More important than the nutrients supplied by compost is its ability to make existing nutrients in the soil available to plants over a long period of time. As noted earlier in this chapter, the availability of nutrients in soil is influenced by pH. By binding with soil particles and enhancing microbial communities, compost moderates soil pH and makes nutrients already present in the soil more accessible to plants. The pH levels of some common soil amendments are compared in Figure 2.14.

figure 2.14: pH levels of soil amendments

Material	pH
Recycled landscape waste compost	5.5 - 7.5
Sphagnum peat moss	3.5
Conifer bark	3.6 - 3.8

4. detoxifies soil

Compost works by binding to soil and other types of particles that exist in soil. These binding properties enable compost to "soak up" and hold on to such potential plant toxins as excess nutrients and heavy metals.

5. protects against pests and plant diseases

Cultivating plant health is the best way to prevent pest and disease infestation. By fortifying plants with appropriate amounts of the nutrients they need (see Chemical-Free Fertilizing), compost suppresses plant diseases and increases insect resistance in plants. Additionally, experiments have shown that the rich soil life in compost helps to control diseases and pests that might otherwise overrun a more sterile soil. By introducing disease-fighting organisms to the soil, compost protects plants from soil-borne pathogens.

6. adds beneficial organisms

The decomposers are also indicators of a balanced soil ecology. The presence of compost organisms—redworms, centipedes, sow bugs, and others—shows that compost is a healthy, living material. In soil, decomposer organisms continue to break down organic material and release nutrients.

7. reduces waste

It's a fact: people who compost dispose of less garbage! As landfills fill up (and close up) and citizen lobbies block the siting of new landfills, alternative waste management strategies— including municipal composting and decentralized community-based compost sites—offer promise for the future. Regardless of what the future holds, however, reducing the amount of garbage we make is an essential first step. Like recycling, home and community composting helps to divert reusable materials from landfills.

compost vs. other soil amendments

In order to grow up healthy and strong, plants require a diet inclusive of both micro- and macro-nutrients.

Like vitamins in humans, micronutrients fortify plants to perform basic life-functions. Although required only in small doses, micronutrients such as iron, manganese, copper, and zinc affect plants' abilities to photosynthesize and to access other nutrients in the soil.

Macronutrients comprise the bulk of plant nutrition. Inclusive of nitrogen, phosphorous, potassium, calcium, and magnesium, macronutrients are the building blocks of plant molecules and, therefore, contribute to plant growth and structure. The three numbers listed on fertilizer bags (e.g., 10-10-10) refer to the percentage of the three primary macronutrients—nitrogen, phosphorous, and potassium (N-P-K)—available in the fertilizer.

Although compost contains both the macro- and the micronutrients that plants require for healthy growth, it is not necessarily a substitute for fertilizers. Chemical fertilizers and lime—while lacking micronutrients—are better than compost at supplying plants with immediately available doses of macronutrients. As a prime supplier of appropriate and accessible amounts of micronutrients. However, compost is an essential dietary supplement in any soil.

Note: Over time, this compost as supplement vs. substitute rule may shift. Regular applications of 3 to 5 inch layers of compost over the course of several years may enrich soil enough to eliminate the need for additional fertilizers.

chapter 3:
compost basics

Regardless of human interest or intention, decomposition happens. Left outside, a pile of leaves, an old cotton rag, or a freshly cut board will start to decompose. But, human manipulation can—and, in the case of composting, *does*—influence both the *rate* at which decomposition occurs and the *quality* of the end product.

It is true that throwing a bunch of organic materials into an untamed, unturned pile will eventually yield good, usable compost. But we can hasten the process and ensure more predictable results by controlling for such factors as:

- the type and size of the materials,
- the availability of moisture and air, and
- the presence of insulating materials around decomposing objects.

Understanding how to create ideal composting conditions will allow you to make compost with confidence and will help you to diagnose and solve other people's composting problems.

recipe for success: essential ingredients in a healthy compost ecosystem

As described in the preceding chapter, a compost pile provides food, water, and shelter for a complex web of decomposer organisms. Bacteria, fungi, and insects thrive on the dead flowers, plant remains, and leftover salads you're ready to throw away. As accommodating as these inhabitants are, however, they'll leave you high and dry if the living conditions in your pile threaten their survival. By feeding your critters a balanced diet of easy-to-eat *Browns* and *Greens*, and by attending to the *aeration*, *moisture* level, *temperature*, and *size* of your pile, you'll make even your most travel-inclined tenants into homebodies.

food: carbon-rich BROWNS and nitrogen-rich GREENS

For a human, surviving on bread alone may be doable, but is it healthy? If you don't mind frail bones, poor eyesight, and persistent sluggishness, you might say yes. Most of us, however, try to eat foods that provide us with the variety of nutrients we need to grow and thrive: dairy or dark leafy greens for calcium, meat or beans for protein, oranges for vitamin C.

Of the many elements required for microbial decomposition, carbon and nitrogen are the most important. *Carbon* acts both as an energy source for microbial organisms and as a basic building block in the composition of microbial cells. *Nitrogen* is a crucial component of the proteins, amino acids, enzymes, and DNA necessary for cell growth and function.

figure 3.1: to compost or not to compost

	C:N Ratio [Ideal = 30:1]
greens:	
fresh, moist, nitrogen-rich materials	
FROM YOUR GARDEN	
• green plants and garden trimmings	15-22:1
• fresh leaves and flowers	15-22:1
• grass clippings (or recycle by leaving on the lawn)	17:1
FROM YOUR KITCHEN/HOME	
• fruit and vegetable scraps	12-19:1
• coffee grounds & tea bags	20:1
• guinea pig or hamster droppings	14:1
• cornstarch- and other plant-based packing materials	25-34:1
browns:	
dead, dry, carbon-rich materials	
FROM YOUR GARDEN	
• fall leaves, small twigs, and woody prunings	40-80:1
• dry plant material	50-60:1
• straw and hay	80:1
• pine needles	100:1
• potting soil	no effect
• bark (hardwood)	225:1
• bark (softwood)	500:1
FROM YOUR KITCHEN/HOME	
• egg shells	calcium
• nutshells	50:1
• corncobs	60:1
• food-soiled paper towels and napkins	150:1
• shredded newspaper	400-800:1
• sawdust and wood shavings (from untreated wood)	500-640:1
• wood ashes	no effect

In order to meet these basic nutritional demands, compost critters prefer a diet that is high in carbon-rich *BROWNS* and nitrogen-rich *GREENS*. *Browns*—the dry or dead materials that add bulk to a pile—include fall leaves, twigs, and woodchips. *Greens*—which tend to be succulent or high in water content—include such living materials as grass clippings, freshly pulled weeds, and food scraps [see Figure 3.1].

Coffee grounds and manure are high in nitrogen, despite their brown color. Inorganic materials, like plastic, metal, and glass that do not decompose are not suitable for composting.

In decomposer diets, the optimal carbon-to-nitrogen ratio (C:N ratio) averages about 30 parts carbon to 1 part nitrogen. While all organic compounds contain more carbon than nitrogen, most materials available for composting don't inherently exhibit this ideal 30:1 C:N ratio. One of the main challenges in composting is to combine Browns and Greens to achieve a 30:1 carbon-nitrogen ratio.

Though a one-to-one mixture of Greens and Browns can produce a good C:N ratio, careful (or new) composters may prefer to deliberately calculate compost "recipes." By adding together the C:N ratios of potential ingredients, it is possible to find a compost recipe that comes close to the 30:1 ideal. While no particular recipe is right or wrong, some combinations work better than others. For example [see Figure 3.2], a one-to-one mixture of one part autumn leaves (40:1 ratio) and one part fresh food scraps (12:1 ratio) would make a pile with a 52:2 or approximately 26:1 carbon-nitrogen ratio. Mixing 2 parts leaves with 1 part food scraps yields 92:3 or about a 31:1 ratio. Experimenting with different mixtures will allow you to see what works well and will cultivate your intuitive ability to determine a pile's needs.

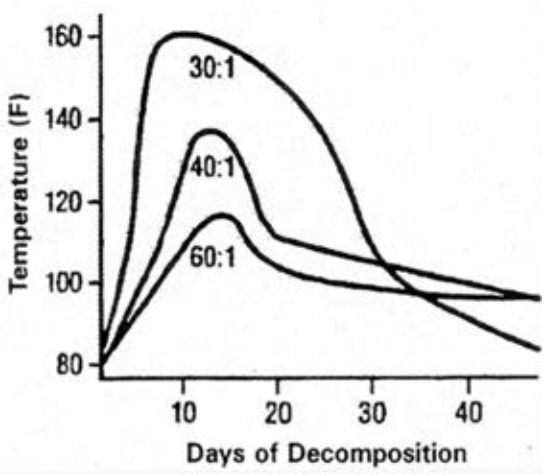
figure 3.2: calculating the carbon to nitrogen ratio

Ideal C:N ratio = 30:1

1 part leaves	(40:1) x 1	40:1	
1 part vegetable scraps	(12:1) x 1	12:1	
		52:2	= 26:1 *(good)*
2 parts leaves	(40:1) x 2	80:2	
1 part vegetable scraps	(12:1) x 1	12:1	
		92:3	= 31:1 *(better)*

Given a steady diet at around the 30:1 ratio, microorganisms decompose organic material very quickly. If the carbon-to-nitrogen ratio in a compost pile is off, however, the compost environment fails to support a community of desirable decomposers. In effect, compost success is all about the nitrogen. Compost organisms can't process more nitrogen than they need; but without nitrogen, they can't function. In a pile that contains too many *Greens*, ammonia (a nitrogen-based compound) is

figure 3.3: carbon:nitrogen ratio effects on composting



leached into the atmosphere causing the pile to become smelly. In a pile that is low in nitrogen and high in *Browns*, microbial growth is compromised, activity slows down, temperatures remain low (cool), and materials degrade slowly. A nitrogen deficient pile will often appear stagnant. While neither extreme is particularly favorable to effective composting, in a highly populated city like New York—where a smelly pile may encroach on your neighbors—it doesn't hurt to bump up the *Browns*. Figure 3.3 shows the effect of carbon-nitrogen ratios on decomposition.

moisture: microorganisms get thirsty too!

In compost as in all ecosystems, water is a necessary life medium. Providing habitat for a variety of aerobic bacteria and fluid replenishment for larger decomposers, water—like carbon and nitrogen—is essential to a healthy compost ecosystem.

In general compost piles should be as moist as a wrung out sponge. This means that composting materials should be damp, but should not drip when squeezed. At this saturation level, thin films of water will surround compost particles creating necessary habitat for water dwelling bacterial decomposers, but no puddling or clumping of materials will occur.

A moisture content of 50-60% by weight is generally considered optimum for composting because it provides sufficient water to maintain microbial growth, but does not impede the circulation of air throughout the pile [see Figure 3.4]. Moisture levels outside of this range—like C:N ratios above and below the 30:1 ideal—cause problematic composting conditions. In a pile that is too dry (moisture level below 40%), the films of water surrounding compost particles dry out. As the microorganisms that live in these films die off, bacterial activity declines and the compost process slows down. Too much moisture also inhibits the rate of decomposition. At moisture levels over 70% a pile becomes wet and swampy allowing very little air to circulate. In the absence of oxygen, aerobic decomposers die off and anaerobic conditions—slower, smellier, nutrient leaching processes—set in.

In sum, the second key to successful composting is to provide enough moisture to maintain the thin films around compost particles, but not so much that water replaces air in the larger pores. An optimum moisture level can be maintained in a compost pile either by mixing a recipe of high and low moisture content ingredients [Figure 3.4] or by adding extra water to the pile. Our climate usually necessitates the addition of extra water both when materials are added to a compost pile and over the course of decomposition.

Troubleshooting

A compost pile that gets too wet should be mixed frequently to allow air back into the pile and to loosen up the materials for better drainage. The addition of dry, brown materials can help to absorb excess moisture. If an undecomposed pile of yard trimmings becomes dry, it can be moistened by adding greens or the trimmings can be pulled apart and watered to speed up the decomposition process. Though prolonged exposure to rain can effectively soak a dry compost pile, watering an intact pile from above is not effective, because dry materials often shed water. Dry materials must be gradually wetted and mixed until they glisten. To retain moisture and prevent nutrients from leaching out, it is best to cover a pile once materials are uniformly moist.

figure 3.4: Average moisture levels of selected materials. Moisture content refers to the amount of water a material contains as a percentage of its total weight. Averaged together, the moisture contents of the materials in a compost pile reflect the total moisture level of that pile.

Material	Percent Moisture Content	
Food Scraps (vegetable and fruit)	80 -87	"WET"
Grass Clippings	82	
Fresh Plant Clippings	70	
Manures with Bedding	70	
Coffee Grounds	63	
	64	
IDEAL FOR COMPOSTING	**50 - 60 %**	**IDEAL FOR COMPOSTING**
Brown Leaves	38	"DRY"
Wood Chips and Shavings	30	
Shrub and Hedge Trimmings	16 - 53	
Woodchips and Sawdust	19 - 65	
Dry Plant Stalks, Straw	12	
Hay	10	
Paper, Newspaper	8 - 49	
Corrugated Cardboard	8	

oxygen

Oxygen is essential to the metabolism and respiration of the aerobic decomposers that fuel thermophilic composting. Aerobes use oxygen to *oxidize* (burn or *metabolize)* organic matter for energy and nutrition. In a wet pile, oxygen—which diffuses thousands of times faster through air than through water—is likely to get trapped in water-clogged pores. When oxygen supplies are depleted, aerobic organisms can't derive the energy they need to survive and the composting process becomes anaerobic. Maintaining the proper balance between moisture and oxygen is, therefore, the third key to quality composting.

Compost systems can be designed to facilitate the circulation of oxygen. While some systems rely on *air holes* or *aeration tubes* to introduce adequate oxygen to a pile, other systems employ blowers or agitators to provide *forced aeration*. *Bulking agents*, large particles such as wood chips, chopped branches, pine cones, and corncobs are often added to piles to enhance aeration. At the end of the composting process, bulking agents that have not decomposed can be screened out of the compost and reused.

A common misconception in composting is that piles should be turned or mixed every couple of weeks in order to maintain optimal oxygen levels. While mixing helps to loosen up a pile and increase pore spaces, studies indicate that the primary mechanisms of oxygen circulation are actually *diffusion* and *convection*—physical processes that facilitate the transfer of particles and energy in space [see Time, Temperature, and Turning].

room to chew: smaller pieces increase available surface area

Everyone knows that you can't get to the center of a Tootsie Roll Pop without breaking through the candy crust. The same rule applies to compost: unless edible material is exposed, it remains inaccessible to decomposers.

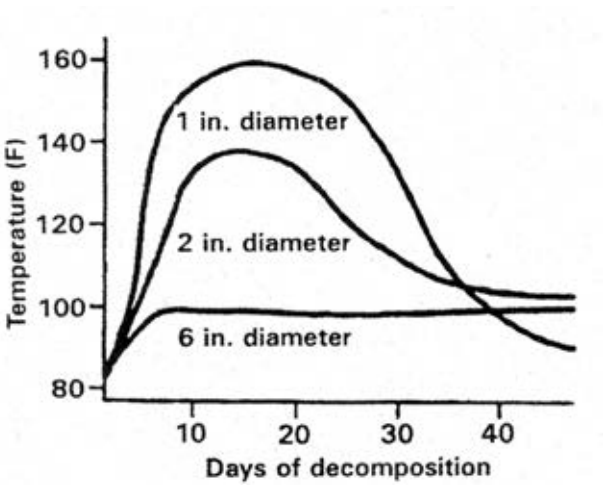
It follows that *the rate of organic decomposition is directly related to the amount of surface area accessible to micro-organisms*. Because most microbial activity occurs on the surface of organic particles, exposing additional surface area increases the amount of food accessible to micro-organisms and the rate of decomposition increases.

A melting block of ice provides a good analogy for how surface area affects the rate of decomposition. A large block of ice melts slowly, but when it is broken into smaller pieces the surface area increases, and the ice melts more quickly. Similarly, one person biting and chewing her way through a whole cookie can't devour and digest that cookie as fast as a group of people who have broken the cookie into many parts. While it would be difficult for two or more people to bite into a single cookie at the same time, a crumbled cookie is equally accessible to many mouths. In the time it takes one person to take one bite, five people take five bites and presto… the cookie is gone! Translated into a compost pile, chopping and shredding large, coarse, and woody organic materials increases microbial access to food and speeds up the composting process [Figure 3.5].

Decreasing particle size also increases the availability of carbon and nitrogen. Nutrient availability is affected by the way that nutrients are stored in food. In microbial food as in human food, nutrients are stored in different types of packages. Some of these packages open readily, but others are so tightly bound up, that consumers—no matter how hard they try—can't break them apart. Because the nutrients inside these boxes remain inaccessible, they cannot be processed or used by the body. While most of the nitrogen in organic materials is readily available to microbes, carbon often gets locked up in compounds like lignin that are highly resistant to biological decay (see Chapter 2). Chopping up food particles begins the process of ripping nutrient packages open and makes nutrients like carbon more accessible to decomposers. For example, comparable masses of wood chips and sawdust contain the same amount of carbon, but—because sawdust has a greater surface area—the carbon in sawdust is more readily accessible to decomposers.

As with C:N ratio, moisture, and oxygen, increased surface area is not always advantageous when applied in the extreme. Particles that are too small tend to pack together causing the pile to become dense and compacted.

figure 3.5: particle size effects on composting



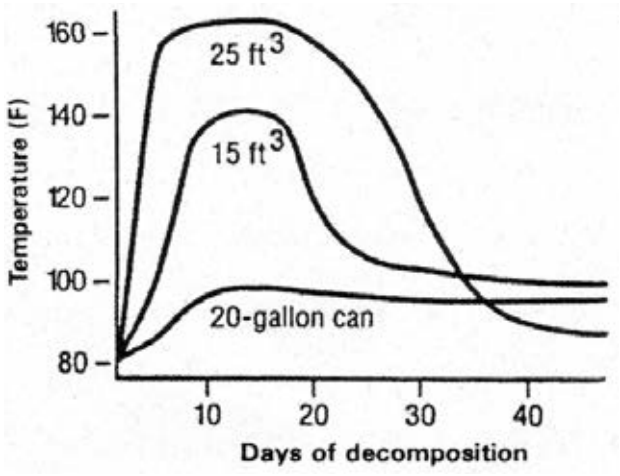
Because compaction inhibits air circulation, the amount of available oxygen decreases and the rates of microbial activity and decomposition decline. Larger, less decay-prone compostables are essential to maintaining a well-aerated pile. Large particles are also necessary in situations where slow decomposition is preferable. Therefore, it is often helpful to apply some bulkier organic material, such as woodchips, as mulch (a surface conditioner applied on top of the soil) on top of the compost pile. Since the larger particles take longer to decompose, they can conserve moisture, suppress weed growth, and moderate temperature changes inside the compost pile for a longer period of time.

Helpful hints for increasing surface area

Run a lawn mower over a pile of the leaves. Use a small chipper-shredder to break down sticks and branches. Break or chop kitchen scraps into smaller pieces before adding them to a pile.

volume: the ability to self-insulate

figure 3.6: pile volume effects on composting



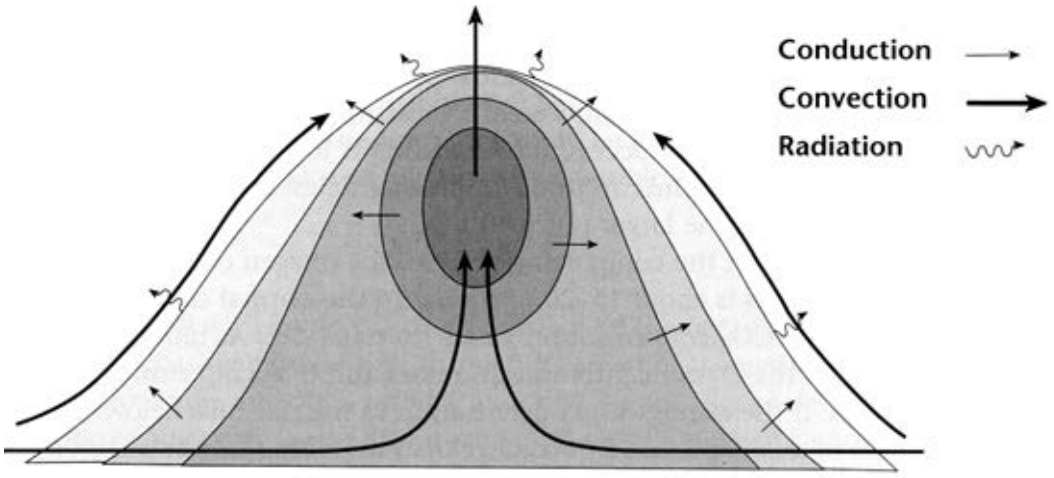
The volume of the pile also effects the rate of decomposition. Piles larger than 5 feet by 5 feet by any length will turn anaerobic unless turned frequently or perforated with ventilation stacks. As a general rule, a compost pile of about 3 feet by 3 feet by 3 feet (one cubic yard) is small enough to allow air circulation throughout the pile, but large enough to retain moisture and heat. For many city dwellers, space constraints make it impossible to keep a pile this large. Rooftop gardeners and residents of terrace apartments can make small-scale composters out of large planter pots and garbage pails. Although small-scale composting can be a slower process, it is equally effective and reaps high quality results. Figure 3.6 shows the effect pile volume can have on decomposition.

Note: When composting in small spaces, it is critical to closely monitor air and moisture content.

time, temperature, and turning

The temperature of a compost pile is the balance between the amount of heat produced by microorganisms and the amount of heat lost through *conduction*, *convection*, and *radiation* [Figure 3.7]. These physical forces move heat out from the inner core of a pile—where most compost heat is generated and retained—into the external layers of organic materials and, eventually, the air.

figure 3.7: three mechanisms of heat loss from a thermophilic compost pile



conduction

Conduction refers to the transfer of heat energy from atom to atom by *direct contact*. On the outer edges of a compost pile, surface particles transmit heat directly into surrounding air molecules. While only small percentages of large piles and windrows are exposed to the air, small piles have large *surface area-to-volume ratios*. Because the portion of a pile immediately exposed to the air influences the rate of heat exchange, small piles tend to lose heat much faster than large piles.

convection

Convection, the transfer of heat by the movement of a substance such as air or water, produces the steam or water vapor that rises from hot compost piles or windrows. In a hot compost pile, slow, steady *convective currents* of heated air move upward through the compost and out the top of the pile. Large-scale compost systems—like the agitated bay facility at Rikers Island—use blowers and fans to augment the natural convective process. By increasing the rates of both convective and conductive heat losses, forced air keeps pile temperatures from climbing too high.

radiation

In addition to transferring heat directly via *conduction* and *convection*, compost piles radiate warmth into the cooler surrounding air. Radiation is transmitted via electromagnetic waves like those that you feel when standing in the sunlight or near a warm fire. Because there is a relatively small difference in temperature between the outer edges of a compost pile and the air, radiation represents a negligible loss of heat from compost.

hot and cold piles

A compost pile is classified as *cold* or *hot* depending on the temperature that it reaches and how it is built. **Hot piles,** which hit high temperatures between 120°F and 180°F (49°C and 82°C), can produce stabilized compost in as little as six weeks. In order to realize enough volume to self-insulate, hot piles must be built in *batches*. This means that enough ingredients must be available to build a 27 cubic foot (one cubic yard) pile either in one shot or over the course of a few days. While the centers of hot piles

reach temperatures high enough to kill weed seeds, the edges often remain too cool to have the same kind of impact. It's best to clip the seeds off of unwanted weeds before putting them into the pile.

As effective as hot piles may be, they should not automatically be considered ideal. Generally, **cold piles**—which tend to range in size from 1 to 20 cubic feet—produce finished compost within a year. Built up over time by the continual addition of new materials, cold piles decompose with the help of mesophylic bacteria at temperatures that plateau between 50°F and 113°F (10°C and 45°C). However, a small or "cold" compost pile built with careful consideration to carbon-to-nitrogen ratios, surface area, volume, moisture, and aeration can heat up to 150°F (66°C), and produce stabilized compost in as little as three weeks.

Regardless of whether you're building a hot or cold pile, all organic materials should be kept moist and well mixed. In a moist pile, water acts as a thermal stabilizer, damping out changes in temperature as microbial activity ebbs and flows. Turning compost ensures that drier and cooler materials from the edges of a pile get mixed into the center where more constant heat and moisture promote optimal decomposition.

building from scraps: how to feed and maintain your compost pile

While the science of decomposition can seem complex, it's really as simple as finding the balance between the physical properties of a compost system and its ingredients: a pile or compost bin should be large enough to retain heat and moisture, yet small enough to allow good air circulation; compost should be sufficiently moist to support microbial growth, but not so wet that it becomes anaerobic; organic materials should be large enough to prevent compaction, but not so large that decomposition is inhibited. If you keep your critters happy by avoiding extremes, starting and maintaining a compost pile is really quite simple.

putting it all together

Begin your compost pile with a layer of Browns. Over this layer, add approximately equal volumes of Greens and Browns. Using a pitchfork and/or spade, break up large materials and mix your ingredients thoroughly. Assess for moisture. A compost pile should feel *as moist as a wrung out sponge* (i.e., damp, not wet!). If your pile feels dry, you may want to add some water.

Before closing your bin, make sure that all food scraps are covered over. Food scraps left exposed to the air may attract pests. If you've added food scraps to your pile, it's a good idea to cap your pile with a thin layer of Browns.

Continue to add equal amounts of Browns and Greens to your pile. Mix periodically to promote the circulation of oxygen through the pile. Add water as needed. Over time, finished compost will settle to the bottom of the pile. To harvest, turn the top of the pile onto a new location and scoop out your finished product. If you're concerned about removing partially decomposed materials—woodchips, etc.—use a piece of 1/2" hardware mesh to screen the compost.

when to say NO!

Anything derived from something once living will decompose, but not everything belongs in a compost pile. The following materials should be kept out of home composting systems:

Plants infected with disease or insects: Because most home compost piles remain relatively cool, insect eggs, disease spores, and insects are likely to survive the composting process and be distributed in finished compost. To avoid compost contamination, throw out (or commercially compost) infested materials.

Evergreen leaves: The leaves of plants such as Holly and Juniper break down very slowly. Try composting small amounts of these mixed with other materials, or shred them for use as mulch.

Ivy and certain pernicious weeds: Plants that spread by rhizomes or runners (i.e., bind weed, Morning Glory, Comfrey, Johnson, Bermuda, Dallis and crab grasses) can survive even hot composting and may choke out other plants when finished compost is used in the garden.

Weeds that have seeds on them: Temperatures over 140°F (60°C) are required to kill most weed seeds. It is extremely difficult to consistently achieve these temperatures in a home composting system.

Poisonous plants: Keep poison ivy and other skin irritants out of the compost pile.

a note on composting food scraps

Because of New York City's population density and demographics, our waste stream has a much lower percentage of leaves and yard trimmings and a higher percentage of food scraps than most U.S. municipalities. Although compost produced from food scraps contains more nutrients than compost produced from yard trimmings, convincing New Yorkers to compost food waste presents many challenges. Primarily, people are concerned that food waste compost will produce odors and attract pests.

Handled properly, however, food-waste composting can be a virtually odor-free endeavor. Figure 3.1 on page 42 (and the "What to Compost" Tip Sheet) lists the types of food scraps appropriate for home composting and those that should be avoided.

Excluding fatty food scraps from home compost piles eliminates the biggest challenge to odor-free food-waste composting. Although fatty food scraps (meat, cheese, dairy, oily foods, or leftovers) can be composted in properly maintained, hot compost piles, few backyard compost piles generate enough heat to break fats down before they begin to putrify. Because improperly composted fatty food scraps create unpleasant odors, attract rats and roaches, and can make compost unhealthy to handle, most sources recommend leaving them out entirely.

To protect public health, the City of New York strongly urges that all food scraps be composted using rodent-resistant systems. Master Composters should encourage food-waste composters to:

- Use an enclosed, rodent-resistant compost bin.
- Add dry, carbon-rich materials (Browns), such as fall leaves or shredded newspaper, each time you add food waste.
- Bury food waste underneath a layer of Browns.

tools of the trade

Unless you identify with the minimalist composter who tosses random organic artifacts atop an unmanaged, ever-expanding heap of decomposition and never looks back, you may want to add these compost accessories to your list of must haves:

scoop shovel

Scoop shovels come in particularly handy when you're ready to harvest finished compost. Because compost is relatively homogenous and soil-like in its composition, a scoop shovel—with a broad, flat blade similar to a snow shovel—passes through a finished pile fairly easily. If you'd rather spend your time gardening than shoveling, make a scoop shovel your compost harvesting partner: each scoop holds up to 3 times as much material as a spade.

If you maintain a 3-bin system, you'll also want to use a scoop shovel to turn nearly finished compost from the middle compartment into the third bin.

spade

The sharp, pointed edge of a spade makes this tool ideal for breaking apart larger and thicker materials such as stalks, vines, melons, and uneaten vegetables. Thrust your spade straight down into your compost pile to "chop up" intact materials. You can also use your spade to turn partially finished compost and to harvest your finished product.

pitchfork

In its early phases, a compost pile is not unlike a bird's nest: a dense entanglement of twigs, grasses, and other readily-identifiable fibrous materials. Turning or aerating a pile of interwoven brush, plant parts, corncobs, and watermelon rinds demands the breaking and entering capacity of a pitchfork. No shovel can move through or grab pre-decomposed materials as effectively as fork tines. Pitchforks can also be used to break apart large compostables (i.e., melon rinds or whole vegetables) and to harvest compost for mulching.

aerator

As your compost gets closer to done, it becomes more uniform and more compact: fewer big pieces means fewer intact air channels throughout the pile. In a pile that lacks oxygen, the composting process will slow down and decomposition may become anaerobic (i.e., *smelly!*). Using an aerator to loosen your pile is a quick, easy way to ensure that your pile gets the air that it needs. Insert the aerator into the top of the pile and drive it down to the bottom. Pulling the aerator back up and out of the pile loosens the compost creating corridors for air circulation.

pruning shears and loppers

Remember, smaller pieces decompose faster because more surface area is exposed to decomposers. When adding yard and garden materials to your pile, take the time to cut large scraps into manageable pieces. Pay special attention to sunflower stalks, tomato plants, tree prunings, and other woody or brushy materials which, because of their physical composition, are generally slow to decompose.

watering can and hose

A compost pile breaks down faster when it is *as moist as a wrung out sponge*. During the summer and early fall, nitrogenous materials (Greens) may not contribute enough moisture to ensure optimal composting. Prevent your compost from drying out by watering it as necessary. During extended heat waves and drought, your pile is likely to need a water boost.

is it working?

If it heats up, it's working! Check the process of your compost by monitoring your pile with a thermometer. At peak digestion, a compost pile may reach 160°F (71°C).

when is it done?

Finished compost resembles dark, crumbly topsoil and should bear no resemblance to the original materials. Compost should have a pleasant, earthy smell to it. Compost is not ready to use if it is still hot, smells like ammonia, or contains recognizable remnants of the original organic materials. Using "unfinished" or immature material that contains food scraps can attract pests and can cause harm to young plants, so make sure your compost has fully decomposed before adding it to your garden beds.

A dark, earthy looking pile that has returned to air temperature (around 50°F or 10°C) is, most likely, stabilized or finished compost. However, the simplest way to tell if your compost is mature and ready-to-use is by doing the "bag test." Put a handful of moist compost into a zip-lock bag and leave it for three days, then open the bag. If you detect an ammonia-scent or sour odor, the microorganisms are still at work and you need to let your compost finish curing. Test your compost again in a week.

The "Compost Troubleshooting Guide" [Figure 3.8], also included as a Tip Sheet, identifies the most common problems with compost piles and suggests solutions.

using compost

Compost is one of the most effective and restorative remedies for human interference with the land. From home gardens to commercial agriculture to highway roadsides and rights-of-way, the properties and behaviors of compost continue to prove out the "black gold" legend: compost has the power to heal even the most depleted—and seemingly unlikely—landscapes. As people experiment with new uses of compost, the list of tried and true compost applications continues to grow. Increasingly, compost is being used to repair abandoned mines and construction sites where topsoil has been removed or destroyed. Compost also plays critical roles in the restoration of such "wild" habitats as forests and stream-beds, and in the development of urban parks and waterfront greenways. Most commonly, however, compost is found in the topsoil mixes utilized by homeowners, gardeners, and landscapers.

As explained in Chapter 2, compost improves soil structure, releases necessary plant nutrients, retains water, suppresses diseases, and provides vital aeration to plant roots. A soil's need for compost depends on its condition—as reflected by texture and nutrient content (see Chapter 2, *Properties of Soil*)—and its prospective uses. While

figure 3.8: compost troubleshooting guide

Compost Troubleshooting Guide

SYMPTOM	PROBLEM	SOLUTION
rotten-egg odor	Excess moisture and not enough air (anaerobic conditions).	Turn pile frequently; add dry Brown material such as autumn leaves, woodchips, or newspaper. Make sure bin has drainage; leave lid off to allow more air to flow.
ammonia odor	Too much Green, high-nitrogen material (such as food scraps, grass clippings).	Add Brown, high-carbon material (such as autumn leaves, woodchips, shredded newspaper, straw).
slow decomposition	Lack of moisture.	Add water while turning pile.
	Lack of air.	Turn pile; add aeration tubes.
	Lack of nitrogen; too much Brown, high-carbon material.	Add material high in nitrogen (more Greens), such as food scraps or grass clippings.
low pile temperature *(If you have a small pile, or if it is very cold out, don't be concerned if your compost is not generating heat; decomposition is still occurring, but at a slower pace.)*	Pile too small.	Increase pile size (space permitting).
	Insufficient moisture.	Add water while turning pile.
	Poor aeration.	Turn pile; add aeration tubes.
	Lack of nitrogen.	Add more Greens (material high in nitrogen), such as food scraps or grass clippings.
	Cold weather.	Increase pile size, or insulate pile with straw or other material.
high pile temperature (over 140°F, 60°C)	Pile too large.	Reduce pile size.
	Insufficient ventilation.	Turn pile.
unwanted pests	Wrong materials in the pile.	Avoid meat, dairy, and fatty foods.
	Food scraps are exposed.	Make sure food is well covered.
	Bin isn't rodent-resistant.	Make bins more rodent resistant by adding hardware cloth to areas where animals could get through. Add a screening barrier vertically 6 to 8 inches into the ground; keep pile moist; turn pile more often to increase temperature and disturb nesting.

rocky or sandy-soil that will be used to support plant life may require a significant compost-boost, soil that is rich in organic materials demands minimal enhancement, and dirt for a sandbox can be left "as-is."

Compost is typically utilized in four ways:

- as a soil amendment
- as a mulch or top dressing
- as a liquid fertilizer or compost tea
- as a component in potting mixes.

If you have ever used peat moss, wood chips, manure, or topsoil, then you're already familiar with the uses of compost. If you add materials sprayed with pesticides to your compost pile, do not use the finished compost on edible crops as the chemicals may not have fully broken down.

compost as a soil amendment

Before planting annuals, groundcovers, shrubs, or trees, integrate compost (or topsoil mixes containing compost) into the top 3 to 5 inches of existing soil. *Thorough mixing* is essential to effective soil enhancement. If compost is not well-integrated into the soil, burgeoning plant roots will hit an imaginary wall between the layer of nutrient-rich matter and the untouched soil underneath. In this type of an environment, plants develop shallow root systems, making it more difficult for them to acquire the water and nutrients they need.

for vegetables

Give your vegetable garden plenty of compost in the fall. Spread several inches of compost on top of the existing bed, then till it in come springtime. Put a handful of compost in each hole when you're planting. Once plants begin to grow quickly, you can add a half-inch layer of compost around the base of the plants. Provide "heavy feeder" plants such as tomatoes, corn, and squash with half an inch of compost monthly—this will result in great produce!

for flowers

In the spring, loosen the top few inches of annual and perennial beds and mix in a one-inch layer of compost. Or apply a one-inch layer of compost as a mulch to protect plant roots from freezing and conserve moisture.

for potted plants & window boxes

Even the best potting soil gets depleted of its nutrients as plants grow. To replenish nutrients, add an inch of compost to potted plants and window boxes twice a year. Or, make your own potting soil using two parts screened compost to one part sand or perlite.

for trees and shrubs

When planting a tree or shrub, compost can be added to the tree/shrub hole to improve the existing soil. The tree hole should be twice as wide and slightly shallower than the root ball. Backfill three quarters of the hole with existing dirt and one quarter with compost. Be sure that you don't add too much compost, as the tree roots will not grow

past this gold mine of organic matter, depriving the tree of the stability of a deep root system. Just the right amount of compost will give the tree a nice boost for the first few years of its life.

Try to make sure that the soil of the root ball matches the texture of the native soil. A simple test is to feel the soil texture. If the root ball is a sandy soil and the native soil is clay based, the tree will be fighting to survive. Applying compost to the back-filled soil will help by easing the transition between soil types, but it does not necessarily create the ideal situation for the tree. When in doubt, refrain from adding any type of amendment to the hole. [see Figure 3.9, planting trees]

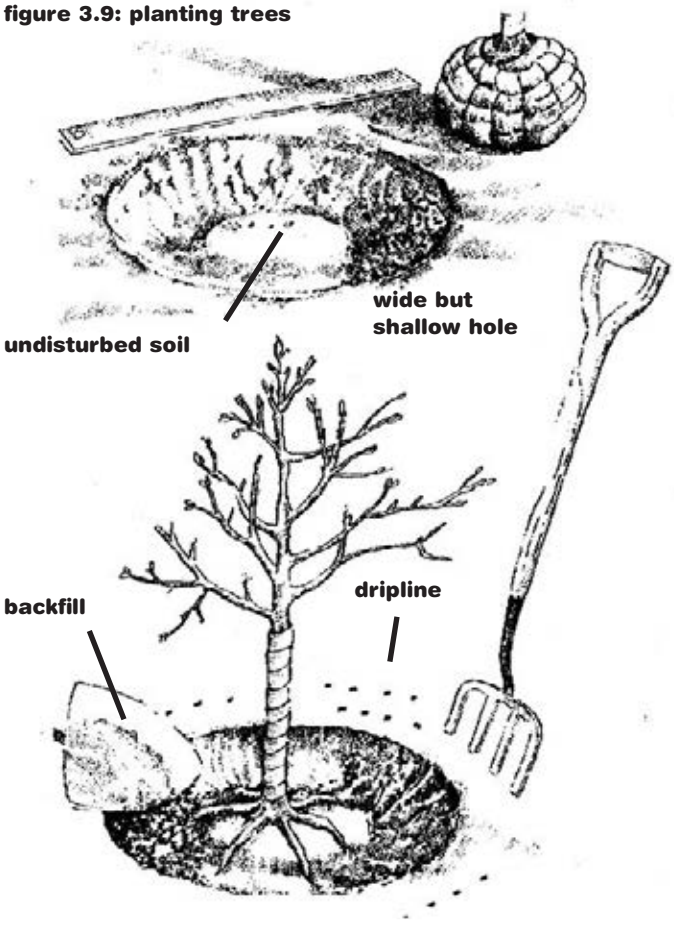
for lawn and turf

New turf: When establishing new turf, incorporate up to three inches of compost into the existing soil base. If possible, till to a depth of five to eight inches before seeding. Otherwise, seed directly over the compost.

Existing turf: You can treat bald spots by incorporating an inch of compost into the soil and then reseeding. This will fight compaction and help suppress soil-borne diseases.

You can also topdress existing turf with one-half inch of finely screened compost. This is easiest to do with a spreader, but you can use a shovel for small areas where you want to add compost. Rake the compost evenly throughout the grass area to enable the compost to readily sift down to the soil. The compost will settle down into the soil, improving its structure and providing nutrients. Over time, this will mean less compaction, fewer bald spots, and a reduced need for synthetic fertilizers.

figure 3.9: planting trees



compost as mulch or top dressing

Mulch is a protective covering of material that is spread over the soil surface. It reduces evaporation from the soil surface, keeps down weeds, and stabilizes soil temperature. Mulch also protects sloping ground from soil erosion and stops soil compaction caused by driving rain on the soil surface. Once your plants begin to grow quickly, you can use a 50-50 mixture of soil and compost as mulch

to improve your soil conditions. For flowers, you can use 100% compost, but be sure to finely screen the finished material before applying an inch layer as mulch.

To use compost as a mulch for trees, remove grass from underneath the tree and work one-half inch to one inch compost into the top two inches of soil. Be careful to avoid damage to the roots. The mulched area should extend from the trunk of the tree out to the dripline—the outermost parameter of the tree's canopy [Figure 3.9]. To prevent the spread of certain tree and bark diseases, leave a ring (several inches wider than the trunk) of "mulch-free" space around the base of the trunk. Compost used in this way serves as a substitute for the layer of organic matter that naturally exists on the forest floor: it provides organic nutrients, reduces moisture loss, and keeps the soil cool.

compost as a liquid fertilizer or as compost tea

Water your plants with compost! A great source of readily available nutrients for flowering plants and vegetables, compost tea is easy to make and even easier to use. Compost tea provides an abundant population of microorganisms (beneficial bacteria, fungi, protozoa, and nematodes) that can help your plants in several ways: they compete with harmful bacteria for available nutrients, they compete for space on the surfaces where they were applied, and they may even consume harmful bacteria.

compost extract

Place about one quart of good quality compost in a burlap, cloth mesh, or nylon bag. (Best results are achieved when using vermicompost; it's substantially higher in nutrients than compost made from a pile or bin.) Suspend the bag of compost in a 5-gallon bucket or barrel of water. Let it steep for several days until the water turns dark in color. The extract will contain the water-soluble nutrients from the compost, and can be used as a tonic or fertilizer when watering your plants. Compost extract is extremely potent and should be diluted with water before application.

making compost tea, bucket-bubbler method

Follow the same steps to prepare the bag of compost and suspend it in water. Use an aquarium air pump with air tubes and up to 4 air stones to generate air bubbles. This will increase the levels of oxygen in the water so that the microorganisms will grow and multiply in the tea. Add a microbial food and catalyst sources to the solution as an amendment. (Examples of *microbial food sources:* molasses, kelp powder, and fish powder. Examples of *microbial catalysts:* humic acid, yucca extract, and rock dust.) Leave the compost in the aerating bubbles for at least 8 hours, up to several days. That said, a prolonged brew time (more than 3 days) may require the addition of more microbial food to maintain a healthy microbial population.

using compost tea

Drench the soil with this fertilizing tonic. Or spray plants such as roses, lilacs, and tomatoes with compost tea about every two weeks until the peak of the growing season to help them fight harmful bacteria.

Compost tea should be used within 24 hours after it is brewed to prevent the microorganisms from using up all of the available oxygen, and creating an anaerobic

condition in which they will die. Once anaerobic conditions exist, only harmful bacteria will flourish; the tea will start to smell rotten and should be discarded.

compost as a component in potting mixes

Compost is excellent for potting mixes because it stores moisture effectively and provides a variety of nutrients not typically supplied in commercial fertilizers or soil-free potting mixes. To provide an adequate supply of macronutrients (N-P-K), however, it is essential to amend compost-based potting mixes with a "complete" fertilizer. Generally, a good potting soil is equal parts loam, sand, and finely screened compost. Compost can be used to enrich purchased potting mixes or to make your own mixes.

simple recipes for making your own compost mixes

For starting and growing seedlings in flat or small containers:

- Sift compost through a 1/2-inch mesh.
- Mix two parts compost, one part coarse sand, and one part loamy soil or coconut coir.
- Add 1/2 cup of lime for each bushel (8 gallons) of mix.
- Use liquid fertilizers when true leaves emerge.

For growing transplants and plants in larger containers:

- Sift compost through a 1-inch mesh or remove larger particles by hand.
- Mix two parts compost; one part ground-up bar, Perlite, or pumice; one part coarse sand; and one part loamy soil or coconut coir.
- Add 1/2 cup of lime and 1/2 cup of 10-10-10 fertilizer for each bushel (8-gallons) of mix.
- An organic alternative fertilizer can be made from 1/2 cup bloodmeal or cottonseed meal, one cup rock phosphate, and 1/2 cup of kelp meal.

chapter 4: composting systems

Small-scale composting is an easy way for households, schools, community gardens, and other institutions to reduce their volume of organic waste. Methods range from minimal-work techniques that require maintenance a few times a year to more active methods that require weekly or biweekly maintenance. As a Master Composter, you will help people decide which composting methods are most appropriate for them.

compost bins

Though few New Yorkers enjoy suburban-sized "backyards," many city residents have access to courtyards, gardens, and other patio spaces. While yards like these are too small to house rambling, uncontained compost piles, they provide plenty of space for compost bins.

what is a compost bin?

A compost bin is a ventilated structure used to contain composting materials. Crafted in assorted shapes and sizes, compost bins can be made out of wood, plastic, modified trash cans, cinder blocks, bricks, and/or wire mesh.

While some people enjoy building bins from scratch, others prefer to purchase ready-made alternatives. Commercial bins—typically made out of recycled plastic—have tight-fitting lids, ventilated sides, and a door at the bottom for harvesting finished compost [see Figure 4.1].

New York City residents can purchase various types of backyard compost bins and tools, as well as worm compost bins, from certain NYC Compost Project sites. These bins are relatively inexpensive, compact, rodent resistant, and are ideally suited for composting in New York City.

enclosed commercial compost bins

ADVANTAGES

Compact

Rodent resistant

Insulated

DISADVANTAGES

Accepts limited amount of material

Not suitable for "hot" composting

homemade compost bins or holding units

ADVANTAGES

Accepts larger amounts of material

Often less expensive than commercial bins

Can be modified to your specific requirements

Can compost in batches

DISADVANTAGES

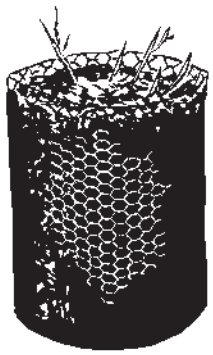
Not as easily rodent resistant

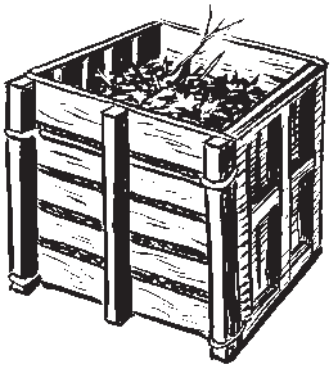
Not always practical for small, urban yards

figure 4.1: enclosed, commercial compost bin

types of compost bins

figure 4.2: homemade compost bins or holding units





Bins fall into three categories: holding units, enclosed bins, and tumblers.

A variety of compost bin models are on display at NYC Compost Project sites. Your Master Composter training will familiarize you with the advantages and disadvantages of each one.

Holding units: Simple bins usually constructed of chicken wire or wood slats. Most appropriate for containing fall leaves and yard trimmings [see Figure 4.2].

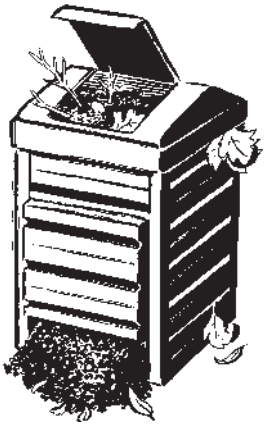
figure 4.3: examples of enclosed bins

Enclosed bins: Plastic and metal containers punctured with air holes to allow for ventilation. Appropriate for composting both kitchen scraps and yard waste [see Figure 4.3].

Tumblers: Enclosed bins manufactured for easy turning. A mixing chamber sits on a base or frame and can be rotated manually. Some have crank handles, others have indented hand-holds. Rather than turning your compost, turn the whole bin! [Figure 4.4]

how to choose a bin

When deciding how to compost, it is important to identify available space, time constraints, cost limitations, and the types of materials you plan to include. Ask yourself the following questions:



space

How much space can I allot for my compost pile?

time

How much time do I want to put into maintaining my pile? Composting demands only as much work as you're willing to put in. It's true that a pile that gets turned periodically will produce finished compost faster than a pile that is left to decompose without the help of human hands. But, if you're prepared to wait a few years, even a completely neglected pile will decompose. Your intended level of involvement may inform your choice of bin. For example, if you know that you'll rarely have the time to turn your pile with a pitchfork you may prefer to use a rotating or tumbling composter that you can turn every time you walk by.

cost

How much money can I afford to put towards a bin?

contents

What materials do I plan to compost? If you're going to be composting food, it's a good idea to work with a fully enclosed bin. An enclosed container helps to discourage unwanted pests from invading your pile.

compost bin design

Once you know your limitations, you're ready to build or buy your bin. As you review your options, look out for:

ease of access for loading/unloading

Tumblers, with their relatively small hatches, can be challenging vessels to unload. Notice how and where the doors to your compost bin are located. Does the opening allow enough room for easy turning? Can you reach into the bin comfortably enough to turn things over with a pitchfork? Can you fit a shovel in to scoop compost out? A compost bin with two or more portals—one on the top, one at the base—can be ideal for incremental composters who continue to add materials over an extended period of time. In this type of bin, finished compost can be harvested from the bottom without disrupting the unfinished materials on top.

ventilation

Compost is an ecosystem that relies on aerobic—oxygen breathing—decomposer organisms. If your pile lacks oxygen, it may become *anaerobic*. A by-product of anaerobic decomposition is methane. If you like the smell of rotten eggs, anaerobic composting is for you! If you prefer to reap the benefits of composting without fumigating your neighbors, look for a bin that has plenty of air holes.

rodent resistance

In an urban setting, it's vital to consider whether the bin is rodent resistant. Enclosed commercial bins do a good job of keeping rodents out. Homemade bins should be lined with quarter-inch square wire mesh to cover any openings large enough for a rodent to enter. This should be done even if food scraps are not going to be composted—in the colder months rodents may find the compost heap an attractive place to live. Keeping the pile moist and disturbing the pile by turning it regularly will discourage pests from moving in.

bin materials

Both plastic and wooden bins produce good compost. While *wooden bins* look nice, they tend to warp over time and—unless they are made of rot-resistant wood—they will gradually decay. A non-toxic weather-proofing substance can be used to increase the lifespan of a wooden bin. In order to prevent toxic contamination of your compost, stay away from chemical coatings and paint. Advantages to *plastic bins* include lighter weights and the promise of longer lifespans. Plastic bins can be

figure 4.4: tumbler

easily assembled and disassembled which makes them easier to move around both the garden and the city. However, some plastic bins break easily, especially during disassembly. Also consider that the manufacturing process creates toxins, and uses non-sustainable resources.

build or buy your bin

Manufactured compost bins can be expensive. Prices range anywhere from $50 to $100+. To contain your costs as well as your compost, you might opt to build your own bin using chicken wire, 2 x 4s , and/or shipping pallets [Figure 4.2]. See links on **nyc.gov/wasteless** to find suggestions and directions for bin building on other composting websites.

New York City residents are encouraged to purchase low-cost compost bins through the NYC Compost Project. Visit the website (**nyc.gov/wasteless/compost project**) for more information on where to purchase or how to make your own compost bin or worm bin.

where does a bin belong?

To encourage maximum exchange of nutrients, decomposer organisms, water, and air, compost bins should be set up on soil. If a soil base is not an option, set your bin on pavement and line the bottom with a 2- to 3-inch layer of soil or finished compost. Be aware, though, that water percolating through the compost may stain the concrete. In general, it *does not* make any difference to the composting process whether you set your bin in the sun or in the shade.

soil incorporation and in-soil digesters

ADVANTAGES

Doesn't take up much room

Requires little attention to such things as recipe formulation or moisture levels

Accepts large quantity of food scraps

DISADVANTAGES

Requires longer times to produce finished compost

Might attract animals

Might generate odors

underground composting

Not everyone opts to contain composting materials in a bin. While some people maintain unenclosed piles in designated parts of their yards or gardens, others simply bury food wastes right into the soil.

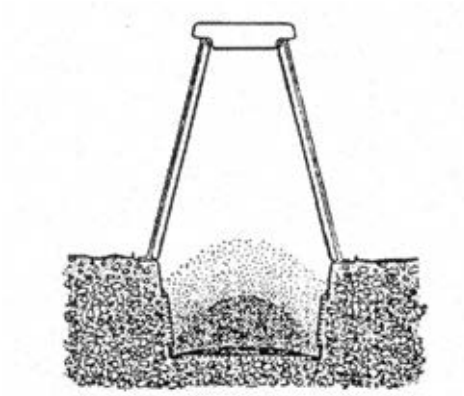
soil incorporation & in-soil digesters

If you ask gardeners if they compost, they might respond, "No, but I bury my food scraps in the garden." Burying organic material is one of the oldest methods of composting. There are many variations of this method. The most basic is to simply dig a hole and drop in food scraps. Food scraps should be covered with at least 8 inches of soil to prevent animals from detecting their presence and digging the scraps up. Depending on soil conditions and material buried, it can take from two weeks to one year for the material to decompose.

An *in-soil digester* [figure 4.5] allows you to bury your organic material without having to dig a new hole each time. A digester is like a modified trash can. Whereas a

garbage can sits on top of the ground, however, a digester sits in a hole 2-3 feet deep. Only one-third to one-half of the digester should remain above ground. Holes in the bottom of the unit allow water and leachate to be released into the soil; a tight fitting or locking lid keeps pests out. Because digester composting is *anaerobic*, it may smell when the lid is opened. To suppress fly populations, cover food scraps with a layer of sawdust or soil. Depending on the amount of food waste generated by a family or an individual, it may take as long as several months to fill a digester. Materials will take about a year to compost.

figure 4.5: in-soil food scrap digester



Note: In order to prevent flooding and the subsequent exposure of leachate to the air (which can be smelly!), a digester should be placed in well-drained soil.

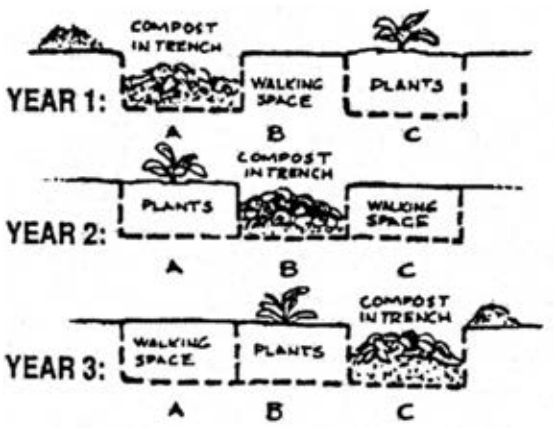
trench composting

Trench composting is a more methodical variation of burying organic material. Garden rows or squares are rotated on a three year plan. The first year plot A is used to bury organic material, plot C is planted, and plot B is left fallow. The second year, plot C is left fallow, plot B is used to bury compost, and plot A is planted. In the third year, plot B is planted, plot A is left fallow, and plot C is used to bury compost [Figure 4.6].

sheet composting

Sheet composting is a method of passive composting also described as Lasagna Gardening by Pat Lanza in 1998. This method is perfect for urban settings, allowing gardeners with limited space to create a bed of rich compost without giving up precious garden space to plant in. Unlike an active compost pile, sheet composting is never turned and will decompose slowly over the course of a year. The plants grown in a sheet gardening bed will flourish as the nutrients in the decomposing materials below are released. You can start a bed anywhere, without tilling, digging, or weeding; and still grow healthy plants while rich compost is produced before the next spring.

figure 4.6: pit and trench composting



To build your Lasagna Garden, simply mark off the area that you would like to use. The size and height of the bed is only limited by the amount of material you have available. Start by covering the area with a thick layer (1 inch) of newspaper to prevent any weeds from growing through the bed. Add a layer of brown material (mulched leaves, straw, sawdust, compost) about 4 to 6 inches deep. Follow with a layer of greens (fruit

and vegetable waste, grass clippings, garden waste) 3-5 inches deep. Add a 1-inch layer of peat moss or finished compost. Water the bed after applying each layer.

Repeat the process several times until you have reached the desired height. The top layer should consist of finished compost to act as planting medium. The bed can be planted immediately, or you can wait a few weeks or months to plant in it. To plant, simply pull back some of the materials to create a hole for the plant, add some additional compost, and water it well.

After about a year, when the process is complete, you will have about a third of the volume that you started with. The new compost that you created can be incorporated into the existing soil, or left in place as a new bed.

This method works well on clay and hard pan soil; the earthworms will churn and loosen up the soil below as they find their way to the organic matter in the pile!

worm bins

Worm composting systems use redworms, also called *red wrigglers*, to compost food scraps. As residents of relatively small, indoor containers, red worms transform food waste and other household organics into *vermicompost*—a nutrient-rich plant fertilizer and soil amendment. Worm bins are well-suited to New York's high population density and tight living spaces because they enable people to compost under sinks and inside closets: indoors and out of the way! [Figure 4.7]

worm bins

ADVANTAGES

Ideal for apartment-dwellers or people without access to an outdoor space

Produce high-quality compost

Fun and interesting for kids

DISADVANTAGES

Require harvesting and new bedding three or four times a year

Prone to fruit fly infestations

Require careful monitoring

how worms work

figure 4.7: worm bin

A red worm processes half its own weight in food scraps every day! This means that two pounds of worms will process a pound of food scraps a day or 7 pounds a week To determine how many worms you will need, estimate the amount of food waste your household generates each week. If you generate 3 pounds of food scraps, start with one pound of worms; if you want to compost 10 pounds of food scraps, you'll need three pounds of worms to get the job done.

Red worms can be purchased, found in leaf and manure piles, or taken from other worm bins. When ordering red worms from a supplier, specify either *Eisenia fetida* or *Lumbricus rubellus*. Unlike these compost-specialized species of red worms, nightcrawlers and other common garden worms will not survive in a worm bin.

preparing a worm bin

As a rule, the number of worms you adopt determines what size worm bin you use. Each pound of worms requires approximately one square foot of surface. An appropriate box is *shallow*—8" to 12" deep—and *covered*. Without a lid, it is impossible to maintain the moist, dark internal conditions necessary to keeping worms alive.

To make your own bin, drill holes in the top and sides of a container (like the one pictured in Figure 4.8) and cover holes with screen to keep houseflies out. Good air circulation requires at least ten half-inch holes in the top and several more on each side. If you prefer to go the ready-made route, pre-fabricated worm bins can be found on the internet. New York City residents also have the option to purchase worm bins from select NYC Compost Project sites (see **nyc.gov/wasteless/compostproject** for more info).

To create a habitat for your worms, add moistened bedding materials to your bin. An eight-inch layer of leaves, potting soil, strips of newspaper, and/or coconut coir (the fibrous waste from coconut shells) makes ideal red wriggler turf. Bedding should be *as moist as a wrung-out sponge*. Adding food waste will keep the bedding relatively moist. On occasion, however, it may be necessary to spray the bedding with water.

When you add your worms, lay them on top of the bedding and leave the lid off the worm bin for an hour. Since worms are sensitive to light, they will burrow into the bedding. Remember: worm bin inhabitants can't burrow to escape extreme temperatures. Although worms can be left outdoors at temperatures between 55°F and 75°F (13°C to 24°C), worms left in extreme heat or extreme cold will die. To avoid exposing worms to drastic temperature shifts and/or direct sunlight, keep your bin in the kitchen, basement, or garage year round.

figure 4.8: drill ventilation holes for air circulation

figure 4.9: bury food waste under bedding material

figure 4.10: move all the contents over to one side of the worm bin

worm maintenance

Red worms eat fruit and vegetable scraps, leftover bread and grains, crushed egg shells, coffee grounds, and tea bags (remove the staples first!). They do not eat meat or fish scraps, or fatty, oily foods. Feed worms small amounts every day or a whole week's food supply at one time. Cut up broccoli stalks and other large items.

to feed

Move some bedding aside and add food waste. Cover over with bedding, being careful not to leave any food exposed to the air [Figure 4.9]. Each time you feed your worms, bury the food scraps in a different part of the bin. Worms will eat both the food and the bedding, producing a dark, rich vermicompost. As older bedding disappears, add newspaper (or other bedding materials) to enhance the carbon level and keep the moisture level down.

harvesting

If left in the worm bin for too long, vermicompost starts to become toxic to worms. It is time to harvest vermicompost when the bedding starts to resemble dark, crumbly soil (usually in four to six months). Move all the used bedding over to one side of the worm bin and add new dampened bedding to the empty side [Figure 4.10]. For the next month, feed only the new bedding. This will encourage most of the worms to migrate into the new bedding and will allow you easy access to your relatively worm-free vermicompost.

troubleshooting

odor

An odor problem signifies that the vermicomposting system is malfunctioning. Make sure to cover the food waste with bedding material. If the problem persists, excess moisture and/or food may be interfering with the circulation of oxygen in the bin. Food should decompose within two weeks of its addition to the bin. If you notice that food is not breaking down, you may be feeding your worms more than they can handle. Reduce the amount of food that you place in the bin, and add dry bedding to wick away excess moisture.

If your worm bin has an unpleasant odor, one of the following may be the culprit:

- Bin is too wet. Stop adding water and foods with a high percentage of water (e.g., melons). Add more dry bedding.
- Bin does not get enough air. Add fresh bedding and fluff bin contents daily. Add paper tubes or bulking agents such as leaves to create air pockets.
- Food in bin is naturally odorous. Because meat, bones, dairy, and oil products become rancid when decomposing, they should not be fed to worms. Foods like onions and broccoli—which take longer to breakdown—also tend to get stinky. Remove any food source that smells bad.

flies

As long as you cover food waste with bedding, houseflies will stay away from your bin. Fruit flies, however, can be harder to deter. To avoid a fruit fly infestation:

- bury food scraps thoroughly
- wash all vegetables and fruits—especially banana peels and citrus rinds—in hot water
- avoid overfeeding the bin and try to keep it on the dry side
- place an extra section of dry, folded newspaper on top of the bedding

If fruit flies become a problem, traps may help to eliminate them. Hang fly paper above the bin, or follow the directions in Figure 4.11 to make a trap that you can place nearby. Any sugary drink can be substituted for apple cider or beer. Stop adding fruit to the bin until the problem subsides. If a fruit fly problem cannot be controlled, harvest the worms and start a new bin.

figure 4.11: trapping fruit flies

Here are some fruit fly traps you can make yourself:

1. Bottle fly trap (right). Cut a small plastic water or soda bottle in half. Fill the bottom half with some apple cider or beer and a drop of detergent. Turn the top half upside down and place it into the bottom half so that the neck forms a funnel. Secure the two halves with tape.

2. Fruit fly bait: in a small glass, vase, or similar vessel place one drop liquid dish soap, 2 t. concord grape or other juice, and 1 t. vinegar (any kind). Swirl together and coat the sides of the glass. Place on a dish (in case of spillage) near flies or on top of refrigerator. Dump out dead flies along with bait as needed (may be as often as twice a day initially). Replace bait and repeat until flies are gone.

3. Vacuum: Use a hand-held vacuum to remove flying insects. Don't let flies linger to lay new eggs.

dead worms

Dead worms decompose rather quickly. If you do not monitor the internal conditions you can have a bin with no worms before you realize it.

distressed worms

If you notice the worm population dwindling or that worms are crawling all over the bin trying to escape, check for the following:

- Bin is too wet: worms are drowning.
- Bin is too dry: worms are drying out.
- Bin is not getting enough air: worms are suffocating.
- Worms are not getting enough food. Once the worms devour all of their food and newspaper bedding, they will start to eat their own castings which are poisonous to them—TIME TO HARVEST.
- Bin is exposed to extreme temperatures. The worms thrive in temperatures between 50°F and 80°F (10°C to 27°C).
- An overpopulation of mites is interfering with the worms: take out the food where the mites are congregating.

more food, more worms

Larger worm bins exist for composting larger volumes of organic material. There are worm bins with the capacity to compost around 20 pounds of food scraps per day, which could be ideal for small restaurants or apartment complexes. They also make larger industrial vermicomposters, 6 feet x 5 feet x 4 feet, that can handle up to 150 pounds of organic waste daily!

See the “Worm Bin Troubleshooting Guide” [Figure 4.12], also included as a Tip Sheet.

figure 4.12: troubleshooting worm bins

Worm Bin Troubleshooting Guide

Taking steps to avoid problems with your worm bin is often easier than getting rid of problems once they've started, so it's important to monitor your bin regularly for the problems below. If a problem develops that cannot be controlled, the best solution may be to harvest the worms and start a new bin from scratch, using what you have learned from your past experience to create a better bin.

SYMPTOM	PROBLEM	SOLUTION
odor	exposed food	Cover food scraps with bedding.
	too much moisture	Add dry bedding so that it can soak up pooling water, particularly in wet areas. Reduce the amount of food placed in the bin.
	not enough oxygen	Add dry bedding; fluff up the bedding if it appears matted down.
	too much food; food not decomposing	Break food into smaller pieces, especially hard, woody items like stems; freeze and thaw to break down cell walls. Feed worms less so that they have time to go through the food in the bin.
	food in bin is naturally odorous	Some foods are naturally odorous when decomposing (such as onions, broccoli, or cabbage, plants in the allium or brassica family). Therefore, remove foods that produce unpleasant odors if it bothers you. Don't add meat, bones, dairy, or oil products, as these turn rancid.
	dead worms	See worm death section below.
fruit flies *If fruit flies become a problem, you can try using flypaper traps or make your own fruit fly trap; house flies should not be attracted to your worm bin if you cover the food scraps with bedding material.*	exposed food	Bury food under bedding material; cover the contents with a section of dry newspaper.
	too much moisture	Avoid overfeeding; add dry bedding.
	fruit fly eggs in food scraps	Cut fruit into small pieces; wash all fruits and peels, particularly bananas and citrus. Freeze fruit before feeding to worms or microwave fruit for 60 seconds. These actions help to kill fruit fly eggs. You can also simply avoid adding fruit.
worm death *Dead worms decompose rather quickly; you can have a bin with no worms before you realize it.*	bin is too wet; worms are drowning	Add dry bedding; leave lid off for an hour or two to allow water to evaporate. Make sure bin is well ventilated.
	bin is too dry; worms are drying out	Lightly moisten and turn bedding; add moist foods. Make sure it's not too hot for the worms.
	not enough air; bedding and food are matted together; worms are suffocating	Fluff bin contents to aerate. Be sure bin is adequately ventilated with holes; add paper tubes or other bulky paper products such as torn up paper egg cartons to increase air flow.
	not enough food	Increase food, or reduce number of worms.
	worms not eating	Avoid adding too much food at one time. Avoid very spicy foods, salty foods, large amounts of citrus, or toxic ingredients like alcohol.
	bin is too hot or too cold	Worms prefer the same temperatures that people do, so it's best to keep the bin in a location where the surrounding temperature is between 55°F and 80°F (13°C and 27°C). Smaller bins are more impacted by surrounding temperatures so keep these in a location with temperature controls.
	overabundance of mites (A small mite population is natural, but if you notice large collections of mites, you should try to remove them.)	Remove any food that has a congregation of mites. To reduce mites, bring bin outside and leave it open in the sun for 1–2 hours to dry it out a little. Repeat as necessary until mite population is reduced. To trap mites, place a slice of fresh bread in the bin, wait until mites congregate on it, and then remove the bread.

chapter 5:
yard waste and lawn care

Gardeners and landscapers can contribute to yard waste reduction efforts by mulch mowing, mulching with yard trimmings, turning in crop residuals, and keeping smaller lawns.

"leave it on the lawn"

mulch mowing
- **makes mowing quicker and easier**
- **recycles nutrients and creates healthier lawns**
- **requires mowing every 5 to 7 days in warm weather**
- **inefficient in wet weather**
- **may require changing mower settings**

The figures are in: New Yorkers who let their grass take care of itself cultivate healthier lawns and enjoy more free time! Mulch mowing—leaving grass clippings where they fall—replenishes soil organic matter and eliminates raking and bagging (processes that can be time consuming and costly). Although you may need to mow more frequently—an estimated five versus four times a month in the height of the growing season—you'll still pull out ahead with time saved in clean-up and fertilizing. Left on the lawn, grass clippings return water and important nutrients to the soil and can reduce fertilizer needs by up to 20 percent!

So, what's the catch? Why aren't more people leaving their grass clippings on the lawn? Some people are concerned about aesthetics; others are worried about *thatch* (see below); still others simply don't know how easy it is to mulch mow.

myth 1: a mulch-mowed lawn is an ugly lawn

Many people equate mulch mowing with a patchwork lawn speckled with intrusive clumps of grass. Avoid clumping by cutting grass when it is dry, keeping your mower blades sharp, and giving your grass frequent trims. For best results, mow over clippings a second time and/or scatter them in thin layers. As in a compost pile, small pieces spread over a large amount of surface area increase the rate of decomposition.

myth 2: mulch mowing contributes to the build-up of thatch

Thatch—a layer of living and dead roots, stems, and organic matter that collects on the soil surface—starves plant roots by blocking water and fertilizer from penetrating the soil. Accumulating in areas where rate of decomposition is much lower than rate of grass growth, thatch impedes the growth of grass roots, making turf more susceptible to stress and pests.

Researchers at the Cornell Cooperative Extension have demonstrated that—contrary to aggravating the symptoms of thatch—mulch mowing *protects* lawns against drought injury, root-feeding insects, and root-pruning diseases. Done right, mulch mowing does not contribute to the build-up of thatch.

myth 3: mulch mowing is a complicated process that requires special equipment

Although specialized *mulch mowers* have claimed a place for themselves on the lawncare market, *effective mulch mowing does not require the purchase of any specialized equipment.* A few minor adaptations to your trusty rotary mower will have you mulch mowing in no time. To convert reel-type mowers, just remove the catcher. On other mowers, try removing the grass-catching bag and covering the outlet spout, or cutting the bottom out of the catcher to allow clippings to fall to the turf.

Once your mower is ready to go, follow these easy steps to successful mowing:

figure 5.1: don't mow off more than an inch, or a third of the grass blade, at a time.

mow regularly

Remove no more than 1 inch of grass each time to avoid heavy deposits of clippings. Never cut off more than one-third of blade height in one cutting. If, for example, grass is 3 inches tall, cut off no more than 1 inch [Figure 5.1]. During spring and summer, mow every 5 to 7 days.

fertilize late

While moderate fall fertilizing and watering encourages deep root growth, increases drought resistance, and helps to reduce the number of required mowings, fertilizing in the spring and summer stimulates grass growth and fuels demand for frequent mowing. Avoid fertilizing during these warm months.

why recommend taller mowing heights?

When you set your mower at a higher cutting height, the grass plant produces a deep and efficient root system that can reduce the need for watering. Taller mowing also helps to "shade out" many weeds. Simply remember to set your mower at a tall setting so clippings fall easily into the lawn.

apply yard waste as mulch

Mulch differs from compost in that it is applied only to the *surface of the soil* and functions primarily as a *protective covering.* Where compost works to enhance soil by integrating nutrient-rich, moisture retaining, organic aggregates into soil, mulch acts as a barrier between soil and the elements. By shielding soil from direct exposure to sun, wind, dry air, and other abrasive forces, mulch slows the evaporation of soil moisture, suppresses weed growth, moderates soil temperature, and impedes soil erosion.

Use mulch in garden or planting areas, place it in rings around individual plants, or apply it to paths and play areas as soft "paving." Before applying, remove weeds and turf from the entire area and loosen compacted soil so that water and air can reach

plant roots. Because invasive plants thrive in mulches and can quickly overgrow them, take special care to eliminate all invasive plant roots (quack grass, ivy, etc.).

Grass clippings, leaves, shredded stalks, and wood chips make excellent mulches. Not all plants, however, share the same mulch preferences. Choose mulch materials based on plant and/or landscape needs.

annual and perennial plantings (flowers and vegetables)

Annuals and perennials prefer fine-textured mulches that break down quickly. Apply mulches made from grass clippings, shredded leaves and stalks, and/or finished compost in thin, 1- to 2-inch layers. Till mulch into the soil when cultivating the garden or planting a new crop. *Do not use fresh wood chips or sawdust to mulch annual plantings*. Fine woody materials compete with plants for nitrogen when they are mixed with soil, causing plants to become yellow and stunted.

shrubs and trees

Wood chips, shredded branches or evergreen leaves, wood shavings, and coarse ground bark make good woody plant mulches. Woody mulches protect the soil surface for a long time, require little maintenance, and, because of their coarse grain, are more water permeable. Apply woody mulches in thick, 2- to 6-inch layers. Spread mulch in rings that extend from the main stem or trunk to the tips of each plant's outermost branching, or *dripline*. When working with newly planted trees and shrubs in turf areas, spread a circle of mulch 3 to 4 feet in diameter. To prevent diseases of the plant crown, keep all mulches at least a few inches away from the main stem or trunk.

pathways

Garden paths can be covered with thick layers of chipped wood for comfortable walking and a natural appearance. Put layers of cardboard down before spreading the mulch to suppress weeds and make the chips last longer.

Note: Tree trimming companies will often deliver wood chips for free. Look under the Tree Services listing in the Yellow Pages to find a service that operates in your area.

turn in crop residuals

At harvest time, chop or till crop stalks and debris from annual vegetable and flower gardens into the soil. Spring crops will decompose quickly if cut when they are still green and succulent. Fall crop debris can be turned in or cut roughly and left on the surface to protect soil from erosion and compaction. A few weeks before spring planting, till surface remains (along with fertilizers) into the soil.

reduce lawn area

Replacing grass with plants that require less maintenance and produce less debris can dramatically reduce yard waste. Shrubs, trees, perennials, and groundcovers generate less debris than lawns, and require less fertilizer, water, and labor than turf.

Low, spreading shrubs provide interesting alternatives to lawns, as do drought-tolerant groundcovers.

In shade and other substandard growing conditions, groundcovers prove healthier and more attractive than lawns. Replace grass in low-traffic areas with such low-maintenance groundcovers as Saint John's Wort, Ivy, Ajuga, Periwinkle (Vinca), and Beach Strawberry.

In place of maintaining lawns, some people opt to plant natural-looking wooded areas and wildflower meadows. In addition to supplying shade and oxygen, woodlands provide areas where grass-clippings, leaves, needles, and other yard trimmings can be mulched. An initial thick layer of wood-chip mulch will help create a woodland look and reduce the need for watering, weeding, and other maintenance. Meadows can be created by seeding turf with wildflowers and pasture grasses. Though meadows should be mowed after flowering (approximately once each summer), these landscapes remain attractive even when left unwatered and unmowed. To view alternative groundcover demonstration areas and learn more about lawn replacement, visit your local botanical garden.

natural lawn care calendar

For more detailed information, see **nyc.gov/wasteless/compost**.

winter

- Avoid walking on your lawn; wet and soggy turf is more subject to damage. If you walk on your lawn when it's wet, you can permanently harm the soil structure.
- Have your mower tuned up before the spring rush. Make sure blades are sharp and properly balanced.
- If you are in the market for a new mower, consider a rechargeable, electric mulching mower. They are quiet and reduce air pollution.

spring

- Hold off on fertilizing until September or October so that grass won't grow excessively in the spring.
- Have your soil tested. Do not use lime until you know from the soil test how much lime your lawn needs, if any at all.
- Mowing height should be set to 3 inches. Mowing high reduces plant stress, making grass less susceptible to diseases.
- Avoid removing more than the top third of the grass blade, or mowing when the grass is wet.
- If grass clippings are clumpy or unsightly, mow over them a second time, scatter grass clippings with a blower or rake, or collect them and add them to your compost pile.
- Do not water your lawn (unless re-seeding) until temperatures stay consistently in the 80°s F (30°C) and/or rainfall drops off to less than one inch per week.

summer

- Keep mowing height high—3 inches or more, especially in hot, dry weather.
- Lawns need a total of one inch of water per week—this includes rainfall. Set out an empty tuna fish or cat food can to gauge. When the can is full, this is one inch of rainwater.
- If temperatures stay in the 90°s F (35°C) for more than three days, lawns need 2 inches of water per week. Apply a half inch every other day.
- For best results, water early in the morning—before 9 am.
- Follow drought-watering guidelines if restrictions are in effect. Your lawn may go dormant and turn brown, but it will green up as soon as rainfall increases and cooler temperatures return.

fall

- Fertilize. Use a slow-release, organic fertilizer formulated for fall application. This may be applied anytime from September through November.

seasonal guide to a healthy lawn (naturally)

Here's a summary chart of what to do each season to maintain a healthy lawn without chemicals (each of these steps is described below):
Information adapted from the newsletter of the New York Coalition for Alternatives to Pesticides. Do not reproduce without attribution.

spring

aerate
rake thatch
test the soil pH
topdress
overseed
fertilize late, if at all

summer

mow high & often
leave clippings on the lawn;
don't fertilize
water properly, if at all
combat weeds intelligently
renovate lawn in late summer

fall

mow your leaves
aerate
fertilize
overseed bare spots & "old" lawns

winter

wait!
winterize your mower
get out your snow shovel
see **nyc.gov/wasteless/calendar** for any winter workshops that might be of interest

aerate

Research suggests that compaction is the prime cause of weed growth. Lawns fed with a steady diet of chemicals often suffer from compaction, since the aerating organisms, such as earthworms, have been eliminated. Old lawns or those exposed to heavy traffic are also likely to be compacted. When soil is compacted, water and nutrients can't reach the turf roots and the hardened soil prevents roots from penetrating the ground. Consequently, bare areas open up and opportunistic weeds move in.

It is best to wait until the ground is relatively dry before aerating—otherwise, you'll end up with a muddy mess. There are several different tools available for aerating. For a large area, you can rent a power aerator. Smaller tools include (hand- and foot-powered) aerators, or aerator footwear (with long spikes on the soles) that you put on while walking over the yard. If you use a core aerator, leave the plugs on the surface. They will help break down thatch.

rake thatch

thatch rake

Raking thatch, or dethatching, is the process of removing dead organic matter from your lawn. If there's a build-up of dead surface roots and woody fibrous material, then you need to dethatch. Dethatching is critical if your lawn is made up of a sod-forming species of grass, such as Kentucky bluegrass, or if you've over-watered or over-fertilized in the past. Up to a half inch layer of grass clippings, however, can be beneficial for your lawn, because it retains water and protects root systems.

Wait for the ground to be somewhat dry before dethatching, since dethatching is an aggressive process that can pull grass out by the roots if the soil is wet. Tools for dethatching include a dethatching attachment for the front of your mower or a metal dethatching rake. Be sure to save any organic material for your compost pile.

test soil pH

It is important to test the pH of your soil, since grass species grow at a pH between 6.5 and 7.0. Here in the Northeast, soil is usually slightly acidic and needs to be amended with an application of lime, but test first, because local conditions can vary. Do not apply lime without knowing the pH of your soil! Cornell Nutrient Analysis Lab can test the pH of your soil, or you can buy a do-it-yourself kit from Solvita or most home and garden stores.

topdress

Topdressing is the practice of covering the turf with a 1/8-inch to 1/4-inch layer of weed-free topsoil or screened organic compost. Topdressing is especially helpful in resuscitating lawns previously sterilized by chemical use.

The perfect time to topdress is just after aerating, filling those tiny holes with loose, rich organic material—such as your compost!

fertilize

Never fertilize too early in the season. A common misunderstanding is that spring is the time to fertilize, but grass will green-up and grow naturally in the spring. Fertilizing in the summer is not recommended, since it encourages weeds to overwhelm the grass when it is most vulnerable. By simply leaving the grass clippings on your lawn after mowing in the summer, you provide your lawn with 25% of the total nitrogen it needs.

The best time to fertilize is in the fall. Try to choose natural and organic fertilizers even if they sometimes cost more in the short term, since natural or organic fertilizers release more nutrients in the long run.

Testing your soil will help you determine what fertilizing is needed, if any:

Nitrogen (N) promotes growth and good color. If your soil tests reveal that your soil has a low organic matter content, you can increase nitrogen in your soil with organic composted cow manure, or fish or seaweed foliar sprays.

Phosphorous (P) promotes strong roots and help plants to flower. If your soil test indicates a phosphorous deficiency, you can spread rock phosphate or bonemeal.

Potassium (K) promotes the flow of nutrients through plants and helps plants withstand stress such as drought, insect damage, or extreme temperatures. An organic source of potassium is Sul-po-mag (0-0-22), the commercial name for the mined mineral sulfate of potash-magnesia.

mow high

Mowing height is important, especially during the hottest months of the summer. As a general rule, mow high and mow often. Mowing grass too close to the ground increases the vulnerability of grass to the hot sun, exposes delectable parts to insects, and weakens the root system. The growth of new green grass is hindered because the plant directs its energy towards the struggling roots. Mowing higher also helps control weeds like crabgrass by "shading" them out. For every eighth-inch that a lawnmower blade is raised, there is a 30% increase in the leaf surface area. That means a relative increase in photosynthesis, which feeds a larger, healthier root system.

You can maximize the health of most grass species by letting grass grow to four inches and mowing it to three inches. Never mow off more than one-third of the grass blade length. Keep mower blades sharp. Consider buying an extra set to use while the other set is being sharpened. Grass cut with dull blades is jagged and irregular, which promotes moisture loss and increases recovery time. Sharpened blades make a clean cut that allows for faster recovery.

water properly, if at all

Watering improperly during the summer can do your lawn more harm than good. Many people let their lawns become dormant during hot months rather than water them incorrectly. This conserves water when it is most needed for other, more important uses. A healthy lawn will bounce back when weather conditions change in the fall.

If you decide to water, water deeply, so that roots have to push deep into the soil to reach the water. Briefly sprinkling your lawn on a hot summer day only moistens the surface, permitting roots to soak up nutrients from the top few inches of soil. This results in a weak, shallow-rooted lawn.

Lawns need a total of one inch of water per week, including rainfall. If your soil holds water well, watering for at least an hour every week to ten days is sufficient. Water twice as often in sandy areas, or when temperatures stay above 90°F (30°C) for more than three days. To prevent waste through evaporation, water in the early morning, before 9 am.

combat weeds

The first step in combating weeds is to realize that they are merely misplaced wild plants—nature's way of promoting diversity and balance. In some cases, weeds are beneficial. Dandelions, for example, have very deep roots that bring leached nutrients up to the surface. Clover is a legume, a plant that captures free nitrogen from the atmosphere and shares it with grass. Because of these unique traits, both dandelions and clover can survive a harsh drought and stay green long after grass has turned brown.

Weeds can also be indicators of lawn problems, however. Crabgrass thrives in sandy soil that drains too quickly. And dandelions favor compacted soil that is slightly acidic. If you are plagued with a particular species of weed, save a sample for identification by NYC Compost Project staff, a landscape professional, or the Cornell Cooperative Extension. By remedying the factors that encourage weed growth, you can prevent or eliminate weed problems and improve the overall health of the soil ecosystem. To remove existing weeds, get to the root of the problem—that is, be sure to pull up the main root, sometimes called the tap root, to ensure that the plant doesn't grow back.

renovate your lawn

Thought late summer was too late to start working on your lawn? Not so. Here in the Northeast, mid-August through the end of September is the best time to build the health of your lawn. Warm temperatures help seeds to grow. In addition, grass planted in the late summer will be well established for almost a year before it has to combat stress caused by the next summer's sun.

If there are large sections of your lawn thoroughly plagued by brown spots and weeds, you may want to consider starting from scratch—removing all of the existing grass in that area and beginning anew. You can remove the existing turf by digging it up or tilling it under, then raking up and removing the clumps. A less labor-intensive method is to cover the area with black plastic until all of the grass is dead, which conserves topsoil while creating organic matter. Till 2 to 3 inches of compost into the top 5 to 6 inches of lawn to alleviate drainage problems and maximize the amount of nutrients available to turf.

Choose seed to complement the soil and climate. For help deciding how to integrate different species and cultivars, contact your local Cornell Cooperative Extension or a landscaping expert. Here in the Northeast, four main turfgrass species are recommended: Perennial Ryegrass, Tall Fescue, Fine Fescue, and Kentucky Bluegrass. Lawn seed mixtures generally contain quick-growing annuals and some sturdier perennial grasses.

Make it a habit to sprinkle fresh seed on small bald spots and brown spots after every mowing. If you have time, raking the spot will loosen the top 1/4 inch of soil to help establish the seedlings.

mow your leaves

Unlike grass clippings left on the lawn during summer, dry leaves from deciduous trees are not a source of nitrogen or moisture. Thick layers of fallen leaves, especially when they are wet and compact, block light and air and suffocate grass underneath. But fallen leaves do contain carbon and other nutrients and add considerable organic matter to the soil. By mowing the leaves on your lawn, you shred them into smaller pieces that microorganisms can break down more quickly. This prevents excessive amounts of leaves from settling and becoming an impenetrable matted layer.

You can also rake leaves up, bag them, and keep them on hand as a source of Browns to balance out Greens in your compost bin over the winter.

If you have more leaves than you can mow or store, place them out at the curb in brown paper lawn & leaf bags during the Department of Sanitation's special fall leaf collection period, and they'll be brought to a DSNY composting facility. Leaves placed at the curb at other times are collected as garbage. See the website for all special collection dates and procedures at **nyc.gov/wasteless**. Or check with your local NYC Compost Project to find out if there is a community garden in your area that will accept leaves for composting.

chapter 6:
outreach tools

The Master Composter classroom training is just the first step toward becoming certified. To receive the Master Composter certificate, each volunteer must contribute 30 hours of community outreach over a one-year period. It is your own outreach efforts that will determine the impact of this educational program.

There are a variety of ways you can spend your 30 hours of outreach. You can work individually on a project, work with a group of Master Composters with similar interests or complementary skills, or do some of each. You can work on outreach opportunities scheduled by the program coordinators or initiate projects of your own. During this time you will be responsible for staying in contact with the program coordinators to choose an appropriate project, to get the resources you need, and to report on your outreach activities.

This manual offers ideas for teaching methods and activities that will serve as a resource for you to refer to throughout your reign as Master Composter. You can use many different learning tools to instruct the public about the benefits of composting and how to start composting at home.

demonstrations and displays

Demonstrations are a great way to convey a particular point to a group. Demonstrations are most effective when they are kept relatively short and are presented with fascinating visual aids that catch your audience's interest while demonstrating an idea. It is very important that every one in the group is able to see and hear your demonstration, so be sure to check with those farthest away from you before you begin.

Compost displays can be set up at block parties, at greenmarkets, in shopping areas, and in classrooms. Effective displays will catch the eye of a person walking by and demonstrate an idea through visuals. When designing a display, especially for children, include objects that can be picked up or touched. When others see that people are handling some compost tools, bags or trays of compost, a worm bin, or other objects at your booth, they will be more likely to come over and check it out. Creating a portable display is one way to fulfill part of your 30 volunteer hours.

figure 6.1: inviting compost displays

example: compost phases

Set up an exhibit of compost in various stages. With one glance, feel, and sniff, students will be able to see the evolution of organic waste into compost.

- Collect compost in three or four stages of decomposition.
- Place each stage of compost in a separate tub and label the different phases of compost with numbers.
- Have students observe the compost and encourage them to feel the texture of the different states.

demonstration sites

Demonstration sites are effective because they serve as an ongoing promotional piece and allow people who have never seen a compost pile to observe first-hand how the piles are constructed. These sites also provide a location for workshops and a source of sample compost. For those skeptical citizens who say, "I'll believe it when I see it," demonstration sites are a perfect way of revealing the benefits of composting. Building and maintaining a compost demonstration site is an excellent project for a Master Composter.

"location, location, location!"

figure 6.2: compost demonstration site at queens botanical garden

When deciding upon a site for your compost demonstration site, location is critical. Your site should be situated in a place where there is a heavy flow of traffic, such as a local park or community garden. It is also very important that the site is of adequate size and displays as many different bins as possible. It is also worthwhile if the site is well-landscaped because the beauty of the site will attract more people. You may want to mulch the pathways and plant flowers and shrubs. Leave adequate space between the bins and mount recognizable signs that will draw people over to the site. Information about composting should be available on site.

maintaining your compost demonstration site

Keep your compost demonstration site well maintained. Many people will not be enthusiastic about visiting a site that looks overgrown and neglected. A work schedule can be prepared for the Master Composters to coordinate the maintenance of the site. Master Composters should staff the demonstration sites occasionally in order to answer questions. It is also a good idea to staff the site during special events. Master Composters may also staff the site on weekends for two or three hours to answer questions and provide composting advice. A sign explaining who to call for more information should be prominently displayed.

alternatives to your own demonstration site

Creating a whole demonstration site from scratch may seem like a daunting task and for many people this may not be a feasible project. However, there are many alternatives to starting your own independent compost demonstration site.

One of the best ways a Master Composter can contribute is by working with already-existing composting locations. For example, perhaps you know of a community or school garden where composting already occurs but where that activity is not prominently displayed. Perhaps there is no information about what is going on that is accessible to other members of the community. You can offer suggestions on how to make composting more of a focus of the garden and help to make colorful signs to explain the composting process.

Another option is to work on sites that are either understaffed or in disrepair. Oftentimes compost sites and gardens are established only to fall into neglect over time. This is where your enthusiasm and expertise may be of greatest help.

audiovisuals

Videos are a productive way to break up your presentation. Videos can provide comic relief while demonstrating an important point, and most importantly, videos give you a break from speaking. Take advantage of the many informative composting and recycling videos that are available. DSNY-BWPRR's recycle more, waste less website (**nyc.gov/wasteless**) contains videos on recycling and composting.

Slide shows or PowerPoint presentations are also useful because slides can be used as a focal point for your audience while you explain a particular concept. For example, if you are speaking about the basics of composting, a slide titled "The Basics of Composting" that lists "Moisture,

figure 6.3: examples of different types of home composting bins, at brooklyn botanic garden demonstration site

Aeration, Browns & Greens" will indicate to your audience exactly what you are lecturing about at that particular time.

If it is not possible for you to use a projector or laptop monitor due to the location of your workshop, then an easel and poster board are an excellent alternative. Outline the concepts you will be introducing on different pieces of poster board and change the boards as you move through your lecture. Helping to create a slide show is another way to fulfill your 30 volunteer hours.

questions

Ask your audience questions throughout your presentation. This is very important because students will gain more from a presentation if they feel involved and are given the opportunity to share their experiences.

Ask your students if they already compost, how they compost, if they composted as a child, how they heard about the workshop, and any other questions you think may spark your students' interest. You just might learn something you never knew before.

It may be beneficial to prepare a question for each topic of your presentation and open each subject with a question. This will no doubt stir up some interest and your students will be anxious to hear what you have to say on the subject. In addition to asking questions of your class, make sure you also encourage your audience to ask questions.

Being a resource does not mean you must have all the answers. In your outreach you will not only provide information, but you will also learn from other people's ideas and experiences. Be open to feedback, and collect tips and ideas from those with whom you talk.

If you come across a question for which you don't have the answer, feel free to call one of the Compost Helpline numbers. You can also suggest that people call or visit the website themselves anytime they have a compost-related question. Check the website to get current Compost Helpline numbers for each borough: **nyc.gov/wasteless/compostproject**.

discussions

Open discussions provide a forum for members of an audience to ask questions. Discussions are one of the simplest learning tools, although one of the most valuable since students and teachers can learn from each other.

example: what's garbage?

You can open up a discussion by asking the audience what happens to garbage once it's thrown away in the garbage cans at home or in school. Ask what we mean when we say "garbage?" Have members of the audience suggest things they believe are garbage and write them on the chalkboard.

Is garbage everything we throw away? Or can we reuse some of the things we discard? What happens to garbage after it gets picked up from your house? Where does the garbage truck take it?

Refer to the list of garbage items on the board and ask the audience which items could be used again for something else? Which items could be composted? Which items could be recycled? Which items could be replaced with reusable products? For example, plastic wrap could be replaced with a reusable plastic container.

Adapted from "Composting Across the Curriculum—A Teacher's Guide to Composting"

interviews

Interviewing others is a good way to learn about a variety of composting and waste management topics. Interviews can be conducted with family members, neighbors, friends, or experts within the community.

example: the evolution of garbage

Have students interview a senior citizen (grandparent, neighbor, family friend). Give them the following questions. Students may also add their own questions.

- Did you produce more or less garbage 40 years ago than you produce now?
- What were your toys made of when you were a child?
- What did you do with broken toys?
- What did you take to school for lunch? How was it packaged?
- What did you do with your garbage? Did a garbage truck come pick it up from your house or did your family take it away themselves?
- What did you do with your food waste?
- How were meat, milk, produce, and other foods packaged in the grocery store?
- Do you know what people used before there was plastic?

field trips

The knowledge and experience that can be gained from a field trip is extremely hard to re-create in a classroom situation. Excursions to compost demonstration sites and community gardens that are actively composting will most likely make a considerable impact on your students. You may wish to prepare some type of presentation to be given while you are at your destination. A follow-up discussion back in the classroom is a great way to reinforce what the students have observed on their field trip.

experiments

Experiments are an effective way to capture your students' interests, especially if they are children. Through experiments, students are able to form a hypothesis about what they believe will be the outcome of the activity and test that hypothesis. This is a very active method of learning because students' actions and decisions become part of the learning process.

Some are designed for a single sitting and others require follow-up activities and periodic observations. If you will be conducting experiments that require follow-up activities in a school classroom, it is beneficial if you are able to come back into the classroom on a weekly or monthly basis. For example, you can schedule the class two hours a week for four weeks. This schedule may have more of an impact on the students than a longer single session because the students will have to recall your previous presentation. This will help instill your composting and recycling suggestions.

figure 6.4: it might be interesting to track the rate of decomposition for different materials.

If it is not possible to return to the class on a regular basis, you may set up a particular experiment and hand over the observation and conclusion portions of the activity to the teacher, so he or she can continue the activity with the students. Another alternative for long-term experiments is to give the teacher all of the information and materials needed to set up and conduct the experiment. Don't limit your educational programs for children just to classrooms. Master Composters are always welcome at area youth organizations such as Boy Scouts, Girl Scouts, and after-school groups.

reminders for master composters

The Discovery Activities following this chapter include a number of actual compost experiments and games appropriate for many different age groups and situations. Share your experiences with fellow Master Composters regarding which experiments are successful or if you come up with any of your own.

figure 6.5: start small

As you head off into your respective communities, keep in mind that you are not alone in your mission! You are part of a larger network of community gardens, schools, "greening" organizations, and resident composters. Many times the most effective way to contribute your time is to figure out how you as a Master Composter can fit in to these numerous, already-existing networks and help do what needs to be done. Also, remember to not take on more than you can manage. It is always better to start your projects off small and build as you feel more confident.

In the end, you are the one who will make the difference. You will help others learn how they too can make a difference. Good luck!

chapter 7: presentations and workshops

This chapter offers ideas and tips to make your interactions with the public more effective.

After you have completed your technical training, get ready to share your expertise with your community. Perhaps you'll speak with students in an elementary school classroom, or assist with organizing workshops at local community gardens, or maybe you will be answering questions at an NYC Compost Project outreach table.

Pulling together a presentation may seem daunting at first for a new Master Composter. What should you talk about? What activities might you conduct? If you are tabling, what are the best ways to draw people in and get them engaged? The activities covered in this chapter will help you formulate a base for your presentation; you can fill in the gaps with your own expertise.

Usually, a combination of hands-on activities and animated demonstrations will have the most impact on an audience. People will be more impressed if they are able to see the compost process rather than just hear about it. If you are speaking about a compost pile, take your audience outside and break a pile open. Have them look for decomposers, and examine compost at various stages. If you are explaining how worms break down food wastes, let people look in a worm bin and inspect it for themselves.

In any case, it is important that you keep the message light and have fun with your audience, especially if this is the first time some people will be hearing about compost. Technical terms and strict guidelines may overwhelm some people and discourage them from composting because they may have the impression that composting is too complicated. Composting is easy, and composters can put as much or as little energy into making their compost as they choose.

figure 7.1: compost instructor shows students how to use compost to topdress lawns.

The Ten Helpful Tips below are useful guidelines for effective communication, no matter what the setting. This section is followed by advice for staffing compost tables and displays, and for conducting different types of workshops.

general presentation skills

Public speaking trainer Dale Carnegie has said, "The way you say it is as important as what you are saying." This is valuable advice for Master Composter volunteers, no matter what type of public outreach activities you choose to conduct. Be aware of how you are communicating with people. Your final class project will give you a chance to practice teaching and outreach skills in class and help to pinpoint some of the elements of good communications.

ten helpful tips:

1. be enthusiastic

People will respond to your mood and attitude, so if you aren't interested in the activity, then they probably won't be either. Take the initiative and start conversations at events. It is hard for many people to break the ice, but a simple lead-in, such as: "Do you want any information about composting?" can get people started. People are more interested in having a positive, enjoyable experience than in gaining any single piece of knowledge. They will have more fun this way, and so will you.

2. make eye contact

Looking people in the eye lets them know that you are paying attention and that you care about what they have to say. It also gives you a much better sense of whether they understand what you are saying and whether they are interested in it. This goes for kids, too, and sometimes an effective way to connect is to literally crouch down so that you are talking "eye to eye" with them. Often, direct eye contact is also an easy, non-threatening disciplinary measure, for both children and adults, because it acknowledges and warns against disruptive behavior. Keep in mind, however, that direct eye contact can be interpreted negatively by some cultural groups, so be prepared to back off when people seem uncomfortable.

3. speak up

People not only need to hear you, but they need to understand you as well. Speak loudly and clearly, talking directly to visitors rather than into your sleeve, behind your hand, or through a prop or plant. In addition, be aware that you need to project your voice more when working with a larger group.

Sometimes it helps to begin by asking if the people in the back of the group can hear, then adjust your voice as necessary, before people become frustrated. When talking to audience members that may have hearing impairments or difficulty with the English language, remember that enunciating clearly is just as helpful as increasing your volume. Basically, just make sure that people can see your mouth form the words as you speak.

4. ask questions that encourage thinking

Questions are an excellent way to involve people in an activity or discussion, but the wrong question can just as easily alienate people and turn them away. Developing effective questions is important and should be done ahead of time.

figure 7.2: nyc compost project workshop at the new york botanical garden in the bronx

Before you ask something, consider what type of thinking is required by the situation (i.e., Does it direct someone to look more closely at something? Does it encourage comparison of two viewpoints? Does it challenge a preconception?) and evaluate whether it is an appropriate question.

If the question is solely a "yes/no" or a "right answer" question, then it narrows the discussion rather than widens it. Sometimes, this may be an appropriate strategy—for instance, if you are trying to wrap up an activity and send people on their way—but more often this type of question only reinforces the idea that you have all of the answers already, and are simply "testing" your audience. Nobody wants to feel put on the spot if they are voluntarily participating in an activity.

Rather, you will usually want to use open-ended types of questions. These are questions that don't just lead to a "yes" or a "no," but encourage originality and allow for more than one right answer.

5. slow down

You may explain the same principles many times, but keep in mind that this is a new experience and new information for each new person with whom you speak. Don't let yourself switch over to "auto-pilot." Allow people time to process what you are saying, as well as anything you might be doing.

In addition, give people plenty of time to think about the questions that you ask before jumping in with an answer. If you have to, count to five in your head, and keep encouraging people to raise their hands with ideas, so that slower thinkers have an equal opportunity to respond. Another strategy is to repeat and/or rephrase the question, which gives people time to think without feeling pressured. However, avoid rushing in to rephrase a question or even answering it yourself if people don't answer immediately. Thinking takes time!

6. listen to your audience

People will tell you whether they are enjoying an activity and understanding the concepts, but they may do so through tone of voice, body language, or interactions with other audience members. These are all things that you need to "listen" for and respond to, rather than simply moving ahead with a set "script." If people are talking to each other rather than to you, or are asking seemingly unrelated questions, they are telling you something about their interest and/or comprehension. Don't be afraid

to stop, back up, or change gears entirely—just make sure that you are not challenging anyone or making them feel singled out. Also, be sure to genuinely listen to the answers people are giving to your questions.

figure 7.3: compost project staff answers questions about vermicomposting system at dewitt clinton high school in the bronx.

7. don't be afraid to admit you don't know the answer

Curiosity is part of human nature, and people will often ask questions for which you do not know the "answer." This is OK, and can actually be used as an opportunity to set an example of how one might go about finding the information. Try to acknowledge and respond to the question ("That's an interesting question, and one I've never really thought about. What brought it to mind? Does anyone else in the group know something about this topic?"). If appropriate, take a phone number and call back with the information as soon as possible. Remember, you can call any of the Compost Helpline numbers for help in answering questions on composting. Whatever you do, though, don't just make up an answer, because that doesn't benefit anyone!

8. invite people to share their knowledge

The people you will be addressing as a Master Composter are mothers, fathers, working people, students, etc., and they do not check these identities at the door. Keep this in mind, and don't be afraid to pick up on personal interests, family relationships, etc. Let your audience know a little bit about you, also—you never know what common interests might show up.

The people you will meet as a Master Composter will have all sorts of life experiences and varying degrees of background knowledge about compost, recycling, and solid waste-related topics. Part of the positive experience in their interaction with you is being able to articulate these thoughts to someone who will validate them. Be sure to encourage the positive steps people are taking. However, if you sense that the comments are inaccurate or inappropriate, you should certainly say something, but in general try to incorporate their knowledge and interests into your talk or activities. Welcome it, in fact, because you'll probably learn something new.

9. keep your goals in mind

Encouraging audience input and interaction does not mean that you hand over all responsibility for your presentation or activity. It is easy to get sidetracked, especially when a lot of people are around; but as the facilitator you should always be aware of the steps that need to happen in order to successfully communicate what you are trying to say or to complete each activity. Specific goals may change depending on audience age or interest, but there should always be some purpose in what you are saying or doing.

10. keep a sense of humor

No matter how much preparation you do, things will occasionally go wrong. Don't be afraid to laugh at yourself, and to let your audience do the same—it just shows that you're human, and people will respect you for it. Few things are worth getting upset over.

staffing tables and displays

If you choose to fulfill your volunteer hours working side-by-side with program coordinators, chances are at some point you'll be staffing a compost information table or exhibit. The basic set-up here involves presenting some type of information or in a display that is meant to draw people in and hopefully teach them something about composting.

figure 7.4: staffing a compost information table

A table or exhibit should be colorful and immediately appealing to people. A variety of loose objects that they can pick up or touch helps attract people. Helping to construct these types of displays and props is another way you can fulfill your volunteer hours.

People will react to your display in different ways. Some people will hardly talk to you at all and will just want to "play" with things; others will ask you question after question. You and your fellow Master Composters will be present to allow people with different learning styles to gain as much information as possible while remaining at ease. In short, you ideally want to allow for an audience-driven experience.

what is an audience-driven experience?

People bring their own experiences to any educational encounter. Whether they bring a great deal of expertise or a great deal of misinformation, as a Master Composter you want to help guide them through the information that your table or display has to offer. As people arrive, let them explore on their own. They may start asking you questions right away. Your job is to figure out how to engage them. What are they interested in? Take their lead. Audience-driven discussions acknowledge that the information our audience brings is an important part of how they will react to information presented at the composting display table.

As they begin to look over different objects on display—which might include different stages of compost from raw to finished, a worm bin, or samples of compost and soil to touch and compare—you may wish to ask them some questions to introduce the theme of composting. The more open-ended the question the more people will be encouraged to interact and explore with you and your fellow Master Composters at the table.

While visitors look at or handle samples in your display, consider asking questions such as:

- "What do you see?"
- "How does it feel?"
- "What does the compost smell like?"
- "What's the difference between the compost and the soil?"

If they are interested in the worm bin, hand them the trowel and suggest that they try to find the worms. If they are looking at a particular book or brochure, suggest other items at the table that might relate to that topic.

Often, as people begin to handle the objects—touching, smelling, and playing with them—they will begin to share stories and facts about them with you and the others gathered around the table. In a situation like this, the person is already engaged, and will be quite willing to enter into a dialogue with you and the other visitors, about the display objects.

audience interaction at a table or display

figure 7.5: searching for compost critters

It is often a good idea to have visitors who are already at the table or display show objects to new arrivals and share their knowledge with them. Adults should be encouraged to share their knowledge, plus any stories or cultural information that the objects on the table or composting in general bring to mind. Usually, children love to share their knowledge but some may be shy. You should never force any child or adult to participate if they are uncomfortable with being in the spotlight. If a visitor to your table seems to have extensive knowledge of composting, direct other visitors' questions to him or her. This will encourage people to talk to each other. Everyone, no matter how old or young, relates to objects and can discuss how an object makes them feel or makes them remember a personal experience. Getting the group around your table to discuss and share information like this is a great way to engage with each other as well as the display.

As a Master Composter, your role is to facilitate people's learning about composting. Although you may be anxious to share all the information you have recently learned yourself, remember that people who visit a table or display are not always ready or interested to hear everything you know. Listen to visitors' questions and be open to learning how to teach!

conducting workshops

If you choose to fulfill any of your volunteer hours (and beyond!) without the assistance of a program coordinator or not as part of an already structured event, you might want to come up with your own event.

Workshops provide a useful framework for communicating a lot of information in a short span of time. The information below provides sample outlines and activities designed for sharing composting information with different audiences and age groups. As you come up with your own outlines and activities, be sure to share successful strategies with program coordinators and fellow Master Composters.

workshop location

Choosing the location of your workshop is an important factor in planning your presentation. It is a good idea to consider the pros and cons of indoor and outdoor presentations and tailor your choice of location to your particular objectives. For example, if you are giving a presentation on indoor worm composting, an indoor location would obviously be appropriate. Decide first what you want to accomplish and then pick your site accordingly.

You will be most effective when your audience is able to have a "hands on" experience. Therefore, you should try not to limit your presentation to a lecture format only. One idea is to combine both the indoor and outdoor aspects by providing a short "field trip" to a local community garden or compost site after an indoor presentation. If you are planning to hold a workshop outside, it is also important to keep in mind the possibility of bad weather and have an alternate indoor location available.

adult workshops

The purpose of an adult workshop is to teach New York City residents how to compost kitchen and yard wastes at home or in a community garden. At the conclusion of the workshop, participants should have learned all of the essential information, including everything from setting up the compost unit to harvesting and using the finished compost.

Topics in your adult workshop should include: environmental benefits of composting; different methods of composting; building or purchasing a bin; materials that can and cannot be composted; maintaining a compost pile; and using the finished compost. The following sample outlines may also be helpful when developing your presentation. They are intended as a guide, as a presenter you should adapt them to your specific needs. Note that the focus is not on vermicomposting. This might be something to add in your presentation.

sample adult workshop *(1 hour 30 minutes)*

I. introduction *(5 min.)*

- Introduce yourself as a Master Composter.
- Ask your audience if anyone knows anything about composting or is already composting.
- Ask why they are interested in composting.

II. composting basics *(5 min.)*

define composting

Composting is the process whereby we create the ideal conditions for the rapid decomposition of organic materials. You can think of composting as speeding up the way nature recycles.

define compost

Compost (or humus) is decomposed organic materials that have a soil-like texture with many valuable nutrients. It is the result of the decomposition process. Compost can be combined with existing soil for growing plants.

III. environmental benefits of composting *(5 min.)*

Compost is a much needed resource. It is useful for the home gardener as a soil amendment. It is essential to the restoration of landscapes where topsoil has been removed or destroyed during construction or mining operations, and it is increasingly being applied to agricultural and forest lands depleted of their organic matter. In addition, by composting organic wastes, at least 20% of your garbage can be diverted from landfills, reducing the waste stream.

IV. the compost process *(10 min.)*

composting—how does it happen?

Microorganisms (e.g., bacteria and fungi) break down organic matter, turning it into an earthy humus. Distribute and review the "Decomposer Identification Guide" Tip Sheet; refer to "Key Players in the Compost Ecosystem," Chapter 2.

how do decomposers get into the pile?

They are present in the environment. Note: Different types of decomposers are able to break down different plant forms, therefore, which decomposers are present in your pile depends on what materials you have put in the pile. See "Decomposer Identification Guide" Tip Sheet.

V. compost factors *(20 min.)*

Compost factors are the conditions that can be altered to enhance the decomposition process. They include:

surface area/particle size

The more surface area, or the smaller the particle size, the more food will be "available" for the decomposers to break down. Although the materials do not necessarily have to be cut up for decomposition to occur, this will quicken the process. For example, leaves can be cut up with a lawn mower before they are put in the compost pile.

outside temperature

In cold weather, especially below 40°F (4.5°C), the compost process slows down.

pile size and temperature

Only large piles (greater than 3' x 3' x 3' in size) typically trap heat. These compost piles can get as hot as 180°F (82°C). Smaller piles do not generally produce as much heat. These smaller, cold piles are built up over time and decompose with the help of species in the mesophylic category of bacteria—bacteria that thrive in temperatures from 50°F to 113°F (10°C to 45°C). High temperatures are good because they kill weed seeds and plant diseases. High temperatures also speed up the compost process. In the best situation, the pile should reach 140°F (60°C) during the first week.

To identify the temperature, use a temperature probe.

If the pile is too hot, certain decomposers will die.

Solution: Turn the pile to let the heat escape or decrease the size of the pile if it is too large. (One cubic yard is an ideal pile size.)

If the pile is too cold, decomposers are not active.

Solution: Insulate the pile or make the pile larger if it is too small. The pile can be insulated with leaves, Styrofoam boards, bubble wrap, etc.

oxygen/aeration

The ideal oxygen content is 5%.

To identify insufficient oxygen/aeration, check for heaviness and the smell of the pile.

If there is insufficient oxygen, as the pile gets heavier and compacts, air will not be able to circulate through the pile. Aerobic decomposers will not be active and anaerobic decomposers will take over. The pile may emit hydrogen sulfide and methane, which have offensive odors, or acids and alcohols that are toxic to growing plants (phytotoxic).

Solution: Turn the pile to circulate air through the pile, and/or mix bulk materials with fine materials to create aeration holes throughout the pile. Aeration pipes and poles can also be inserted into the center of the pile to ensure uptake of oxygen.

To turn the pile, break the pile open and bring the inside materials to the outside and vice versa.

carbon to nitrogen ratio

The ideal carbon to nitrogen ratio is 30:1, or 30 parts carbon to 1 part nitrogen by weight. In practical terms, this means a mixture of approximately two-thirds high carbon materials (Browns), and one-third high nitrogen materials (Greens). It will take a certain amount of experimentation with different quantities of high carbon and high nitrogen materials to determine which combination produces the quickest compost.

To identify improper carbon to nitrogen ration, check for odors.

If there is too much carbon, decomposers are not as active because they need more nitrogen to work. Decomposers use nitrogen as their protein source.

Solution: Add high nitrogen materials such as fresh grass clippings or food scraps.

If there is too much nitrogen, aerobic decomposers will work too fast, using all of the available oxygen; and anaerobic decomposers will take over, causing the pile to smell.

Solution: Turn to add more air, or add high carbon materials such as dried leaves, paper, or sawdust.

moisture

The ideal moisture content is 50%.

To identify proper moisture level, squeeze a handful of the compost; a drop or two of liquid should fall.

If the pile is too dry, the decomposers will become dormant.

Solution: Turn pile and add water.

If the pile is too wet, not enough air will circulate through the pile and decomposition will become anaerobic.

Solution: Turn the pile to increase evaporation and add dry materials.

VI. what can and cannot be composted *(10 min.)*

All organic wastes can be composted, including vegetable and fruit scraps, as well as leaf and yard waste. Paper and untreated wood can also be composted.

However, large amounts of meat, cheese, or fatty products are not recommended for the backyard compost pile because they can attract pests. Nor should weed seeds, rhizomes, or plants infected with disease or insects be composted at home. These are suitable for large, institutional anaerobic composting operations.

Dog and cat manure should not be composted because they may contain human parasites or diseased organisms.

Inorganic waste such as glass, metal, and plastic cannot be composted.

VII. composting systems *(15 min.)*

The choice of compost method will depend on:

- available space
- time
- materials to be composted

compost bins

(6 months to a year depending on compost factors)

Compost bins can be purchased or made. Kitchen scraps and yard trimmings are mixed together in the bin. It is important that the kitchen wastes are buried within the pile to avoid pests. The pile should be turned occasionally and kept moist. Homemade bins can be built with:

- wire fencing
- wood
- snow fencing
- concrete blocks
- wooden shipping pallets

Bins should have a tightly sealed lid and, if they are resting on soil, a piece of screen underneath them to keep out borrowing pests.

three bin holding unit

Each bin will hold compost in different stages of decomposition. Fresh organic wastes will be held in the first unit. After a month or so, this compost can be shifted into the next bin, where it will stay for another month or so, and then be shifted into the last bin. As the compost is shifted from one bin to the next, the materials are aerated, which helps accelerate decomposition.

incorporation, pit and trench composting

(1 month to 1 year depending on the ground temperature and type of organic waste)

1. Dig a hole in the ground and fill with food and soil.
2. Cover with at least 8 inches of soil.

worm composting/vermicomposting

(3 to 6 months)

This method of composting is ideal for someone who does not have a large area to work with. To start a worm compost bin, you will need a bin approximately 16" x 24" x 8" (see "Worm bins," Chapter 4) with holes for aeration and a fitted lid. Fill the bin with damp bedding such as leaves, shredded paper, coconut coir, or straw. Add approximately 1 pound (600-1000) redworms and food scraps. The bin should be kept in an area with temperatures between 55-77°F (12-25°C). A kitchen, basement, or garage is an ideal place to keep a worm bin. As the worms digest the food waste, they leave "castings," a quality soil amendment rich in minerals and nutrients.

mulching

Mulching is another way to recycle organic materials. Lawn clippings, pine needles, chipped branches, bark chips, and sawdust can be placed on pathways and gardens, and under trees, etc.

Mulching helps to:

- stop weed growth
- prevent erosion
- insulate underlying soil
- conserve soil moisture

In garden mulching, do not use woody mulch because it will not break down quickly. Lawn clippings, pine needles, and leaves are good garden mulches. They should be spread about one-inch thick.

VIII. using compost *(10 min.)*

deciding when compost is ready

If compost is still hot, smells like ammonia, or you can still recognize much of the original material that went into the pile, then it is not yet ready to use. The simplest way to tell if your compost is ready to use (mature) is the "bag test":

- put a handful of compost into a zip-lock bag and leave it there for a week or so
- open the bag and smell it—if you detect an ammonia or sour odor, the microorganisms are still at work and you need to let your compost finish curing
- test it again in several weeks

screening

When compost is harvested, it can be screened to get a finer compost material. Compost is great for gardens, lawns, houseplants, street trees, or any other plant growth because it:

- improves soil structure and helps roots penetrate better
- holds moisture better than regular soil
- holds soil together giving it a crumbly texture
- attracts earthworms

applying compost

The best time to apply compost to your garden is when the soil is prepared for planting seeds or plants. Compost can be applied to shrubs, houseplants, and lawns at any time during the year.

IX. building a compost pile *(10 min.)*

Give each participant a bag of organic waste (containing a mixture of high nitrogen and high carbon materials). Have each person take a turn mixing the waste in the compost pile, alternating between high nitrogen and high carbon materials. Make sure the high nitrogen materials are completely covered with high carbon materials.

youth presentations

When you begin designing your youth compost program, you will need to decide where you will conduct your presentation. You may want to work with children in the school classroom outside at a local community garden or botanical garden during a special school excursion, or anywhere or anytime you feel is appropriate. Make sure to make your presentation age-appropriate so as not to alienate your audience.

The most important aspect of working with children is to spur their interest, not to impart specific knowledge. Be open to children's natural inquisitiveness and keep in mind that there is no such thing as a "wrong" answer. A denigrating "no" deters self-esteem and a child's association with composting. On the other hand, avoid excessive praise, as this can also be a turn off to the rest of the group. Finally, avoid using rhetorical questions as these often confuse young people. (Rhetorical questions are questions that do not expect an answer; for example, "Why me?")

sample youth presentation *(15-30 minutes)*
worm fun!

This presentation is appropriate for elementary school students and can be given in 15 to 30 minutes.

materials

Worm bin with worms and cocoons, one tray per four or five students, spoons, easel, and large writing tablet or dry eraser board.

introduction

1. Begin by introducing yourself and explain that you will be talking about worms.
2. Explain the difference between earthworms and redworms.
   - Earthworms live deeper under the soil than redworms.
   - Earthworms can live in colder temperatures and do not require as much food as redworms do.
   - Redworms are surface eaters and live within the first 8 inches of the soil.

You may want to share with your students the scientific name for the redworm: *Eisenia fetida*, pronounced eye-SEN-ee-uh FE-ti-duh.

3. Ask the students what worms do to help us. (**Possible answer:** They make the soil better for growing plants.)

4. Ask the students how the worms make the soil better for growing plants. (**Possible answer:** Worms eat dead plants and transform them into compost by digesting organic matter and leaving worm castings. The castings contain nutrients plants need to grow and stay healthy. Worms also plow tunnels in the soil, which allow air and water to get down to the plants' roots.)

5. You may pass around a sample of worm compost and ask the students what they think it looks and smells like. (**Possible answer:** It has an earthy smell, like dirt.)

building a worm bin

6. Explain to the students that we can build a home for worms and can keep it in our basement, terrace, or classroom. Show the students the closed worm bin. Point out the approximate size of the bin and tell them how they could make the same type of container from easily accessible materials, such as a Rubbermaid®-type container.

7. Ask the students what they think should be put inside of the bin to make a good home for the worms. (**Possible answer:** Bedding—leaves, newspaper, coconut coir, or straw—and food.)

8. Ask the students how many worms they think need to be put into the bin. (**Possible answer:** About 1000 if we put one-half pound of food in the bin per day.)

9. Explain to the students that the compost worms make is called Vermicompost, "vermi" means "worm" in Latin.

keeping worms healthy

10. Ask the students what they think needs to be done to keep the worms healthy.

- **Moisture**—Ask students, "Have you ever noticed that worms come to the surface after a heavy rain? Why do you think this is?" (**Possible answer:** It has become too wet for them underground and they are unable to breathe. The worm bin should not be so wet that the worms can't breathe. The bin should not be too dry, on the other hand, because the worms' skin needs to be moist.)
- **Temperature**—Worms are most comfortable between 55-80°F (13-27°C)—the same temperatures we like! Worm bins can be kept in the basement, laundry room, garage, classroom, etc.
- **Light**—Worms need to be kept out of the light. Your worm bin should be kept in a dark place or have a lid.
- **Aeration**—Your worm bin should have plenty of holes to allow air to flow through the bin.
- **Food**—Don't forget to feed your worms! Tell the students that worms will eat any type of food that we eat, especially fruits and vegetables. Ask the students what kinds of food they think worms like to eat. Explain to students that they should not put meats, cheese, or fatty foods into their worm bin because it may smell and worms don't like them very much. You may add that worms eat almost half as much as they weigh in one day. Worms will also eat food faster if it is cut up into smaller pieces.

examine vermicompost

11. Divide students into small groups and pass out a tray of worm compost with a spoon for each student. Have the students look for adult worms, baby worms, worm

cocoons, and other compost critters. Warn students not to cut the worms in half. They may believe both ends will survive; however, the end with the head will generate a new tail and the tail end will die.

Ask students to figure out which end is the worm's head by watching which direction it moves.

12. At some point show students the inside of your worm bin and explain that at one time the material that looks like "dirt" was once newspaper (or other bedding), and food scraps.

13. See *Worm Bin Checkup* Discovery Activity.

teachers workshops

If your goal is to bring composting into the classroom, then one way to achieve this is to work with school teachers directly. The following information can be used to conduct a workshop specifically designed for teachers of any grade level. You should allow for 3-4 hours to conduct the workshop, however this will depend on how many activities you plan to present. For example, a workshop on only vermicomposting may only take 1-2 hours. Be aware of how much your audience already knows; for example, whether there are science teachers present.

During the training session it is important that you convey how composting can relate to several subjects they may already be teaching, such as science, math, and language arts. Hands-on activities are also an important component of a teacher's composting workshop. Successful compost experiments and exciting activities that involve discovering and observing compost critters will win over any teacher with the slightest interest in composting. In addition, compost education resources should be made available for the teachers to browse through, as well as a list indicating where to obtain these materials. Most importantly, teachers should leave with the impression that composting is fun and easy!

sample teachers workshop *(3 hours 30 minutes)*

I. icebreaker *(20 minutes)*

- Personal and organizational introduction
- Ask teachers to share their experience or any stories they know about worms and composting, or even just worms!

II. introduction to composting *(25 minutes)*

what is composting:

- biological breakdown of organic matter
- with human intervention, we can accelerate this process
- compost uses (gardens, lawns, mulching trees shrubs, house plants)
- compost as a soil amendment (improves soil structure; holds moisture; holds soil together; attracts earthworms)
- composting to reduce the waste stream (since yard and kitchen waste make up about 20% of the waste stream, we are significantly reducing the waste stream by composting these materials)

methods of composting:

- "Who already composts in the classroom or at home?"
- "What method are you using?" (holding unit, tumbler, heaps, incorporation, worm composting)

backyard composting factors:

- particle size
- temperature/size of pile
- aeration
- Browns and Greens (carbon:nitrogen ratio—2/3 Browns or high carbon, 1/3 Greens or high nitrogen)
- moisture

why compost in the classroom?

- overview of the compost activities I will demonstrate today
- composting can be incorporated into many different subject areas. Some examples include:

Science: observing the decomposition process, discovery of decomposing organisms, the food chain, horticulture
Environment: recycling by composting, sustainability, "put back into the earth what we take out"
Math: graphing, measuring, calculating the size of a worm bin, word problems, "how much waste would a school divert from a landfill if half of the school composted?"
Art: drawing gardens, compost bins, or materials from observation; drawing from imagination
Computer Technology: research related topics; create computer graphics, slide-shows, or webpages
Language Arts: poetry: "This Compost" by Walt Whitman in *Leaves of Grass;* essays: "How a Worm Moves," oral presentations: "How to Compost," role playing: "My Compost Smells, What Do I Do?"

III. compost reactor activities *(50 minutes)*

Soda bottle bioreactor—see "Discovery Activities" *(30 minutes)*
Two-can bioreactor—see "Discovery Activities" *(20 minutes)*

IV. worm composting activities

Getting acquainted—worm observation
Setting up a worm bin (see "Worm Bins," Chapter 4)

V. closing

- Pass around resources you have that might be useful to the teachers
- Briefly describe each book or video
- Have teachers fill out an evaluation form

sample english language arts activity *(40 minutes)*

"This Compost" from *Leaves of Grass* by Walt Whitman

Share and discuss this poem with older students and adults.

Ask students to summarize the author's message. Do you find this poem dispiriting or hopeful? Find images of renewal and decay. Make a list of archaic or poetic spellings; how are these words spelled today? Walt Whitman was among the first poets to publish in free verse; explain how his organic meter and lack of rhyme helps or hinders his expression. Can you think of any songs that do not rhyme? Look for instances of internal rhymes and alliteration. Find where Whitman repeats or revisits particular phrases; does he also do this with particular images and settings? What purpose does this serve?

This Compost.
Author: Walt Whitman (1819–1892)
Volume: "Leaves of Grass" 11. Leaves of Grass
Published 1900

1
Something startles me where I thought I was safest;
I withdraw from the still woods I loved;
I will not go now on the pastures to walk;
I will not strip the clothes from my body to meet my lover the sea;
I will not touch my flesh to the earth, as to other flesh, to renew me.

O how can it be that the ground does not sicken?
How can you be alive, you growths of spring?
How can you furnish health, you blood of herbs, roots, orchards, grain?
Are they not continually putting distemper'd corpses within you?
Is not every continent work'd over and over with sour dead?

Where have you disposed of their carcasses?
Those drunkards and gluttons of so many generations;
Where have you drawn off all the foul liquid and meat?
I do not see any of it upon you to-day—or perhaps I am deceiv'd;
I will run a furrow with my plough—I will press my spade through the sod, and turn it up underneath;
I am sure I shall expose some of the foul meat.

2
Behold this compost! behold it well!
Perhaps every mite has once form'd part of a sick person—Yet behold!
The grass of spring covers the prairies,
The bean bursts noislessly through the mould in the garden,
The delicate spear of the onion pierces upward,
The apple-buds cluster together on the apple-branches,
The resurrection of the wheat appears with pale visage out of its graves,
The tinge awakes over the willow-tree and the mulberry-tree,
The he-birds carol mornings and evenings, while the she-birds sit on their nests,
The young of poultry break through the hatch'd eggs,
The new-born of animals appear—the calf is dropt from the cow, the colt from the mare,
Out of its little hill faithfully rise the potato's dark green leaves,
Out of its hill rises the yellow maize-stalk—the lilacs bloom in the door-yards;
The summer growth is innocent and disdainful above all those strata of sour dead.

What chemistry!
That the winds are really not infectious,
That this is no cheat, this transparent green-wash of the sea, which is so amorous after me,
That it is safe to allow it to lick my naked body all over with its tongues,
That it will not endanger me with the fevers that have deposited themselves in it,
That all is clean forever and forever.
That the cool drink from the well tastes so good,
That blackberries are so flavorous and juicy,
That the fruits of the apple-orchard, and of the orange-orchard—that melons, grapes,
peaches, plums, will none of them poison me,
That when I recline on the grass I do not catch any disease,
Though probably every spear of grass rises out of what was once a catching disease.

3
Now I am terrified at the Earth! it is that calm and patient,
It grows such sweet things out of such corruptions,
It turns harmless and stainless on its axis, with such endless successions
of diseas'd corpses,
It distils such exquisite winds out of such infused fetor,
It renews with such unwitting looks, its prodigal, annual, sumptuous crops,
It gives such divine materials to men, and accepts such leavings from them at last.

chapter 8:
discovery activities

Experiments and discovery activities are rewarding ways of learning new things because students are able to explore, prod, and inspect to find out their own answers and draw their own conclusions. Children are very perceptive and one might be surprised to see what they may be able to identify on their own.

Role play, oral presentations, and skits are always a fun way for students to demonstrate what they have learned. These types of activities are usually best saved for the conclusion of the unit on composting. Students get an opportunity to bring together the many aspects of composting they have learned into one comprehensive presentation. Students may either speak to the class about the benefits of composting or work with other students to produce a composting TV commercial or any number of performances relating to composting.

Games are perfect for releasing some of that energy your students have been building up since you began your composting spiel. If you are working with younger students especially, it is important to provide a balance of straight learning activities with some compost play. You can think of ways to adapt other standard games so that they relate to composting, as a great way to break up your session.

experiment: composting in nature

(one session)

(finding evidence of composting in nature)

Take students to a local park or botanical garden and have them find organic materials that are in the process of breaking down. For example, leaves decaying under trees, chopped grass, or an out-of-season flower. When the students encounter evidence of degradation, ask them how they believe plant materials change into soil and explain the process of decomposition.

experiment: planting with compost

(multiple sessions)

(comparing plants grown in compost to those grown in soil)

During this experiment, students will plant seeds in regular soil and in a compost/soil mixture and compare the growth of each plant. Students can take part in planting their seeds and forming their own hypotheses. They will see first hand the benefits of using compost when they observe how much healthier the plants growing in the compost are.

materials

- two plant containers per student (Styrofoam cups, yogurt cups, half pint milk containers, etc.)
- 6 seeds per student (bean seeds, marigold seeds, or any other seeds)
- soil from school yard or local park (not potting soil)
- compost

procedure

1. Have students fill one of their planters with soil and place 3 seeds, one inch under the soil.

2. Have students fill the other planter with a mixture of half soil and half compost and place 3 seeds, one inch under the mixture. It is better to let the students mix their own soil and compost so they can feel the difference in the texture of compost compared to regular soil.

Ask students to observe and describe how the texture is different. Ask how this will help the plants grow. **Possible answers:** The mixture holds the soil together, holds more moisture, contains nutrients from the compost, and allows the plant's roots to penetrate the soil more easily due to the crumbly consistency.

3. Add water to the planters and place in a sunny spot.

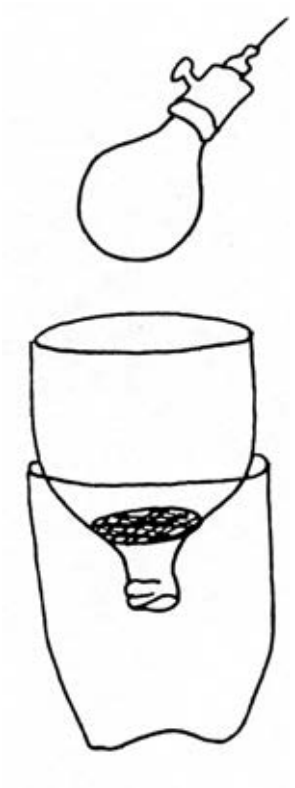
observe

After one week, observe the seedlings and compare the seedlings grown in soil to those grown in the compost mixture. Record the results. Continue to observe the plants and record the results for as long as you feel is appropriate.

experiment: compost critters in the spotlight *(one session)*

(separating decomposers from compost)

In this experiment, visible decomposing organisms such as sow bugs and ants are separated from a scoop of compost.



materials

- glass jar & funnel (alternatively: 2- or 3-liter plastic soda bottle)
- bright light (flashlight)
- wire mesh or netting (e.g., onion bag)
- 1-2 cups fresh compost
- isopropyl alcohol (optional)

Note: A 2- or 3-liter soda bottle can be used instead of the glass jar and funnel (see diagram). Cut the soda bottle in half and place the top of the bottle upside down inside of the bottom portion of the bottle.

procedure

1. Place a piece of wire mesh over the bottom of the funnel to keep the compost from falling out.
2. Place the funnel inside the neck of the glass jar.
3. Fill the funnel with compost.
4. Cover the top of the funnel with wire mesh, netting, or plastic wrap, to keep the critters contained.
5. Shine a light into the funnel. Leave the light over the compost for several hours or until you have extracted the number of decomposers you will need. The decomposing organisms will try to escape the light and make their way down the funnel and into the glass jar.
6. Optional: If you would like to preserve the organisms, pour isopropyl (rubbing) alcohol into the glass jar before attaching the funnel.

observe

After you have separated the decomposers from the compost, identify the decomposers using the "Decomposer Identification Guide" in the Tip Sheets section.

record

Students describe the step-by-step procedure and the results, using words and illustrations.

experiment: compost critter critique *(one session)*

(observing decomposers)

In this observation activity, students will become wildlife biologists, investigating compost life. Students will observe the organisms that were extracted in the "Compost Critters in the Spot Light" experiment, or by picking out compost critters with a spoon from a sample of compost.

materials

- one glass jar per student or pair of students
- one type of compost critter per jar
- observation sheet

procedure

Place one decomposing organism in each jar.

observe

Have students record their answers to the following questions:

- What are some of the most outstanding features of your organism?
- How many legs does it have? Are the back legs different from the front legs?
- How many eyes do you see? What do the eyes look like?
- Do you see a mouth?
- Do you see antennae? What do the antennae look like?
- How does your organism move?
- What colors is your organism?
- What does your organism eat?

record

Students draw a picture of their organism, and describe it in writing.

analyze

After discussing results, have the students let their organisms go free in your compost pile. Explain to them that they need to live within the pile so they will be able to find the conditions they need and food to survive.

Adapted from "Project Wild, K-12 Activity Guide: Grasshopper Gravity!" with permission from the Council for Environmental Education, Houston, Texas.

experiment: the banana breakdown

(multiple sessions)

(comparing the decomposition of a banana in different situations)

Students will be able to compare the breakdown of a banana in different conditions: water, soil, sunlight, with and without oxygen.

materials

- 5 one square inch pieces of banana peel
- 5 small sealable containers such as baby food jars or zip lock bags
- moist garden soil or compost
- plastic wrap.

procedure

1. Place one piece of banana peel in a jar filled with water. Seal the lid.
2. Place one piece of banana peel in a jar filled with soil or compost, exposing a portion of the peel through the glass. Seal the lid.
3. Place banana peel in an empty jar. Seal the lid and place in a sunny spot.
4. Place one piece of banana peel in an empty jar. Seal the lid.
5. Cover the last piece of banana peel with plastic wrap. Place in the jar and seal the lid. This jar represents *anaerobic* decomposition—*without* air.
6. Place all of the jars except the one prepared for #3 in a dark place.

observe and record

After one week observe the jars without opening them. Ask students: has the color changed? Has the texture changed? What else do you observe? Tell students to record their observations.

After 2 weeks, observe the jars (opened or unopened) and record your results.

analyze

Ask the following questions: Did the peels change in the same way? Which changed the most? What conditions caused these peels to break down faster? Why? Did any of the banana peels stay exactly the same?

banana breakdown chart

trial	time	color	texture	description
water	week 1			
	week 2			
soil	week 1			
	week 2			
sun	week 1			
	week 2			
air	week 1			
	week 2			
no air	week 1			
	week 2			

Adapted from "The Compost Learning Guide," Missouri Department of Natural Resources

experiments: decompose yourself

(multiple sessions)

(observing decomposition rates and factors)

decompose yourself—outdoors

Students observe and compare the decomposition rates of different organic and inorganic materials buried outside in soil.

materials

- outdoor plot of soil or compost
- sticks and labels for markers
- at least six different materials (such as a nail, nylon rope, a bone, plastic container, fruit and vegetable peelings, cotton sock, newspaper, "biodegradable" plastic bag, or grass clippings)
- mesh bags (if available)
- magnifying glass for observation (optional)

procedure

1. In a designated area of soil or compost, dig holes big enough for each item. All of the holes must be the same depth.
2. Make a list of the items, and labels for each item.
3. Have students bury each item in a different hole. Placing each item in a mesh bag makes removal easier.
4. Mark each spot with a stick labeled with words or pictures.
5. Once a week, have students dig up the items.

observe

Ask students to observe how fast and in what ways the items are decaying.

record

Record observations using words, illustrations, or photographs. Make a chart showing the rate at which different objects decompose.

analyze

Ask students: what is in the ground that causes the items to decompose? What characteristics of the materials make them break down faster or slower than other items?

Answers: See "Compost factors," "Decomposer Identification Guide" Tip Sheet.

decompose yourself—indoors

Students observe and compare the decomposition rates of different organic and inorganic materials buried in containers indoors.

materials

- clay or plastic flower pot, aquarium, large tub, or other container
- soil or compost
- sticks and labels for markers
- selection of organic and inorganic materials (as above)
- magnifying glass for observation (optional)

procedure

1. If there is a hole at the bottom of the flower pot, cover it to prevent spillage. Fill the container 1/3 full with soil or compost.
2. Make a list of the items, and labels for each item.
3. Place pieces of organic and inorganic items in the pot.
4. Fill the rest of the pot with soil or compost, and label the pot.
5. Add enough water to keep the contents moist. Cover with a plate or other covering, and place in a warm location. Keep pot moist and warm.
6. After 4 weeks, place the contents of the pot onto newspaper.

observe

Compare these materials with the materials on your list. Which materials have decomposed and which have not? Why?

record

Record observations using words, illustrations, or photographs. Make a chart comparing how different objects decompose.

analyze

Ask students: what is in the ground that causes the items to decompose? What characteristics of the materials make them break down faster or slower than other items?

Answers: See "Compost factors," "decomposer identification guide."

bonus: indoors vs. outdoors

Conduct this experiment both indoors and outdoors, using the same materials. Compare results. Are the decomposition rates different? Why?

Answers: See "Compost factors." Explain "hot" and "cold" piles.

size matters

Students observe the decomposition of different sized apple pieces buried in soil and learn that the more surface area that is exposed, the faster materials decompose.

materials

- four apples (or other piece of fruit) of the same size
- knife & cutting surface
- soil or compost, outside or in pots
- sticks and labels

procedure

1. Bury one whole piece of fruit in compost or soil; mark with a labeled stick.
2. Cut a small section out of the second piece of fruit; bury in compost or soil; mark with a labeled stick.
3. Cut the third fruit in fourths; bury the quarters in compost or soil; mark with a labeled stick.
4. Chop fourth fruit into small pieces; bury them in compost or soil; mark with a labeled stick.

observe

Dig up the fruit weekly. Observe changes and how fast each piece of fruit is breaking down.

record

Younger students may fill in a chart describing the fruit each week, using words and/or illustrations. Older students may also estimate the percentage of decay each week.

analyze

Ask students how the amount of surface area affects the rate of decomposition. What would break down faster, a 200 pound log or 200 pounds of broken sticks?

Answers: Explain that the more surface area that is exposed to the decomposers, the faster they will be able to break it down into soil.

experiment: two-can bioreactor

(single or multiple sessions)

(building an odorless indoor compost bin with two garbage cans)

Two-can units are designed to be used as small-scale indoor composting units for home composting, and as an educational tool in the classroom. Two-can composters consist of a 20-gallon garbage can containing organic wastes placed inside a 32-gallon garbage can. Although many classrooms have successfully composted with a single container, placing the can that holds wastes inside another container helps alleviate any odor and fly problems that may arise. The outside container can also be used to collect leachate.

A 20-gallon can holds only about 10% of the cubic meter volume commonly recommended for thermophilic composting. Thermophilic composting is possible in these smaller systems, but careful attention needs to be paid to C:N ratios, moisture content, and aeration requirements.

A system using a 10-gallon plastic garbage can inside a 20-gallon can may be substituted if space is a problem. The smaller system may operate at lower temperatures, thereby lengthening the time for decomposition. Or students may want to experiment with various aeration and insulation systems and mixtures of wastes to see if they can come up with a 10-gallon system that achieves temperatures as high as those in a larger system.

materials

- 32-gal. plastic garbage can
- 20-gal. plastic garbage can
- drill
- brick
- 6 pieces of nylon window screen (each about 2" x 2")
- dial thermometer with stem at least 24" long
- sphagnum peat moss or finished compost to make a 2" layer in outer can
- compost ingredients including high-carbon Browns such as wood chips and high-nitrogen Greens such as food scraps (see Step 8 below)
- spigot (optional)
- duct tape (optional)
- insulation (optional)

procedure

1. Using a drill, make 15 to 20 holes (approximately 1/2" in diameter) through the bottom of the 20-gallon can.

2. Drill five 1/2" aeration holes just below the rim of the larger garbage can, and cover them on the inside with pieces of nylon window screen.

3. Design and build a spigot at the bottom of the larger can for draining leachate. One way to do this is to fit a piece of pipe into a hole at the bottom edge of the outer can, sealing around the edges with waterproof tape or sealant. Close the outer end of the pipe with a tight-fitting cork or stopper that can be removed to drain the accumulated leachate, and cover the inner end with a piece of nylon screening to block the flow of solid particles.

4. Place a brick or some other object in the bottom of the 32-gallon can. This is to separate the two cans, leaving space for leachate to collect. (Students may want to measure the leachate and add it back into the compost.)

5. If you are composting in a cold area, you may want to attach insulation to the outer barrel and lid with duct tape, making sure not to block aeration holes.

6. To reduce potential odors, line the bottom of the outer can with several centimeters of absorbent material such as sphagnum peat moss or finished compost. Periodically drain the leachate to avoid anaerobic conditions that may cause odors. The leachate can be poured back in the top if the compost appears to be drying out. Otherwise, dispose of it outside or down the drain, but do not use it for watering plants. (This leachate is not the "compost tea" prized by gardeners, and it could harm vegetation unless diluted. Compost tea is made by soaking mature compost, after decomposition is completed.)

7. Fill the reactor, starting with a 2"-4" layer of Browns such as wood chips, finished compost, or twigs and branches. Loading can take place all at once (called "batch composting") or in periodic increments. With batch composting, you are more likely to achieve high temperatures quickly, but you will need to have all the organic material ready to add at one time. If you are going to add layers of materials over a period of time rather than all at once, the material probably won't begin to get hot until the can is at least 1/3 full.

Whether you fill the reactor all at once or in batches, remember to keep the ingredients loose and fluffy. Although they will become more compact during composting, never pack them down yourself because the air spaces are needed for maintaining aerobic conditions. Another important rule is to keep the mixture in the inner can covered at all times with a layer of high-carbon Browns such as finished compost, sawdust, straw, or wood shavings. This minimizes the chance of odor or insect problems.

8. To achieve thermophilic composting, you will need to provide the ingredients within the target ranges for moisture, carbon, and nitrogen. For *moisture*, the ideal mixture is 50-60% water by weight. Remember the rule of thumb that the ingredient mix should feel about as damp as a wrung-out sponge. For *carbon and nitrogen*, the mixture should contain approximately 30 times as much available carbon as nitrogen (or a C:N ratio of 30:1). Using a specified quantity of one ingredient, you can calculate how much of the other you will need to achieve this ratio. Or, you can simply make a mixture of high-carbon Browns and high-nitrogen Greens. Organic materials that are high in carbon include wood chips or shavings, shredded newspaper, paper egg cartons, and brown leaves. Those high in nitrogen include food scraps, green grass or yard trimmings, coffee grounds, and manure. (Do not use feces from cats or meat-eating animals because of the potential for spreading disease organisms.)

observe and record

You are now ready to begin monitoring the composting process. The composting process should take 2-3 months after the can is filled. At the end of this period, you can either leave the compost in the can or transfer it into other containers or an outdoor pile for the curing phase.

Adapted from "Composting in the Classroom, Scientific Inquiry for High School Students"

experiment: soda bottle bioreactor

(single or multiple sessions)

(building an odorless indoor compost with two soda bottles)

Soda bottle bioreactors are designed to be used as tools for composting research rather than as a means to dispose of organic waste. They are small and inexpensive, enabling students to design and carry out individualized research projects comparing how compost temperatures are affected by variables such as moisture content or nutrient ratios.

Use the instructions below as a starting point. Challenge students to design their own soda bottle reactors and to monitor the temperatures that their reactors achieve.

materials

- two 2-liter or 3-liter soda bottles
- Styrofoam plate or tray
- one pizza box lid support or smaller plastic container such as a margarine tub that fits inside the bottom of the soda bottle (optional—see Step 3)
- drill or nail for making holes
- duct tape or clear packaging tape
- utility knife or sharp-pointed scissors
- insulation materials, such as sheets of foam rubber or fiberglass, fine-meshed screen or fabric (such as a piece of nylon stocking), large enough to cover holes at top and bottom of soda bottle to keep flies out
- dial thermometer with stem at least 8" long
- chopped vegetable scraps such as lettuce leaves, carrot or potato peelings, and apple cores; or garden wastes such as weeds or grass clippings
- bulking agent such as wood shavings or 1/2" square pieces of paper egg cartons, cardboard, or wood
- hollow flexible tubing to provide ventilation out the top (optional—see Step 8)

procedure

1. Using a utility knife or sharp-pointed scissors, cut the top off one soda bottle just below the shoulder and the other just above the shoulder. Using the larger pieces of the two bottles, you will now have a top from one that fits snugly over the bottom of the other.

2. The next step is to make a Styrofoam circle. Trace a circle the diameter of the soda bottle on a Styrofoam plate and cut it out, forming a piece that fits snugly inside the soda bottle. Use a nail to punch holes through the Styrofoam for aeration. The circle will form a tray to hold up the compost in the bioreactors. Beneath this tray, there will be air space for ventilation and leachate collection.

3. If your soda bottle is indented at the bottom, the indentations may provide sufficient support for the Styrofoam circle. Otherwise, you will need to fashion a support. A small plastic pizza box lid support works great. Or place a smaller plastic container upside down into the bottom of the soda bottle. Other possibilities include

wiring or taping the tray in place.

4. Fit the Styrofoam circle into the soda bottle, roughly from the bottom. Below this tray, make air holes in the sides of the soda bottle. This can be done with a drill or by carefully heating a nail and using it to melt holes through the plastic. If you are using a plastic container to hold up the Styrofoam tray, you may need to drill holes through the container as well. The object is to make sure that air will be able to enter the bioreactors, diffuse through the compost, and exit through the holes or tubing at the top. Avoid making holes in the very bottom of the bottle unless you plan to use a pan underneath it to collect whatever leachate may be generated during composting.

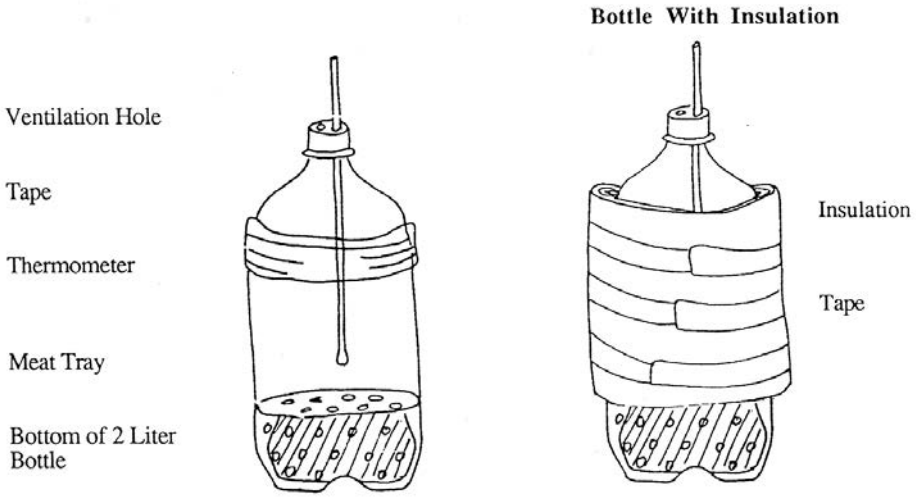
5. Next, determine what you will compost. A variety of ingredients will work, but in general you will want a mixture that is 50-60% water by weight and has approximately 30 times as much available carbon (Browns) as nitrogen (Greens)(a C:N ratio of 30:1).

- Materials that are high in carbon (Browns) include wood chips or shavings, shredded newspaper, and brown leaves. High-nitrogen Greens include food scraps, green grass or yard trimmings, and coffee grounds. By mixing Browns and Greens, you can achieve a successful mixture for thermophilic composting.
- Try to include more than just a couple of ingredients; mixtures containing a variety of materials are more likely than homogeneous ones to achieve hot temperatures in soda bottle bioreactors.
- The particle size of compost materials needs to be smaller in soda bottle bioreactors than in larger composting systems. In soda bottles, composting will work best if the materials are no larger than 1/2"-3/4" in size.

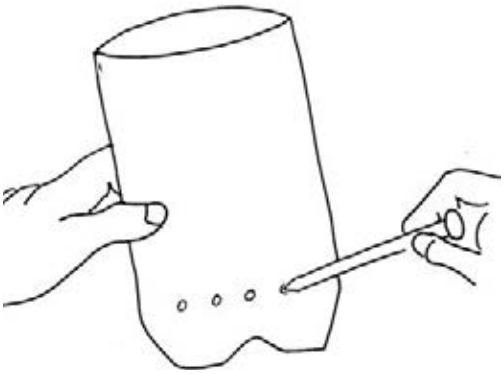
6. Loosely fill your bioreactors. Remember that you want air to be able to diffuse through the pores in the compost, so keep your mix light and fluffy and do not pack it down.

7. Put the top piece of the soda bottle on and seal it in place with tape.

8. Cover the top hole with a piece of screen or nylon stocking held in place with a rubber band. Alternatively, if you are worried about potential odors, you can ventilate



your bioreactors by running rubber tubing out the top. In this case, drill a hole through the screw-on soda bottle lid, insert tubing through the hole, and lead the tubing either out the window or into a ventilation hood.



9. If you think flies may become a problem, cover all air holes with a piece of nylon stocking or other fine-meshed fabric.

10. Insulate the bioreactors, making sure not to block the ventilation holes. (Because soda bottle bioreactors are much smaller than the typical compost pile, they will work best if insulated to retain the heat that is generated during decomposition.) You can experiment with various types and amounts of insulation.

observe

Now you are ready to watch the composting process at work! You can chart the progress of your compost by taking temperature readings. Insert a thermometer down into the compost through the top of the soda bottle. For the first few days, the temperature readings should be taken at least daily, preferably more often.

In these small systems, it is possible that temperatures will reach their peak in less than 24 hours. To avoid missing a possible early peak, use a max/min thermometer or a continuously recording temperature sensor, or have the students measure the temperatures several hours after they add their wastes, and early the next morning.

Soda bottle reactors generally reach temperatures of 104-113°F (40-45°C) somewhat lower than temperatures achieved in larger composting systems. If conditions are not right, no noticeable heating will occur.

analyze

Challenge your students to design systems that show temperature increases, and use their results as a starting point for a discussion of the various factors that affect microbial growth and decomposition (C:N ratios, moisture levels, air flow, size, and insulation).

Because the bottles are so small, you may not end up with a product that looks as finished as the compost from larger piles or bioreactors. However, you should find that the volume shrinks by one-half to two-thirds and that the original materials are no longer recognizable. You can let the compost age in the soda bottles for several months, or transfer it to other containers or outdoor piles for curing.

Taken from "Composting in the Classroom, Scientific Inquiry for High School Students"

activity: sizing up your worm bin

(multiple sessions)

(determining how large a worm bin your classroom will need)

In this experiment students will collect their food scraps for three weeks to determine what size worm bin your classroom will need. This experiment provides helpful information if you plan to put all of your food scraps in your worm bin every day.

Redworms are surface eaters and prefer living in shallow containers. For this reason the square footage of the base of the container is more important than the volume, in determining the size of your worm bin. The standard measurement used when sizing a worm bin is: One square foot of surface area per pound of scraps per week.

materials

- bucket with lid to collect food scraps
- a scale

procedure

1. Weigh the empty bucket and lid.
2. Collect food scraps for one week, weigh the bucket and food scraps. Record the results, subtracting the weight of your bucket. (Donate the scraps to someone with a compost pile, if possible.)
3. Repeat this procedure for 2 more weeks. Find the average weight of food scraps generated by your class in one week.

analyze

For every pound of scraps, you will need a square foot in your worm bin. One large bin is not necessary; you may prefer to use several small bins.

Just for fun, determine how many square feet you would need to compost for the whole school. (Square footage for your class x number of classrooms in your school.)

week 1 _____ lbs. of food scraps

week 2 _____ lbs. of food scraps

week 3 _____ lbs. of food scraps

_____ _____ _____ _____ divided by 3 = _____ square feet

week 1 + week 2 + week 3 =

Adapted from "Composting Across the Curriculum—A Teacher's Guide to Composting"

activity: what's in my waste?

(identifying the different materials in your waste)

In this activity students will take items out of a previously prepared trash can and talk about the proper disposal of these items.

materials

- clean garbage can
- recyclable and non-recyclable items such as glass bottle, plastic bottle, soda can, yogurt container, Styrofam tray, cardboard egg carton, plastic clamshell, plastic take-out tub, plastic spoon, milk carton, tissue box, plastic pen, cardboard, non-sticky food scraps, paper, and battery
- recycling checklist flyers for each student

procedure

Have students pick items, one by one, out of the garbage can. Talk about where they should go (recycled, composted, reused).
Taken from "Composting Across the Curriculum—A Teacher's Guide to Composting"

activity: worm bin checkup

Checklists are a simple yet highly effective learning tool. Students must observe conditions carefully and decide whether the item should be checked or not. This task requires students to make keen observations, and they learn that this will help them make decisions about what direct actions they can take to adjust future results. (See the Worm Bin Checklist in the "Worm Bin Troubleshooting" Tip Sheet.)

activity: exploring for compost creatures

(finding and identifying organisms in compost)

This activity is extremely simple but will be one of your students' favorites. Students will prod and poke through a sample of compost and look for decomposing organisms such as sow bugs, millipedes, worms, and worm cocoons.

materials

- one tray per student or group of students (aluminum pie pan)
- one spoon per student
- "Decomposer Identification Guide" (in Tip Sheets)
- compost
- observation containers (optional)
- magnifying glasses (optional)

procedure

Fill each tray with a few scoops of compost. Explain the various organisms they will be looking for. Backyard compost will contain more sow bugs, millipedes, and beetles; worm compost will contain more worms and worm cocoons. Give each student a spoon to poke with, a tray of compost, and the "Decomposer Identification Guide."

observe

Let students examine their compost. When they find a living decomposing organism, have them carefully put it into an observation container so everyone can have a closer look at it.

analyze

Record descriptions. Answer any questions.

activity: my compost stinks, what do I do?

In this role play activity, students will be given a compost problem and their partners will diagnose the problem and tell them how to fix it. Students will learn compost troubleshooting techniques while they have fun acting out these scenarios with their classmates.

1. Give each pair of students the list of Compost Problems, below, and the "Compost Troubleshooting Guide" in Tip Sheets.

2. One student will look at the "Compost Problems" and choose a problem to explain.

3. The other student will use the "Compost Troubleshooting Guide" to determine the reason and solution to their partner's problem.

compost problems

problem #1

"My pile is not heating up. I have been taking the temperature every day since I built my backyard compost pile two weeks ago but it has not gotten over 68°F (20°C). Isn't it supposed to be between 90 and 140°F (32-60°C)?"

problem #2:

"The worms in my worm bin look unhealthy and are not eating the food that I have been putting in there. I keep my worms outside; is this bad for them?"

problem #3:

"Two nights ago, I saw some animals around my compost pile when I brought out my food scraps from dinner. I think they were eating some of the food I put in the pile last week. What should I do?"

problem #4:

"My pile really stinks. Why does it smell, and what should I do?"

problem #5:

"My compost pile is not turning into compost fast enough. What can I do to make compost more quickly?"

projects: spreading the word about compost

(creating compost education and marketing tools to promote composting)

Here are four project ideas for Middle and High School composters (6th through 12th grade). One project may be selected for the entire class, or groups of students may have a choice between the four projects. Before assigning these projects, students should have a basic understanding of how to build a compost pile and why composting is important.

compost presentation

Students develop a 20 minute composting workshop for fellow students, adults, or younger children. Students begin by deciding what information they will teach (examples: "Why Compost?," "How to Compost," "Troubleshooting"), and what type of visual aids they will need to create for their presentation. Students may need to conduct research on the compost process, uses for compost, etc. Next, students will rehearse and then finally give their presentation to their classmates. They may want to video tape their performance, producing a short program about composting.

compost pamphlet

Students develop a four page pamphlet that teaches how to compost. Have students begin by brainstorming about topics that should be included in the pamphlet. Students can gather other examples of brochures and pamphlets associated with composting or other subjects, so they can get an idea of how they want their pamphlet to look. Students will write the text to be included, and create or find pictures to go with this material. Students can also create a compost logo for their pamphlet. Next, students will create a rough draft of the pamphlet and then a final copy.

marketing compost products

Students design a package and marketing slogan for one or more compost products. *Sample compost products: finished compost*, *worms*, *compost T-shirts*, *bumper stickers*, *compost bins.* First, have students decide what they would like to sell. Then students will brainstorm together what they believe are good selling points for their product. They will design a package for selling their product, which will involve decorating the outside with words, illustrations, and text that will help sell the product. Students may also create posters to advertise their product. For a final presentation, students can perform a two-minute commercial in front of the class about their product.

publicizing a compost program

Students create a publicity campaign for a compost workshop, compost product, or to promote composting in the community. First, students decide what type of compost program they will be publicizing. Then, they will brainstorm ways they can promote the program (TV, radio, newspaper, displays, subway ads, etc.) and decide which ones will be the most effective. Each group of students chooses a different method of advertisement, and creates articles, press releases, ads, visual aids, television and radio scripts, etc. For a final presentation, students may act out a television commercial, radio ad, or other advertisement.

Adapted from "Composting Across the Curriculum—A Teacher's Guide to Composting"

game: worms made my chocolate milk shake

In this game students will understand how worms are responsible for the health of the cow that provides milk for a chocolate milk shake. Students learn that cows would not have anything to eat if it were not for the worms who decompose dead grass and turn it into soil. New grass is able to grow using the sun, rain, and nutrients from the soil because the worms release these nutrients when they break down dead plants. The cow eats the new grass and produces milk for chocolate milk shakes.

This can be demonstrated by having the students form a circle and naming some of the students "worms," "soil," "sunshine," "rain," "dead grass," "live grass," and "cows." Tell students that all of the worms are now extinct and have the "worms" sit down on the floor. Since the worms are not there to break down the dead grass into soil, have the "soil" sit down on the floor. The "dead grass," "rain,' and "sunshine" are of no use because new plants will not grow without nutritious soil so these students can sit down along with the "live grass." Next tell the "cows" to sit down because without any grass to eat, they die of starvation. Now there aren't any cows to make milk for chocolate milk shakes.

Try playing this in reverse to renew the earth. End with all the children jumping up and down to blend their milk shakes!

game: compost critter, guess who?

During this game, students will learn how to identify various decomposer organisms found in a compost pile. First, make photocopies of the "Decomposer Identification Guide" Tip Sheet, and cut out a compost critter for each student. The same critters can be assigned to more than one student. Tape one compost critter to each student's back, making sure students do not see their own critter. The students will ask their classmates yes and no questions about the critter on their back while they try to figure out which compost critter they are. It may be easier for the students to guess what they are if they are able to refer to a copy of the "Decomposer Identification Guide."

game: compost jeopardy

Students should be divided into two, three, or four teams. The first team begins by choosing any section on the grid, for example “Wonderful Wigglers for 100 points”. The game facilitator will then ask a 100 point question from the “Wonderful Wigglers” section. The team will get a chance to talk with each other and come up with their answer in less than a minute. If the team has the correct answer, they will receive the amount of points the particular question is worth. If the team has the incorrect answer then they will have the points subtracted from their score.

If the question was correctly answered, the question is excluded from the rest of the game and the spot on the grid is closed out (close out with a large “X”). If the question was incorrectly answered, it will be excluded from the rest of the game (unless all other questions have been used) and the grid space will not be closed out.

Teams continue to take turns answering questions until the entire grid is closed out or time has run out. The team with the most points is the winner.

Note: Some questions are multiple choice or True or False, while other questions require a short answer. On the following pages, there are enough questions for each category to play this game several times.

compost critters	smelly solutions	wonderful wigglers	black gold
50 points	50 points	50 points	50 points
100 points	100 points	100 points	100 points
150 points	150 points	150 points	150 points
200 points	200 points	200 points	200 points

“compost critters” for 50 points

1. Aerobic decomposers require which of the following to break down a compost pile?
(a) rain
(b) oxygen
(c) sunlight
Answer: **B**

2. As aerobic decomposers break down organic materials they release the following byproducts:
(a) oxygen and heat
(b) carbon and nitrogen
(c) carbon dioxide and heat
Answer: **C**

3. A compost pile usually rises to temperatures of:
(a) 300-360°F (148-182°C)
(b) 90-140°F (32-60°C)
(c) 30-55°F (-1-12°C)
Answer: **B**

4. Decomposers turn organic materials into compost, which can be used for:
(a) lawns
(b) gardens
(c) house plants
(d) all of the above
Answer: **D**

“compost critters” for 100 points

1. What kind of decomposer spreads by forming spores?
(a) bacteria
(b) fungi
(c) sow bug
Answer: **B**

2. What type of decomposer helps to give soil a loose and well-draining structure?
Answer: Worm

3. Decomposers need carbon for a source of:
(a) energy
(b) heat
(c) protein
Answer: **A**

4. A food web is:
(a) the kinds of food decomposers eat
(b) a map of the flow of energy to consumers
(c) the four food groups
Answer: **B**

“compost critters” for 150 points

1. What decomposer are we not able to see with our naked eye?
(a) bacteria
(b) fungi
(c) millipede
Answer: **A**

2. What type of decomposer rolls up into a ball and resembles a sow bug?
(a) pill bug
(b) millipede
(c) ground beetle
Answer: **A**

3. Decomposers need nitrogen for a source of:
(a) energy
(b) heat
(c) protein
Answer: **C**

4. Where can decomposers be found?
Answer: There are an unlimited number of answers to this question; some include: forest floor, under rocks, in a compost pile, and inside of a garbage can.

“compost critters” for 200 points

1. Name one type of arthropod decomposer—”arthropod” meaning an organism having jointed legs.
Possible answers: sow bug, ant, centipede, millipede, collembola, ground beetle, rove beetle or beetle mite

2. Name three decomposing organisms.
Possible answers: sow bug, ant, centipede, beetle mite, ground beetle, collembola, and earthworm

3. Which of the following is a byproduct of anaerobic decomposition?
(a) salt
(b) methane gas
(c) oxygen
Answer: **B**

"smelly solutions" for 50 points

1. Should meat be put in your compost pile?
Answer: Small amounts of meat, such as those found in casseroles or plate scrapings, can be composted if the food is well covered. In general, meats are not recommended because of the potential for odor problems, and possible animal attraction.

2. True or False: If your compost pile is not turned at least once a week, composting will not occur.
Answer: False, compost will occur wherever there are dead organic materials, whether it is turned or not.

3. Which of the following materials will *not* decompose in your compost pile?
(a) soda bottle
(b) egg shell
(c) coffee filter
Answer: **A**

"smelly solutions" for 100 points

1. For the best results, what type of materials should be put in your compost?
(a) high carbon materials (Browns)
(b) high nitrogen materials (Greens)
(c) a combination of carbon and nitrogen materials
Answer: **C**

2. Which of the following foods are not recommended for your worm bin because they could cause an odor problem?
(a) eggshells, tomatoes, and banana peels
(b) meats, fatty foods, and cheese
(c) grapefruit, bread, and cereal
Answer: **B**

3. To help absorb any odors in your worm bin...
(a) pour water on top
(b) take out some of your worms
(c) place a piece of cardboard or sheets of paper on top of the compost
Answer: **C**

4. Your compost pile can become rodent resistant by:
(a) placing it on a cement slab so animals will not be able to borrow underneath the pile
(b) having holes no larger than 1/2 inch in your compost bin
(c) not putting large amounts of meats, fatty foods, or cheese in your pile, and covering all exposed food
(d) all of the above
Answer: **D**

“smelly solutions” for 150 points

1. What is the difference between aerobic and anaerobic decomposers?
Answer: Aerobic decomposers use oxygen and anaerobic decomposers do not use oxygen. Anaerobic decomposition can also create an offensive smell; is slower; and makes more plant toxins.

2. For the best results, which combination is best for your compost pile? Remember, carbon = Browns and nitrogen = Greens:
(a) 1/3 high carbon materials and 2/3 high nitrogen materials
(b) 1/2 high carbon materials and 1/2 high nitrogen materials
(c) 2/3 high carbon materials and 1/3 high nitrogen materials
Answer: **C**

3. Your compost pile may emit an odor if too many high nitrogen materials are placed in your pile because:
(a) nitrogen has a small atomic weight
(b) the high moisture content in nitrogen materials can lead to anaerobic conditions
(c) the high moisture content in nitrogen materials can lead to aerobic conditions
Answer: **B**

4. If your pile has not warmed up, it may be because:
(a) your pile is too small and cannot retain its temperature
(b) there are not enough high nitrogen materials in your pile
(c) either a or b
Answer: **C**

“smelly solutions” for 200 points

1. What may happen if your pile is too wet or compact and air is not able to get into the pile?
Answer: Anaerobic decomposition will set in because there is no oxygen available for the aerobic decomposers.

2. When constructing a two-can compost reactor, it is important to do which of the following to prevent odors?
(a) drain or absorb excess water leaching out from the smaller can into the bigger can
(b) keep the lid on tightly so oxygen will not seep inside of the can
(c) pour at least one gallon of water in the bottom of the larger can
Answer: **A**

3. Name one reason your compost pile may smell and what you can do to avoid this.
Some possible answers: If large amounts of meat, oil or cheese are placed in your pile, your compost may smell—take these materials out and do not put any more in. If pile has been compressed or soaked with water, your compost may smell—turn pile and possibly add dry bulky materials, such as leaves or wood chips.

4. When constructing a soda bottle compost reactor, why are holes made in the soda bottle?
Answer: So oxygen can get to the composting materials and smelly anaerobic decomposition will not occur.

“wonderful wigglers” for 50 points

1. What is another name for a worm compost?
Answer: Vermicompost

2. True or False: Worms are sensitive to light and will try to seek shelter in a dark place if a light is shone on them.
Answer: True

3. What type of worm is most commonly used for vermicomposting?
Answer: The best worm for vermicomposting is the Redworm scientifically named *Eisenia fetida*.

4. True or False: Setting up a worm bin is complicated.
Answer: False—all you need is a bin, worms, bedding, a handful of soil, and some food scraps.

“wonderful wigglers” for 100 points

1. What must a worm bin have in order for air to circulate through the bin?
Answer: Aeration holes

2. What temperatures do worms feel most comfortable in?
(a) 40 to 55°F (4-12°C)
(b) 55 to 77°F (12-25°C)
(c) 77 to 98°F (25-36°C)
Answer: **B**

3. In addition to adequate oxygen and comfortable temperatures, what else is necessary to ensure a healthy environment for worms?
Answer: Clean, loosely-packed bedding (moistened, shredded newspaper) provides moisture the worms need, and helps to keep air circulating through the bin.

4. Why should the amount of bedding in your worm bin be checked regularly?
Answer: Because the worms digest the bedding along with the food wastes.

"wonderful wigglers" for 150 points

1. What do worms like to eat?
(a) most food scraps—with the exception of large amounts of garlic, onions, meats, or pure dairy products
(b) glass and metal products
(c) plastic and rubber products
Answer: **A**

2. How much do worms eat per day?
(a) about two-thirds their total weight
(b) almost double their weight
(c) barely one fourth of their weight
Answer: **A**

3. How big should a worm bin be?
Answer: Sizing your bin will depend on the amount of food waste you will be placing in it. One square foot of surface area is needed for every pound of food waste you plan to place in your bin per week.

4. True or False: The deeper a worm bin the better.
Answer: False—the depth of your bin should always be 8-12 inches deep no matter how long or wide the bin will be since Redworms are surface eaters.

"wonderful wigglers" for 200 points

1. What's a good size bin (length x width x height)?
(a) 10" x 10" x 10"
(b) 12" x 12" x 16"
(c) 16" x 24" x 8"
Answer: **C**

2. If your class produces three pounds of food scraps per week, how many square feet should your worm bin be?
(a) 3 square feet
(b) 6 square feet
(c) 9 square feet
Answer: **A**

3. What are the most important conditions to monitor in a worm bin?
Answer: Temperature, moisture, and the amount of bedding and organic waste.

4. True or False: Worms frequently escape the worm bin.
Answer: False—if you provide the proper environment for the worms (i.e., adequate amounts of air, moisture, and fresh food scraps), the worms will rarely try to escape.

“black gold” for 50 points

1. What kinds of materials can be put in a compost pile?
Answer: Organic, biodegradable

2. Compost is referred to as “Black Gold” because it is a black color and
(a) was used in the 1800s for trading
(b) was not discovered until the 1800s
(c) is the most valuable soil amendment for your garden
Answer: **C**

3. Compost enhances the soil and helps plants grow by:
(a) adding nutrients to the soil
(b) holding moisture
(c) both a and b
Answer: **C**

4. Composting is:
(a) a way to recycle yard and kitchen wastes into a soil amendment
(b) *not* a method of reducing the amount of trash we produce and send to the landfill
(c) difficult and expensive
Answer: **A**

“black gold” for 100 points

1. Name two uses for compost.
Possible answers: gardens, lawns, mulch, shrubs, trees, and houseplants

2. Compost enhances the soil and helps plants grow by:
(a) adding oxygen to the soil
(b) giving the soil a crumbly texture, which helps plant roots penetrate the soil more easily
(c) allowing sunlight to reach underneath the soil
Answer: **B**

3. Composting reduces the amount of waste we generate because:
(a) organic wastes are transformed into a soil amendment, instead of taken to the landfill
(b) composting means we are buying products with less packaging
(c) we no longer throw away any food waste whatsoever
Answer: **A**

“black gold” for 150 points

1.What does finished compost look like?
Possible answers: brown color, like “dirt,” like soil

2. When compost is finished it will be:
(a) green and smelly
(b) brown and crumbly
(c) black and slimy
Answer: **B**

3. True or False: If you do not have a backyard, then you cannot compost.
Answer: False—apartment and condominium dwellers can compost with a worm bin, a two-can bioreactor, or an indoor compost bin.

4. What does finished compost smell like?
Possible answers: earthy, like “dirt,” like soil

“black gold” for 200 points

1. Name one possible way to compost.
Possible answers include: worm bin, compost pile outside, two-can compost, compost bin outside, tumbler

2. A compost pile in your backyard will take about how long to complete without turning?
(a) 6 months
(b) 1 year
(c) 2 years
Answer: **B**

3. What percentage of the average household’s garbage is kitchen and yard waste?
(a) 5%
(b) 10%
(c) 20%
Answer: **C**

resources:

glossary

Actinobacteria—A type of bacteria, distinguished by their branching mycelia. Include both mesophilic and thermophilic species. These organisms play an important role in the breakdown of cellulose and lignin and are responsible for the earthy smell of compost.

Aeration—Process through which air in compost pores is replaced by atmospheric air, which generally is higher in oxygen.

Aerator—A tool used to create new passages for air and moisture in a compost pile.

Aerobic Decomposition—The oxidation of organic matter into carbon dioxide and water by microorganisms in the presence of air.

Aerobic—With oxygen.

Aggregate—A group of soil particles cohering so as to behave mechanically as one unit.

Agitated Bay Composting System—System confined on two sides (bay) that uses a mechanical mixing system to turn, aerate, and move composting material.

Ambient Air Temperature—The temperature of the air in your vicinity.

Anaerobic—Without oxygen.

Bacteria—Single-celled microscopic organisms lacking an enclosed nucleus. Commonly have spherical, rod, or spiral shape. Some bacteria provide a gummy substance (a mucus) that binds soil particles together.

Bedding—Material like newspaper and leaves used as an organic medium for worm composting.

Bioavailability—Refers to how readily available nutrients are to microbes or plants.

Biodegradable—A material that is capable of undergoing decomposition.

Bio-filter—A filter that uses microbial action to reduce odors. Finished compost commonly is used as a biofilter to reduce potential odors from active compost systems. In systems using forced aeration, the air commonly is blown through a biofilter of finished compost before being released to the environment.

Biomass—The mass of living organisms.

Browns—Dry or dead high-carbon materials that add bulk to a pile, including fall leaves, twigs, and wood chips.

Bulking Agent—Material (usually wood chips or large pieces of garden debris) that is added to a compost system to enhance airflow.

BWPRR—NYC Department of Sanitation, Bureau of Waste Prevention, Reuse, and Recycling.

Carbon-to-Nitrogen Ratio (C:N ratio)—The ratio of the weight of organic carbon to the weight of total nitrogen in soil, compost, or other organic material.

Catalyst—A substance that facilitates a chemical reaction.

Catalyze—Term used when substances enable or speed up other biochemical reactions.

Cellulose—A long chain of tightly bound sugar molecules that constitutes the chief part of the cell walls of plants.

Clitellum—A swollen region on mature worms containing gland cells which secrete the cocoon material.

Coconut Coir—The fibrous waste from a coconut pod.

Cocoon—Worm eggs or egg cases.

Curing—The last stage of the composting process that occurs after most of the material has been decomposed which provides additional stabilization.

Cubic Yard (yd^3)—A unit of measure equivalent to 27 cubic feet. A box that is one yard wide, one yard long, and one yard high has a volume of one cubic yard (1 yd^3).

Decomposers—The microorganisms and invertebrates that cause the normal degradation of natural organic compounds.

Decomposition—The breaking down of organic material by microorganisms.

DSNY—Department of Sanitation.

Enzymes—Any of numerous complex proteins produced by living cells to catalyze specific biochemical reactions.

Exponentially—A rapid rate (e.g., of growth or decay).

Extracellular Digestion—Occurring outside a cell or the cells of a body.

Fungi—Plural of fungus. A kingdom that includes molds, mildews, yeasts, and mushrooms. Unlike bacteria, fungal cells do have nuclei. Fungi lack chlorophyll, and most feed on dead organic matter. In compost, fungi are important because they break down tough debris like cellulose, and they grow well during the curing stage, when moisture and nitrogen levels are low.

Greens—High-Nitrogen materials, which tend to be succulent or high in water content, including such living materials as grass clippings, freshly pulled weeds, and vegetable scraps.

Humus—The stable organic complex remaining after plant and animal residues have decomposed in soil or compost.

Hyphae—Branched or unbranched chains of cells, as in fungi and actinobacteria.

Invertebrates—An animal without a backbone such as an insect or worm.

Inoculant—Microorganisms that are introduced into compost or other culture media.

Inorganic—Mineral, rock, metal, or other material containing no carbon-to-carbon bonds. Not subject to biological decomposition.

In-Vessel Composting—Composting system that encloses the decaying matter in a container. Tends to be designed with forced aeration, and mechanical or static mixing systems.

Latent Heat—Energy in the form of heat that is used to change a substance from frozen to liquid or liquid to gas that does not increase the temperature of the substance.

Leachate—The liquid extract that results when water comes into contact with a solid such as soil or compost. In composting, leachate containing dissolved and suspended substances drains from the system as organic matter decomposes.

Leaf Mold—Partially decomposed leaves. Usually dark brown or black with distinguishable pieces of leaves still visible.

Lignin—A series of complex organic polymers that are highly resistant to microbial decomposition. In wood, lignin cements fibers together and protects them from chemical and microbial decomposition.

Macroorganisms—An organism large enough to be observed with the naked eye.

Mesophilic—Phase of composting that occurs between 50°F to 104°F (10°C to 40°C).

Microorganisms—Small living creatures visible only with a microscope.

MRF—Material Recovery Facility—where recyclable materials are separated from a mixed stream of waste.

Mulch Mowing—Refers to the practice of mowing into small pieces so as to leave grass clippings on the lawn.

Mulch—Any material such as compost, bark, wood chips, or straw that is spread on the soil surface to conserve soil moisture, suppress weed growth, moderate temperature changes, or prevent soil erosion.

Municipal Solid Waste (MSW)—Refuse from residential, institutional, or other non-commercial/industrial activities.

Nitrogen-fixing—Bacteria that transform atmospheric nitrogen to ammonium, a form usable by plants.

N-P-K—The ratio of nitrogen to phosphorus to potassium; usually found on fertilizers labels.

Nutrient Leaching—The washing out of nutrients from soil or compost.

Organic Material—Any carbon-based material of animal or vegetable origin.

Oxidize—To combine chemically with oxygen.

Pathogen—Any organism capable of producing disease or infection.

Percolation—Downward movement of water through the pores or spaces in rock, soil, or compost.

pH—The degree of acidity or alkalinity of a substance, expressed on a scale from 0 to 14. pH less than 7 is acidic; pH above 7 is basic; and a pH of 7 is considered neutral.

Photosynthesis—The ability of a plant, using energy from sunlight, to form sugars out of carbon dioxide and water.

Phylogenic—Based on natural evolutionary relationships.

Phylum—Primary divisions of the animal kingdom.

Phytotoxic—An adjective describing a substance that has a toxic effect on plants.

Putrescible—Describes materials that have the tendency to become putrid or decay rapidly and potentially produce foul odors.

Screening—The process of passing compost through a screen or sieve to remove large organic or inorganic materials, and improving the consistency and quality of the end product.

Specific Heat—The quantity of heat needed to raise the temperature of 1 gram of a substance by 1°C.

Taxonomic Classification System—Orderly classification of plants and animals according to their presumed natural relationships.

Thermophilic—Phase in the composting process that occurs between 104°F to 167°F (40°C to 75°C) it is associated with specific colonies of microorganisms that accomplish a high rate of decomposition.

Topdressing—Applying a layer of compost, or other material, to the surface of soil or over a lawn.

Trophic Level—One of the hierarchical levels of a food web characterized by organisms that are the same number of steps removed from the primary producers.

Vector—Any organism capable of transmitting a pathogen to another organism, such as mosquitoes or rats.

Volume Reduction—The processing of materials to decrease the amount of space they occupy. Compaction, shredding, composting, and burning are all methods of volume reduction.

Windrow—Large elongated pile of decaying matter (usually leaves or yard trimmings).

Worm Castings—The dark, fertile, granular excrement of a worm.

Yard Trimmings—Leaves, grass clippings, brush, and other organic garden debris.

nyc compost project tip sheet

get all the dirt at nyc.gov/wasteless/compostproject

Funded and managed by the NYC Department of Sanitation, Bureau of Waste Prevention, Reuse & Recycling

The NYC Compost Project provides compost education and outreach through host sites in all five boroughs. Educational programs include: compost-related workshops and classes, on-site composting demonstrations, compost helpline, and composting technical assistance.

Compost Made Easy

What is compost?

Compost is a dark, crumbly, porous, soil-like material. In nature, "compost happens" as plant materials break down and form *humus*, the rich, organic component of soil. This break down occurs through the work of many living creatures. By understanding how this process works, we are able to control and manage it to get the results we want.

Why use compost?

Adding compost to your garden soil will improve its structure and drainage by creating spaces for roots, water, and air. Compost also slowly releases and unlocks the nutrients your plants need to grow and remain healthy, resulting in tastier vegetables, bigger flowers, and stronger plants that can more easily resist pests and diseases.

How does it happen?

The chemical and physical break down of plant materials occurs through the work of many organisms. These include various microorganisms (bacteria, actinobacteria, fungi) and macro-organisms (worms, mites, millipedes, sowbugs). As they work to break down your materials, your pile will heat up and shrink in size.

By consistently providing for the basic needs of these organisms – a mixture of greens and browns and a balance of moisture and air – you create ideal conditions for them to thrive and multiply. If you manage your pile intensively by cutting up large pieces of material, frequently turning, and watering as needed, you could have finished compost in just 3 months. However, if you take a more relaxed approach by simply adding materials and letting nature do the rest, you should see finished compost within a year or more.

When is it ready?

Finished compost is a rich, dark material that looks like soil and has an earthy smell.

To check if it is ready, place a few handfuls in a sealed jar or plastic bag. If, after a few days, it has an unpleasant ammonia-like odor, it needs more time to mature.

How do I use it?

Compost can be mixed directly into your soil, applied as a thick layer of mulch, used in a thin layer on your lawn, or soaked in a bucket to make "compost tea" for watering your indoor or outdoor plants. See www.nyccompost.org for details.

Composting Basics

Add equal amounts of "Greens" with your "Browns". *Greens* are fresh, moist, nitrogen-rich plant materials that still have some life in them – fresh leaves, prunings, grass clippings, fruit and vegetable scraps, coffee grounds, tea bags, etc. *Browns* are dry, carbon-rich plant materials with no life in them – autumn leaves, straw, wood chips, twigs, paper, etc. Avoid meat and fish scraps, cheese and dairy products as well as fats, oils and grease.

Keep the entire pile damp, but not soggy. Moist piles provide ideal conditions for the organisms that do the work of turning your plant materials into finished compost. Dried out piles take a LONG time to break down.

Mix your materials. This adds air into your pile, distributes excess water, and speeds the process by providing the most contact between browns and greens. Compacted or soggy piles can produce unpleasant odors.

Chop everything into smaller pieces. Breaking them up creates more surfaces for the organisms to work on. Your pile will compost faster and be easier to mix together.

Pile it up! A 3-foot wide by 3-foot high pile will hold in the heat and moisture that makes compost organisms thrive.

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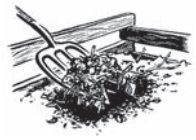
Este proyecto es financiado y manejado por el NYC Department of Sanitation, Bureau of Waste Prevention, Reuse & Recycling

Haciendo Abono Facilmente

¿Que es el abono?

El abono es un material oscuro, poroso y migajoso, parecido a la tierra. En un bosque, cuando las plantas mueren éstas se convierten en humus, un componente rico en nutrientes en la tierra. Este proceso de descomposición sucede gracias a los organismos que viven allí. Cuando entendemos este proceso podemos controlar y manejar la descomposición de materia orgánica y obtener un producto similar, el abono.



¿Por qué debemos usar abono?

Al añadir abono a la tierra de su jardín mejorara su estructura y drenaje mediante la creación de espacios para las raíces, el agua y el aire. El abono también provee nutrientes que sus plantas necesitan para crecer y mantenerse saludables y vigorosas para resistir plagas y enfermedades.

¿Cómo sucede esto?

La descomposición de materiales orgánicos ocurre por medio de procesos químicos y físicos que requieren del trabajo de muchos organismos, estos pueden ser microorganismos (bacterias, hongos, actomicetos), como también por medio de macroorganismos (lombrices, ácaros, escarabajos). A medida que los organismos descomponen los materiales, la pila de abono aumentará en calor y disminuirá en tamaño. Cuando usted provee las condiciones básicas para que estos organismos existan – una mezcla de verdes y marrones y un equilibrio de humedad y aire – usted ha creado las condiciones ideales para que los organismos crezcan y se reproduzcan. Si administra su pila intensamente mediante el corte de piezas grandes de materiales, volteándola frecuentemente, y regándole agua cuando sea necesario, usted podría tener abono vegetal terminado en sólo 3 meses (o ¡6 - 8 semanas!) Sin embargo, si usted toma un enfoque más relajado mediante simplemente añadidura de materiales, y deja que la naturaleza haga el resto, debería ver abono terminado después de un año o más..

¿Cuando estará listo?

El abono ya terminado es un material rico en nutrientes, oscuro que parece tierra y también tiene un olor como a tierra mojada. Para estar seguro de que su abono está listo, ponga un puño de abono dentro de un frasco sellado o una bolsa plástica. Si, después de unos días, tiene un desagradable olor como el amoniaco, eso quiere decir que su abono necesita más tiempo para madurar.

¿Cómo puede ser usado?

El abono puede ser mezclado directamente en la tierra, se aplica como una capa gruesa de mantillo (o cubierta para proteger las raíces de las plantas), tambien puede ser usado utilizado una capa delgada sobre el césped, o se sumergen en un cubo para hacer el "té de abono" para regar sus plantas interiores o exteriores.

Pasos Básicos Para Hacer Abono

Añada cantidades iguales de materiales marrones y verdes. Los materiales verdes son aquéllos que contienen Nitrógeno que aún están frescos y jugosos, por ejemplo: las plantas que están vivas, hojas verdes, poda de ramas frescas, corte de gramas, deshecho de frutas y verduras, etc. Los materiales marrones son todos aquéllos que son ricos en Carbono, por ejemplo: las plantas muertas, hojas secas, paja, ramas, deshechos de madera picada, papel, etc.

Evite la carne y trozos de pescado, queso y productos lácteos, así como aceites y grasas.

Mantenga la pila de abono húmeda pero no mojada. Al mantener la pila de abono húmeda proveeremos las condiciones ideales para que los diferentes organismos trabajen y descompongan los materiales, produciendo el material final que es abono. Las aboneras que se mantienen secas toman mucho más tiempo en descomponerse.

Mezcle los materiales. El mezclar los materiales añade aire a la abonera, también si distribuye el agua va a ir acelerando la descomposición de los materiales secos y verdes por medio del contacto entre ellos. Las pilas de abono que están compactadas y mojadas producen un mal olor.

Corte todos los materiales en pedazos pequeños. Al cortar los materiales en pedazos más pequeños usted crea más área de superficie para que los organismos trabajen mejor. La descomposición dentro de la abonera ocurrirá más rápidamente y será más fácil de mezclar.

Haga pilas. Una pila de 3 pies de ancho por 3 pies de alto mantiene el calor y la humedad que hacen que los organismos del abono prosperen.

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What to Compost

Mix roughly equal parts (by volume) of high-nitrogen **GREENS** and high-carbon **BROWNS**.

Without enough greens, a pile will decompose slowly; without enough browns, the pile may develop an unpleasant odor. In general, it's better to err on the side of too many browns. Chop up bulkier materials. To avoid odors or pests, bury food scraps under browns.

Two other ingredients—water and oxygen—are needed to ensure that your compost pile transforms itself into a mound of black gold.

Add equal parts GREENS and BROWNS

GREENS
fresh, moist, nitrogen-rich materials

FROM YOUR GARDEN
- green plants and garden trimmings
- fresh leaves and flowers
- grass clippings (or recycle by leaving on the lawn)

FROM YOUR KITCHEN/HOME
- fruit and vegetable scraps
- coffee grounds & tea bags
- manure and bedding from animals that ONLY eat plants

BROWNS
dead, dry, carbon-rich materials

FROM YOUR GARDEN
- fall leaves, small twigs, and woody prunings
- dry plant material
- straw and hay
- pine needles
- potting soil

FROM YOUR KITCHEN/HOME
- bread and grains
- egg shells
- nutshells
- corncobs
- food-soiled paper towels and napkins
- shredded newspaper
- sawdust and wood shavings (from untreated wood)
- stale beans, flour, and spices
- wood ashes

Materials to avoid

FROM YOUR GARDEN
- pesticide-treated plants or pesticide-treated grass clippings
- diseased or pest-infested plants
- poison ivy
- invasive weeds
- weeds with seeds
- large branches (call 311 to schedule a special removal)
- non-compostable materials such as sand or construction debris

FROM YOUR KITCHEN/HOME
- meat or fish scraps
- cheese or dairy products
- fats, grease, or oil
- cat or dog feces; kitty litter
- colored or glossy paper
- sawdust made from pressure-treated plywood or lumber
- coal or charcoal ashes
- non-compostable materials such as plastics, metals, or glass

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Compost Troubleshooting Guide

SYMPTOM	PROBLEM	SOLUTION
rotten-egg odor	Excess moisture and not enough air (anaerobic conditions). 	Turn pile frequently; add dry Brown material such as autumn leaves, woodchips, or newspaper. Make sure bin has drainage; leave lid off to allow more air to flow.
ammonia odor	Too much Green, high-nitrogen material (such as food scraps, grass clippings).	Add Brown, high-carbon material (such as autumn leaves, woodchips, shredded newspaper, straw).
slow decomposition	Lack of moisture.	Add water while turning pile.
	Lack of air.	Turn pile; add aeration tubes.
	Lack of nitrogen; too much Brown, high-carbon material.	Add material high in nitrogen (more Greens), such as food scraps or grass clippings.
low pile temperature *(If you have a small pile, or if it is very cold out, don't be concerned if your compost is not generating heat; decomposition is still occurring, but at a slower pace.)*	Pile too small.	Increase pile size (space permitting).
	Insufficient moisture.	Add water while turning pile.
	Poor aeration.	Turn pile; add aeration tubes.
	Lack of nitrogen.	Add more Greens (material high in nitrogen), such as food scraps or grass clippings.
	Cold weather.	Increase pile size, or insulate pile with straw or other material.
high pile temperature (over 140°F, 60°C)	Pile too large.	Reduce pile size.
	Insufficient ventilation.	Turn pile.
unwanted pests	Wrong materials in the pile.	Avoid meat, dairy, and fatty foods.
	Food scraps are exposed.	Make sure food is well covered.
	Bin isn't rodent-resistant.	Make bins more rodent resistant by adding hardware cloth to areas where animals could get through. Add a screening barrier vertically 6 to 8 inches into the ground; keep pile moist; turn pile more often to increase temperature and disturb nesting.

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How to Use Compost

finished compost

Finished compost resembles dark, crumbly topsoil and should bear no resemblance to the original materials. Compost should have a pleasant, earthy smell to it. Using "unfinished" or immature material that contains food scraps can attract pests and can cause harm to young plants, so make sure your compost has fully decomposed before adding it to your garden beds.

how to tell if your compost is finished

The simplest way to tell if your compost is mature and ready-to-use is by doing the "bag test." Put a handful of moist compost into a zip-lock bag and leave it for three days, then open the bag. If you detect an ammonia or sour odor, the microorganisms are still at work and you need to let your compost finish curing. Test your compost again in a week.

using finished compost

There are various ways to utilize your finished compost. You can sprinkle compost on top or mix it into your flower and vegetable beds, gently rake compost into tree beds, blend it with potting soil to revitalize indoor plants, or spread it on your lawn as a soil amendment.

Using Compost in the Home Garden

Health Tip: If you add materials sprayed with pesticides to your compost pile, do not use the finished compost on edible crops as the chemicals may not have fully broken down.

GOAL	WHAT TO DO
amend soil	Work one to two inches of compost into the top three to five inches of soil.
grow vegetables 	Give your vegetable garden plenty of compost in the fall. Spread several inches of compost on top of the existing bed, then till it in come springtime. Put a handful of compost in each hole when you're planting. Once plants begin to grow quickly, you can add a half-inch layer of compost around the base of the plants. Provide "heavy feeder" plants such as tomatoes, corn, and squash with half an inch of compost monthly—this will result in great produce!
grow flowers	In the spring, loosen the top few inches of annual and perennial beds and mix in a one-inch layer of compost. Or apply a one-inch layer of compost as a mulch to protect plant roots from freezing and conserve moisture.
potted plants & window boxes	Even the best potting soil gets depleted of its nutrients as plants grow. To replenish nutrients, add an inch of compost to potted plants and window boxes twice a year. Or, make your own potting soil using two parts screened compost to one part sand or perlite.

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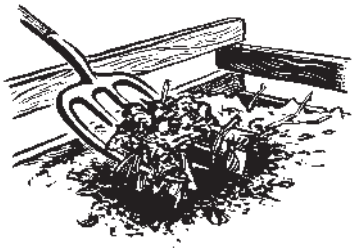
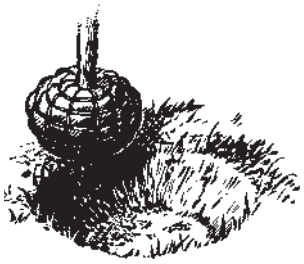
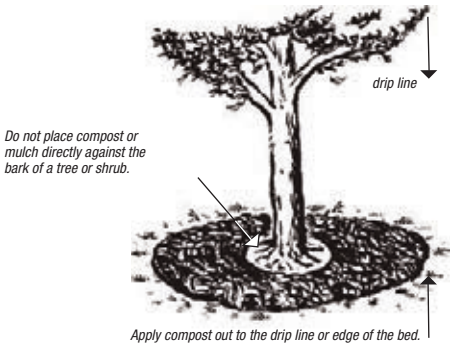
using finished compost

Using Compost for Landscaping Projects

GOAL	WHAT TO DO
for lawn or turf 	When establishing new turf, incorporate up to three inches of compost into the existing soil base. If possible, till to a depth of five to eight inches before seeding. Otherwise, seed directly over the compost. On existing turf, you can treat bald spots by incorporating an inch of compost into the soil and then reseeding. This will fight compaction and help suppress soil-borne diseases. You can also topdress existing turf with as much as one-half inch finely screened compost. This is easiest with a spreader, but you can use a shovel for small areas where you want to add compost. Rake the compost evenly throughout the grass area to enable the compost to readily sift down to the soil. The compost will settle down into the soil, improving its structure and providing nutrients. Over time, this will mean less compaction, fewer bald spots, and a reduced need for synthetic fertilizers.
for planting tree 	When planting a tree, compost can be added to the tree hole to improve the existing soil. The tree hole should be twice as wide and slightly shallower than the root ball. Backfill three quarters of the hole with existing dirt and one quarter with compost. Be sure that you don't add too much compost, as the tree roots will not grow past this gold mine of organic matter, depriving the tree of the stability of a deep root system. Just the right amount of compost will give the tree a nice boost for the first few years of its life. Try to make sure that the soil of the root ball matches the texture of the native soil. A simple test is to feel the soil texture. If the root ball is a sandy soil and the native soil is clay based, the tree will be fighting to survive. Applying compost to the back-filled soil will help by easing the transition between soil types, but it does not necessarily create the ideal situation for the tree.
tree and shrub maintenance (including nyc street trees) 	You can apply compost as mulch by spreading up to two inches of compost under the tree or shrub out to the drip line (the outermost leaves on a tree) or edge of the bed. This will help reduce moisture loss and stabilize soil temperature. You can also incorporate compost into the soil once or twice a year to provide organic nutrients. Before adding compost to compacted soils, gently cultivate the soil with a hand tool; this will prevent damage to shallow feeder roots while making nutrients more readily accessible to the trees or shrubs. Do not place compost or mulch directly against the bark of the tree or shrub or on exposed woody roots as this could cause rot and invite pests and disease.

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Decomposers in a Compost Pile

Compost is produced through the hard work of a number of different decomposer organisms that break down organic material and convert the organics into finished compost. These decomposers are naturally present on the organic materials that you add to your compost pile and also exist in the areas surrounding your compost system.

compost ecosystem

Decomposers in a compost pile are part of a complex compost ecosystem in which food, water, air and shelter are provided for by the organic material within the compost pile. If any of those essential ingredients are missing, the organisms either slow down or stop working all together. It is this web of interdependence that is the driving force behind the production of compost.

Some organisms feed on decomposing plant materials while others feed on other organisms. The two main categories of decomposers are as follows:

Chemical decomposers work by using chemicals in their bodies to break down the organic matter into simple compounds for energy. This is similar to how the acids in our stomachs dissolve the food we eat. Chemical decomposers are mostly micro-organisms that cannot be seen without a microscope. Examples of chemical decomposers include bacteria, protozoa, and fungi.

Bacteria are the most abundant of the microorganisms found in a compost pile and perform the majority of the decomposition. An important by-product of their work is the generation of heat, which can warm up the pile and attract other heat-loving organisms to assist with the breakdown process.

Physical decomposers work by feeding on the organic materials in a pile. Similar to how we use our teeth to break up large pieces of food, physical decomposers chew, grind, and squeeze the materials into smaller pieces. After digestion, they excrete waste products which are then broken down even further by the chemical decomposers. Physical decomposers are mostly macroorgnisms that can be seen without a microscope. Examples of physical decomposers are worms, mites, flies, and snails.

Earthworms do a large amount of the decomposition work among the macroorganisms. Several species of worms dig tunnels and feed on the decomposing materials in the compost pile. The spaces that the worms create as they move through the compost pile allow air, water, and nutrients to circulate, creating the necessary conditions for many of the other organisms to thrive.

compost food web

All of the decomposer organisms in the compost ecosystem are linked by a "what eats what" food web, wherein organisms are classified according to what they eat. There are three levels of consumers in the compost food web: primary, secondary, and tertiary. This web structure keeps the different populations under control and maintains a healthy and balanced compost pile.

Primary (first level) consumers feed directly on dead plant materials (and other decomposers that have died) in the compost pile. This group consists of chemical decomposers such as bacteria and fungi, but also includes larger physical decomposer organisms such as snails, slugs, beetle mites, worms, and flies.

Secondary (second level) consumers feed on primary consumers and their waste products. This group consists of physical decomposers which include springtails, mold mites, and nematodes.

Tertiary (third level) consumers feed on secondary (and sometimes tertiary!) consumers. This group consists of fast moving consumers which include centipedes, pseudoscorpions, predatory mites, and rove beetles.

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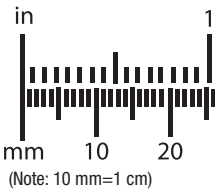
compost food web identification guide

The compost food web is a way of observing organisms according to what they eat and by whom they are eaten! Follow the guide below to identify organisms in your compost pile and learn who may be eating whom.



(Note: 10 mm=1 cm)

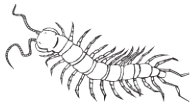
tertiary consumers

Largely macroorganisms that feed on secondary consumers.


Predatory Mite (0.5-1 mm)

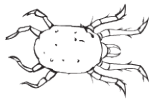

Ground Beetle (8-20 mm)


Pseudoscorpion (1-2 mm)


Centipede (30 mm)

secondary consumers

Largely macroorganisms that mainly feed on primary consumers.


Mold Mite (1 mm)


Springtail (0.5-3 mm)


Feather-Winged Beetle (1-2 mm)

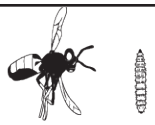

Nematodes (Roundworms) (1 mm)


Protozoa (.01-.5 mm)

primary consumers

Largely microorganisms that primarily feed directly on dead plants or animals.


Green June Beetle Grub (13.5-25 mm)


Black Soldier Fly (20-25 mm) **& Black Soldier Fly Larvae (Maggots)** (18 mm)


Slug (2-25 mm)


Beetle Mite (1 mm)


Earthworm (50-150 mm)


Bacteria


Actinobacteria


Fungi


Snails (2-25 mm)

organic residue

Leaves, grass clippings, other plant debris, and food scraps.


Compost pile

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Worm Bin Troubleshooting Guide

Taking steps to avoid problems with your worm bin is often easier than getting rid of problems once they've started, so it's important to monitor your bin regularly for the problems below. If a problem develops that cannot be controlled, the best solution may be to harvest the worms and start a new bin from scratch, using what you have learned from your past experience to create a better bin.

SYMPTOM	PROBLEM	SOLUTION
odor	exposed food	Cover food scraps with bedding.
	too much moisture	Add dry bedding so that it can soak up pooling water, particularly in wet areas. Reduce the amount of food placed in the bin.
	not enough oxygen	Add dry bedding; fluff up the bedding if it appears matted down.
	too much food; food not decomposing	Break food into smaller pieces, especially hard, woody items like stems; freeze and thaw to break down cell walls. Feed worms less so that they have time to go through the food in the bin.
	food in bin is naturally odorous	Some foods are naturally odorous when decomposing (such as onions, broccoli, or cabbage, plants in the allium or brassica family). Therefore, remove foods that produce unpleasant odors if it bothers you. Don't add meat, bones, dairy, or oil products, as these turn rancid.
	dead worms	See worm death section below.
fruit flies *If fruit flies become a problem, you can try using flypaper traps or make your own fruit fly trap; house flies should not be attracted to your worm bin if you cover the food scraps with bedding material.*	exposed food	Bury food under bedding material; cover the contents with a section of dry newspaper.
	too much moisture	Avoid overfeeding; add dry bedding.
	fruit fly eggs in food scraps	Cut fruit into small pieces; wash all fruits and peels, particularly bananas and citrus. Freeze fruit before feeding to worms or microwave fruit for 60 seconds. These actions help to kill fruit fly eggs. You can also simply avoid adding fruit.
worm death *Dead worms decompose rather quickly; you can have a bin with no worms before you realize it.*	bin is too wet; worms are drowning	Add dry bedding; leave lid off for an hour or two to allow water to evaporate. Make sure bin is well ventilated.
	bin is too dry; worms are drying out	Lightly moisten and turn bedding; add moist foods. Make sure it's not too hot for the worms.
	not enough air; bedding and food are matted together; worms are suffocating	Fluff bin contents to aerate. Be sure bin is adequately ventilated with holes; add paper tubes or other bulky paper products such as torn up paper egg cartons to increase air flow.
	not enough food	Increase food, or reduce number of worms.
	worms not eating	Avoid adding too much food at one time. Avoid very spicy foods, salty foods, large amounts of citrus, or toxic ingredients like alcohol.
	bin is too hot or too cold	Worms prefer the same temperatures that people do, so it's best to keep the bin in a location where the surrounding temperature is between 55°F and 80°F (13°C and 27°C). Smaller bins are more impacted by surrounding temperatures so keep these in a location with temperature controls.
	overabundance of mites (A small mite population is natural, but if you notice large collections of mites, you should try to remove them.)	Remove any food that has a congregation of mites. To reduce mites, bring bin outside and leave it open in the sun for 1–2 hours to dry it out a little. Repeat as necessary until mite population is reduced. To trap mites, place a slice of fresh bread in the bin, wait until mites congregate on it, and then remove the bread.

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Worm Bin Checklist

Use these checklists to make sure your worm bin is functioning properly!

SIGNS OF A HEALTHY WORM BIN

- ☐ Bin smells fresh and earthy like the forest.
- ☐ Bedding (shredded paper) is disappearing over time.
- ☐ Worm castings are piling up.
- ☐ Worms have glistening skin.
- ☐ Sufficient space between the bedding.
- ☐ Bin has small quantities of other critters, such as mites or little white worms.
- ☐ Fuzzy mold on some foods.
- ☐ Bin contents are damp but not soggy.
- ☐ Bin filled with fluffed up, shredded paper.
- ☐ Food is not visible when you open the bin.

SIGNS OF AN UNHEALTHY WORM BIN

- ☐ Liquid dripping from the drainage holes.
- ☐ Puddles of water in the bin.
- ☐ Bedding and castings are dry.
- ☐ Castings and bedding are sticking to the worms.
- ☐ Bin smells rotten.
- ☐ Food and bedding are matted in large clumps.
- ☐ Fruit flies present.
- ☐ Mites present in large quantities.
- ☐ Maggots present.

If the problem with your worm bin can't be controlled, the best solution may be to harvest the worms and start a new bin from scratch, using what you've learned from your experience to create a better bin. Contact the NYC Compost Project in your borough with any worm bin questions or problems.

Worm Bin Placement

Make sure your worm bin is placed in a good location for both you and the worms. Aside from your own aesthetic preferences, red wigglers are happiest when the temperature inside the bin is anywhere between 55°F and 80°F (13°C and 27°C). Common indoor placements that often meet those temperature needs include the kitchen, garage, laundry room, or basement.

If you want to keep your worm bin outdoors, you'll need to make sure it has enough shade in the summer and plenty of insulation in the winter to maintain the desired temperature range. Water can have a negative impact on your worm bin as well, so make sure your worm bin is protected from heavy rains as the worms can drown.

Trapping Fruit Flies

Here are some fruit fly traps you can make yourself:

1. Bottle fly trap (right). Cut a small plastic water or soda bottle in half. Fill the bottom half with some apple cider or beer and a drop of detergent. Turn the top half upside down and place it into the bottom half so that the neck forms a funnel. Secure the two halves with tape.

2. Fruit fly bait (left). in a small glass, vase, or similar vessel place one drop liquid dish soap, 2 t. concord grape or other juice, and 1 t. vinegar (any kind). Swirl together and coat the sides of the glass. Place on a dish (in case of spillage) near flies or on top of refrigerator. Dump out dead flies along with bait as needed (may be as often as twice a day initially). Replace bait and repeat until flies are gone.

3. Vacuum. Use a hand-held vacuum to remove flying insects. Don't let flies linger to lay new eggs.

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Earthworm Essentials

There are thousands of species of earthworms; however, two species in particular play an important role in the decomposition process: *Eisenia fetida* and *Lumbricus terrestris*. These earthworms do the bulk of the work among the macroorganisms in a compost pile by feeding on organic material and helping to transform it into compost.

Eisenia fetida: red wiggler worm

Red wiggler worms (also called tiger worms, manure worms, and brandling worms) are the most important macroorganism decomposers in both indoor and outdoor composting systems. Outdoors, they don't burrow but live in the upper layer of soil where they feed on microorganisms and decaying organic matter. They are prolific, thrive in habitats with high organic matter, can tolerate a wide range of temperatures and moisture conditions, and can live close to one another. An indoor worm bin mimics all of these natural conditions which makes *Eisenia fetida* great for indoor composting.

Lumbricus terrestris: common earthworm

Lumbricus terrestris (also called night crawlers) are one of the most common earthworms in North America and are another important macroorganism at work in an outdoor compost pile. They come up from underground to the bottom of a compost pile to pull leaves and other organic material into their burrows (as deep as 4–6 feet) to eat. This movement helps aerate the compost pile and moves materials around for other organisms to consume.

fun worm facts

- Worms do not have eyes; they have cells in the front part of their bodies that can detect light.
- Worms do not have teeth; they grind up food by using the grit in their gizzard.
- Worms living in an indoor worm bin (*Eisenia fetida*) can eat half their body weight in food scraps every day!
- Worms are hermaphrodites; they have both male and female reproductive organs.
- *Eisenia fetida* have 5 "heart-like" organs called *aortic arches*.

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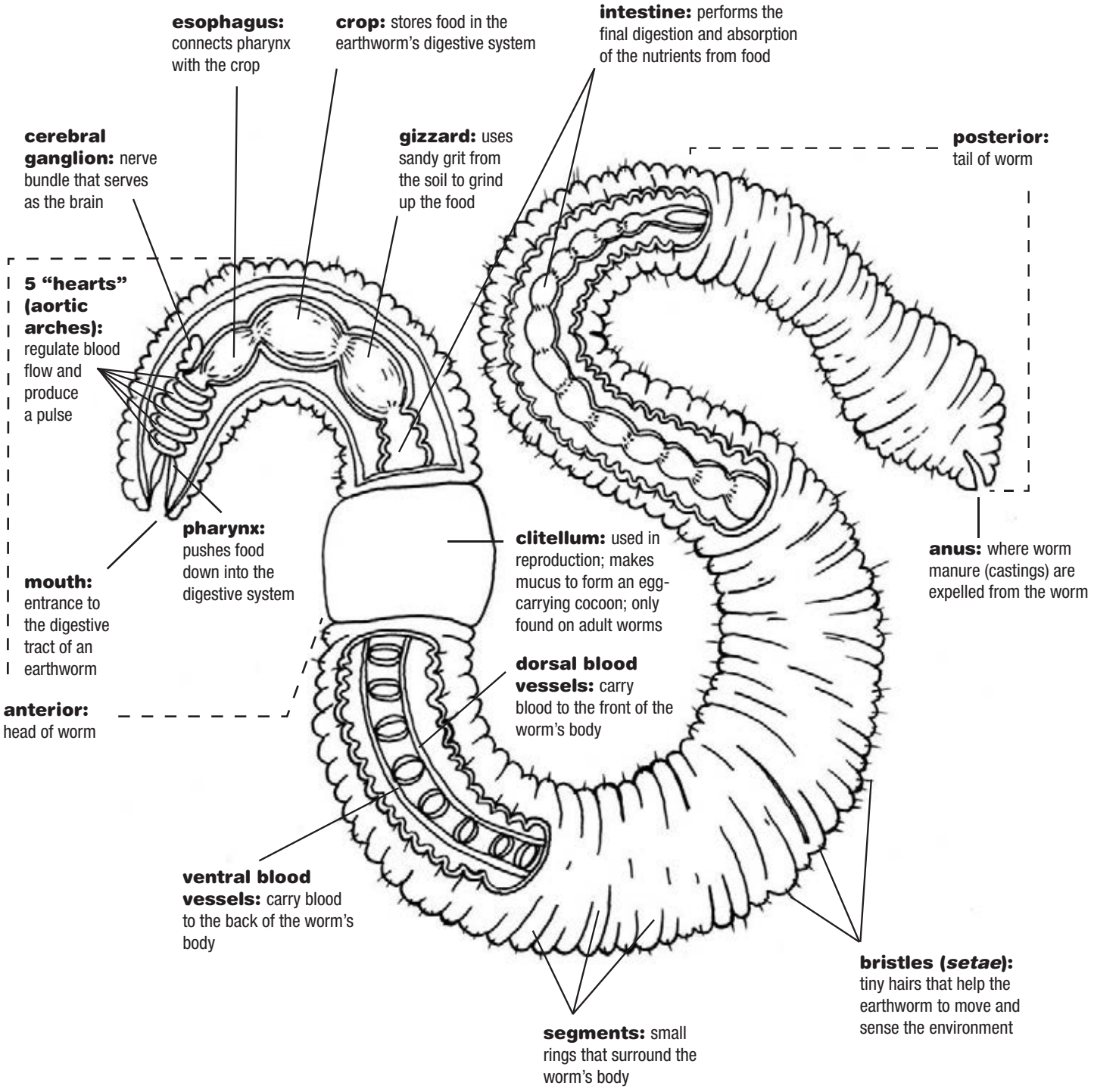
color a wiggly worm!

Color in the *Eisenia fetida* (red worm) image below to help you to identify the various parts of the worm.



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Using Mulch

what is mulch?

Mulch is a protective covering of material that is spread over the soil surface to improve your garden. Organic mulches are made from recycled plant materials, such as compost, yard waste, or chipped woody materials like tree branches and Christmas trees. Organic mulch biodegrades and therefore must be replenished periodically. Inorganic mulches are inert materials such as plastic, fabric, or crushed stone.

what does mulch do?

Mulch reduces evaporation from the soil surface, keeps down weeds, and stabilizes soil temperature. Mulch also protects sloping ground from soil erosion and stops soil compaction caused by driving rain on the soil surface. Organic mulches feed the soil and provide ideal conditions for earthworms and other soil organisms necessary for healthy soil – plus it's readily available, free, and easy to apply!

which mulch?

Annuals (both flowers and vegetables): Mulch with finer materials that break down quickly, such as pesticide-free grass clippings or leaves. On annual beds, till the mulch into the soil at the end of the growing season.

Perennials & woody plants (shrubs, trees, etc.): Mulch with a thick layer (2-3 inches) of compost or chipped wood.

Paths: Mulch with a thick layer of shredded or chipped wood. To keep paths weed-free even longer, put down cardboard or several layers of newspaper before spreading the mulch.

how to apply mulch:

Mulch can be spread around individual plants as far as the distance of the outermost branching (this is called the drip line); or mulch can cover an entire garden bed.

Weed the area to be mulched. Apply up to 3 inches of mulch, (see chart on back). Use less on shallow-rooted plants such as rhododendrons and azaleas.

Be sure water is still able to penetrate the mulch; don't smother the roots of the plants. Make sure the mulch doesn't touch the stems of plants or the bark of trees, or it may cause rotting.

Winter mulches: Insulate the soil by applying compost, shredded leaves, wood chips, or evergreen boughs in late fall (after the first frost) to keep freeze and thaw cycles from damaging plants.

Summer or growing mulches: Apply lighter, organic mulches in spring (after the final frost) to improve the soil, reduce weed growth, and retain soil moisture.

Any time: Mulch can be applied any time in perennial beds or around trees and shrubs, or on paths.

where to find mulch:

New York City residents can get free wood chips at MulchFest events. See the Compost Calendar for details at www.nyc.gov/wasteless/compost.

Another great place to look for mulch is right in your yard. Grass, leaves, or other green and woody materials can all be made into mulch. You can also use newspapers and cardboard.

For chipped or shredded woody wastes, try contacting a tree service in the telephone directory. Some wood shops make their organic byproducts available. *Don't use sawdust or chips from pressure-treated or chemically-treated wood.*

For more information on mulching and composting, see: www.nyc.gov/wasteless/compost

nyc compost project tip sheet

nyc.gov/wasteless/compostproject

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How to Use Common Mulches

organic mulches (recommended)

MULCH MATERIAL	DEPTH	WATER RETENTION	WEED CONTROL	DECOMPOSITION RATE	TIPS FOR USING MULCH
compost	3 in.	good	fair	rapid	can mix with leaves or other mulch
wood chips	2-4 in.	good	good	fairly slow	can rob nitrogen if mixed into soil
leaves	3 in.	fair	fair	slow; adds nitrogen	adds nutrients; use whole or shred with mower
grass clippings	1 in. max.	good if not matted	fair	rapid; green adds nitrogen	avoid grass treated with pesticides or herbicides; mix with leaves for thicker layers
green cover crops	full height	good	good	tilled under	rich in nitrogen
evergreen boughs	several layers	fair	fair	slow	good for erosion and insulation from wind; remove in spring
pine needles	1.5 in.	good	good	slow	good for acid-loving plants (rhododendrons, azaleas, blueberries)
mixed bark	2-3 in.	good	good	slow	replace every 2 years
straw	1-2 in. chopped	good	good	fairly slow, robs nitrogen	can rob nitrogen if mixed into soil; avoid oat straw
newspaper	4-6 sheets	good	best	rapid—lasts 1 season	wet the paper & cover with another mulch to hold in place (ink is not toxic)

inorganic mulches

MULCH MATERIAL	DEPTH	WATER RETENTION	WEED CONTROL	DECOMPOSITION RATE	TIPS FOR USING MULCH
stone	2-4 in.	fair	fair	negligible	permanent mulch, adds some trace elements
landscape fabric	1 layer	good	good	slow, lasts several years	use in permanent beds, cover with top mulch
plastic	1-6 mil.	excellent	best	no decomposition	adds nothing; black is good for heating soil

how much mulch do I need?

Most mulch is sold in cubic yards. Here's a formula to figure out how much you need:

1. Multiply your garden's length by the width (in feet) to find the area's square footage.
2. Check the chart above to see how deep the mulch should be.
3. Multiply the area of your garden in square feet (from #1) by the depth of mulch in inches (from #2).
4. Divide the number you get (from #3) by 324. This is the number of cubic yards of mulch that you need.

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Resources for Community Compost Sites

workshops and technical assistance

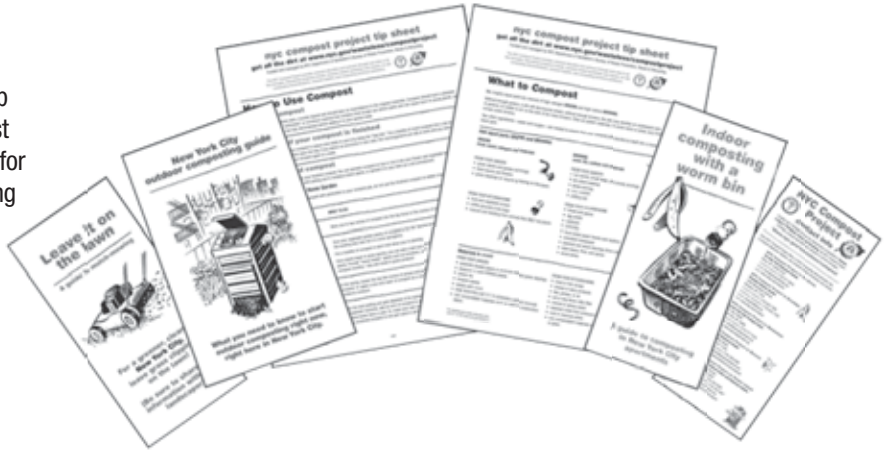
NYC Compost Project staff provide community compost sites with **customized workshops**. These workshops are designed to help ensure that site members have the skills to develop and maintain a successful composting system in an urban setting. Examples of workshop topics include what to compost, ways to speed up the composting process, methods of managing a multi-bin system, and helpful tips on avoiding and solving common problems.

Through **on-site technical assistance**, NYC Compost Project personnel help community compost sites improve or expand their composting operations. This includes advising groups that are starting new sites, assessing and troubleshooting existing systems, organizing workdays, or creating action plans to reach long-term goals.

The NYC Compost Project in each borough also offers the **Master Composter Certificate Course**. This is a comprehensive train-the-trainer program for those that want to help advance on-site composting in NYC.

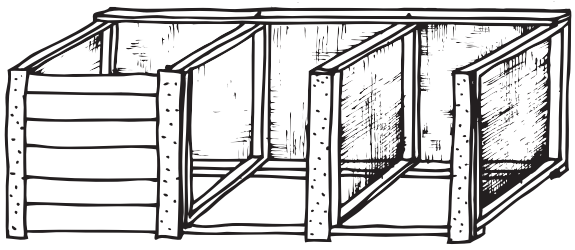
literature

The NYC Compost Project has developed a range of tip sheets and brochures available to community compost sites. These materials are important reference pieces for site members and can also be used as handouts during workshops or public events. Literature is available online (visit www.nyc.gov/wasteless/materials) or through your local NYC Compost Project.



compost bins & sifters

NYC residents and community compost sites may purchase low-cost bins through the NYC Compost Project. In addition, the NYC Compost Project provides assistance in acquiring or building new bins and sifters to a limited number of community compost sites in each borough. Bin and sifter styles, materials, and capacity are tailored to meet the specific needs of each site. To become eligible, sites must demonstrate a commitment to maintaining their own composting system.



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"what to compost" sign

The NYC Compost Project has created a 2' x 2' sign for community compost sites. This sign contains a basic list of items suitable for composting outdoors in an urban setting. It also provides six essential bin maintenance tips for composting outdoors. To become eligible to receive a "What to Compost" sign, community compost sites must:

Develop a relationship with their local NYC Compost Project. This could include having an initial conversation with your local NYC Compost Project about your site or reaching out for composting advice. As a more involved relationship develops, your site may be able to host compost workdays or give tours of your site.

Designate a compost contact. This person serves as the main point of contact with the NYC Compost Project and must be available to answer basic questions about the compost site either via phone or email.

Have an actively managed compost system. A compost site's system is actively managed when one or more persons are working to both address problems and make finished compost.

nyc compost project demonstration site program

The NYC Compost Project Demonstration Site Program recognizes community compost sites that have exemplary composting operations and are committed to teaching New Yorkers about the benefits of composting. These sites are designated by the posting of an NYC Compost Project Demonstration Site sign.

Community compost sites can gain recognition as an NYC Compost Project Demonstration Site by meeting the following criteria:

Have a designated person who is willing to serve as a compost contact. This person serves as the main point of contact with the NYC Compost Project and helps ensure that the site meets Demonstration Site standards.

Have an actively managed composting system for at least 6 months. A compost site's system is actively managed when one or more persons are working to both address problems and make finished compost.

Have a successful composting system that can serve as a model for other sites. This means that the compost site has limited operational issues (pests, odors, etc.) and produces finished compost.

Maintain an ongoing and active relationship with local NYC Compost Project. Keep local NYC Compost Project up to date about your compost operations and help promote NYC Compost Project activities.

Post an NYC Compost Project Demonstration Site sign. The sign is approximately 1.5' x 1' and attaches easily to fences.

Educate others about composting by annually completing two of the following:

- Host a tour of your compost site.
- Host a public or NYC Compost Project composting workshop.
- Host another compost-related activity, such as a public workday or tabling event.
- Distribute NYC Compost Project literature at your site.
- Have an NYC Compost Project Master Composter associated with your site.
- Host NYC Compost Project Master Composter workdays at your site.

nyc compost project tip sheet

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Crazy for Composting

How passionate are you about composting? Circle all the hearts ♥ that describe you or something you did in the name of composting!

♥ Can name at least 3 other people who are composting.

♥ Pocketed fruit cores, peels, or other items to bring back to your bin.

♥ Asked someone for "donations" of compostables.

♥ "Stole" leaves, grass clippings, or other compostables from your neighbor's trash.

♥ Struck up a "composting conversation" with a stranger.

♥ Know "too much" about earthworms—their sex life, number of hearts, how long it takes them to travel one mile, etc.

♥ Tried to get people at your job or school to compost and/or helped them set up a bin.

♥ Know what actinobacteria smell like.

♥ Had a compost pile or bin, even though you lived in an apartment building.

♥ In the same year, worked in bins at multiple locations—home, office, school, community garden, etc.

♥ Had an indoor bin AND an outdoor bin going at the same time.

♥ Set up a compost bin or pile on someone else's property.

♥ Got excited about visiting someone else's compost set-up.

♥ Took the temperature of a compost pile.

♥ Experimented by adding a "no-no" or something "weird" to your bin.

♥ Have "composting cohorts"—people who look the other way or actually help you carry out crazy compost-related activities.

♥ Gave someone a gift of home-made compost or let them "adopt" worms from your bin.

♥ Can name at least 5 organisms in the compost food web.

♥ Weighed what goes into your compost bin.

♥ Bragged about your compost—how fast you made it, how hot it got, how many worms you have, how much compost you made, etc.

♥ Actually calculated C:N ratios.

♥ Ever said, "Want to see my worms?"

♥ Have "secretly" composted without getting the proper permission or approval.

♥ Made your own bin, sifter, or other "compost contraption."

♥ Have friends or family members who roll their eyes whenever you mention composting.

♥ Participated in compost-related activities under "extreme" conditions—in the dark, during a major snow storm, out in the pouring rain, etc.

♥ Have developed "compost radar" that detects compost references in non-compost settings.

♥ Had your own compost-related license plate, e-mail address, or web site.

♥ Ever been called "Compost King," "Crazy Composter," "Worm Woman," or other composting "title"—and took it as a compliment.

Total Items Circled: _____

Scoring:

0 – 9 Your composting knowledge and practical experience are at a very **sane** level.

10 – 19 You are **certifiable**—if you're not already in the NYC Compost Project Master Composter Certificate program, you should consider applying!

20 – 29 You certainly are a **committed** composter!—please call your local Compost Helpline and tell us more about your composting adventures!

nyc compost project
photo/video consent form

activity title: _____

location: _____

I grant NYC Department of Sanitation's Bureau of Waste Prevention, Reuse and Recycling (BWPRR), its employees, and any of its representatives (including but not limited to NYC Compost Project host sites listed below) the right to take photographs or video of me and my property in connection with the above-identified activity.

I authorize BWPRR, its representatives, and employees to use such photographs and/or video of me with or without my name for any lawful purpose, including for example such purposes as publicity, illustration, and Web content.

I have read and understand the above:

Signature _____

Printed name _____

Organization Name (if applicable) _____

Mailing Address (Optional) _____

_____

Email Address (Optional) _____

Date _____ Signature, parent or guardian (if under age 18) _____

Please check the relevant NYC Compost Project associated with the subject and location indicated above:

- ☐ NYC Compost Project in Brooklyn, hosted at the Brooklyn Botanic Garden
- ☐ NYC Compost Project in the Bronx, hosted at The New York Botanical Garden
- ☐ NYC Compost Project in Manhattan, hosted at the Lower East Side Ecology Center
- ☐ NYC Compost Project in Queens, hosted at Queens Botanical Garden
- ☐ NYC Compost Project on Staten Island, hosted at Snug Harbor Cultural Center & Botanical Garden

staff notes:

photo name(s):