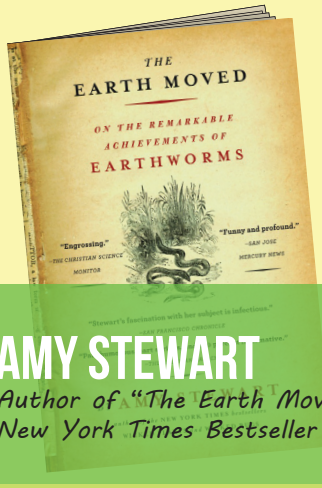
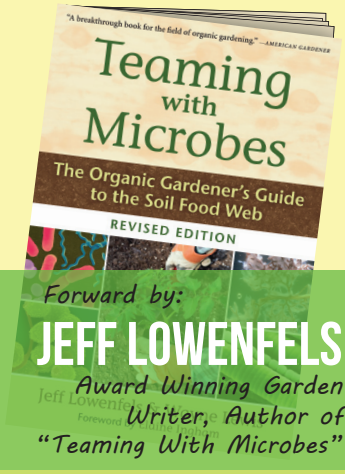
The Complete Guide to

VERMICOMPOSTING

With the Worm Factory® 360

With Excerpts From These Two Books:





AMY STEWART
Author of "The Earth Moved"
New York Times Bestseller

Forward by:

JEFF LOWENFELS
Award Winning Garden Writer, Author of "Teaming With Microbes"

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Foreword

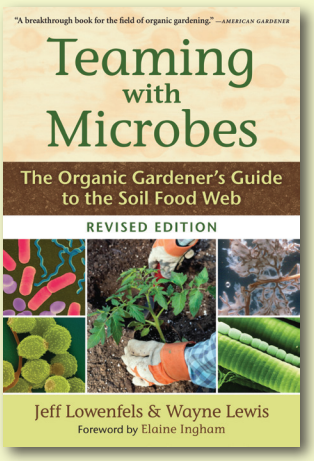
"Worm poop is gold." How many times has a gardener heard this? Well, if you are not vermicomposting, YOU haven't heard it enough, apparently. So as America's longest running garden columnist and the co-author of an award winning book on soil, I am here to assure you that worm poop IS gold, actually even more.

You see, what goes into a worm and then comes out the other end are, truly, two different things. Soil that a worm ingests is suddenly 5 times richer in nitrogen, 10 times richer in potassium, has 7 times more phosphate, 1.5 times as much calcium and 3 times the magnesium.

This unbelievable, free increase in the key, essential, plant nutrients allow worms to do what Medieval alchemists couldn't: turn waste into gold from scraps and wastes and old soil.

Ah, but there is more. The compost produced in a worm bin contains more than just nutrients. It contains enzymes and beneficial microbes that speed up the soil food web to help plants grow. They add polysaccharides and proteins to the soil and they provide texture which builds structure.

Simply put: Worms will make you gold. A worm bin is a veritable Fort Knox.



-Jeff Lowenfels

Author, *Teaming with Microbes*

Read an excerpt from Teaming with Microbes on page 52!

Mission Statement

Nature's Footprint, Inc. believes that vermicomposting is one of the most efficient ways to recycle and minimize society's overall impact on the earth and improve our soil. Our goal is to inform and educate others regarding the benefits of vermicomposting and integrate this form of recycling and waste minimization into household composting and gardening practices.

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www.naturesfootprint.com

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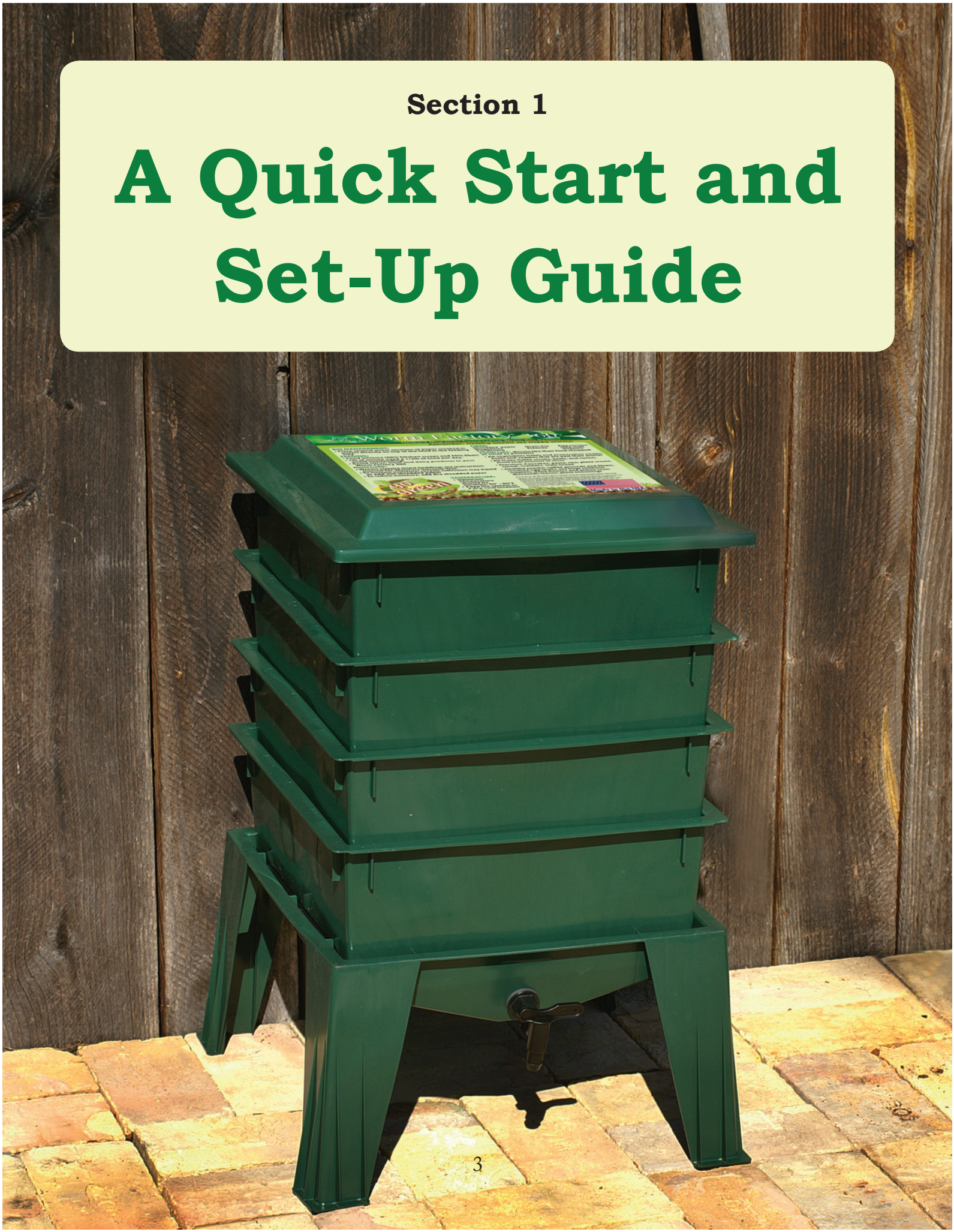
Section 1

A Quick Start and Set-Up Guide



Congratulations!

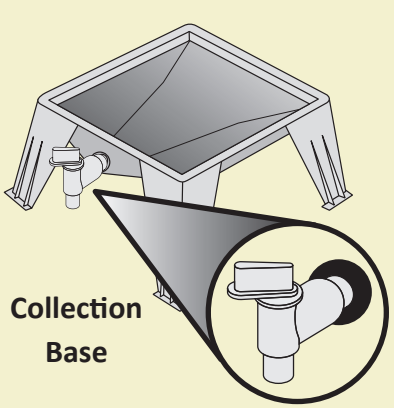
You have taken an important step in changing your impact on the environment by reducing the amount of household waste that would otherwise find its way into landfills. The Worm Factory 360 is an incredibly efficient way to quickly convert your kitchen waste, cardboard, newspaper, junk mail, dried leaves, and other organic matter into nutrient-rich compost for your planters, flower beds and vegetable garden.

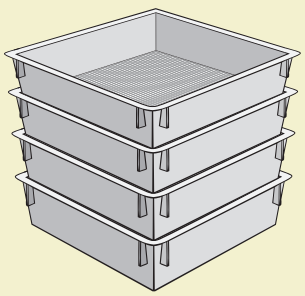
In nature, organic material (anything that once was alive) is broken down into nutrients that plants use for food, a process that can take many years if left alone. Composting worms can do this same job in as little as three months, composting up to five pounds of food waste, paper and junk mail per week.

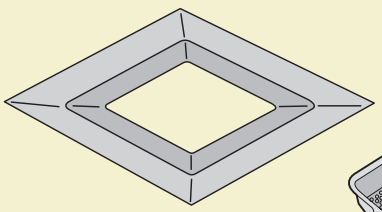
In full operation, your vermicomposter will be home to a livestock population of 6,000 to 10,000 worms. The composting worms and microbes (millions of bacteria, fungi, nematodes, and protozoa) living inside your worm composter are the workhorses that process your household waste and transform it into rich vermicompost.

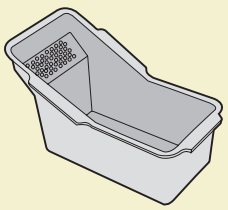
This owner's manual will give you the basic information and procedures necessary to manage your vermicomposter. Managed properly, your Worm Factory 360 will produce a never-ending supply of nutrient rich fertilizer for your plants and garden for many years to come.

Worm Factory® 360 Parts


Collection Base


4 Stacking Trays


Worm Ladder

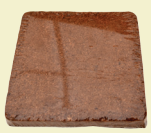

Sprinkler Tray


Quick Tips Lid

Spigot/Washer/Nut Assembly

Manual


DVD


Coir


Shredded Paper


Minerals


Pumice


Accessory Kit

Obtaining Worms

You will need a supply of worms for your Worm Factory 360. There are many thousands of varieties of earthworms, but only a few will work in a worm composter. Most of the earthworms found in your garden are not suitable for your worm composter.

We suggest that you use "red wiggler" worms (*Eisenia fetida*). They eat only decaying organic matter and live only in the top few inches of the soil. They are voracious eaters and reproduce rapidly in a worm composter.

Another worm that can be used for composting is the European (Belgian) Nightcrawlers (*Eisenia hortensis*). This variety reproduces slower but makes a great fishing worm.

We recommend starting with 1 pound (approximately 800-1,000 worms) of worms for a healthy working population. You can start with fewer worms but it will take longer for your system to reach full operating capacity. The following instructions assume you will start your Worm Factory 360 with 1 pound of worms.

There are many ways to get worms for your worm composter:

Worm Voucher:

Some vermicomposters come with a purchased "worm voucher". If this is the case, follow the instructions on the voucher.

Worms by mail:

Composting worms are regularly delivered by USPS Priority Mail. Canadian orders are delivered by Canada Post. For a list of worm suppliers, go to www.findworms.com.

Worms from local worm farms:

Go to www.findworms.com to find a worm farmer near you.

Worms from a friend:

It is possible to obtain worms from a friend who has an active worm composter.

Worms from a bait shop:

Not all fishing worms are suitable for composting. Many bait shops sell "red wigglers" for bait. Be sure to check for the correct scientific *Eisenia fetida* name before you purchase.

Municipal Recycling Programs:

Many municipal recycling programs can help you find a local source of composting worms.

NOTE: *It is important to have your vermicomposter set up with bedding to receive the worms when they arrive.*

Quick Assembly

4 Add the lid

Your vermicomposter is now ready to add bedding materials and worms.

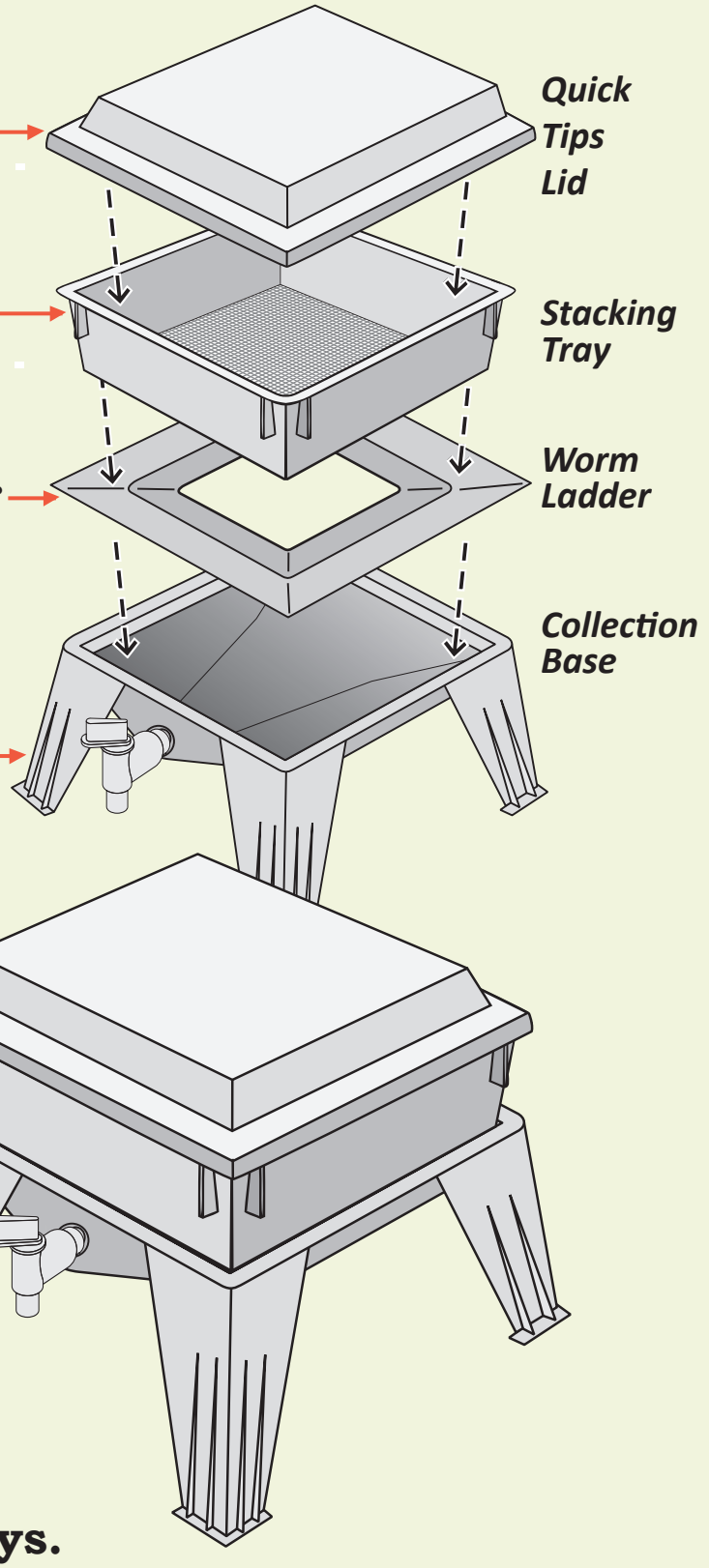
3 Add a stacking tray

This tray will be referred to as the "Starting Tray."

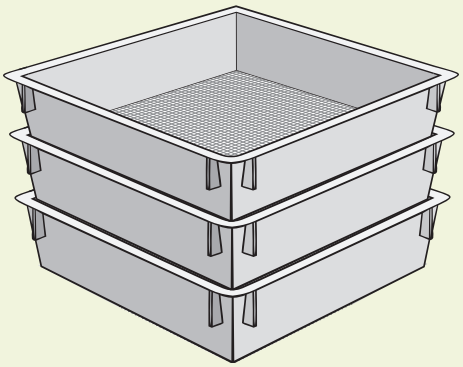
2 Install the Worm Ladder

Set the worm ladder inside the base. The Worm Ladder helps worms that have fallen into the collection tray back into the working trays.

1 Set the collection base



NOTE: *The Lid ships nested inside the base. Remove the lid before placing the worm ladder in the base.*

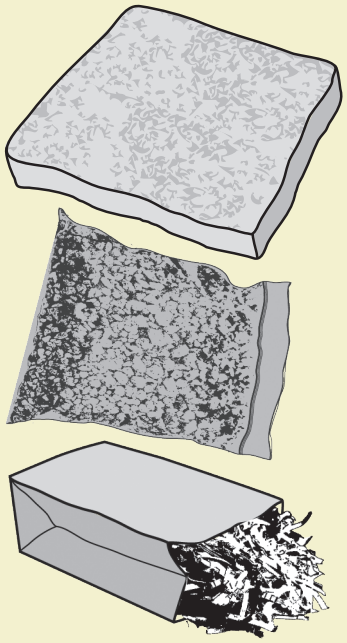


Set aside the remaining trays.

The remaining trays are added one at a time as they are needed. It may take three or four months to put all four trays into operation.

Next: Preparing for Worms

Preparing Bedding



Included with your Worm Factory 360:

Coir

Coir is ground coconut fiber. It is the most desirable bedding material because it retains moisture and improves the quality of the worm castings that go into your garden.

Pumice

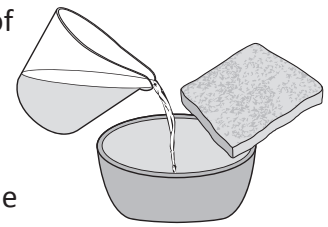
Pumice is a lightweight, porous, volcanic rock which provides excellent aeration and drainage for your vermicomposter.

Shredded Paper

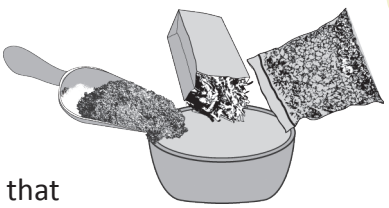
Shredded paper, cardboard, newsprint, egg cartons and other types of paper provide an excellent source of carbon, increase aeration, and are an easy source of food for your worms.

Prepare your bedding before your worms arrive. This bedding material is provided to make sure your worms get off to a good start. *For more details about the bedding process, read page 20.*

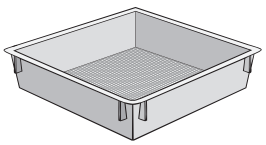
1 Place the end of the brick of coir in a bowl. Pour 1 cup of water over the brick and let it soak until it begins to break apart. Crumble off the loosened coir equal to half the brick. Add more water if needed. Coir should be moist but NOT wet. Set aside the unused ½ brick of coir to use later.



2 Mix together the moistened Coir, ½ Pumice, ½ Shredded Paper, 1 Tbsp. Minerals that came with your Worm Factory 360.



3 Use this mixture in the starting tray. Store the unused Coir, Pumice, shredded paper and minerals to use later when adding your second tray.



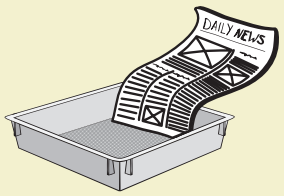
4 Add one or two cupfuls of garden soil or compost to the bedding mixture. This material contains organic organisms that will inoculate your worm composter with the beneficial microbes worms depend on to help them digest their food.

NOTE: ***Coir and pumice make excellent bedding material, however, they are not required.***

Next: Starting your 1st tray

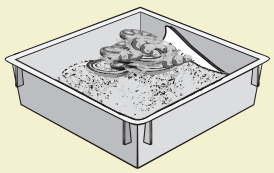
Starting Your First Feeding Tray

1 Cover the bottom of the first starting tray with one or two sheets of dry newsprint. **You'll only do this on your very first tray!**

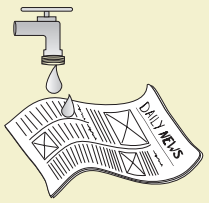


2 Add the moist bedding mixture, spreading it evenly on top of the dry newspaper. Add 2 or 3 cups of food in one corner of the tray.

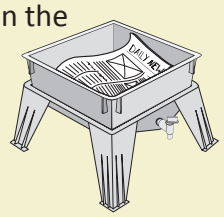
For food suggestions, see page 17.



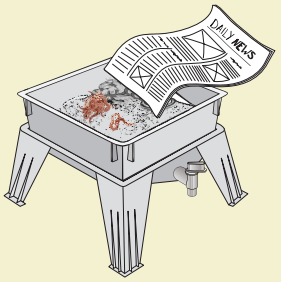
3 Select 5-10 full pages of newspaper (no slick color paper), fold the paper so it will fit into the feeding tray. Wet the paper until it is damp but not dripping. You have just created a moist newspaper cover.



4 Place the moist newspaper cover on top of the bedding and food in the starting tray and wait for your worms to arrive.

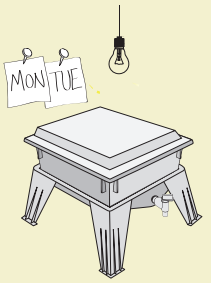


5 When the worms arrive remove the moist newspaper cover. Add the worms, including all of the bedding included with the worms, on top of the moist bedding. Replace the moist newspaper cover.



Read more about adding worms on page 16.

6 Place the lid on the worm composter. It is best to not disturb the worms for the first two or three days while they adjust to their new environment. Your worms will want to explore their new home. Leave a light on for the first 2 or 3 days. This will discourage the worms from exploring outside the composter.



7 Leave the worms alone for two or three days then open the lid and peek in. Lift the moist newspaper cover and look around in your bin. Are the worms actively moving around in their food? If so, GOOD! If not, leave the worms alone, then check them again in 2 or 3 days. Once you see the worms actively feeding, you can start adding more food.

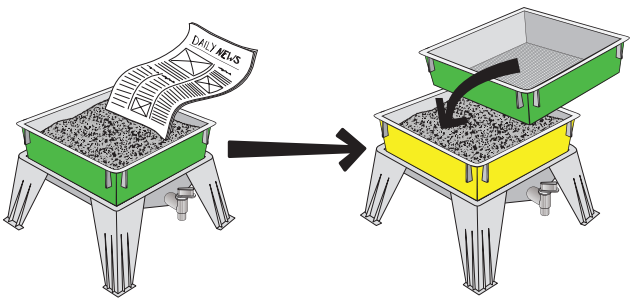
To provide the worms with an adequate food supply, add enough food over the next 4-6 weeks to fill the feeding tray. When the feeding tray is filled to within an inch of the top of the tray, it is time to add another tray.

NOTE: ***From now on, the starting tray will be referred to as the "feeding tray". This tray will always be on top and is shown in the illustration by the color green.***

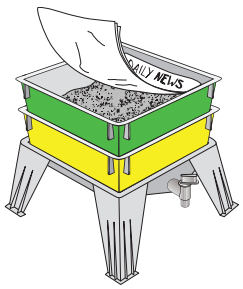
Adding Additional Trays

Once the feeding tray is filled, it is time to start the Worm Factory 360's unique rotating tray system!

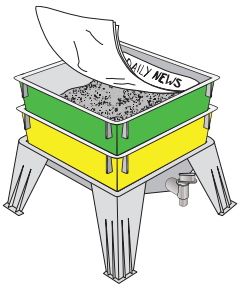
1 Remove the moist newspaper cover. Place an empty tray on top of the feeding tray. This tray now becomes the feeding tray and the lower tray becomes the processing tray.



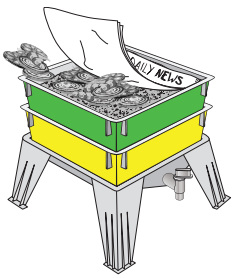
2 Cover the bottom of the tray with shredded paper or other bedding material and add 2 or 3 cups of food. Place the moist newspaper cover on top of the food and replace the lid.



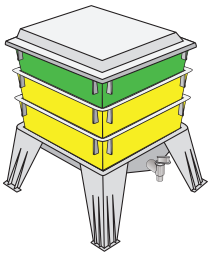
3 After a day or two look under the moist newspaper cover in the second tray. Do you see worms? If so, that's great! They have started migrating up.



4 Continue adding food (a mix of browns and greens) under the moist newspaper cover *For a list of appropriate foods see page 17.*



5 After you have 3 or more operating trays, the vermicomposter is in full operation!



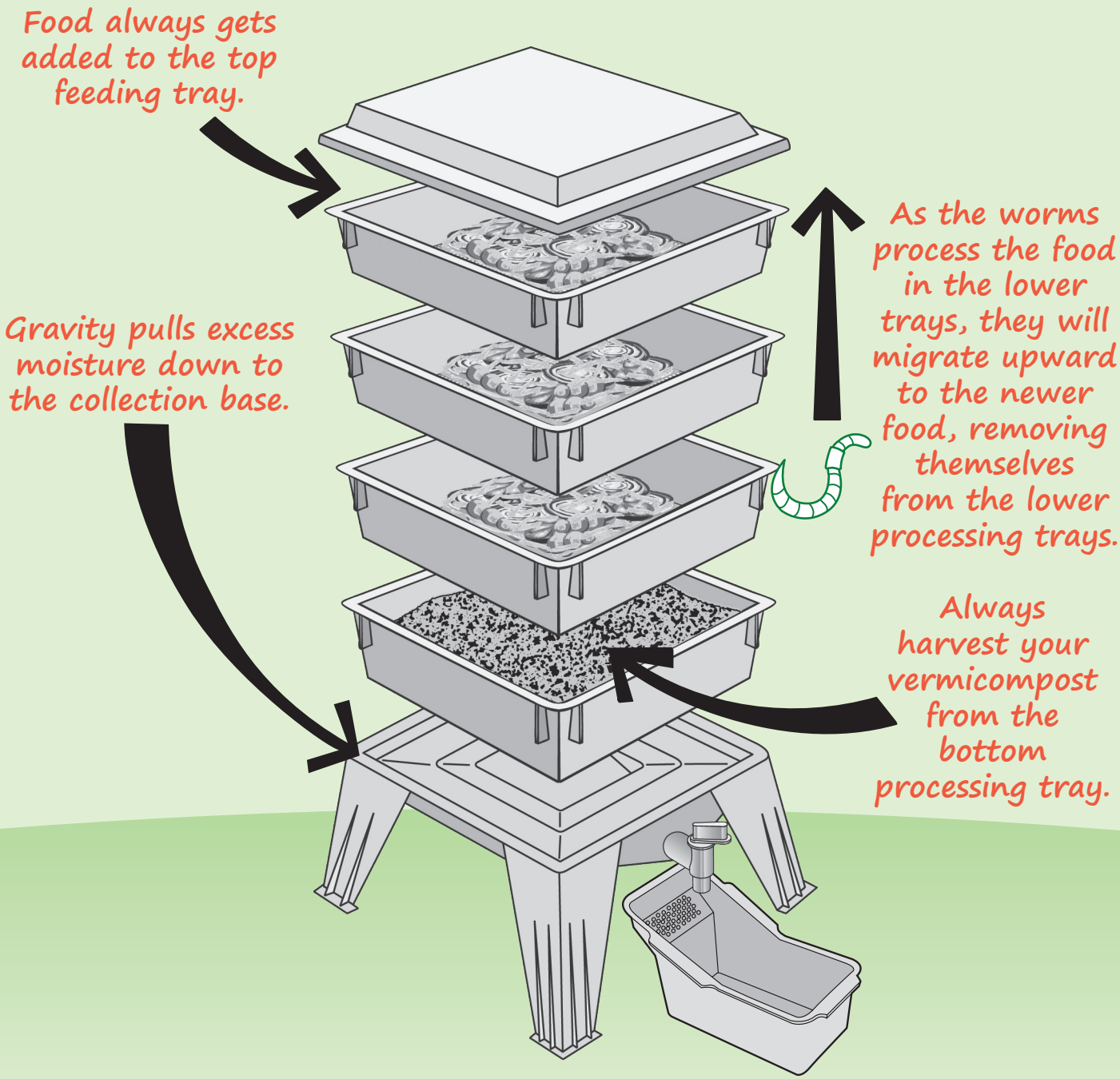
NOTE:

Each time a tray is added the new tray becomes the feeding tray (green, on top) and the former feeding tray becomes a processing tray (yellow, below)

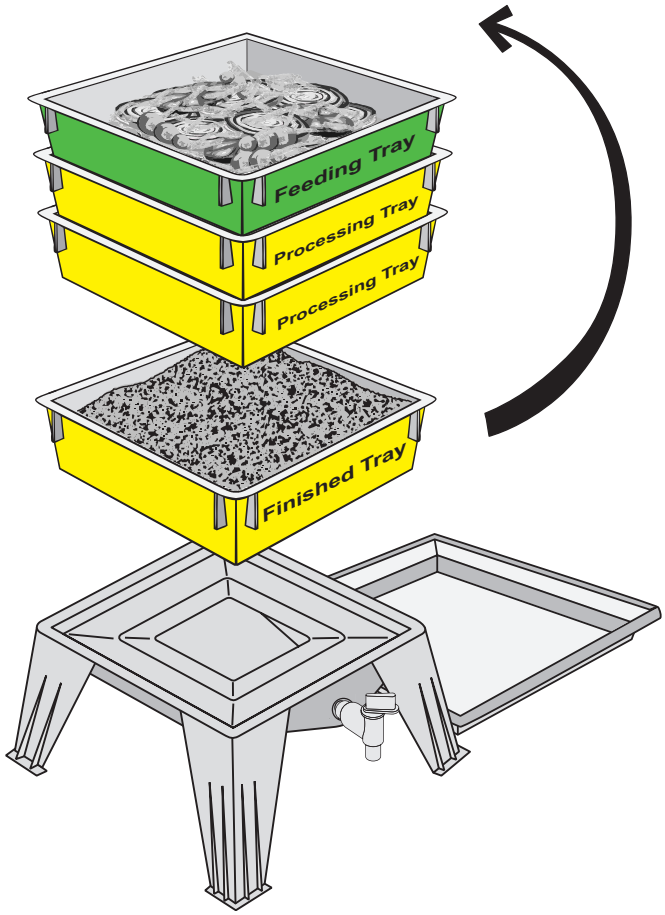
Always move the moist newspaper cover upward into each new tray. Replace the cover when necessary. Each new feeding tray should be filled in 4-6 weeks. A processing tray requires an average of 90 days to be ready for harvest. **Remember! Do not add additional food to the lower trays.**

Self-Sorting Upward Migrating System

This page demonstrates the movement of worms and excess moisture



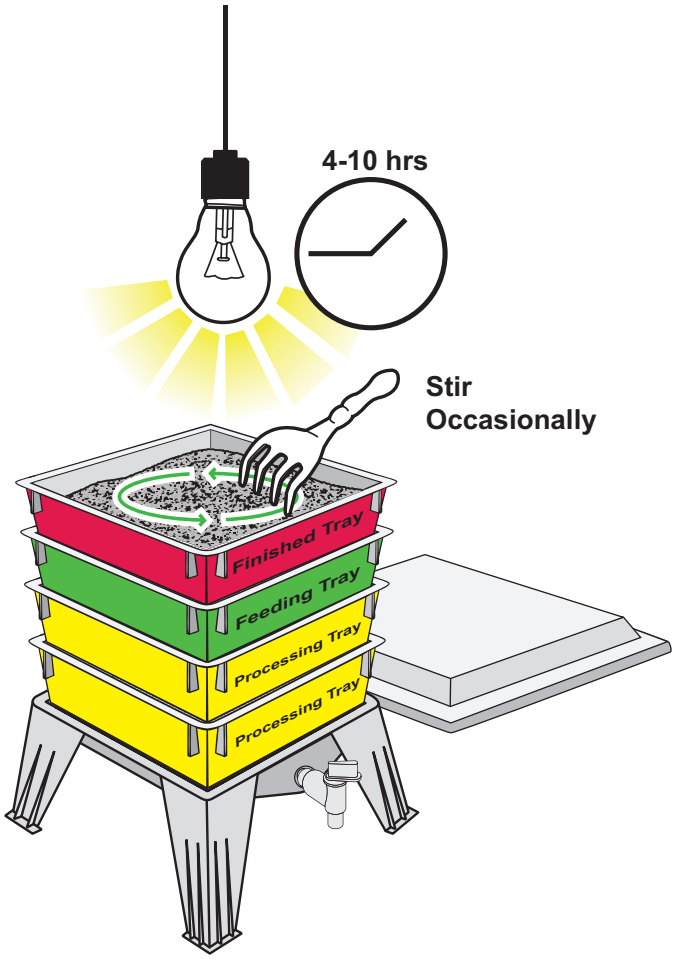
Harvesting Vermicompost



1 Remove the lid and turn it upside down to use as a tray. Transfer all the trays except the bottom "processing" trays onto the lid, keeping the trays in the same order that they were on the collection base. Place the bottom "processing" tray still on the base, on top of the "feeding" tray. Return all the trays to the collection base.

NOTE:

Always replace the processing trays on the collection base in the same order to maintain proper rotation.



2 If outside remove the lid. If inside remove the lid and place a light over the vermicomposter. Stir the compost. This will drive the worms down into the feeding tray below.

3 To speed up the process remove about 1 inch of vermicompost every 1-2 hours into a separate container, stirring the remaining material each time. When the 'finished' tray is empty, it is in the correct position to become the new 'feeding' tray.

For more information on harvesting vermicompost see page 29.

Congratulations! You just completed the first successful rotation of your Worm Factory 360.

Vermicomposting Goals

As you begin working with your vermicomposter, experience will be the best teacher. Following the instructions in this manual will ensure that you will become a successful vermicomposter.

After about four months, you should reach the following goals:

1. You should have an active top "feeding" tray and two or more processing trays in different stages of composting.

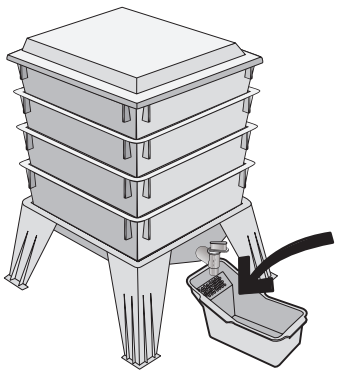
2. The majority of the contents of the bottom processing tray should be converted into dark crumbly vermicompost ready to harvest and use in the garden.

3. After 90 days your worm population should show signs of increasing and you will be feeding larger amounts of food. When you see the worms actively moving around in the top layers of the food you know you need to feed more.

4. The majority of the worms will have migrated to the trays above. The worms are drawn up to the food as you add new food to the upper tray.

5. You may see other beneficial insects in the vermicomposter. These insects help breakdown the food for the worms to eat and indicate your system is working properly. *(refer to the section, A Living Ecosystem on page 34)*

6. You may be getting small amounts of leachate draining from the processing trays into the collection base.



It is important to remember that these are goals. It may take more time depending on your vermicomposting needs and management style.

Section 2

Managing Your Worm Factory® 360

Learn More about Worms and Vermicomposting

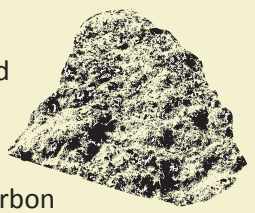
Understanding Basic Concepts of Composting

All types of composting rely on a host of living organisms to break organic material down to the basic nutrients that other living organisms and plants can use. The most common composting organisms are bacteria. Some are anaerobic, preferring a low to no oxygen environment. The rest are aerobic and thrive in an oxygen rich environment. In additions to bacteria, a healthy composting system will also be home to fungi, protozoa, nematodes, molds, arthropods and more.

Home composting systems fall into 3 categories. All three composting systems have populations of aerobic and anaerobic microbes. Depending on conditions one type or the other type will be in charge. Aerobic bacteria have a rich earthy smell we associate with healthy soil. Anaerobic bacteria release methane, ammonia and other nasty odors. How the types of composting are similar and different will help you understand and manage your Worm Factory 360.

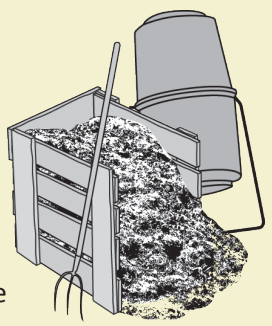
There are three types of compost.

1 Outdoor 'Cold' Composting



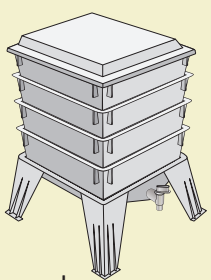
This could be called passive composting. There are many ways to cold compost. Cold compost is dominated by microorganisms that live in temperatures below 115°. Most home owners randomly collect the material in piles as it becomes available. Because it is left to breakdown at its own pace, it may be coarser in texture but will have a high carbon content that feeds the life in the soil as it breaks down. This composting process is what takes place in nature. Because oxygen is not being introduced by constant turning of the pile cold composting is less labor intensive.

2 Outdoor 'Hot' Composting



This requires a managed process. Close attention is paid to the carbon to nitrogen (C:N) ratio, the way material is mixed and the types of material used. Hot compost is made with microorganisms that live in temperatures of 130°F to 160°F. This causes the ingredients to breakdown to a rich black material in as little as 90 days. The high heat, when maintained for three or four days, will kill most pathogens and weed seeds in the compost. To achieve this temperature, **high levels of oxygen** must be periodically introduced into the material. That means turning and fluffing the pile each time it begins to cool.

3 Vermicomposting



"Vermi " or worm composting is an aerobic cold composting process that is accelerated by adding large numbers of composting worms in a contained system. Close attention is paid to the carbon to nitrogen (C:N) ratio. This allows for sufficient airflow and moisture necessary for the worms to thrive. Microorganisms and small insects in the worm composter work together with the worms to breakdown and consume the materials. The materials are processed by the worms and excreted as nutrient rich castings which are readily available to the plants. The only work required is feeding the worms and harvesting the compost. When you compost in the Worm Factory 360, in as little as 90 days, you can start having having safe, nutrient-rich cold compost your garden will love.

A Quick Comparison

	COLD COMPOST	HOT COMPOST	WORM COMPOST
Microorganisms do the work	✓	✓	✓
Compost made in sequential order		✓	✓
Compost processed in several stages		✓	✓
Requires Moisture	✓	✓	✓
Requires Oxygen		✓	✓
Requires High temperatures		✓	
Limited to warm weather		✓	✓
Can be done all year	✓		✓
Can be done indoors			✓
Can be done outdoors	✓	✓	✓
Requires minimal space			✓
90 days or less to finish			✓
90 days or more to finish		✓	
360 days or more to finish	✓		
Regular turning (aeration) necessary		✓	

The most efficient way to compost is in batches. Each new pile or tray is filled to capacity at which time no new material is added. **Adding new materials continuously results in a never ending process.**

Worm compost is special! Worms produce a fantastic "biologically-enhanced humus rich" product that has several advantages over traditional garden compost:

- Full of beneficial soil micro-organisms
- Very high humus content
- Contains slow-release natural fertilizers
- Higher in nutrients than traditional compost
- Concentrated water soluble nutrients that plants can use immediately
- Helps to bind together soil particles
- Enhances disease resistance
- Encourages healthy/strong root system
- Produces strong healthy plants and crops
- Greater water absorption and holding capacity

NOTE:

Compost passes through distinct cycles or stages employing many different microorganisms. This process is disrupted when new food is added to a tray before the process is complete.

Finding a Good Location for Your Vermicomposter

Worms do best in a bedding temperature range of 55°F-75°F (12°C-24°C). The air temperature can be higher or lower than this. The bedding temperature is generally an average of the air temperature on a given day. So, if it is 40°F at night and 80°F during the day, the average temperature is 60°F and your worms will be fine.

A properly maintained worm composter will not have any offensive odor. Keeping it inside should not be a problem. A kitchen, garage, basement or utility area is a good place to keep your composter as long as it is protected from bedding temperatures below 34°F or over 90°F.

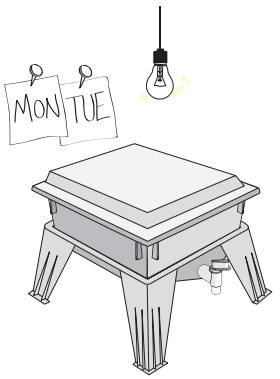
> ***"Earthworm bins may be kept indoors or outside. People have vermicomposting systems in a variety of locations inside their homes, in addition to basements, breezeways, and garages. Earthworm bins may be kept in living rooms, kitchens, bathrooms, bedroom closets, and family rooms."***
>
> (Sherman and Appelhof, *Worms Eat My Garbage*, p. 71)

The Worm Factory 360 can be kept outdoors as long as it is protected from direct sunlight and not exposed to rain and wind. A porch, patio or balcony with an overhang is a good location. If you do not have an overhang, placing it underneath a leafy tree can work. You should move it indoors during conditions of extreme weather (prolonged excessive air temperatures below 34°F or over 90°F). You can check the bedding temperature with the thermometer included with your Worm Factory 360.

Adding Worms

When worms arrive, they are stressed from being jostled around during shipping. They may be confused about their new surroundings and attempt to exit the tray or they may ball up as a natural survival mechanism.

Worms are extremely sensitive to light. If they attempt to leave the worm composter through the top, we recommend leaving a light on in the room or



place a spot light directly over the composter for a few days. The dry newspaper that was placed in the bottom of the first tray *(pg. 8, #1)* helps to keep the worms from leaving the tray at the bottom of the composter. If the worms ball up DO NOT try to separate them. Once they are comfortable they will move around and begin eating their food.

It is important to learn about the worms' anatomy and behavior. *See page 44* for important facts about worms. This information will help you to have a successful vermicomposting system.

Feeding Your Worms

Your worms will require a week or so to become fully acclimated to their new environment. Place only a few handfuls of food under the moist cover in the feeding tray at a time. Be patient. Once the worms become comfortable in their new environment they will begin to eat more and move around.

You can add new food to the top feeding tray at any time. Always make sure that the worms are actively eating the food you added most recently before adding more. If you do not see the worms in the top layer of food it is a sign they are overfed and you should wait to add more food.

Worms can eat up to half their weight in food per day in a fully established, well managed vermicomposter. The frequency and volume of feeding will depend on your management style, how much kitchen waste you produce, where the worm composter is kept, the time of year and how may worms you have working in the entire system.

Amy Stewart, the author of *The Earth Moved:* On the Remarkable Achievements of Earthworms, offers some helpful tips on feeding red wiggler worms:

"They'll eat coffee grounds and stale bread, but they won't touch onions, oranges, or anything too acidic. They can't eat fats in any form (including salad dressing), or meat, or dairy products. They do, however, like crushed eggshells because they provide a source of grit for their gizzards and help to moderate the pH level of the bin. No matter what you feed them, be sure to pile plenty of shredded newspaper on top to hold moisture in and keep fruit flies out." *(p. 204)*

NOTE:

Remember: NEVER add food to the processing trays – only to the top feeding tray under the moist newspaper cover. This ensures the efficient operation of the upward migrating system.

Foods to add to your vermicomposter:

Greens: Vegetable and fruit scraps, bread, pasta, coffee grounds and filters, teabags, dead plant matter from houseplants

Browns: Paper, junk mail, paper egg cartons, cardboard, dry leaves

Equal portions of "greens" and "browns" is recommended.

All organic material will break down, some faster than others. However, there are some suggested foods to avoid: salty foods, oils, fats, meat, dairy products and packaged convenient foods. Prepackaged foods can contain oils, fats, salt, additives and preservatives that could be harmful to the worms. Citrus and spicy foods should only be added in small amounts.

You can puree, freeze, or microwave food scraps before adding them to your worm composter to help break down fibers and speed up the composting process. Make sure that the food has returned to

room temperature before adding it to your feeding tray if it has been refrigerated, frozen or microwaved.

Chopping large chunks of food is recommended but not necessary. Banana peels will disappear quickly but whole carrots take a very long time to break down. Chop up the food into small pieces if you have time, or cook it. If not, focus on cutting the hard, dense foods into smaller pieces and don't worry about the others.

On average, most people can fill a tray in about one month. It may take shorter or longer depending on how much kitchen waste you generate.
On the lid of your vermicomposter, you will find "Quick Tips" with an easy, accessible list of foods that can be added to your vermicomposter.
Food that has been pureed, frozen or microwaved releases liquid rapidly because the cellular structure of the food has been broken down. This can cause the moisture level of the worm composter to rise quickly. Be sure to add dry shredded paper to pureed food to absorb this liquid and promote air flow.

TIP: ***Many foods can be put into the worm composter whole but they take longer to break down. Smaller pieces of food will break down faster, speeding up the composting process.***

The Difference Between BROWNS and GREENS as Compost Ingredients

The meaning of the terms "browns" and "greens" is often not understood by many first time composters or organic gardeners. "Brown" and "green" are general terms for different types of organic matter used in a worm composter. The technical terms are "carbon" and "nitrogen". How these two elements are balanced in the composting process is important.

This is called the C:N (Carbon to Nitrogen) ratio. For best performance, composting microorganisms require the correct proportion of carbon for energy, and nitrogen for protein production. This will result in a faster production of fertile, sweet-smelling worm compost. If the C:N ratio is too low (excess nitrogen) you can end up with a stinky worm composter.

"Browns" are higher in carbon or carbohydrates and lower in moisture content. These foods supply the energy that soil microorganisms need to survive. Carbons help absorb offensive odors. Carbons capture the nitrogen in the compost. This prevents the nitrogen from escaping into the air by evaporation or dispersing into the leachate that drains into the collection area of the worm composter. Carbons take longer to decompose.

"Greens" are higher in nitrogen or protein and higher in moisture content. These foods provide the nutrients necessary for building cell structure in the microorganisms, enabling them to grow and multiply in the worm composter. Nitrogen rich foods break down quickly and create heat as they break down.

Common Browns:


Paper & Junk mail


Unsalted Nut Shells & Dry Leaves


Cardboard

Common Greens:


Fruits & Vegetables


Coffee Grounds & Tea Bags


Pasta & Cereals

A C:N carbon to nitrogen ratio ranging from 25:1 to 30:1 is considered the dividing line for all organic materials between "Brown" and "Green".

C:N RATIO > 30:1 = BROWNS

Any organic matter that has a C:N ratio larger than 30:1 is considered a BROWN.

C:N RATIO < 30:1 = GREENS

Any organic matter that has a C:N ratio smaller than 30:1 is considered a GREEN.

How does the Carbon to Nitrogen ratio relate to what you feed the worms?

The target C:N ratio is 30:1. We recommend at least 50% of the volume of food fed to the worms should be composed of Carbons/Browns and 50% should be composted of Nitrogen/Greens. On the average, most household waste that is cycled through the worm composter will not require adjusting the amount of "browns/carbon" or "greens/nitrogen" as long as you follow the 50% guideline.

C:N ratios are guidelines for determining how to mix "greens" and "browns" in the worm composter. Knowing what materials are high in carbon, for example, will help you to know what to feed the worms if your worm composter has started to develop an odor or is too wet. This will help you to correct this problem. Managing moisture is discussed in more detail on Pages 23-27 of this manual.

Grass clippings are high in Nitrogen but generate a lot of heat so are not recommended in a worm composter. Leaves can have a high nitrogen content when green, but change to carbon as they change color. Deciduous leaves are best for worm composting. Evergreen leaves, needles and sawdust are very acidic and can contain oils harmful to worms.

Here are C:N ratios of common household items you would feed worms or use for bedding:

Material	C:N Ratio	Material	C:N Ratio
Cardboard	350:1	Cocoanut Coir	100:1
Fruit Waste	20 - 50:1	Peat Moss	58:1
Paper, Newspaper	170 - 200:1	Tea Bags	70:1
Peanut Shells	35:1	Leaves *(ash, black elder, elm & alder)*	21 - 28:1
Coffee Grounds	20:1	Leaves *(maple, oak, birch, aspen, beech)*	30 - 80:1
Vegetable Scraps	10 - 25:1	Sawdust	200-500:1
Garden Waste	30:1	Pasta, Breads, Cereals	20:1

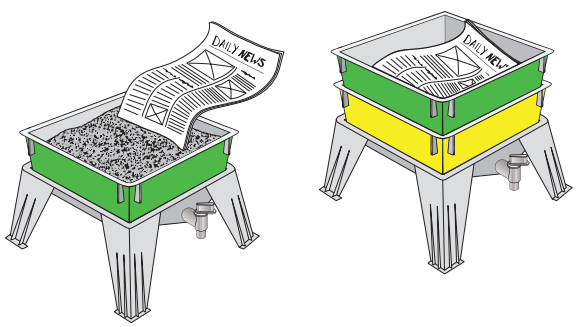
Adding Additional Trays

Your worm composter is an upward migration system. Composting worms migrate both up and down but always move toward newer food, leaving their vermicompost behind. Always add food to the top feeding tray. This encourages the worms to make their way up from the trays below, searching for new food.

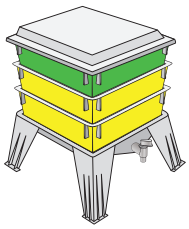
Add a new tray when the current feeding tray is full to the top, or has been active for about 45-60 days. This time frame will be more or less depending on your management style. The material in the current feeding tray does not need to be fully composted before you add a new tray. The worms will continue to compost material in the lower tray. Adding a small amount of finished vermicompost to a new feeding tray is a good idea. This will introduce microbes in the fresh food and help speed up the composting process in the new tray.

If you don't have enough kitchen scraps to fill a tray regularly, consider other sources of food and bedding, such as from friends and neighbors, outside yard and garden waste, or paper products (paper, cardboard, egg cartons, paper towels, and tissues).

Move the moist newspaper cover up to the new feeding tray and add a good mixture of green and brown foods underneath the cover. The browns act as bedding as well as food, so it's good to add at least ½ inch when you start a new feeding tray.



As the material in the tray is broken down it will shrink and reduce in volume. The grid of the new tray should make contact with the material in the lower processing tray. It should not rest on the plastic rim of the tray below (see illustration above). This ensures that as the worms process the food in the lower processing tray and it settles, the worms are still able to migrate upward to the new food in the top feeding tray.



The goal is to have a systematic rotation of trays, each tray in a different stage of decomposition. This helps to speed up the composting process and allows your worms to process food more efficiently.

The Worm Factory 360 comes with four composting trays but can accommodate up to 7 composting trays. Additional trays can be ordered if you find you have more kitchen waste than your present system can handle.

Bedding

Typically, worm bedding is a coarse carbon-based material (browns) that breaks down more slowly than the food (greens). Bedding is essential for airspace. Bedding allows excess moisture to drain down into the collection base. It has little protein or mineral content and won't pack tightly, allowing for air passage between individual particles.

Bedding Material Included With the Worm Factory 360

Coir **Shredded Paper** **Minerals** **Pumice**

Add your worms and the bedding material they were shipped in, to the bedding in the first feeding tray. This gives the worms familiar material and a place to acclimate to their new surroundings. Bedding should comprise 50% of the material you add to the feeding trays.

Worms will not survive in a dry environment. You need to moisten the bedding material when initially setting up your Worm Factory 360 by placing it in a bucket or tub and start adding water a little at a time. You want your bedding material to feel like a wrung-out sponge. A couple of drops should be released from the bedding if you squeeze a handful of it. If more water drips out, add more dry bedding to get the moisture levels right. Once the bedding is right, add it to the tray, fluffing it up a bit. You want your worms to be able to wiggle easily through the bedding. Break up any large clumps.

If possible, add 1 or 2 cupfuls of garden soil or finished compost to your bedding material. Garden soil contains a wealth of microorganisms that are important to the composting process. The microorganisms break down the food for the worms. As worms graze they ingest the microbes, bits of food and bedding. This mixture eventually becomes the biologically-enhanced, humus-rich worm castings. The microorganisms in the compost you add to the bedding help start the composting process and bring the worms up to speed much faster.

Bedding can have an impact upon how quickly worms grow and the maximum size that they will attain.

Eggshells:

Eggshells are a great source of slow release calcium and can help prevent acidic conditions from developing. They are a good source of grit for the worms to help digest the food in their gizzard. As the calcium leaches out of the shells they get very brittle and break into small pieces. You can put dried egg shells in a used bread or sandwich bag and roll with a rolling pin to crush them.

Leaves:

You can place dry leaves in each new feeding tray or add them to your bedding mixed with shredded paper. Use them wet or dry to help manage your bedding moisture. Never use leaves from plants such as bay, eucalyptus, or magnolia trees, and never use needles from pine, fir, and cedar trees. These types of leaves will kill your worms.

Grit:

Grit is small loose particles of crushed rock or shells. Worms have gizzards like birds. Grit helps the worms to crush their food and adds minerals to the finished compost.

Minerals:

Rock dust provides grit and help correct pH levels. Rock dust feeds the microbes that feed the worms and help plants take up minerals otherwise not available. Lime is not necessary unless peat moss has been added as bedding or your worm composter becomes acidic. See page 22 “About Lime...”.

Bedding plays an important role in reproduction rates and has an impact on the manageability of the Worm Factory 360. It helps to prevent odors from forming in the worm composter by providing carbon, without which the system would sour. Bedding (browns) keeps the material in the trays from packing tightly allowing for the free movement of the worms.

Screened coconut coir and pumice, which are included with your start up materials, are always useful in the operation of your Worm Factory 360 but not essential. Other options that are helpful include dry leaves, eggshells, grit and minerals.

TIP: A mixture of various bedding (brown) materials will provide a nice balance and will make a bedding that retains moisture, does not clump and provides food value over time.

Mineral Rock Dust

Mineral rock dust is not mandatory but is recommended. Mineral rock dust adds nutrients to your finished compost and has also been proven to be beneficial to the worm composting process. We recommend adding about 6 tablespoons (two capfuls from the included jar) of mineral rock dust to the top of your full top tray and stir it in a bit before adding a new tray.

Acidity

The ideal pH for a vermicomposting system is 6 - 7, or neutral. Although it is not necessary, testing the pH of your system can be fun and informative. You can test for pH using a pH meter, a litmus paper test, or a garden soil test kit. It is more likely that your vermicomposter will be slightly acidic (lower on the pH scale) than alkaline (higher on the pH scale). Foods such as tomatoes and fruits are acidic and can lower the pH of your bin. An indication that your system is acidic will be high populations of pot worms and mites (*see page 35 for worm bin creature information*). To correct an acidic bin, you can mix crushed eggshell in with food.

About Lime... Lime is used to manage the acidity of the soil. Adding garden lime to your Worm Factory 360 is usually not necessary or recommended. Worms prefer a neutral pH (6-7) but will tolerate slightly acidic conditions. Scientists believe that when worms process waste through their digestive tract the waste is neutralized by the worms' intestinal secretions.

Adding lime to composting materials can cause nitrogen to be released as ammonia gas. This leaves your compost with less nitrogen, which is an important plant nutrient. It is better to adjust the pH of compost after it has completed the composting process.

Adding crushed eggshell to the feeding tray will help to correct the pH of the compost. If the pH reading remains less than 6, add about 3 tablespoons of garden lime to the TOP TRAY before placing a new tray on top. Always test the pH reading of the compost before adding lime.

Aerobic vs Anaerobic

Aerobic bacteria require oxygen and moisture to survive, and they do not give off a bad odor. This is the kind of bacteria that should be prevalent in your vermicomposter. They help worms break down food and thrive in the same conditions that worms enjoy. In contrast, if your vermicomposter gets too wet and does not have enough oxygen, anaerobic bacteria will take over. Anaerobic bacteria are able to live in the absence of oxygen. These are the bacteria that give off a terrible odor. If you notice that your worm composter smells bad or is too wet, it means the anaerobic bacteria have moved in and set up a home. For information on how to correct a smelly or waterlogged worm composter, *see page 25*.

Monitoring the Health of Your System

Weekly Monitoring: Check to make sure your worm composter is draining excess moisture by opening the spigot and collecting leachate. If you feed very moist food, we recommend that you leave your spigot open all the time and keep a plastic container underneath to catch drips. The sprinkler tray that came with your Worm Factory 360 works nicely for this!

If you are getting more than 2-3 ounces of leachate draining from the composter in a weeks' time your system is probably too wet. Just two or three drops of leachate a day indicates your Worm Factory 360 is operating with "the proper moisture level".

Do a pinch test to determine if your compost is too wet or too dry. Take a small amount in your hand and squeeze. If more than a few drops of moisture come out, your system is too wet. If the compost isn't moist at all or you see dry scraps of paper, your bedding is too dry.

An inexpensive moisture meter can help monitor moisture levels. Your worm composter should have a moisture reading of 60%-75%. *See page 24* for tips on how to correct moisture problems.

Be alert to any offensive odors coming from the worm composter. *See page 25* "Dealing With Offensive Odors".

Monthly Monitoring: You can pick up all of your trays off the base to make sure that excess leachate has not collected in the base. *See page 32* for tips on how to use the leachate.

Lift the processing trays one at a time and determine if any worms are hanging from the bottom. If there are, this is a good sign. It indicates that worms are migrating upward to the new food source. Do not dig around in the lower trays unless there is a specific reason to do so. For example, you have noticed a bad odor and are trying to aerate the compost. Worms do not like being disturbed and are sensitive to light and vibration.

Make sure there is not a lot of fine sediment built up on the worm ladder or in the collection base where it can clog the spigot. Remove any sediment and worms on the worm ladder or in the base with the scraper that came with your Worm Factory 360 and place it in the top feeding tray. A buildup of 'fine' sediment is caused by liquid filtering down through the system and is an indication your composter is too wet. It may also indicate that you waited too long to harvest finished castings. Flush the spigot with water to make sure it drains properly and is not plugged with fine sediment.

Be sure to replace the worm ladder in the base before restacking the feeding trays. The worm ladder helps the worms to move from the collection base into the upper processing trays.

If you notice creatures other than worms in your vermicomposter, do not be alarmed. *See A Living Ecosystem, page 34* for a list of worm bin creatures. Most are not harmful to your worms or the composting process and even help out!

Managing Moisture

Understanding the importance of proper moisture levels is critical to the successful functioning of the Worm Factory 360. Moisture affects the available oxygen which the worms need to breathe. It also affects the type of bacteria that thrive in the composter.

There are two types of bacteria active in a worm composter. It is important to keep these two types of bacteria in mind as you read this section.

Aerobic bacteria or bacteria that live in an oxygen rich environment

VS

Anaerobic bacteria or bacteria that live in the absence of oxygen

A properly maintained Worm Factory should not have any unpleasant odor.

In their essay *"Small-Scale School and Domestic Vermicomposting Systems"*, Rhonda Sherman and Mary Appelhof state that:

"People expect offensive odors when they start burying their food waste in a small earthworm bin. Most users express surprise that there is little to no odor." *(p. 75)*

The Worm Factory 360 relies on **aerobic** bacteria in a 'moist' bedding. **Moist bedding** has a spongy texture and a fresh earthy smell. Worms create tunnels as they work their way through the waste. The slime on their bodies seal the tunnels. Oxygen is then able to freely flow through the bedding allowing the worms to breathe through their skin. The design of the Worm Factory 360 also aids this flow of oxygen through the composter. The Worm Factory 360 is designed to "thermo-syphon" air, pulling air upwards through the trays, speeding up the compost process.

In contrast, wet bedding compacts. The browns and greens in the bedding will stick together forcing the oxygen out. The worms are not able to breathe so they seek somewhere else to live. Soon **anaerobic bacteria** take over because they can live in the absence of oxygen, causing an offensive smell.

As mentioned before testing moisture in your bedding can be done by doing a "squeeze" or "pinch" test.

Pick up a small bit of the bedding and pinch it between your index fingers and thumb or pick up several tablespoons of bedding into your hand and squeeze it. If a small amount of moisture is visible your bedding is **MOIST**. If on the other hand, you notice moisture dripping, your bedding is **WET**.

Wet bedding is probably the most common problem in the operation of your Worm Factory 360. Where does most of the moisture in your bedding come from?

Fruits and vegetables are 80% water. Feeding large amounts of these high-moisture foods (greens) and not enough paper (browns) can cause a worm composter to become too moist. As high moisture foods start to break down this water is released into the bedding. The dry brown material will absorb much of the waste if enough brown material has been added to the trays.

Again, it is recommended that 50% of the food you feed should be browns or bedding and 50% should be greens.

Dealing With Offensive Odors

If you notice offensive odors it should alert you to moisture problems. If you have done a squeeze test and determined that there is too much moisture in the bedding there are several ways this can be corrected.

To correct wet conditions, increase the amount of "browns" (dry bedding material) you are feeding. Add dry shredded paper, cardboard, egg cartons, dry leaves or dry coconut coir, which will help to soak up excess moisture.

You can also stop feeding high-moisture foods like fruits and vegetables until your composter becomes drier.

Again, we recommend keeping the spigot in the collection base area open at all times with the sprinkler tray underneath to catch the leachate.

Adding dry coconut coir will give you the quickest results. Coir will absorb the excess moisture, aerate the compost and it will not negatively impact the composting process.

Shredded paper will also work. This is not recommended because it will negatively affect the composting process. When adding shredded paper to a tray that is mostly composted material you will need to allow time for the paper to be processed by the worms. In extreme conditions, aerating or turning over the bedding in a tray that has become anaerobic will help add oxygen to the wet bedding.

Overfeeding can also generate anaerobic bacteria. If you are putting more food in the tray than the worms can process, the food will start to compact and smell. In this case you can remove some of the excess food or stop feeding until you see the worms are visible in the top of the feeding tray, actively working on the food that is already there.

If the smell is coming from foods that have a strong natural odor simply reduce the amount you are adding to the worm composter. Foods like this include cabbage or onions. To cut down on the offensive odor, cover the foods with dry material such as paper, leaves, or coconut coir.

Dry conditions, which can be a result of low air humidity or excessive browns in the bedding, can also be a problem although this is less common.

To correct a dry bin, you should always keep a moist newspaper cover *(see pg 9)* over the food and bedding in your feeding tray. The food under the moist paper cover should be **moist**. If you find that your worm bin is not moist enough, you can add more high-moisture foods and re-wet the moist newspaper cover. In very dry conditions, **very small** amounts of water can be poured on top of the contents of the feeding tray. The water will filter down to the lower trays. Be very careful when doing this. Leave the spigot open to allow any excess moisture to drain into the sprinkler tray. Too much water can cause bedding to compact creating offensive odors.

REVIEW: ***Too much moisture in your bedding will prevent the flow of oxygen and allow anaerobic bacteria to thrive. This will cause a noticeable offensive odor. Worms will not live in this environment. They cannot breathe without oxygen.***

Controlling Bedding Temperature

When composting worms are taken out of the soil and put into plastic containers it is important to keep in mind certain factors in order to keep your worms healthy and productive.

When keeping your Worm Factory 360 outside, place it in a protected location where there is good air movement. ***NEVER place your Worm Factory 360 in the direct sun or rain***.

When you see the word "temperature", this always refers to bedding temperature not air temperature unless otherwise noted.

The average bedding temperature over a specific defined period is referred to as the "**mean air temperature**". So if you have 12 hours at 80°F and 12 hours at 60°F the "mean air temperature" of the bedding for a 24 hour period would be 70°F.

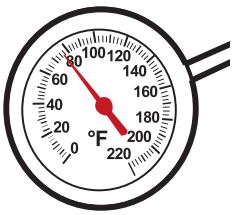
Bedding is slow to react to changes in temperature. If the air temperature reached 100°F during the day it would be unlikely the bedding temperature would be adversely affected. Similarly, if the air temperature dropped to 25°F at night the bedding temperature likely would still be okay. However, if extreme "**mean air temperatures**" persisted over a longer period of time the worms would require your attention.

Worms will die if frozen and in bedding temperatures over 90°F. This is why traditional outside composters seldom have large groups of composting worms.

Red wiggler worms survive in bedding temperatures between 35°F and 85°F. They will thrive in temperatures between 55°F and 75°F (12° to 24° Celsius). The closer the bedding temperature is to freezing the slower the worms will work. They will also slow down their reproduction rate.

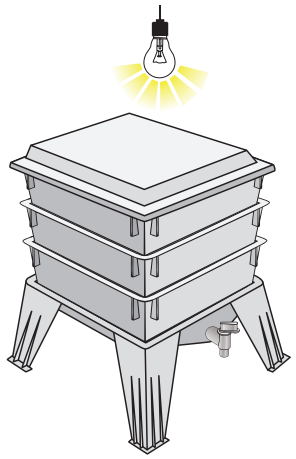
It is common for people to move their worm composters to an indoor location with warmer temperatures during the cold months of winter and to a cooler location during the very hot months of summer.

Use the soil thermometer included with your Worm Factory 360 to monitor the temperature of your bedding. If the bedding temperature is too cold, worms may congregate together in a ball that looks like ground hamburger meat. This is one way that worms react to stress. It is a natural reaction and a signal that the worms are cold and need to be moved to a warmer location.



There are several things you can do to keep your vermicomposter warm:

- **Feed** foods that are high in nitrogen; they generate heat as they break down. These include leafy greens, lentils, peas, tofu, broccoli/cauliflower, beans, oatmeal, and mushrooms.
- **Provide** a heat source. A small portable heater can be placed next to the composter or a low watt lamp can be placed over the composter to help warm it. The worms will naturally migrate toward the warmer food and bedding. Make sure the lid is on because worms are ***sensitive to light***. *See page 51 Insulating and Heating a Worm Composter.*



If conditions in your worm composter become **too hot**, worms will begin to migrate into lower trays where it is cooler. This mimics their response to a hot surface temperature in nature. **Never place your vermicomposter in direct sunlight.**

There are several things you can do to keep your vermicomposter cool:

- If your composter is outside in hot weather, make sure it is in a shady spot with plenty of air circulation.
- Make sure the bedding remains properly moist.
- To increase airflow through the trays and cool the compost, you can place pieces of wood no more than ¼" thick between trays, separating them. This works best at night, and if you find that you need more air movement, you can add a fan. Just be careful that conditions don't dry out.
- You can use ice in emergencies. Place ice cubes in the upper tray and cover with a layer of newspaper. The ice will melt and filter down through the lower trays, cooling them. Only do this in an emergency and be careful of your compost getting too moist. Leave the spigot open to release any extra liquid.

Stressed Worms

Worms become stressed for various reasons, including:

- Temperature extremes: too cold – under 40°F, too hot – over 85°F
- Sudden changes in barometric pressure
- Vibrations such as those from a dryer or refrigerator
- Exposure to light
- Movement to a new habitat (such as when they arrive in your bin)
- Moisture extremes: Too wet – bin smells, and worms migrate to upper trays
- Drastic change in food or feeding food worms don't like, feeding food with high salt content

Signs of stress include:

- Worms gather and form a ball – this is a protection mechanism
- Worms attempt to leave the trays or move into the collection base in large numbers
- A sudden decrease in worm population as worms die

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

- Bin is too wet and worms are drowning.
- Bin is too dry and worms dry out.
- Bin does not get enough air and worms suffocate.
- Worms do not get enough food.
- Worms were fed salty or offensive (a food they particularly dislike) food.
- The bin is exposed to extreme temperatures. The worms thrive in temperatures from 55°F to 75°F.

NOTE:

Dead worms decompose rather quickly. If you do not monitor the above conditions you can have a dead box of worms before you even realize it.

When Should You Harvest Your Worm Compost?

As your worms migrate into the upper feeding tray, the bottom processing trays will contain fewer worms and be filled with nutrient rich microbially-enhanced worm castings and bits of decomposed organic matter. Vermicompost is evenly granulated and is a dark coffee color. Worm compost contains minerals, enzymes, plant growth hormones, humus, and living organisms. *Refer to page 61 for a list of reference materials.*

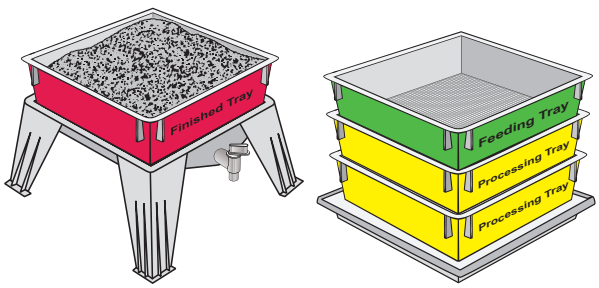
There is no exact point in time when the bottom processing tray is ready to be emptied, but it generally takes 3-4 months to complete the composting process. When the material is nearly black and the chunks of matter are small and crumbly, your worm compost is ready to harvest.

Over time you will have multiple processing trays working at one time. Your worm population should have increased, so you should be able to harvest compost about once a month, although this varies.

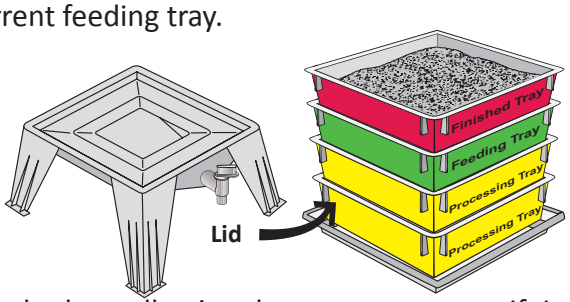
Establish a regular harvesting schedule to help prevent your finished vermicompost from going anaerobic (which smells bad). If finished compost is left too long in your system, it can become compacted and waterlogged and the lack of oxygen invites anaerobic bacteria to move in and create a stink. Harvesting compost regularly also ensures that the finer compost doesn't get into the holding tray and clog the spigot.

Compost Harvesting Steps

1 A good time to harvest the finished vermicompost is when the top "feeding tray" is full. Start by removing the lid and turn it upside down next to your Worm Factory 360. Remove all trays except for the finished tray on the bottom and place them on the lid.

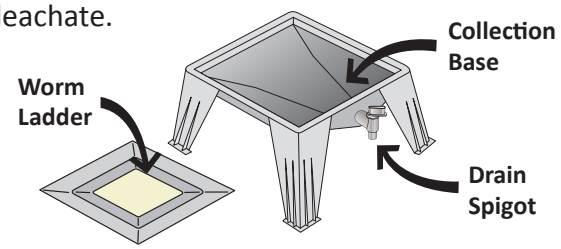


2 Remove the bottom (finished) tray and place it on top of the stack of trays on your lid. The finished tray should be directly on top of the current feeding tray.

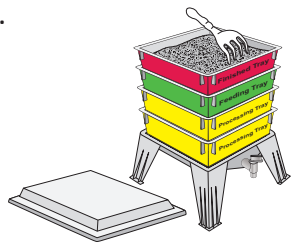


3 Check the collection base area to see if it needs attention. Worms sometimes gather in the collection base area. Drain your leachate if you have any. Remove any buildup of castings

or worms and put them in the feeding tray. Flush the spigot with water to ensure that it is not clogged. *See page 32* for tips on using leachate.



4 Replace the stack of trays on the collection base. The tray that was previously second from the bottom should now be on the bottom, and the finished tray should be on top, stacked on the feeding tray.



5 Leave the lid off, allowing light to shine on the tray of finished vermicompost. Worms do not like light and any remeaining worms will begin to migrate downward into the feeding tray below. Use your hands or the rake and spatula that came with your system to gently loosen the compost, pulling it away from the sides of the tray to the center, forming a hill or a pyramid. This exposes more surface to the light and will encourage the worms to migrate down faster into the lower tray.

The raking action will loosen and aerate the vermicompost. This will cause it to lose moisture and become lighter and fluffier. You do not want it to dry out! *See Pg 29, Storing Your Worm Compost*. Wait at least 30 minutes and then begin to scoop off the compost until you encounter worms. Repeat this process several times, always allowing time for the worms to move down into the lower tray.

After you have done this a few times most of your worms should have migrated down and the tray should be empty. It is now ready to reuse or set aside for later use. The empty tray is now in the correct position to become your next “feeding tray” and the “feeding tray” below now becomes a “processing tray”.

Storing Your Worm Compost

Vermicompost is a mixture of worm castings (worm poop), decomposed organic matter that did not pass through the worm, and partially decomposed organic matter that is still somewhat recognizable. In most situations, castings comprise the bulk of the material, usually around 70-80% of the total, depending on how the compost has been managed and how long the compost has been processed in the system.

The partially decomposed organic material in vermicompost continues to break down during storage. Placing actively decomposing organic materials in an airtight container encourages anaerobic organisms to take over, and form plant toxic by-products which can cause a foul smell. Allowing vermicompost to become too dry halts the decomposition and can cause the material to become impossible to re-wet.

If you store vermicompost it is best to first let it dry a little, so it is damp but not wet. This ensures sufficient air flow through the material to prevent anaerobic bacteria. Then, store your compost in a non-airtight container. Place a moist blanket of newspaper over the stored compost. Stored this way, the vermicompost slowly stabilizes in an aerobic environment and has a shelf life of more than three years.

Using Finished Vermicompost

Reduce your Impact, Recycle-

A worm composter can reduce the amount of household waste going into landfills by up to 30%.

As Shelley C. Grossman and Toby Weitzel say in *Recycle with Earthworms:* The Red Wiggler Connection,

"By diverting all or part of your kitchen, paper, and yard waste you will save landfill space and gain a valuable soil amendment. Recycling, composting, and vermicomposting are the logical steps to aid in our personal, local, national, even global ability to deal with our growing trash crisis." *(p. 2)*

5X NITROGEN **10X POTASH** **1.5X CALCIUM**

worm castings are *"50% higher in organic matter than soil that has not moved through worms...The benefits don't stop there. The worm's digestive enzymes (or, properly, those produced by bacteria in the worm's intestines) unlock many of the chemical bonds that otherwise tie up nutrients and prevent their being plant-available."*

(Lowenfels and Lewis, *Teaming with Microbes*, p. 87)

If you don't have a garden or planter pots, give your vermicompost to a friend to use! Composting is a great way to recycle household waste.

As a fertilizer-

Worm castings on average contain five times the available nitrogen, seven times the available phosphate, ten times the available potash, and one and a half times more calcium than found in average topsoil. The nutrients are water-soluble and are immediately available to plants. In addition, worm castings can be worked into the soil before planting, used as a side dressing or mixed into potting soil.

There are several ways to use your worm compost in a garden or planter.

- Because worms concentrate nutrients you can use castings as a fertilizer.
- Nutrients in worm castings are very stable and can replace "commercial" fertilizers in potting mixes.
- Worm castings will not burn plants so you can work castings into the soil before planting seeds or bedding plants.
- Worm castings can be used periodically as a top dressing around the base of plants.
- Worm castings can be used as an ingredient of potting soil.
- By soaking worm castings in water, you can also make a great liquid fertilizer.

As a soil conditioner-

- Worm castings stabilize toxins and the beneficial microbes in castings often reduce or eliminate harmful fungi and bacteria in the soil.
- Worm castings buffer soil by binding with and holding heavy metals in the soil. This prevents plants from absorbing more of these compounds then they need and releasing them later when needed.

In *The Worm Book*, Loren Nancarrow and Janet Hogan Taylor state that:

"Castings are food for other beneficial microorganisms. They will contain thousands of bacteria, enzymes, and remnants of plant and animal material that were not digested by the earthworm. The composting process then continues long after the casting is excreted, adding beneficial microorganisms back to the soil and providing a source of food for the ones already there. Some of these soil organisms release potassium, phosphorus, calcium, magnesium, iron, and sulfur into the soil ready for plant use." *(p. 4)*

- Humic acid in worm castings stimulates plant growth and development of beneficial micro flora populations in the soil.
- Worm castings increase the ability of the soil to retain water. They form aggregates or mineral clusters that combine to withstand water erosion and soil compaction.

Worm Castings "are vitally important in developing water stability, that property of soil which enables it to remain loose to accept and retain moisture for growing crops." **(Minnich, *The Earthworm Book*, p. 142)**

- Worm castings lockup acid-forming carbon in the soil which increases nitrogen levels in a form that the plant can easily use.

As a suppressor of plant pests and diseases-

- Worm castings discourage many plant pests and strengthen plants against diseases.

In *Vermiculture Technology*: Earthworms, Organic Wastes, and Environmental Management, Allison L. H. Jack states:

"The potential of vermicomposts to suppress disease in a variety of pathosystems has been extensively documented." *(p. 175)*

Use worm castings in planters or pots-

- Worm castings can be used as part of a total planting mix. A starting medium mixed with 5-10% of the mix of worm castings makes an excellent germination mixture and will ensure continuous, lush growth for about 3 months without adding any other plant food.
- Worm castings aren't harsh: they won't burn your plants.
- Worm castings suppress "damping off" in new seed starts.

Use worm castings in houseplants-

Side dress your houseplants by applying vermicompost around the base of the plant or make little holes in the soil and fill the holes with worm castings to get it closer to the root systems. The nutrients will soak into the soil when you water.

Leachate Vs. Worm Compost Tea

Keeping the distinction between these terms is important.

Leachate –

The liquid runoff that settles in or below the vermicompost or worm castings is known as leachate. Leachate can contain phytotoxins (toxins that can harm plants and humans). Some of these toxins are created by bacteria. Every worm composter has good and bad bacteria. This is ok of course, as long as the good ones outnumber the bad ones. Some leachate can contain harmful pathogens because it has not been processed through the worms intestinal tract. It should not be used on edible garden plants.

During decomposition, waste releases liquid from the cell structure. This liquid or leachate seeps down through the worm composter into the collection area. The leachate should be drained regularly and if you are getting more than 2-3 ounces of liquid in a week, your worm composter is probably too wet! We recommend leaving your spigot open with the sprinkler tray underneath to catch the leachate to avoid having it build up in your system. Just keep an eye on it to make sure your container doesn't overflow! *See* ***Managing Moisture in the Worm Factory 360*** *on page 25 to determine if you need to adjust the moisture level in your composter.*

While leachate can have value as a liquid fertilizer it should be treated with caution. For every story extolling the benefits of using leachate there is one lamenting the problems from having used it. If you decide you want to use the leachate we recommend taking some extra steps.

1. ***Do Not use if it smells bad! Pour it out on an area where it cannot harm living plants.***
2. ***Dilute it ten parts water to one part leachate (10:1).***
3. ***Aerate it with an air pump if available or stir it vigorously.***
4. ***Use it outdoors on shrubs, ornamentals or flowering plants only. DO NOT use on any edible plants you intend to eat.***

Worm Compost Tea –

Worm compost tea is known mostly for its ability to boost microbiological activity in soil by adding bacteria, fungi, actinomycetes, and protozoa to the soil. It is brewed by either soaking a porous bag full of worm castings in water or simply dumping the castings into a container of clean chemical free water. Molasses (a food source) may then be added to the water as a catalyst to stimulate growth of the microbes. Then, an air pumping system is installed to increase oxygen levels and create a healthy aerobic environment. The population of beneficial microbes will explode.

Worm compost used in making tea is like the starter you use in making yoghurt or the yeast you put in bread dough. The worm compost inoculates the tea with a diversity of beneficial microorganisms. These

Salter and Edwards state: ***"Direct foliar application of vermicompost tea provides nutrients that may be utilized directly by the plant while also introducing a diverse array of microorganisms that colonize leaf surfaces. An increase in scientific studies is showing this to be instrumental in the disease suppression capabilities of vermicompost teas."*** **(Edwards, Arancon, Sherman,** ***Vermiculture Technology*****, p. 160)**

beneficial microbes help the plants by occupying infection sites on the plants' root and leaf surfaces, out-competing any anaerobic or pathogenic organisms present.

Worm compost tea that is applied to the plants is absorbed more rapidly by the plant than worm castings, which are broken down and used over time. It has been proven that the worm compost tea, along with the castings, can significantly increase plant growth, as well as crop yields in both the short and long term.

Along with these great benefits come a boost in the plant's own immune system to be able to resist parasites like the infamous aphid, tomato cyst eelworm, and root knot nematodes. Plants produce certain hormones (like the jasmonic acid hormone) that insects find distasteful so they are repelled. Worm tea also helps a plant to resist diseases such as Pythium and Rhizoctonia.

When worm tea is sprayed on leaves and foliage, the bad disease-causing microbes are again outnumbered and cannot populate to the levels of taking over a single plant. The tea also aids the plant in creating the "cuticle", a waxy layer on top of the epidermis, or plant skin. This waxy surface protects the leaves from severe elements and reduces attacks by certain harmful microorganisms and insects.

Plants differ in their soil preferences. Some need a bacterial-dominated soil, others want a fungal-dominated soil, and still others like a soil that's somewhere in between.

To make fungally dominated vermicompost tea, feed larger amounts of cardboard and paper or organic materials that are high in carbon or considered "browns" to your worms. To make bacterially dominated vermicompost tea, use food waste, green plant waste or organic materials that are high in nitrogen or considered "greens" to your worms. **Always use only de-chlorinated water, rainwater, pond or distilled water for brewing.**

Brewing nutrients which are not necessary, can be added to the finished tea. To encourage the development of fungi in the tea, mix two parts humic acid, two parts yucca, saponin or aloe vera and one part fish hydrolyzate or other proteins into the water. For bacterial dominance, you'll feed one liquid ounce black strap molasses per gallon of tea and an equal amount of cold-water kelp. For the molasses, you can also substitute brown sugar, honey or maple syrup if you like.

Making organic worm compost tea involves several important steps: 1) choosing the right compost, 2) choosing the right nutrients 3) brewing and applying tea correctly. Our instructions are only meant to give you some background to tea making.

> ***"Since the path from bacterial to fungal domination in soils follows the general course of plant succession, it became easy to predict what type of soil particular plants preferred by noting where they came from. In general, perennials, trees, and shrubs prefer fungally dominant soils, while grasses and vegetables prefer soils dominated by bacteria."***
>
> **(Lowenfels and Lewis, *Teaming With Microbes,* p. 25-26)**

A Living Ecosystem

The Microbial Community

A vermicomposting tray is small, but it contains billions of organisms. These include: bacteria, protozoa, nematodes, fungi and molds.

These microbes are either swallowed with the earthworm's food or are already present in a worm's gut. They work hard to aid the digestion of the worm's food.

Earthworms actually lack the enzymes to break down much of what they eat, so they rely on these microbes to do it for them. It is the nutrients released by the bacteria that are absorbed into the worm's bloodstream as nourishment. Then the broken-down organic matter is excreted as a worm cast (and is teeming with microbes), and we can use it in our gardens.

> ***"A mere teaspoon of good garden soil, as measured by microbial geneticists, contains a billion invisible bacteria, several yards of equally invisible fungal hyphae, several thousand protozoa, and a few dozen nematodes."***
>
> **(Lowenfels and Lewis, *Teaming with Microbes*, p. 19)**

It is this incredible community of life that supports all gardening, agriculture and forestry in our world. By adding worm casts to this equation, you boost it and help it flourish. In this way, worm castings are the ultimate organic fertilizer. The opposite of chemical pesticides that poison everything in the soil in the name of abundant yields.

Bacteria are the most numerous organisms in the vermicompost system, and the primary decomposers of organic matter on earth. They work on organic material by secreting enzymes which break the bonds holding molecules together, thus simplifying and reducing the molecules to their component elements for absorption. As bacteria simplify the organic matter they make it available to earthworms and other organisms in the system as well.

> ***"The composting process continues after a worm casting has been deposited. In fact, the bacterial population of a cast is much greater than the bacterial population of either ingested soil, or the earthworm's gut."*** **(*Sherman* & Appelhof, *Worms Eat My Garbage*, p. 68)**

Actinomycetes are basically a higher form of bacteria which have several very notable characteristics. When you think of the smell commonly associated with fresh soil, that's actinomycetes you are smelling! When you think of all the wonderful benefits that are derived from humus, that's actinomycetes! They are crucial to the formation of humus. Often working very deep in the soil, actinomycetes convert dead organics into a type of peat, and also release various nutrients such as nitrogen and carbon, making it available for mixture into the topsoil. Since actinomycetes possess the ability to produce antibiotics, many other detrimental bacterial populations decrease as the number of actinomycetes increases.

Protozoa eat mineral releasing, nitrogen fixing microbes. The digested microbes, which are rich in amino acids and minerals, are excreted into the compost. Plants are then able to take up these nutrients from the soil. This is the basis for the production of chlorophyll in the leaf and for the duplication of DNA and protein chemistry basic to plant growth.

Molds and fungi are common organisms in a healthy worm system. Fungi are simple living organisms. Fungi are not classified as plant or animal, but are organized into their own group. The Kingdom of Fungi includes yeasts, molds, and mushrooms. They survive on energy which they obtain from the organic matter in dead plants and animals. They feed on decaying organic matter with tiny, hair-like hyphae, secreting enzymes which break down and simplify the organic material. They are also an additional food source to other organisms in the system, including earthworms. Mold is a good indicator of whether or not the feeding rate is adequate. Because mold and fungi grow most prolifically in still, quiet environments, large amounts of mold and fungi indicate there is more food than the system can quickly manage and the feeding rate should be decreased.

Mold and fungi pose no threat to the garden or the animals living in the worm bin, but can cause irritation to humans with mold allergies. If you are allergic to molds, your bin should be kept outdoors or in a garage or basement that is well ventilated to reduce or eliminate irritation.

Nematodes are very small, translucent, unsegmented roundworms that mineralize nutrients contained in bacteria and fungi. There are about 20,000 species of nematodes on the planet, and there will be several of them in your worm bin. They are mostly beneficial in your bin, eating bacteria and fungi and helping to break down the nutrients contained in those organisms to make them plant-available.

Arthropods

An **arthropod** is an invertebrate animal having an exoskeleton (external), a segmented body, and jointed appendages. Arthropods include insects, arachnids, crustaceans and other organisms. Soil arthropods are abundant small invertebrates that live in the soil and litter layer. Typical soil arthropods include mites, springtails, pseudo scorpions, and insect larvae. These soil arthropods can be important in controlling the rate of litter decomposition and altering nutrient cycling in your worm composter.

Amy Stewart offers some words of wisdom on worm bin creatures in *The Earth Moved:* On the Remarkable Achievements of Earthworms:

"Be prepared for a few critters to find their way into your bin no matter what you do. After all, the worms eat the microorganisms—bacteria—that occur in the bin as food scraps decompose. A few creatures that are large enough to be seen may also start to show up, and they are harmless additions to the system. Pill bugs—roly-poly bugs—are always attracted to compost piles and are considered a sign of good health in any composting system. Pot worms, or terrestrial enchytraeids, are often mistaken for baby earthworms. (Pot worms are white, but baby worms are reddish and faintly translucent.) The pot worms are closely related to earthworms and feed alongside them, causing no harm. A small population of fruit flies may be inevitable, although they are also harmless." **(P.204-205)**

Arthropods and other organisms you will find in your Worm Factory®360 are described below.

Potworms

Pot worms are small white worms commonly found in soil. They can develop into massive populations, especially in compost piles or in earthworm farms. They're scientifically known as enchytraeids (enn-kee-TRAY-ids) and are segmented relatives of the earthworm. They are often thought to be baby red wigglers, but baby red wigglers are reddish even when they are tiny.

The name “pot worms” comes from the fact they inhabit the soil in pots and containers. There is some unnecessary worry that overpopulation will choke out the worm population. That is typically not the case as pot worms and a host of other creatures, including those that cannot be seen except under a magnifying glass or microscope, reside peaceably with earthworms, often in great numbers.

Adults measure about a quarter of an inch, and can literally appear to be in the millions in comparison to your red wiggler worm population.

Pot worms feed on the same type of litter as earthworms and inhabit organic rich environments. They are efficient at aerating soil and breaking down just about any organic material. This species prefers an acid environment that is moist. Commonly they will spring up (seemingly out of nowhere) when lots of acidic materials are added to the bin, or when starchy materials are added and allowed to ferment. If the bin is too dry, they will die.

To keep potworm populations in check avoid feeding large quantities of acidic or starchy foods. You can also try enticing them with bread soaked in milk. They are attracted to the soaked bread and can be lifted out and destroyed in large batches.

Just as pot worms won’t harm other living worm species, they do no damage to living plants either. Pot worms feed on bacteria, fungi and dead organic matter. However, they have no enzymes for digesting these complex carbohydrates. They ingest small mineral particles and may play a role in mixing organic matter into the soil. Pot worms tend to congregate together under food. They are also known to prey on nematodes.

Earwigs

Earwigs are outdoor insects usually found under mulch, logs or dead leaves. They both need and are very attracted to moisture. Earwigs are rapid runners, and are easily identified by the prominent pincers on the end of the abdomen. The common earwig is a light, reddish brown flattened insect, up to one inch in length. Most species of earwigs are scavengers that feed on dead insects and decaying plant material. Some species are predators. Earwigs may try to pinch if handled carelessly, but are harmless to people. They are not harmful in a worm composter but may eat some of the earthworm feed.

Beetles

The most common beetles in compost are the rove beetle, ground beetle and feather-winged beetle. Feather-winged beetles feed on fungal spores, while the larger rove and ground beetles prey on insects,

worms, snails, slugs and other small animals. Rove beetles are the most common group of beetles found in composting bins. They are slender, elongated beetles with wing covers (elytra) that are much shorter than the abdomen; over half of the top surface of the abdomen is exposed. Their tail often bends upwards and they can be mistaken for earwigs. Most rove beetles are black or brown and are medium sized beetles; a few species are up to one inch long. Rove beetles are active fliers or runners. When they run they often raise the tip of the abdomen. Rove beetles don't sting, but can give a painful bite. They are found in or near decaying organic matter and feed on other insects such as fly maggots.

Beetles are not harmful in the worm composter.

Springtails

Springtails are tiny, wingless insects, usually white in color but may also be yellow, gray, red, orange, metallic green and lavender. They feed on mold, fungi, bacteria and decomposing plant material so they are harmless to earthworms. Springtails can "jump" about 75 mm. They have a tiny spring-like structure under their bellies that causes them to jump when disturbed. Springtails are most numerous in wet bedding, while numbers decrease as the bedding dries out.

Although they have on occasion been observed to eat dead or weak worms, springtails are primarily a nuisance because they eat the worm's food and can, when the populations are big enough, drive the worms deep into the beds and keep them from coming to the surface to feed. One deals with them the same way one deals with mites. (See below)

Mites

Mites are the most common insect to show up in your vermicomposter and play an important role in decompostion. Most worm composters contain several species of mites. Mites are small and are usually whitish brown to reddish brown in color. Most worm beds usually contain several species of mites. They tend to concentrate near the edges and surfaces of the worm beds and around clusters of feed. They are not known for attacking the earthworms but do eat the worm's food. When the mite population is too high the worms will burrow deep into the beds and not come to the surface to feed, which hampers worm reproduction and growth.

Mites can compete with the worms for available food if the population spirals too high. High mite populations usually result from:

- Feeding the earthworms overly moist food and vegetable refuse.
- Too much moisture. Keep the trays damp but not wet. *Review Pages 24 & 25 on Managing Moisture.*

Remember the same conditions that ensure high worm production will be less favorable to mites. If you find your Worm Factory 360 overrun by mites, cut back on water and feed. Add additional shredded

paper or coconut coir to absorb any excess moisture. Drain off any liquid that has collected in the base and check to make sure the spigot is not plugged.

Fruit Flies and Fungus Gnats

The worm bin is the perfect fruit fly and fungus gnat haven because both have a preference for organic matter and damp, moist conditions.

Fruit fly invasions are a fact of life in the worm composting world, and they can be unpleasant guests, but they are NOT harmful to your worms or the composting process. They are simply a nuisance. Fruit flies can be a problem year round but are especially prevalent in the summer and fall because they are attracted to ripened or fermented fruits and vegetables.

Fruit flies reproduce quickly and abundantly – each adult can lay 500 eggs in their lifecycle, which is about a week long. The eggs attach to the surfaces of fruits and vegetables, and that is how they travel into our homes. They have light brown heads and red eyes and reach about 1/8" in length.

Fungus gnats feed on and lay eggs in plants or rotting vegetable matter. They have black bodies and long, gangly legs. Gnats are usually encountered in warm, damp conditions flying around in small circles in groups called "ghosts."

See page 42 for further Reading– How to Deal with Fruit Flies and Fungus Gnats.

Centipedes

Centipedes resemble millipedes, but their bodies are more flattened and less rounded at either end. Centipedes have one set of legs per segment on the bodies and a pair of pincers which originate behind the head.

Centipedes are fast moving predators that will

kill worms and should be removed. The stingers behind their head possess poison glands that they use to paralyze small earthworms, insect larvae and small insects and spiders. The only way to control centipedes is to remove them by hand which should be done carefully. They will use the pincers to sting. Centipedes can be relocated to an outside garden area. They eat a lot of bad bugs so are considered a beneficial insect in the proper setting.

Millipedes

Millipedes have wormlike segmented bodies with each segment having two pairs of walking legs. Colors range from black to red, but those species

found in the worm bin are commonly brown or reddish-brown. Millipedes are vegetarians that break down plant material by eating decaying plant vegetation. They will roll up in a ball when in danger. They are harmless to earthworms. Millipedes move much more slowly than Centipedes and have a rounder body.

Sow bugs or Pill Bugs (isopods)

Sow bugs, also known as a "wood louse" are fat bodied crustaceans with delicate plate like gills along the lower surface of their abdomens which must be kept moist and a segmented, armored shell similar in appearance to an armadillo. They are brown to gray in color and have seven pairs of legs and two antennae. They move slowly, grazing on decaying vegetation. They shred and consume some of the toughest materials, those high in cellulose and lignins. Sow bugs are usually found in the upper areas of the worm composter where there is an abundance of unprocessed organic matter. They are highly beneficial in the worm composter but can harm young plants.

Pill bugs or "rolly polly bugs" look similar to sow bugs but roll up in a ball when disturbed. They belong to the crustacean family. They do not bite or sting or harm other plants or animals. Pill bugs require a moist habitat because they have delicate gill-like breathing organs that must be kept moist.

Slugs & Snails

Slugs and snails can be found in your vermicomposter. While they will not harm the worms they will eat any fresh kitchen waste in the composter. The biggest detriment is the eggs they lay. The eggs can be transferred into your plantings in the compost providing them with a meal of succulent young plants.

It is best to remove any slugs or snails you find immediately. If they become a problem you can make a slug trap as follows:

Cut several 1 inch openings in the sides of a clean, covered plastic container. Sink the container into the bedding of the top tray of the worm composter so that the holes are just above the level of the compost. Remove the lid and pour in ½ inch of beer or a yeast mixture of 2 tablespoons flour, ½ teaspoon baker's yeast, 1 teaspoon sugar, 2 cups warm water. The slugs will be attracted to the beer or yeast mixture, fall in and drown. Check the container regularly.

Ants

Ants are attracted to the food in the composting trays. They feed on fungi, seeds, sweets, scraps and other insects. Keep any food that is spilled in and around the worm composter cleaned up. The presence of ants is also an indication of dry bedding. If ants have begun to establish themselves in the worm composter you can discourage their presence by soaking the area where they are located with water and turning the bedding with a trowel or hand rake. They will usually go away.

One way to keep ants out of your worm composter is to put each of your bin's legs in a dish of water that has had a drop of dish soap placed in it to reduce the surface tension of the water. This prevents the ants from walking across the water. Most garden centers sell a sticky substance that will deter ants. It can be painted on the legs of your worm composter. It is eco friendly and does not contain any insecticide poisons. DO NOT use any insecticide on the actual worm bedding or you will kill your worms!

Most ants do not bother the worms. The exception is Fire Ants (see below). In nature ants benefit the composting process by bringing fungi and other organisms back to their nests. The work of ants can make worm compost richer in phosphorus and potassium by moving the minerals from one place to another.

Fire Ants

Fire ants are a variety of stinging ant. They can be distinguished from other ants by their copper brown head and body with a darker abdomen. They bit in order to latch onto your flesh with a barbed mandible and will sting repeatedly in a circular motion. The venom will burn and cause tiny blisters that persist for days if left untreated. They can quickly destroy your worm populations.

Blow Flies & House Flies

Blow flies and house flies are attracted by the smell of fresh or rotting meat, greasy food waste or pet feces. This is the perfect environment for them to lay their eggs. Their larvae or maggots feed on the

rotting waste or feces when they hatch. Blow flies are often metallic in appearance. House flies are commonly gray in color. Adults have yellow abdomens. Blowflies and house flies can spread disease. A properly maintained worm composter will not stink and therefore not attract blow flies and house flies.

If you have a problem with blow flies or house flies where you live, you can hang up fly strips, which will attract them away from the worm composter.

Soldier Flies

Soldier flies are true flies that resemble wasps in their appearance and behavior. Adult flies vary in color from black, metallic blue, green or purple, to brightly colored black and yellow patterns.

The larvae of the fly are a type of small maggot that feeds exclusively on decayed or rotting material. They are often found in worm composters but are not a real threat to the worms. They do not attack them or compete with them for food and may in fact complement the compost worm's activities. Like the vermiculture worms their feces make excellent compost. They can best be kept out of the worm composter by not using meat and fatty waste and by keeping the moisture on the dry side. Make sure that there is a good cover of bedding material over the feeding area.

These remarkable creatures, unlike the common housefly, do not spread bacteria or disease. In fact, the larvae ingest potentially pathogenic material and disease-causing organisms and thus render them harmless. Moreover black soldier flies exude an odor which positively discourages houseflies and certain other flying pests. When the larvae reach maturity they leave the feeding area to pupate. The adult fly is nocturnal and characterized by very fast and rather clumsy flight. It has no mouth and cannot bite or sting.

Soldier fly larvae are harmless to you, your worms and your plants. They are very good decomposers and, if allowed to stay in your vermicomposting system, will help to recycle your waste. Just be sure that your worms get plenty to eat as well. The soldier fly manure does make good worm feed, as well.

Larvae

Larvae are the immature form of an insect that undergoes some metamorphosis. Larvae are often reffered to as maggots. The most common type found in a worm composter are grey-brown and about 1/2" long. These are the larvae of the soldier fly, a large pretty, blue/black fly. These larvae are attracted to compost piles and to the worm bin, and will not harm you or your worms. In fact, they are good decomposers and, like the redworms, will produce a high quality casting.

If you haven't added animal proteins, and don't have any foul odors in the bin, then in all likelihood the maggots you are seeing will be soldier flies. Once your bin has soldier flies, it can be difficult to get rid of them. Your best tactic is to simply allow them to grow out of the larval stage (which they do quickly) and fly off. If you really can't stand them, you'll have to harvest the worms and get rid of all your vermicompost material (put it in an outdoor compost pile, or bury it in the garden). Then put your worms back into fresh bedding.

Flat Worms or Land Planarian

Land Planarians, also called Flatworms, are iridescent slimy worms, gray to brown in color, with dark stripes running down their back. They have a hammer or disk shaped head. Feeding and movement occur at night. Land Planarians thrive in high temperatures and require high humidity to survive. They hide in dark, cool, moist areas during the day. They are native to tropical and sub tropical areas and are thought to be dispersed with rooted tropical plants.

Land Planarians are cannibalistic. They eat slugs, insect larvae, each other, and **are a voracious predator of earthworms. They should be removed and destroyed as soon as you see them.** Smashing will not destroy them. They will grow back from small pieces. The best way to destroy them is to spray them with orange oil or bleach, or collect to dry out in hot sun.

How to Deal with Fruit Flies and Fungus Gnats

Destroy the Eggs

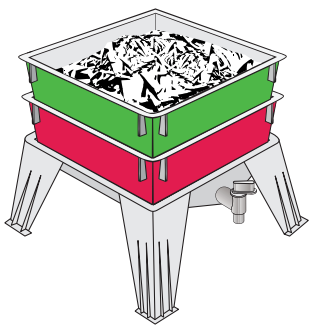
Prevention is the best strategy for dealing with fruit flies and fungus gnats. The goal is to reduce the chance of infestation.

- The eggs laid on fruit and vegetable peels are on the surface. Wash all produce well before peeling and adding to the worm composter.

- Microwaving waste for 2-3 minutes or freezing food before placing it in the worm composter destroys any eggs that exist in the food waste. Make sure the food has returned to room temperature before adding it to your composter.

Create a Barrier

- Add a layer of shredded paper and/or moist coir on the surface of your top feeding tray to help discourage adults from laying their eggs. This allows air and moisture to escape but thwarts the pesky flies.



- Add a tray on top of your feeding tray with just shredded paper or cardboard in it. This creates a barrier to fruit flies looking to lay eggs in your food scraps.

- Drape the worm composter with finely woven piece of cloth. This will stop the fruit flies from getting into the feeding tray and prevent any that are in tray from getting out.

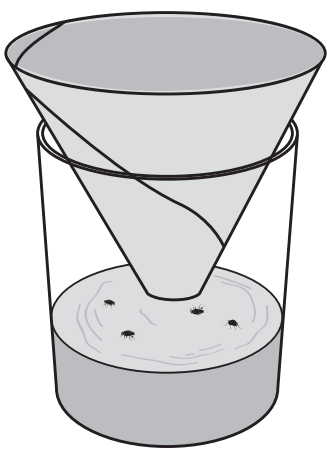
Eliminate an Infestation

If you already have a fruit fly infestation in your worm composter, here are some options for how to get rid of them:

- Sticky fly tape or sticky fly traps can help to control adult populations. Situate one close to your worm bin and the flies will get trapped.

- Build a fruit fly trap. This is a simple, effective tool for management, especially when used in conjunction with other methods. We recommend having a trap in operation near your worm bin at all times. By trapping the adults, you prevent them from laying eggs in your bin.

1. Place some apple or red wine vinegar (NOT white vinegar) in a container with a drop of dish soap to break the surface tension of the vinegar. Then, do one of the following:



2. Make a funnel out of paper that goes down into the container. Fruit flies are attracted to the vinegar, but once they touch it they cannot get back out and drown.

3. Put a Ziploc bag over the container. Do not seal the bag. The flies can fly underneath the bag to get in, but have trouble getting back out because of the weight of the bag.

4. Cover the container with saran wrap and secure with a rubber band. Punch small holes in the surface of the saran wrap. Flies go through the small holes and then have trouble escaping and drown in the vinegar.

NOTE:

Many people advise using banana peels and other fruit in fruit fly traps. The problem is that flies can continue to fly and breed in these traps. The advantage to the vinegar traps is that flies drown.

- Use a vacuum cleaner to suck up the flies as they emerge from your bin during feeding, or if they are congregating in another area of the house. The flies tend to cluster around windows and other light sources so that is a good place to look for them. It is possible for fruit flies to live inside the vacuum cleaner so use care when emptying the vacuum.

- Use a battery operated fly zapper. The key is to get one that is designed for small insects. This is effective in killing adult flies as they escape from the bin or congregate in lighted areas.

- Carnivorous plants can put a dent in your fruit fly population when set near the worm bin.

- Stop adding food scraps to the worm composter and feed them exclusively moistened shredded newsprint, paper, cardboard or egg cartons. There is nothing in the papers that will attract the fruit flies. When you are sure the files are gone, start adding food scraps to the trays again.

Bio-Controls

There are also various biocontrol organisms that will help deal with a fruit fly or fungus gnat population. A combination of several biocontrol methods seems to work to eradicate emerging fly populations, however the expense and complication of managing this method often renders it impractical.

- A bacteria called *Bacillus thuringiensis* can be applied as a soil or compost drench to help kill off larvae.

- Another method is a predatory mite called *Hypoaspis miles* that eats gnat and fly larvae.

- Predatory nematodes called *Steinernema spp*. also kill larvae.

- Neem is an organic oil found in many garden centers that can be sprayed to control pests in and around the garden. This should be used only when you have an extreme infestation because it has some negative effect on the beneficial organisms in the bin, but it does not harm the worms.

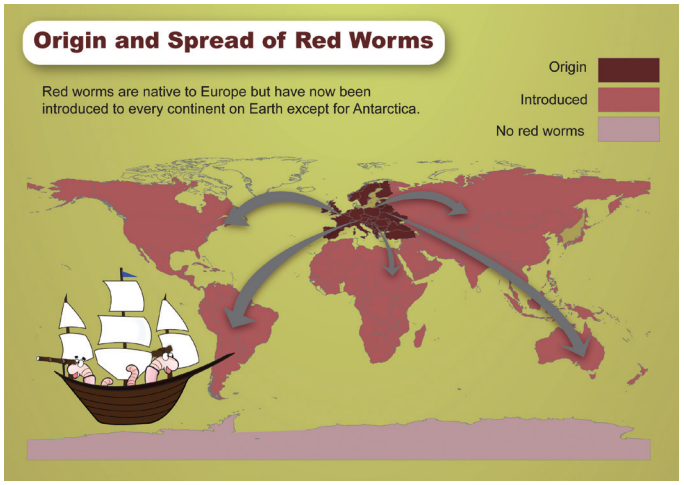
About Worms

Most of us are unaware and perhaps do not appreciate how important worms are. They are vital to the development and function of the soil. The ancient Greeks considered them to be 'the intestines of the soil'.

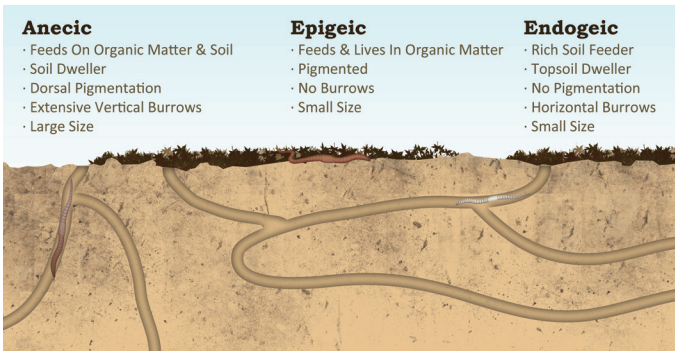
> ***"Worms are ruminators. They sift through whatever surrounds them, turn it over, explore it, move through it. They are deliberate creatures, in no great hurry, but always in motion, twisting and burrowing, shrinking and contracting and eating. They spend their lives in a kind of active mediation, working through the detritus in which they live, the bits of leaves and grass and particles of soil for a being with such a simple brain, a worm seems, in this way, almost thoughtful."***
>
> **(Stewart, *The Earth Moved*, p. 148)**

Types of Worms

There are about 7,000 species of earthworms on our planet. They are present in soil everywhere except for the harshest desert and arctic regions. Many of these species originated in the Middle East, Europe, and Asia and have since been introduced to the Americas and islands around the world.



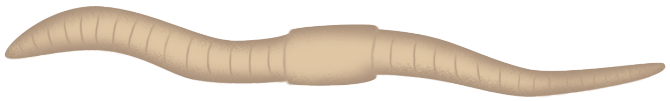
Earthworms can be separated into three major groups based on their **burrowing** and **feeding** habits. All three groups play important roles in the soil food web but only one group makes good composting worms.



Endogeic worms live in the deeper soil layers and mineral horizon of the upper layers of soil. They ingest mineral soil and digest the organic material and microorganisms found there. They make complex horizontal burrow systems that are very important for aerating soil and allowing moisture and nutrients to move through the soil.

> ***Amy Stewart informs us that:***
>
> ***"many endogeic species inhabit the rhizosphere, the area immediately around plant roots, where they feed on soil that has been enriched by decaying roots, bacteria, and fungi."*** **(Stewart, *The Earth Moved*, p. 27)** *See illustration above.*

Endogeic worms are probably the least recognizable to most people since they very rarely come to the



surface. These worms are medium-sized and pale in color and **are not suitable** for worm composting.

Anecic worms build permanent, **deep vertical burrows**, up to 6 feet deep, and rise to the surface at night to search for food. They feed on fresh surface litter and often pull leaves or other decaying matter into their burrows to feed. They also eat soil. Anecic worms often leave little mounds of castings alongside or atop the opening of their burrows and are important for aerating the soil and helping with water retention.

These large worms have long lives – sometimes up to six years. They mature and reproduce slowly and require stable burrows and a low population density to survive. Anecic worms **are not suitable** for worm composting but are great for fishing bait.

The third group of worms are the ones we are most interested in. These are the composting worms!

Epigeic worms are surface dwellers and feed **only on decaying organic material.** They will not survive in most garden soils unless there is a good layer of organic matter on top. Because they are not powerful burrowers, they prefer to live in loose organic litter, like fallen leaves, or very loose topsoil rich in organic matter.

Because epigeic worms live on the very surface of soil, they are better able to withstand temperature and moisture fluctuations than other worms.
Epigeic worms create castings that are many times higher in nutrients than the material they originally consumed, and are a vital part of the soil food web.

For your vermicomposter, we recommend using the epigeic worm ***Eisenia fetida***, or red wiggler, also known as manure worms, trout worms, tiger worms, or compost worms.

Small and reddish-brown, they are perfect for worm composting because their natural habitat can be duplicated in a worm composting bin.

- They reproduce at a high rate in ideal conditions.
- They are happy to live in high-population density situations.
- They are able to handle fluctuating temperature and environmental conditions.
- They are voracious eaters, consuming up to half of their body weight in decaying organic matter per day.
- Red wiggler worms are tolerant of handling by humans.
- They have a very wide range of potential foods.

There are several other epigeic worms that are good for composting.

Lumbricus rubellus, or redworm, is very similar to the red wiggler in size, feeding and habitat preferences, and suitability for composting.

Eisenia hortsenis, or European nightcrawler, is also known as the Belgian, Super Red, Carolina Crawler, Giant Redworm, ENC and Blue Worm. These are larger than *Eisenia fetida* and live deeper in a worm composting bin. They reproduce more slowly than the *Eisenia fetida*.

Eudrilus eugeniae, or African nightcrawler, which is even larger than the European nightcrawler and is good for fishing. It cannot handle extreme cold, disruption of its environment, or being touched very much.

Perionyx excavatus, also known as Malaysian Blue Worm or Indian Blue Worm, is thinner and faster than the *Eisenia fetida* and has an iridescent blue sheen. It is a tropical species not suitable for conditions in most of North America (Hawaii excepted). In hot, tropical weather, *Perionyx excavates* has been known to invade worm composting systems and drive other species of worms out.

For sources of composting worms, visit www.FindWorms.com.

Worm Biology

Understanding the biology of a worm will help you to understand how worms create compost. Knowing what food is best for them and how to maintain their living environment will help to avoid possible problems. This will result in a successful worm composting experience.

Amy Stewart recognizes the beauty and strength of worms:

"They [worms] are clean, quiet, well-behaved creatures, interesting to watch, and even beautiful in the way that any organism can be if you know just how to look at it. Put a worm in your hand and watch it expand each segment in turn, arch its back, flex its muscles. You will be won over. Lift up the top layer of food and newspaper in your bin and you will surely be awestruck at the spectacle of such industry taking place…: thousands of worms churning through your apple cores and coffee grounds, your newspaper and dryer lint, taking it all and turning it back into earth." *(The Earth Moved, 205-206)*

Structure

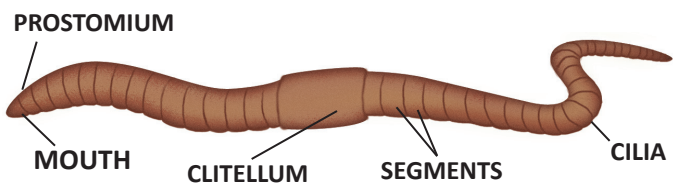
Earthworms are cold-blooded, and they remain cool because they are always moist (think of it like humans sweating to stay cool). They breathe through their skins through osmosis. Oxygen is taken in through the body wall, introduced into the blood, and circulated throughout the body. Staying moist is vital to this process. There is a film of mucus on the worm's skin that helps it to hold moisture, lubricates the worms' pathways through soil, cements the walls of burrows and is vital to the reproductive process.

Because worms live below ground, or at least underneath a layer of litter, they have no need for eyes. They also have no ears, teeth or limbs. They are streamlined to move beneath our feet sensing vibration, light and movement.

Worms have segments called 'somites.' Larger worms have more segments than smaller worms. Each segment is heavily muscled. The segmented structure of a worm allows it to push through dense soil, lift sticks and rocks and move with agility. Along each segment there are tiny bristles called 'setae 'or cilia.

Adult Red Worm (*Eisenia fetida*)

Anterior (Front) Posterior (Back)



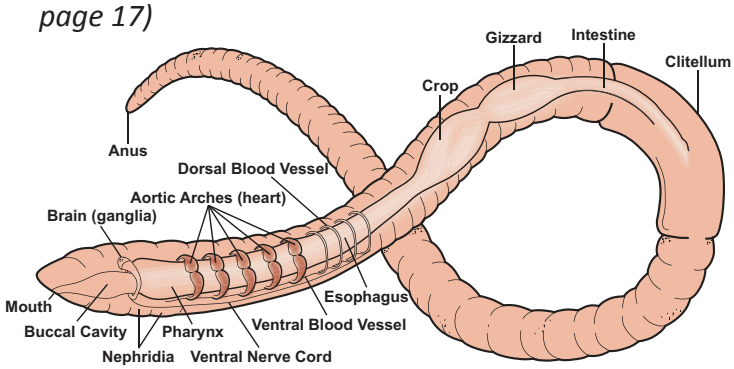
The 'setae' help the worm to move, to stay put in the ground when a robin or person is trying to capture it and to hold onto another worm while mating.
Worms have five "hearts" that are vessels between

the intestine and the body wall. These vessels direct blood through two major blood vessels that run on the top and the bottom of the worm's body. There are minor vessels and capillaries that carry blood to all parts of the worm's body, much as ours do.

Digestion

Because worms have no teeth or stomach and very few digestive fluids, they depend on bacteria, fungi, molds, nematodes and other organisms to break down the fibers and predigest their food. Worms can survive on any organic matter, including cellulose, wood fibers and starches.

Worms are separated into two main parts. The front of the worm where the "head" is located is called the **anterior**. The rear portion of the worm is called the **posterior**. The mouth of a worm is in the first section of the anterior, and is overhung by a "lip" called the prostomium. This helps to guide food into the mouth, or push aside objects that are too big to eat. After a worm brings a piece of food or soil into its mouth, it enters the buccal cavity, where there are taste cells. Worms have shown strong preferences and dislikes for various foods. *(For information on which foods to feed your composting worms, see page 17)*



Next, food enters the pharynx, which is kind of a suction pump, drawing food from the mouth into the esophagus. From the esophagus, the food moves through the crop to the gizzard. Worms have gizzards like birds, which powerfully contract to grind food for further digestion.

After the gizzard comes the intestine. This is where most of the digestion and absorption takes place. Micro-organisms in the worm's gut help it to break down food into water-soluble nutrients, which, when they are excreted, make for excellent plant food. The end product of the digestive process is a worm cast. Worm casts are the main ingredient in vermicompost.

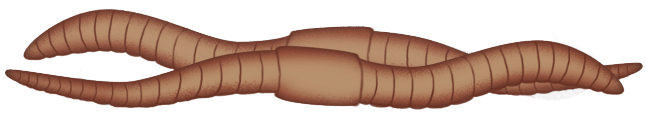
Nervous System

In each segment of the worm's body, a nerve cord enlarges into nerve cells and forms a ganglion. Pairs of these ganglia are basically the worm's "brain", from which impulses are given off to other parts of the body. The central nervous system then transmits impulses on nerves that coordinate muscle action, reaction to light and moisture sensation.

Worms have cells scattered on their skin, particularly toward the anterior, which detect light. These cells are particularly sensitive to blue light but have trouble detecting red light. These cells help worms stay out of UV light rays, which can kill them very quickly. Worms have a very sensitive sense of touch, which helps them to find other worms to mate with, avoid danger, and find food.

Reproduction

Earthworms are hermaphrodites. This means that each worm possesses both male and female sexual parts. However, they are not self-fertilizing. Two worms are needed in order to reproduce and they can't mate across species. The sexual organs are located in the anterior part of the worm. Two worms of equal length lie with the undersides of their bodies together, their heads pointing in opposite directions and their clitellums touching.



The male organs on one worm line up with the female organs on the other. Mucus is secreted around the clitellum of each worm and this makes for the safe transfer of sperm between them. It also helps the worms cling to one another, along with the setae.

Worms separate from each other after a few hours, but fertilization of the eggs does not happen immediately. The eggs and sperm are held together in mucus formed on the clitellum, and the mucus begins to harden. The worm wriggles backwards, with the mucus in a ring around it, until the mucus containing the eggs and sperm finally slides off the front of the worm, and in doing so, seals itself.

This is the worm cocoon. Sizes vary based on the species of worm, but it will not be much wider than the worm that produced it. It is lemon shaped and brownish or dirty yellow in color. When the cocoon is separate from the worm, fertilization finally takes place. That is, if conditions are ideal. If it is too hot too cold or too wet or too dry, the sperm and eggs can stay separate inside the cocoon for months before fertilization.

A few days, weeks, or months after fertilization, depending on the species of worm, the cocoon hatches one to six baby worms. Worms do not have a larval stage. When the baby worms hatch, they are about half an inch long and light red in color. Parent worms do not nurture their young. The babies are on their own as soon as they are born.

Under ideal conditions, your *Eisenia fetida* worms can double in population every 90 days. If the worms aren't happy with their environment, they will not reproduce. The average incubation period for worms is between 30 and 80 days, depending on environmental conditions. Once the new worms hatch, it will take 8 to 10 weeks for them to become sexually mature and begin producing cocoons themselves.

Your worm population should double every 3 to 4 months, as long as they have adequate space, food, moisture, and bedding temperatures are between 60° and 80° Fahrenheit (15° - 27° Celsius). The baby worms in the cocoons will not mature and hatch if the bedding is too cold. However, cocoons are viable for long periods of time and will hatch baby worms when bedding temperatures become warmer.

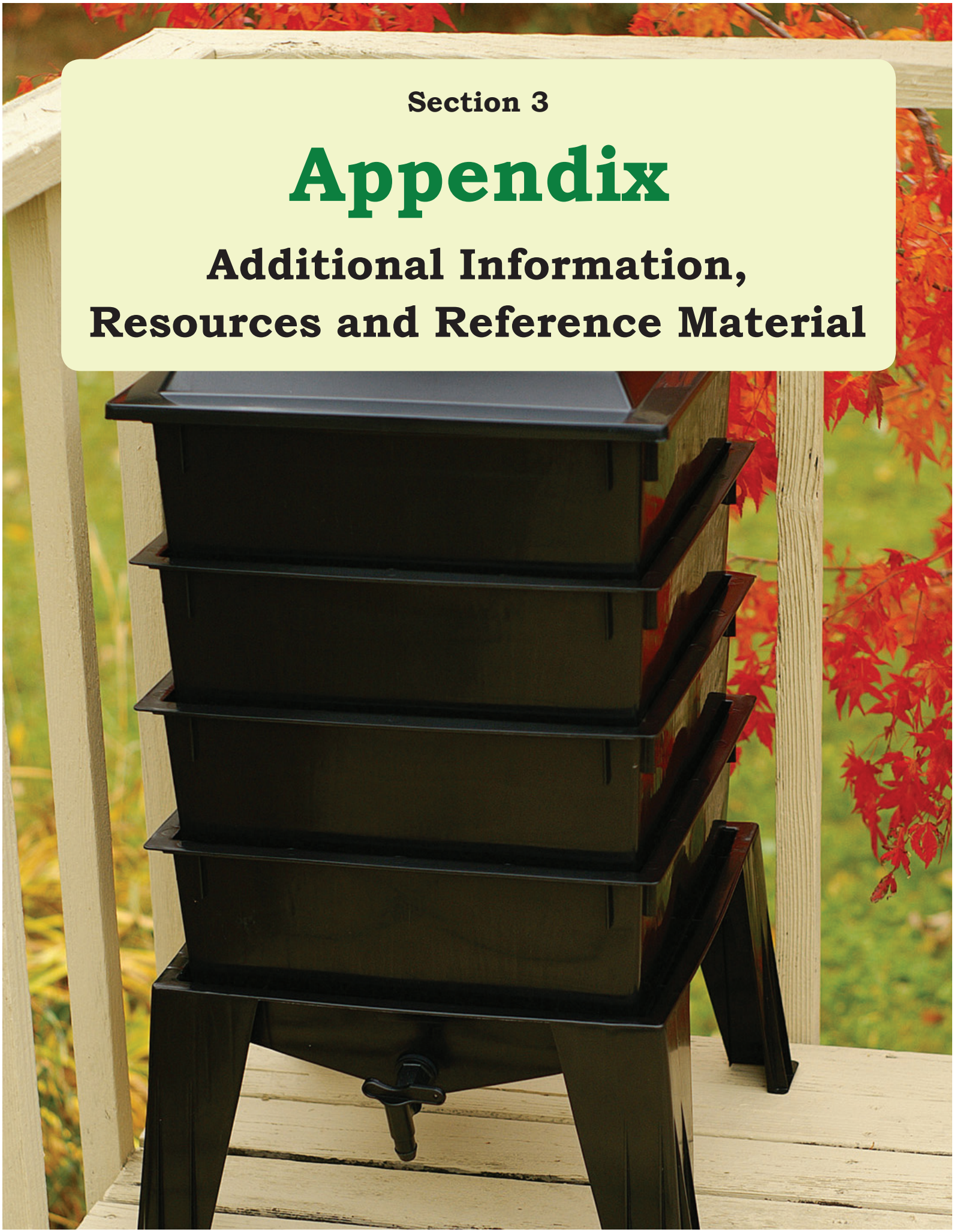
Worms self-regulate their population. This means that they hold off on reproduction unless they have sufficient food, space and the correct environment to support their offspring.

A wonderful resource for worm biology is *The Earthworm Book:* How to Raise and Use Earthworms for Your Farm and Garden, by Jerry Minnich, pages 5-16.

Section 3

Appendix

Additional Information, Resources and Reference Material



How to Fatten Worms for Fishing

1 ***Feed your worms lots of green vegetables. Limit starches and highly acidic fruits and vegetables.***

2 ***Make a power snack.***

- Place 12 rinsed & dried eggshells into a blender and pulse until they are a powder.
- Add 2 cups oatmeal and 1 cup cornmeal, each in small amounts, continuing to pulse until the ingredients are mixed.
- Sprinkle the dry mixture over the top of the worm bin. Spray down this mixture with water using a spray bottle. Place a thin layer of shredded newspaper on top and spray this down, too.
- Repeat this as desired every few days.

What To Do If You Go On Vacation

Worms do not need to be fed every day. How much you feed will depend on how many worms are in your system.

When leaving for a few days you can add enough food to last for several days. If you are planning to be gone for an extended period of time, say several weeks, you need to consider the amount of food the worms will need and how to handle any moisture runoff so that the bedding doesn't get too wet. Worms will reprocess the material in the trays so it is possible to go away for several weeks without any attention or additional food.

If you plan to be gone for an extended period of time (several months) it would be a good idea to make arrangements with someone to check on your worms after 30-45 days and periodically thereafter. They should be briefed on basic care instructions and provided with food packets that have been made up in advance and frozen. Place the sprinkler tray that came with your Worm Factory 360 under the spigot. Leave the spigot open to collect any leachate. A large can or plastic container that fits under the spigot will also work. Have additional bedding (shredded paper/coconut coir) available should they need it.

Insulating and Heating a Worm Composter

This is only practical in specific weather zones: If your winter weather is above freezing most of the time, only occasionally drops below freezing, or does not go below 32°F for more than a few days at a time. The worm composter should be placed in an area that is protected from wind and rain.

It is **NOT** for winter weather that will stay below freezing for 5 or more days in succession. Under those weather conditions you should bring your worms inside. **Remember worms will die if the bedding freezes.**

Purpose: As temperatures approach freezing, worm activity and the compost process comes to a stop. Worms are cold-blooded so their bodies adjust to the temperature of their environment. Using a small heater and insulation can raise the temperature of your bedding as much as 10 to 20 degrees, increasing worm activity. Insulating the worm composter is of no benefit unless you provide a continuous heat source.

There are different ways to raise the temperature of the worm composter in winter. What works depends largely on how cold the temperature is where the composter is located.

How To Make An Insulating Blanket

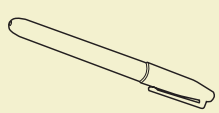
You can make an insulating blanket from bubble or foam packing material that has a foil cover. It should fit over the top, covering the lid and trays. It can then be easily removed when tending to the composter. You want it to fit loosely to allow for air flow. A piece of rigid foil covered insulation can also be used under the composter to insulate against cold concrete floors. This works best if used with a heater.

Parts:

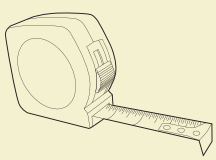
5 pieces of foam core poster board cut to size as follows: 4 - 18” x 24” core poster board for the sides. 1 - 18” x 18” core poster board for the top

1 sheet of bubble insulation large enough to cover core poster board or purchase foam packing material that has a foil cover and cut to size.

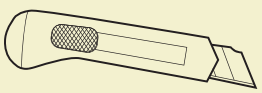
Tools:



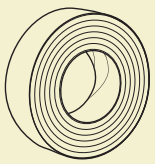
Marker Pen



Tape Measure



Cutting Knife



Duct tape

Instructions

1. Cut poster board to size if needed.
2. Tape the 4 large pieces of poster board together both inside and out forming the sides of the box.
3. Then tape the top of the box sides.
4. Tape the bubble insulation to the poster board box covering all 4 sides and the top. Wrap the bubble insulation so that any seams wrap at least 2 inches around the corners. This will help to reinforce the box, making it stronger.
5. Cut a small ¼ - ½ inch x 1 inch slit in the lower edge of one side for the cord.

How To Build A Heater

1. Purchase a small aquarium 110 volt heater that will fit inside of a one quart canning jar. Make sure you use a canning jar which is made of tempered glass. A common glass jar could easily crack.
2. Place the heater in the jar and fill it with moistened garden sand (no salt).
3. Line an empty tray with paper to prevent the sand from falling down into the collection base. Place the jar in the tray and fill the tray, covering the jar, with more moistened garden sand. The cord will hang over the side of the tray. The sand will allow moisture to move down through the tray to the collection area below and will spread the heat evenly through the sand.
4. Conduct a safety test for at least 24 hours using the tray you just made. Use a thermometer to check the temperature of the sand. The sand should never be above 70 degrees.
5. Remove the feeding and processing trays from off the base. Place the tray with the jar, heater and sand at the bottom of the worm composter just above the collection base. Replace the feeding and processing trays.
6. Monitor the temperature of the trays for several days and periodically thereafter, to insure the composter does not get too warm. *See Page 26, Controlling Bedding Temperature*. Some worms may move into the sand and you may have to remove them. They will be OK as long as the sand is moist.

Care should always be taken when handling electrical apparatus around liquids and should be tried at your own risk.

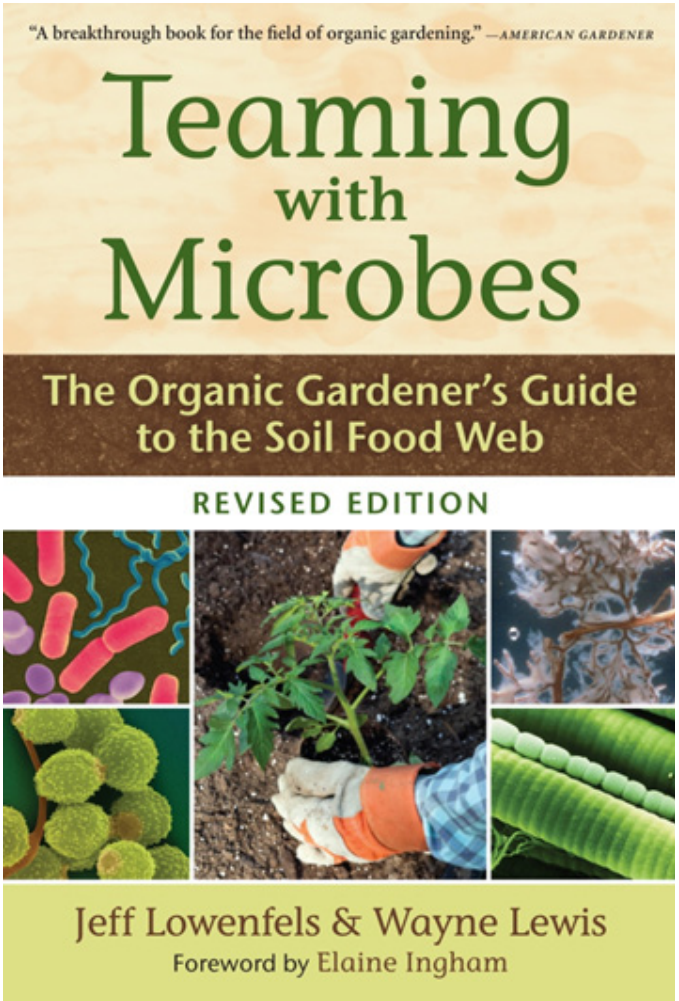
Teaming with Microbes

By Jeff Lowenfels & Wayne Lewis

Jeff Lowenfels has had a weekly column in the Anchorage Daily News for over 27 years and hosted Alaska public television's most popular show, Alaska Gardens with Jeff Lowenfels.

For the last 30 years, Jeff has lived in Anchorage, Alaska, where he founded Plant A Row for The Hungry, an active program that created over 14 million meals to feed the hungry in 2005.

A popular national garden writer and leading proponent of gardening using the concepts of the soil food web, Jeff is the former president of the Garden Writers of America and was made a GWA Fellow in 1999. In 2005, he was inducted into the GWA Hall of Fame, the highest honor a garden writer can achieve.



To obtain your copy of Jeff Lowenfels' *Teaming with Microbes*, please visit: naturesfootprint.com/teaming-with-microbes

Excerpt from *Teaming With Microbes*

We were typical suburban gardeners. Each year, at the beginning of the growing season, we carpet bombed our lawns with a mega-dose of water-soluble, high nitrogen fertilizer and watered like crazy; then we strafed their weeds with a popular broadleaf herbicide. Next, we attacked our vegetable gardens and flower beds with a bag or two of commercial fertilizer and leveled them with a rototiller until the soil, the color and texture of finely ground coffee, lay as smooth and level as the Bonneville Salt Flats. These things we did religiously, as did most of our neighbors. Once was never enough either. We continued to use chemical fertilizers throughout the season as if we were competing in the large-vegetable contest at the Alaska State Fair—and at the end of the season, we rototilled again, for some inexplicable reason.

When necessary (and it often was), we would suit up into protective clothing—complete with rubber gloves and a face mask—and paint our birches to protect them from invading aphids by using some god-awful smelling stuff that listed ingredients no normal person could pronounce, assuming he or she took the time to read the incredibly small print on the chemical's label. Then we sprayed our spruce trees with something that smelled even worse—something so strong, one application lasted not one but two years. It was a good thing we did protect ourselves, as both spray products are now off the market, withdrawn as health hazards.

Don't misunderstand us. At the same time we were also practicing what we considered to be an "appropriate" measure of environmental responsibility and political correctness. We left the grass clippings on the lawn to decompose and tilled fallen leaves into the garden beds, and occasionally we let loose batches of lacewings, ladybird beetles, and praying mantids—our version of integrated pest management. We composted. We recycled our newspapers and aluminum cans. We fed the birds and allowed all manner of wildlife to wander in our yards. In our minds we were pretty organic and environmentally conscious (if not downright responsible). In short, we were like most home gardeners, maintaining just the right balance between better living with chemistry and at least some of Rachel Carson's teachings.

Besides, we were mostly using water-soluble, high-nitrogen fertilizer. How bad could that be for the environment? It sure made the plants grow. And we really employed only one weed killer, albeit a nonselective, broadleaf one. Okay, we occasionally resorted to an insecticide too, but when we considered what was on the shelves of our favorite nurseries, these didn't amount to much in our minds. Surely we couldn't be causing harm when we were only trying to save a spruce, help a birch, or prevent noxious dandelions and chickweed from taking over the world?

Central to the way we cared for our gardens was a notion shared by tens of millions of other gardeners and, until you finish this book, perhaps you as well: nitrogen from an organic source is the same as nitrogen from an inorganic one. Plants really didn't care if their nitrogen and other nutrients came from a blue powder you mixed with water or aged manure. It is all nitrogen to them.

Then….we stumbled upon the work of Dr. Elaine Ingham, a soil microbiologist famous for her work with the life that resides in soil and, in particular, who eats whom in the soil world. Since some organisms eat from more than one food chain or are eaten by more than one type of predator, the chains

are linked into webs—soil food webs. Ingham, an excellent teacher, became our guide to the whole world of complex communities in the soil.

Naturally, we begin to wonder what other heretofore-unseen things were going on down there in the soil. Might the world revealed to us by tools like the electron microscopes affect how we care for the plants in our gardens, yards, and lawns? We have all been dazzled by Hubble images of deep space, incomprehensibly far away, yet few of us have ever had the opportunity to marvel at the photographs produced by a scanning electron microscope (SEM), which provide a window to an equally unknown universe literally right under our feet.

We looked for answers, and soon realized that while we were out spreading fertilizer and rototilling our garden beds by rote, an ever-growing group of scientists around the world had been making discovery after discovery that put these practices into question. Many scientific disciplines—microbiology, bacter-iology, mycology (the study of fungi), myrmecology (the study of ants), chemistry, agriculture—came together in recent decades to focus jointly on understanding the world of soil. Slowly, their findings about what goes on in the soil are being applied to commercial agriculture, silviculture and viniculture. It is time we applied this science to things we grow in our home yards and gardens.

Most gardeners are stuck in traditional horticultural land, a place where a blend of old wives' tales, anecdotal science, and slick commercial pitches designed to sell products dictates our seasonal activities. If there is any understanding of the underlying science of gardening, it is almost always limited to the soil's NPK chemistry and its physical structure….Since chemical fertilizers kill the soil microorganisms and chase away larger animals, the system we espouse is an organic one, free of chemicals.

What makes this book different from other texts on soil is our strong emphasis on the biology and microbiology of soils—relationships between soil and organisms in the soil and their impact on plants. We are not abandoning soil chemistry, pH, cation exchange, porosity, texture, and other ways to describe soil. Classic soil science is covered, but from the premise that it is the stage where biology acts out its many dramas. After the players are introduced and their individual stories told, what evolves is a set of predictable outcomes from their interrelationships, or lack thereof. In the second half of the book, these outcomes are formed into a few simple rules, rules that we've applied in our yards and gardens, as have many of our neighbors in Alaska, where we initiated these new practices. So have others, throughout the Pacific Northwest in particular, but in other parts of the world as well. We think that learning about and then applying soil science (particularly the science of how various forms of life in the soil interrelate—the soil food web) has made us better gardeners. Once you are aware of and appreciate the beautiful synergisms between soil organisms, you will not only become a better gardener but a better steward of the earth. Home gardeners really have no business applying poisons, and yet apply them they do, to the food they grow and eat (and worse, feed to their families) and the lawns on which they play.

We now know not all nitrogen is the same and that if the plants and the biology in the soil do their jobs, gardening becomes much easier and gardens much better. May your yard and your gardens grow to their

natural glory. We know ours now do….

Given its vital importance to our hobby, it is amazing that most of us don't venture beyond the understanding that good soil supports plant life, and poor soil doesn't. You've undoubtedly seen worms in good soil, and unless you habitually use pesticides, you should have come across other soil life: centipedes, springtails, ants, slugs, ladybird beetle larvae, and more….Good soil, however, is not just a few animals. Good soil is absolutely teeming with life, yet seldom does the realization that this is so engender a reaction of satisfaction.

In addition to all the living organisms you can see in garden soils (for example, there are up to 50 earthworms in a square foot of good soil), there is a whole world of soil organisms that you cannot see unless you use sophisticated and expensive optics. Only then do the tiny, microscopic organisms—bacteria, fungi, pro-tozoa, nematodes—appear, and in numbers that are nothing less than staggering. A mere teaspoon of good garden soil, as measured by microbial geneticists, contains a billion invisible bacteria, several yards of equally invisible fungal hyphae, several thousand protozoa, and a few dozen nematodes.

The common denominator of all soil life is that every organism needs energy to survive. The first order of business of all soil life is obtaining carbon to fuel metabolism—it is an eat-and-be-eaten world, in and on soil.

Most organisms eat more than one kind of prey, so if you make a diagram of who eats whom in and on the soil, the straight-line food chain instead becomes a series of food chains linked and cross-linked to each other, creating a web of food chains, or a soil food web. Each soil environment has a different set of organisms and thus a different soil food web….

Most gardeners think of plants as only taking up nutrients through root systems and feeding the leaves. Few realize that a great deal of energy that results from photosynthesis in the leaves is actually used by plants to produce chemicals they secrete through their roots. These secretions are known as exudates. A good analogy is perspiration, a human's exudate.

Root exudates are in the form of carbohydrates (including sugars) and proteins. Amazingly, their presence wakes up, attracts, and grows specific beneficial bacteria and fungi living in the soil that subsist on these exudates and the cellular material sloughed off as the plant's root tips grow. All this secretion of exudates and sloughing off of cells takes place in the rhizosphere, a zone immediately around the roots, extending out a tenth of an inch, or a couple of millimeters. The rhizosphere, which can look like jelly or jam under the electron microscope, contains a constantly changing mix of soil organisms, including bacteria, fungi, nematodes, protozoa, and even larger organisms. All this "life" competes for the exudates in the rhizosphere, or its water or mineral content.

At the bottom of the soil food web are bacteria and fungi, which are attracted to and consume plant root exudates. In turn, they attract and are eaten by bigger microbes, specifically nematodes and protozoa…, who eat bacteria and fungi (primarily for carbon) to fuel their metabolic functions. Anything they don't need is excreted as wastes, which plant roots are readily able to absorb as nutrients.

At the center of any viable soil food web are plants. Plants control the food web for their own benefit, an amazing fact that is too little understood and surely

not appreciated by gardeners who are constantly interfering with Nature's system.

Worms, together with insect larvae and moles and other burrowing animals, move through the soil in search of food and protection, creating pathways that allow air and water to enter and leave the soil. Even microscopic fungi can help in this regard. The soil food web, then, in addition to providing nutrients to roots in the rhizosphere, also helps create soil structure: the activities of its members bind soil particles together even as they provide for the passage of air and water through the soil.

When any member of a soil food web dies, it becomes fodder for other members of the community. The nutrients in these bodies are passed on to other members of the community. A larger predator may eat them alive, or they may be decayed after they die. One way or another, fungi and bacteria get involved, be it decaying the organism directly or working on the dung of the successful eater. It makes no difference. Nutrients are preserved and eventually are retained in the bodies of even the smallest fungi and bacteria. When these are in the rhizosphere, they release nutrients in plant-available form when they, in turn, are consumed or die.

Without this system, most important nutrients would drain from soil. Instead, they are retained in the bodies of soil life. Here is the gardener's truth: when you apply a chemical fertilizer, a tiny bit hits the rhizosphere, where it is absorbed, but most of it continues to drain through soil until it hits the water table. Not so with the nutrients locked up inside soil organisms, a state known as immobilization; these nutrients are eventually released as wastes, or mineralized. And when the plants themselves die and are allowed to decay, the nutrients they retained are again immobilized in the fungi and bacteria that consume them.

The nutrient supply in the soil is influenced by soil life in other ways. For example, worms pull organic matter into the soil, where it is shredded by beetles and the larvae of other insects, opening it up for fungal and bacterial decay. This worm activity provides yet more nutrients for the soil community.

Why should a gardener be knowledgeable about how soils and soil food webs work? Because then you can manage them so they work for you and your plants. By using techniques that employ soil food web science as you garden, you can at least reduce and at best eliminate the need for fertilizers, herbicides, fungicides, and pesticides (and a lot of accompanying work). You can improve degraded soils and return them to usefulness. Soils will retain nutrients in the bodies of soil food web organisms instead of letting them leach out to God knows where. Your plants will be getting nutrients in the form each particular plant wants and needs so they will be less stressed. You will have natural disease prevention, protection, and suppression. Your soils will hold more water.

The organisms in the soil food web will do most of the work of maintaining plant health. Billions of living organisms will be continuously at work throughout the year, doing the heavy chores, providing nutrients to plants, building defense systems against pests and diseases, loosening soil and increasing drainage, providing necessary pathways for oxygen and carbon dioxide. You won't have to do these things yourself.

Gardening with the soil food web is easy, but you must get the life back in your soils.

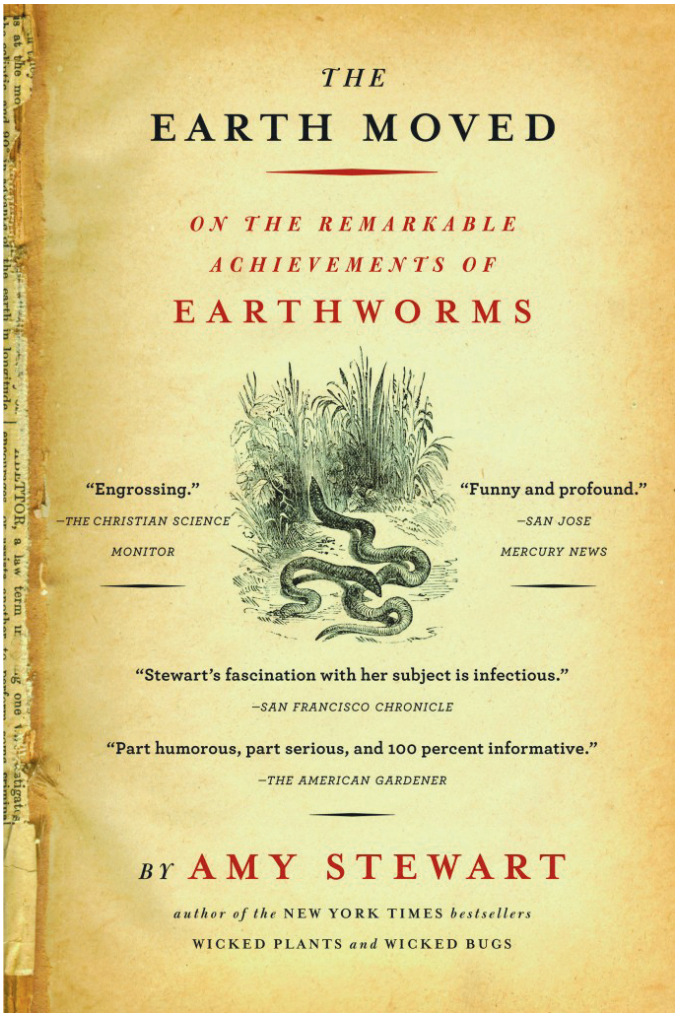
The Earth Moved: On The Remarkable Achievements of Earthworms

By Amy Stewart

Amy Stewart is the award-winning author of five books on the perils and pleasures of the natural world, including three New York Times bestsellers, Wicked Bugs, Wicked Plants and Flower Confidential.

Stewart has appeared on hundreds of national and regional radio and television programs, including CBS Sunday Morning, NPR's Morning Edition, Fresh Air, and Good Morning America. She has written for the New York Times, the San Francisco Chronicle, and every national garden magazine, including Fine Gardening, where she is a contributing editor.

She is the recipient of a National Endowment for the Arts fellowship, the American Horticulture Society's Book Award, and a California Horticultural Society Writer's Award.



Nature's Footprint is pleased to present this free excerpt from one of our favorite books on earthworms. THE EARTH MOVED: On the Remarkable Achievements of Earthworms has inspired us and we know it will delight you as well. Amy Stewart goes beyond the how-to and explores the remarkable history and science behind our relationship with the humble worm. She includes her own personal guide to worm composting, but that's only the beginning of the fascinating journey she takes through the surprising hidden world of earthworms.

To obtain your copy of Amy Stewart's *The Earth Moved* please visit: naturesfootprint.com/the-earth-moved

Excerpt from *The Earth Moved (Continued)*

The first time I held a worm in my hand, I was surprised at how light it was, how harmless. It didn't slither around or try to get away. Instead it lay curled in near-perfect circle, as if it had already accepted its fate.

The worm I held was a red wiggler, Latin name Eisenia fetida. It is in many ways a quintessential worm, small and reddish pink, with faint stripes between each segment. It is a master composter, preferring a heap of rotting garbage to just about anything else. Dig around in pig slop, barnyard manure, or a mound of damp leaves, and you'll probably find red wigglers, eating and laying cocoons in the mess. But the worms themselves are not messy; this one slipped out of its pile of rubbish perfectly clean.

It came out of my worm bin, a small composting operation on my back porch in which I deposit scraps from the kitchen. I don't know how many of them live in the bin—ten thousand, maybe. Sometimes when I dig around in there, the worms are so thick that they look like ground beef set in motion, a mass of churning bodies. It is hard to think of them as individuals, but when it came time to pull one out of the bin and set it on my palm, I did spend a minute looking down at them, trying to choose the right one. A good sturdy specimen was working its way up the side of the bin as if it was ready for adventure.

With one finger, I poked at the worm in my hand. It was completely limp. I could see a purplish vein running along the length of it, just beneath the skin. I curled my palm around the worm, folding it in half and in half again. It didn't react. I began to wonder how a creature this weak could do anything, even move through dirt. Then a few seconds later, it seemed tired of this expedition. It raised one end up—the head, I suppose—and extended one segment at a time into the air. Now, finally, it moved and left a little slime in my palm. I shuddered but didn't drop it. This slime, this worm mucus, was its way of reacting to stress—stress that I had brought on by pulling it out of its bedding and exposing it to light. The worm moved to the edge of my hand, and this time pointed its head down towards the bin, towards home. It was intent on getting back. Just then it looked as if it were capable of doing something after all. It moved with purpose, seeking to escape, trying to return to its familiar habitat. I dropped it into the bin, where it ducked under a layer of damp newspaper and disappeared.

When I stand over a patch of earth and wonder about the subterranean activity taking place underfoot, I am not alone. Gardeners are inquisitive by nature; we are explorers; we like to turn over a log or pull up a plant by the roots to see what's there. Most of the gardeners I know are, like me, quite interested in earthworms, in the work they do, churning the earth, making new dirt. We hold soil in our hands, squeeze it and smell it as if we are checking a ripe melon, and we sift through it to see what inhabits it. Ask a gardener about the earthworm population in her garden, and I guarantee she will have something to say on the subject.

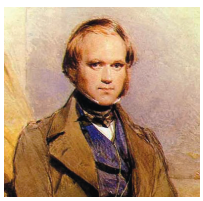
It seems strange, then, that most scientists before Charles Darwin didn't consider worms worthy of study. Very little was known about them in the nineteenth century, when Darwin emerged as a sort of champion of worms, devoting his last book to a painstakingly detailed research of their physiology and behavior. The Formation of Vegetable Mould, Through the Action of Worms, With Observations on Their Habits was published in 1881. He was an old man when he wrote the book, but the subject had interested him for decades.

"As far as I can judge, it will be a curious little book,"

he wrote prior to publication of The Formation of Vegetable Mould. "The subject has been to me a hobby-horse, and I have perhaps treated it in foolish detail." Nevertheless, the book attracted nonscientific readers who enjoyed its clear and vigorous writing and its surprising conclusions.

He described the volume of soil that earthworms swallow and eject as castings, or earthworm manure, reporting that an acre of garden soil could contain over fifty thousand earthworms and yield eighteen tons of castings per year. He studied earthworms' ability to bury objects in soil, from handfuls of chalk scattered on the ground to Roman ruins that had, he believed, come to be buried and preserved for archaeologists by an industrious earthworm population. Most of all, though, he credited them with the transformation of the soil itself. "Their chief work is to sift the finer from the coarser particles, to mingle the whole with vegetable debris, and to saturate it with their intestinal secretions … no one who considers the facts … will hereafter, as I believe, doubt that worms play an important part in nature."

At the time, people thought his estimates were grossly over-inflated and his claims exaggerated. No scientist before Darwin had taken such an interest in the creatures living underfoot. Earthworms were still largely considered a garden pest that damaged plant roots and spoiled clean green lawns with their castings. At best, they were thought to provide some small service by perforating the earth and allowing water to penetrate. At least one reviewer of Darwin's early papers insisted that they were too small and weak to carry out the massive movements of soil to which Darwin assigned them. Another critic dryly observed, "In the eyes of most men … the earthworm is a mere blind, dumb, senseless, and unpleasantly slime annelid. Mr. Darwin undertakes to rehabilitate his character, and the earthworm steps forth at once as an intelligent and beneficent personage, a worker of vast geological changes, a planer down of mountainsides … a friend of man."



Darwin wasn't deterred by the criticism of his colleagues. "The subject may appear an insignificant one," he admitted, "but we shall see that it possesses some interest." He could hardly restrain himself before laying out his central thesis: his remarkable conviction that "all the vegetable mould over the whole country has passed many times through, and will again pass many times through, the intestinal canals of worms." It is a stupendous achievement for a blind and deaf creature with no spine, no teeth, and a length of only two or three inches. Scientists of the day could scarcely believe it, and they were quick to express their skepticism.

Today, among earthworm scientists, Darwin is a kind of touchstone, a muse. He looked belowground with real interest and treated the dark earth as the mysterious unexplored territory that it is. He lived at an exciting time for scientists: in every corner of the world, exotic plants and birds and fossils awaited discovery. But he chose to look underground, to seek out the earthworm. Now we know that Darwin had only glimpsed the potential power of worms: his conclusion that over fifty thousand worms could inhabit an acre of soil was in fact quite low. Scientists have shown that figure to be one million. Earthworms in the Nile valley can deposit up to a thousand tons of castings per acre, helping to explain the astonishing fertility of Egypt's agricultural land. As Darwin had only just begun to suspect, earthworms pass the top few inches of soil through their guts every year. This makes them beings to be reckoned with, a force for change in more ways than even he could have guessed.

Over the last one hundred years, earthworm

Excerpt from *The Earth Moved (Continued)*

scientists (called oligochaetologists, named after the taxonomic class in which earthworms fall, Oligochaeta),

have come to quantify what farmers had always known: that worms, through their actions, substantially change the earth. They alter its composition, increase its capacity to absorb and hold water, and bring about an increase in nutrients and microorganisms. In short, they prepare the soil for farming. They work alongside humans, extracting a life from the land. They move the earth, a remarkable accomplishment for a creature that weighs only a fraction of an ounce.

An earthworm travels through the soil, pushing some particles aside and ingesting others. Although its food choices may look alike to the casual observer, the worm is actually sorting through the soil in search of tiny bits of decaying organic matter, which it will swallow along with some clay or sand particles. It builds a permanent burrow as it goes. At night it rises to the surface of its burrow, ejecting a small mound of castings around the entrance. It searches for food, tugging leaves, pine needles, and other detritus into its burrow. This simple routine is enough to ingratiate it to the farmer or gardener. On its nightly forage for food it acts like a small, very efficient, plough.

The body of an earthworm is perfectly designed for life underground. Sight is unnecessary in the subterranean world; a sensitivity to light is all a worm needs to avoid straying out of its habitat. Lungs are not much use in the tight confines of a burrow; instead, the earthworm breathes through its skin, exchanging oxygen for carbon dioxide, relying on damp interior of a mammal's lungs facilitates the passage of air into the body. The earthworm's shape allows it to be an extraordinary vessel for soil—the perfect container for holding, transporting, and transforming the earth.

One of Darwin's most extraordinary qualities was his ability to recognize when a scientific question could not be answered due to the limitations of the science of his day. He knew, for instance, that during his lifetime, no significant progress would be made on the question of how life first began. Near the end of his life he wrote to a colleague, "You expressed quite correctly my views where you said that I had intentionally left the question of the Origin of Life uncanvassed as being together ultra vires [beyond the powers] in the present state of knowledge." The same could be said of Darwin's insight into the role of earthworms in the soil. The technology that would allow scientists to understand the complex relationships between soil microbes, plants, and earthworms would not be advanced for several more decades.

When The Formation of Vegetable Mould was published in 1881, it was a novel idea that an earthworm could possess enough intelligence to judge how to best pull objects into its burrow. No scientist had paid so much attention to this seemingly trivial matter, nor devoted so many pages of published work to it. But even Darwin could not grasp the importance of the earthworm's impact on the soil ecosystem. Scientists in his day knew that bacteria and other microorganisms lived in the soil, but the ideas were quite new. Louis Pasteur initiated the science of microbiology during the last few decades of Darwin's life. A strain of bacteria was first identified as the cause of a plant disease in 1878. Still, the relationship between the microscopic world of soil and the macroscopic ecology—the earthworms and other visible creatures that inhabit the earth—was largely a mystery. Over the next several decades, the study of earthworm behavior was eclipsed by the study of its role in the soil. To understand what's happening underground, we have to know more about this creature that lives below our feet, selectively drawing organic matter down from the surface, creating pockets of air everywhere it goes, sifting and digesting particles of earth.

Glossary of Terms

ACTINOMYCETES (AC-tin-o-mi-see-teez): A type of photosynthetic bacteria which gives soil its characteristic earthy smell.

ACIDIC: Having the properties of an acid, or containing acid; having a pH below 7.

AERATION: Adding air to a compost pile through turning or ventilation to allow increased microbial action and decomposition.

AEROBIC COMPOSTING: A method of composting organic wastes using bacteria that need oxygen. This requires that the waste be exposed to air, either by turning or by forcing air through the material.

ALKALINE: Having the properties of an alkali, or containing alkali; having a pH greater than 7.

ARTHROPOD: Invertebrate animals that have an outer skeleton or shell with jointed legs.

BACTERIA: Microorganisms that break down organic materials in the first stages of composting. It is bacteria that releases the heat associated with hot composting. The three types of bacteria are psychrophilic, mesophilic, and thermophilic.

BACTERIAL DOMINATED: Soils that have an alkaline pH which encourages nitrogen-fixing bacteria to thrive.

BEDDING MATERIAL: A coarse carbon based material that breaks down slowly, has little protein or mineral content and won't pack tightly but allows for air passage and draining of excess moisture. This includes such things as coconut coir, shredded paper, pumice, garden soil/compost, leaves, grit.

BENEFICIAL ORGANISMS: Any organism that benefits the growing process including insects, arachnids, other animals, bacteria, fungi, viruses, and nematodes.

CALCIUM: A chemical element with the symbol Ca; calcium is a soft gray alkaline earth metal and is the fifth most abundant element by mass in the earth's crust.

CARBON: The chemical element with the symbol C; it is nonmetallic; the 15th most abundant element in the earth's crust and in the human body the second most abundant element by mass after oxygen.

CARBOHYDRATES: An organic compound that consists of carbon, hydrogen and oxygen; any food that is particularly rich in the complex carbohydrate starch (such as cereal, bread or pasta) or the simple carbohydrate sugar (such as candy, jams and desserts).

CASTINGS: The nutrient rich byproduct of earthworms, used as a soil conditioner; worm feces.

CLITELLIUM: A thickened section on earthworms that contains male and female sex organs.

C:N RATIO: The ratio of the mass of carbon to the mass of nitrogen in a substance.

COCONUT COIR: Ground coconut fiber; helps retain moisture and improve aeration in compost. A sustainable alternative to peat moss.

COLD COMPOSTING: Dominated by microorganisms that live in temperatures below 115°F; random materials are use and left to break down at their own pace, does not require turning so is less labor intensive; can take 1-2 years to finish.

COLLECTION BASE/AREA: The area of the Worm

Factory composter where any liquid leachate, released from the food waste as it breaks down, collects.

COMPOST: Organic matter that has been decomposed and recycled as a rich fertile soil amendment. It is dark, rich in nutrients and has an earthy smell.

COMPOSTING: A controlled biological decomposition of organic material in the presence of oxygen to produce a stable, pathogen-free, humus-like material called compost.

COMPOST TEA: An aerobic water solution that has extracted the microbe population from the compost along with the nutrients.

DECOMPOSITION: The breakdown of organic matter through microbial action.

DOLOMITE LIME: See "lime".

***Eisenia fetida*:** Small composting worm also know as "red wigglers", live in decaying vegetation and manure piles and does well in closed container composting; eat only decaying organic matter.

ENZYMES: Energized protein molecules found in all living cells. Enzymes catalyze and regulate all biochemical reactions that occur within the human body.

FEEDING TRAY: The top tray of the Worm Factory composter where food waste and dry material is placed for the worms to eat.

FOOD WASTE: Food residuals generated from human food preparation and consumption.

FUNGAL DOMINATED: Soils that have an acid pH in which the nitrogen remains in ammonium form encouraging fungi to thrive.

FUNGI: Microorganisms found on decaying carbon-based plant material.

GANGLIA: A network of cells forming a nerve center in the nervous system of invertebrate insect and earthworms.

HOT COMPOSTING: A managed process where close attention is paid to how materials are mixed and the types of materials used; temperatures of 130°F - 160°F are needed to kill pathogens and weed seeds, this is achieved by turning the pile when it cools to introduce oxygen; can produce compost in as little as 90 days.

HOUSEHOLD WASTE: Waste that is generated in the day to day operations of a household.

HUMIC ACID: Principal component of humic substances which are the major organic constituents of soil; increases the ability of the soil to hold nutrients in a way that can be easily taken up by plants.

HUMUS: The organic component of soil, formed by the decomposition of leaves and other plant material by soil microorganisms.

INVERTEBRATE: Insects that do not have a backbone or an internal skeleton.

KITCHEN WASTE: Any food substance, raw or cooked, which is discarded.

LEACHATE: Liquid which has percolated through, or condensed out of mixed solid wastes and extracted dissolved and suspended materials; liquid that drains from the mix of fresh organic matter, such as in a worm composter.

LIME: A compound of calcium or calcium and magnesium capable of counteracting the harmful effects of an acid soil. Dolomite limestone contains

about equal parts of magnesium and calcium carbonate.

LITMUS TEST: A test for acidity or alkalinity using litmus, a dye obtained from certain lichen (fungus) that is red under acid conditions and blue under alkaline conditions.

LIVING ORGANISMS: An individual form of life, such as a plant, animal, bacterium, microorganisms, or fungus; a body made up of organs, organelles, or other parts that work together to carry on the various processes of life.

MICROORGANISM: These are microscopic plants and animals. They exist in the soil for the purpose of breaking down organic matter into basic mineral elements. They include bacteria, fungi, actinomycetes, algae, protozoa, yeast, ground pearls, and nematodes.

MINERALS: Naturally occurring inorganic solids with a definite chemical composition and an ordered atomic arrangement.

MOISTURE METER: An instrument used to measure the percentage of water in a given substance.

N-P-K: An abbreviation for nitrogen (N), phosphorus (P), and potassium (K). In the agrochemical industry, these three elements are considered important to force crop production (as opposed to the organic philosophy goal of improving the biodiversity of the soil). US law requires that the ratio of these three elements be specified on every bag of commercially available fertilizer. A ratio of 3-1-2 or 4-1-2 is considered good.

NEMATODE: Small, usually microscopic, un-segmented roundworm with elongated rounded body pointed at both ends; mostly free-living but some are parasitic; the most numerous multi-cellular animals on earth.

NITROGEN: A Chemical element with the symbol "N"; a colorless, odorless uncreative gas that forms about 78 percent of the earth's atmosphere; essential for growth and reproduction in both plants and animals.

NUTRIENTS: The chemical elements necessary for healthy plant growth.

ORGANIC: Of or relating to or derived from living organisms; foods raised according to standards of organic agriculture; A fertilizer that is derived from vegetable or animal matter.

ORGANIC CONTAMINANTS: Synthetic trace organics including pesticides and other synthetic chemicals.

ORGANIC WASTE: Any waste material that was once alive. For the purposes of vermicomposting, this excludes human and pet waste, except where a composter is specially dedicated and monitored.

PATHOGEN: An organism including viruses, bacteria, fungi and protozoa capable of producing an infection or disease in a susceptible host.

pH: The standard abbreviation for "potential hydrogen" which denotes the hydrogen ion concentration of a solution. A scale of 1-14 expresses the relative acidity or alkalinity of water or soil. A pH of 7 is neutral. Values below 7 are acidic, increasingly more acidic towards 1. Values above 7 are alkaline, increasingly more alkaline as the values increase towards 14.

pH METER: A device used for measuring the acidity or alkalinity of a liquid or semi-sold substance.

PHOSPHORUS: A chemical element with the symbol "P"; combustible nonmetal of the nitrogen group; a dietary mineral that is important for bone development, energy production and normal cell membranes; promotes the growth of seeds, fruit,

flowers and root growth in plants.

PINCH/SQUEEZE TEST: A simple test used to determine moisture content of soil.

PYTHIUM: A pathogenic parasite found in water or humid environments causing problems with crops and gardens; can also cause disease in humans or animals.

PHYTOTOXIN: toxins which may endanger plant viability or functionality.

PLANT GROWTH HORMONES: Molecules in plants that regulate cellular processes.

POTASSIUM: A chemical element with the symbol "K"; important for the proper function of all cells, tissues and organs in the human body; helps promote plant growth and make strong stems.

PROCESSING TRAY: The trays below the feeding tray of the Worm Factory 360, that are in various stages of decomposition.

PROTOZOA: Single-celled microscopic animals that include amoebas, flagellates, ciliates and sporozoa (parasites).

PUMICE: A type of igneous rock formed from molten or partially molten material that cools and solidifies quickly trapping air with in it. It is similar in appearance to perlite. Pumice is added to potting soils to increase aeration, porosity and drainage. Pumice is full of microscopic holes which can hold and release water and nutrients to grow plants over time.

RED WIGGLER: See *Eisenia fetida.*

RHIZOCTONIA: A common soil fungus that sometimes causes plant diseases such as damping off and root rot.

ROCK DUST: Rock powders or minerals; a natural fertilizer consisting of finely crushed rock containing minerals and trace elements.

SEDIMENT: Solid material that is moved and deposited in a new location through the process of water, ice or wind.

SOIL AMMENDMENT: Matter that when added to the land will make the soil healthier by balancing and adding nutrients and the pH, encouraging the activity of microorganisms. From a legal standpoint this is different than "fertilizer" and is not governed by laws which regulate fertilizers.

SOIL THERMOMETER: An instrument that measures the temperature in soil or compost at different depths.

STABILITY: The degree to which compost or other material can resist further break down or the absorption of other compounds.

UPWARD MIGRATION: The movement of worms in a Worm Factory 360 from the lower trays into the upper trays.

VERMI: Latin for worm.

VERMICAST: See castings.

VERMICOMPOST: The process by which earthworms digest organic matter; the soil-like byproduct resulting from worms digesting organic matter, which can in turn be applied to plants.

VERMICULTURE: The raising and production of earthworms and their byproducts.

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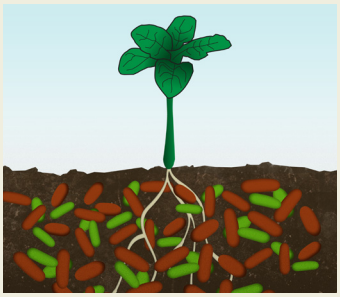
Notes:

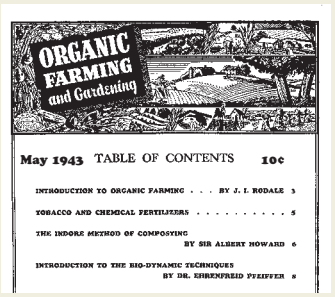
DID YOU KNOW?

From the time plant life first appeared on Earth hundreds of millions of years ago, nature has used the same system to feed plants through their roots in the soil. Living things die and decay and their nutrients are released into the soil. Then water carries these nutrients into the plant roots and feeds them.



Nature's system of feeding plants still works. Unseen below the surface of your garden, vast herds of microscopic organisms including bacteria, fungi, and nematodes – all members of the "soil food web" – are busy supplying nutrients to your plants above. Nature relies on a slow composting process.

All plants require nitrogen and it is an essential process for gardening and agriculture. Around 1900 a scientist discovered a way to "fix nitrogen", a chemical process which was the first step of our present-day synthetic fertilizer industry. There are many well known synthetic fertilizer brands on the market today.

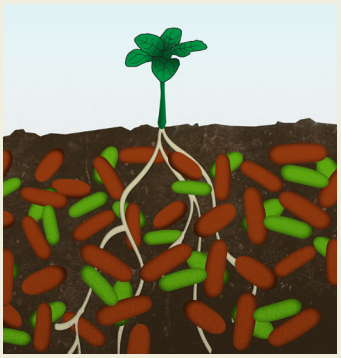


The word *organic* first appeared in the early 1940s in an effort to better describe the difference between nature's "organic" process and the ever-expanding use of synthetic fertilizers and their insidious side effects on our food supply.

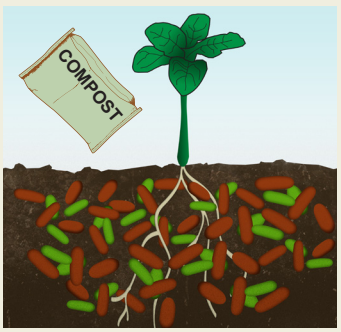
Synthetic fertilizers skip nature's continuous composting process by feeding nutrients directly to roots bypassing the soil. Plants **grow rapidly** but these synthetic fertilizers act similar to a "steroid" for plants. Plants no longer rely on nature's organic system, but become dependent on the fertilizers, requiring more and more. You have to re-apply their products constantly.

In fact, synthetic fertilizers are salt-based, and overtime they kill off the microscopic organisms that nature's process relies on. In time, they sterilize the soil. Serious side effects appear, in the form of diseases and pests attacking your plants because nature's "immune system" has been destroyed.

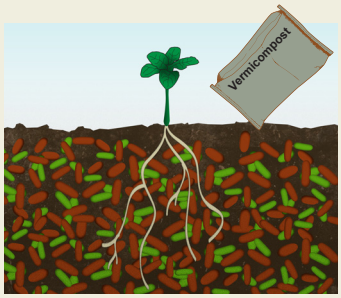
In contrast to synthetic fertilizers, compost is a natural organic source of nutrients from plants and animals that were once alive. Compost feeds the living organisms in the soil. These organisms pass the nutrients on to the plant roots. This is a continuous sustainable process.



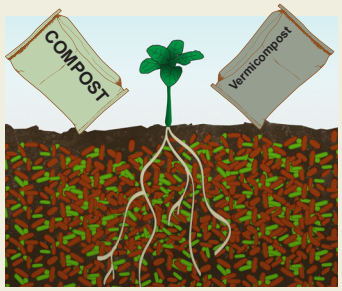
Compost provides the nutrients soil organism require to increase in population. Those microorganism in turn, provide a never-ending supply of nutrients to the plants while warding off disease and pests.



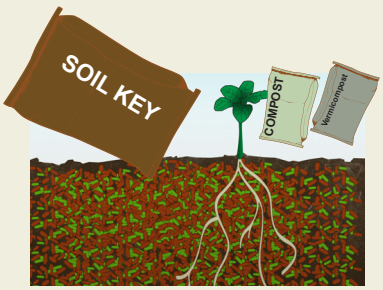
Organic compost generates huge numbers of additional microorganisms on top of those already present in living soil. They feed plants in a two-step process, first feeding on the soil and organic matter, and next making those nutrients available to plants as food when they die..



Vermicompost (worm compost) contains hundreds of thousands of additional microorganisms – even more than traditional compost – and these convert more nutrients to plant food. These microorganisms break nutrients down to a water-soluble state so that plants can absorb them through their roots.



By supplying **organic compost** and adding **vermicompost** to your organic soil, you create a powerful combination that feeds the soil and in turn feeds your plants. Adding rock dust assures a good supply of the trace minerals all living organisms require.



Nature's Soil Key is designed to feed the **microorganisms** from organic compost and vermicompost, accelerating their growth, multiplying them again with a result "*Teaming with Microbes*" as described in the Jeff Lowenfels best-selling garden book, generating permanent organic colonies that will remain in your soil for years to come if not disturbed by tilling.

SOIL KEY available at www.naturesfootprint.com/soilkey

New

UrBin Grower™

A new way to GARDEN!

go green one step at a time

Grow Organic anywhere

backyard, frontyard porch, patio, or deck

A sub-irrigation watering system

Patent Pending

Contents
1 UrBin growing container
1 water reservoir
1 soil separator
1 seed tray
1 DVD
1 instruction manual

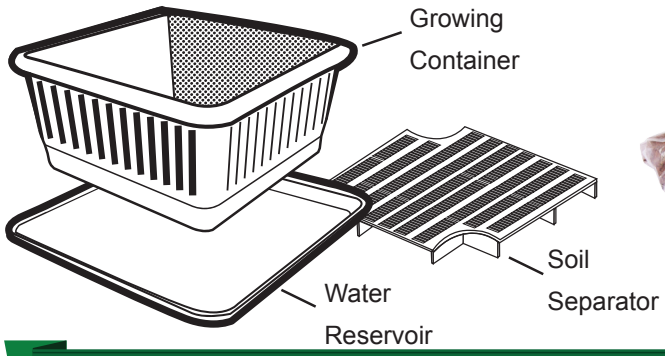
Contents
1 bag coir with trace minerals
1 bag volcanic pumice
1 block of coir mulch

Microbial Nutrients
1 bag vermicompost
1 bag Soil Key

EASY TO SEE
Water reservoir on the **OUTSIDE**

Food Grade Quality Plastic

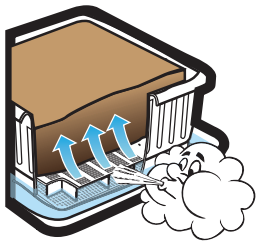
MADE IN USA



*Supply 3 gal of additional compost

THREE UNIQUE SYSTEMS

Soil Separator

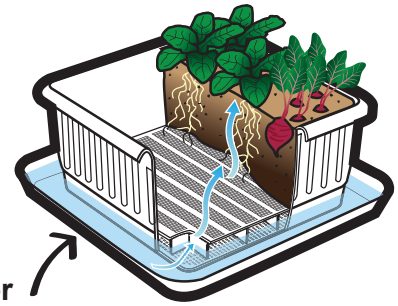


The soil separator provides significant air space in the bottom of the growing container. Oxygen in the soil helps plants take up water, nutrients, and promotes healthy growth and plant vigor. The air space created by the soil separator stimulates new root development and prevents the roots from circling.

By just adding the soil separator, you will see...
A significant improvement in any plant you grow!

Microbial Nutrients

One cup of Soil Key will multiply the millions of living organisms already found in the vermicompost package. The results are truly spectacular, producing an advanced soil medium which is 100% organic. Working with the organic compost you supply, the included coconut coir (with minerals added) and volcanic pumice will create a soil that allows you to grow organic vegetables for years to come.



Sub-Irrigation Watering System

By adding water to the water reservoir tray during peak growing periods, your plants will always have enough water. As roots extend into the soil drawing water upward, capillary action in the soil replaces the water from the water reservoir below. This is exactly how nature continually replaces the water in the soil surrounding roots. Your plants only take up water as needed. All you have to do is watch the reservoir and you will never over or under water again.

Getting Started

***For 100% Organic Vegetables**
You will need
3 Gallons of Organic Compost
(not included in this kit)
See suggestions and options below

UrBin Grower™ Soil Mix

2 gal coir W/ Trace Minerals 30%
1 gal Pumice.....15%
5 Cups Vermicompost 5%
1.3 cups Soil Key.....0.8%
PLUS *3 gal Organic Compost ..50%
(you provide)

Can I use a "potting " soil from the store?
It is not recommended for several reasons. The soil mix you are preparing is an "organic potting soil or mix". Most commercial "potting" soil found in stores contain chemical wetting agents, and synthetic fertilizers. Read the label carefully.

Why am I asked to supply organic compost?
Organic compost, along with the enclosed items in this kit, will create the best soil mix for growing organic vegetables.

The UrBin Grower™ has been tested using many popular commercial fertilizers and soil mixes that are available at most garden centers with good results. We still recommend growing in a more natural soil environment that you create. As with any garden, individual results vary.

Where can I find organic compost?
Many gardeners make their own backyard compost, which we recommend. You may also purchase organic compost at your local garden center. Request one that has not been sterilized.

What should I look for when purchasing organic compost?
If the bag says "certified organic" this is the best. Read the label carefully. A good substitute for organic compost is garden soil mixed with aged composted manure. Do not use fresh manure! Fresh manure could be too rich in nitrogen and may burn plants. Dried manure can have a lower nitrogen content and is not a biologically active as mature composted manure.

What else should I look for?
When reading the bag look for: "composted plant material" including garden and kitchen waste, leaves, manure, from chicken, rabbit, horse, or cow. Avoid compost that contains "forest products".

What will you grow in your UrBin Grower™?

Most flowers, herbs and vegetables can be grown successfully in the UrBin Grower™. Keep in mind you will be growing in a small space. Tomatoes are the most popular vegetable. One plant will provide a bountiful crop in the UrBin Grower. Most important is that you grow what you like to eat!

*not included in this package.

1

Set aside the coir mulch and seed tray to use later.

2

Reserve 2 cups of coir and 1/3 cup Soil Key for later use. *See pg 6.*

3

Place the soil separator in the bottom of the growing container.

4 Mix all the soil ingredients together in a large container such as a plastic tub. Slowly add water to moisten the materials as you mix them.

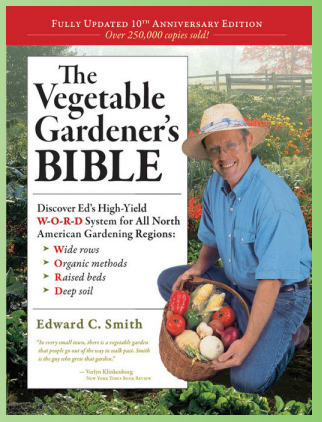
- When finished, the soil mix should be moist, NOT WET

5 Fill the growing container with the UrBin Grower soil mix. Place the water reservoir under the container.

Do not add water quite yet.

6 Wait 5 to 6 days before planting. This gives the Soil Key time to work with the vermicompost in the UrBin Grower soil mix.

We recommend two great garden books
that will provide valuable additional information!



New Wicky Grower™

A New Way To Garden

Grow Anywhere!

go green one step at a time!

Contents:
1 Soil Separator
1 Growing Container
1 Saucer Reservoir

Patent Pending

Backyard, front yard, porch patio or deck

Berries	Vegetables
Blackberries	Corn
Blueberries	Beans
Raspberries	Peas
Huckleberries	Tomatoes
	Artichokes
	Potatoes
	Peppers

EASY TO SEE
Water Reservoir
on the **OUTSIDE**

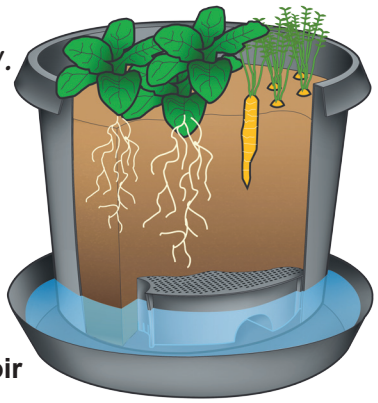
Soil Separator

The Soil Separator provides significant air space in the bottom of the growing container. Oxygen in the soil helps plants take up water nutrients, and promotes healthy growth and plant vigor. The air space created by the Soil Separator stimulates development and prevents the roots from circling.

By just adding the Soil Separator, you will see a significant improvement in any plant you grow.

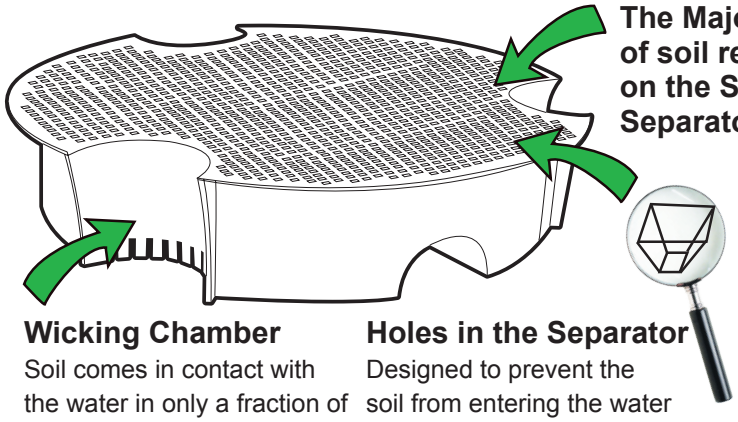
Sub-Irrigation Watering System

By watering in the water reservoir tray during peak growing periods, your plants will always have enough water. As roots extend into the soil, drawing water upward, capilary action in the soil replaces the water from the water reservoir below. This is exactly how nature continually replaces the water in the soil surrounding roots. Your plants only take up water as needed. All you have to do is watch the reservoir and you will never over or under water again.



Water Reservoir

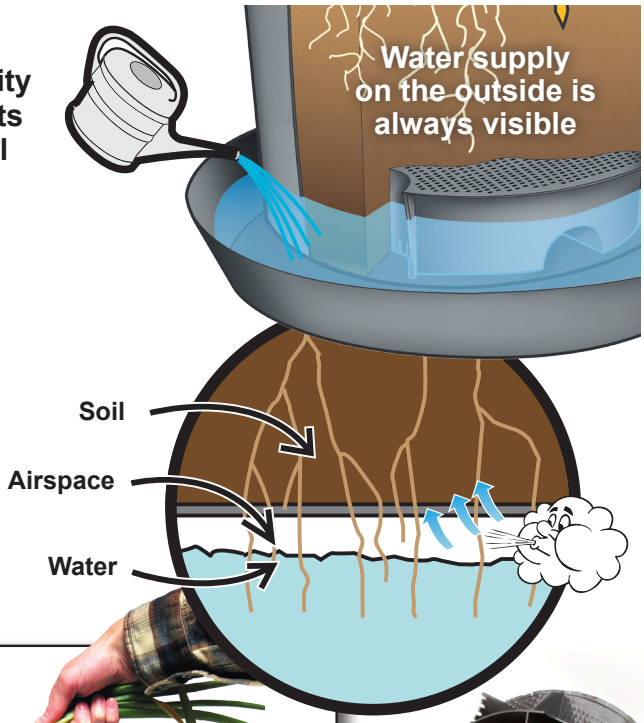
Sub-irrigation Watering System



The Majority of soil rests on the Soil Separator

Wicking Chamber
Soil comes in contact with the water in only a fraction of the surface area, wicking up moisture.

Holes in the Separator
Designed to prevent the soil from entering the water below, While allowing roots to penetrate.



Extending Plant Life & Stimulating New Root Growth

Pot with circling roots

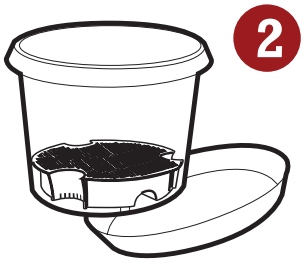
"Circling roots (in potted) plants have difficulty getting enough water and nutrients, shortening plant's life span."
-Oregon State University

Pruning Circling Roots
"Circling roots are 'burned' off or pruned when exposed to air, causing the plant to constantly produce new and highly branched roots."
-Washington State University

Long non-circling onion roots
2011 Test

The Soil Separator creates an air gap between the soil and the water

Getting Started



Before you plant

Make sure the soil in your Wicky Grower is well-watered by either filling the watering tray a few days before you're ready to plant, and letting the water wick-up, or makeing sure your soil medium is moistened before adding it to your Wicky Grower.

Growing Medium

The Wicky Grower has been successfully tested using a broad range of commercial potting grow mixes available at your local garden center.

Note: it is important to purchase "potting mix" soil media, which is designed for containers and contains amendments to help aerate the mix and retain moisture.

Directions for making your own growing medium can be found in garden books, on web sites or by following our suggestion below.

Nature's Footprint's Suggestions:
5 gal high quality compost
1 1/2 gal coconut coir
or sphagnum peat moss
1 1/2 gal pumice or perlite
2 1/2 gal of soil

Coco Coir

Organic Growing Medium
100% abundant renewable resource

What is Coir, and where does it come from?

Coir is a bi-product of coconut harvesting. For centuries, rope, twine, and mats have been made from the fiber in the husk of coconuts. These fibers are obtained by husking or breaking up the hard shell, then soaking it in water-filled pits to soften the fibers.

These fibers make up about one third of the husks with the remaining two thirds consisting of pith or dust which previously was discarded as waste. It was not until the 1980's that horticulturists began studying Coconut Coir dust as a substitute for sphagnum peat moss.

About 60% of the world's Coir fiber is produced in the state of Kerala on the western coast of India. Sri Lanka and India together produce 90% of the annual coir production world wide.

Many times coconut husks are processed in water-filled pits of sea water, it is important to make sure Coconut Coir is washed and free of any salt.

The Coir in this package has already been screened, washed and graded as a premium horticultural product.

Coir as a growing medium

Coir contains no nutrients, unlike your backyard garden compost which contains fungi and bacteria. Vermicompost is loaded with these nutrients. The Worm Factory® can easily convert Coir into a superior growing medium.

Compost and Coir have many of the same characteristics, such as a spongy texture, expanding air space, and high moisture holding capability.

Backyard/garden compost breaks down rapidly in the soil and must be re-applied annually. Coconut Coir, on the other hand, will last in soil for years.

Coir has a high lignin content. Lignin is an organic substance that, along with cellulous, forms a chief part of woody tissue. It is the lignin that resists rapid breakdown in the soil, and is the source of Coir's longevity. After adding Coir to soil it has an estimated lifespan of 5 to 10 years before it begins to break down. Coir out performs peat moss, rockwool, vermiculite, and perlite as a soil amendment.

Most commercial bagged potting mixes contain chemical wetting agents. Coir is a 100% organic wetting agent. Its ability to rehydrate repeatedly as soil moves from wet to dry with little loss in yield is remarkable. In addition, wet Coir holds around 1000 times more air than soil, making Coir the superior choice for creating potting mixes.

With its high water-holding capacity, Coir provides plant roots with excellent drainage. Coir's high air to water ratio is extremely valuable for healthy root development. Coir is an excellent high quality, general purpose soil amendment, perfect for potted plants and gardens. Coir has the ability to store and release nutrients to plant roots for extended periods of time. With better nutrient absorption, coir fosters excellent growth and plant formation.

FEATURES:

- **High water holding capacity**
  Up to 7 times its weight
- **Retains and releases nutrients**
  Over an extended period of time
- **Naturally weed free**
  Absence of weeds, seeds and pathogens
- **Disease resistant**
  Significant reduction of root diseases
- **Spongy texture**
  Similar to traditional compost
- **Excellent air space & drainage**
  Similar to traditional compost
- **Develops elaborate root systems**
  Unmatched medium for seed starting
- **Neutral to slightly acidic pH**
  Unlike peat moss which has a high acidity
- **Soil amendment & conditioner**
  Excellent in both clay or sandy soils

Sandy soil is by far the largest of the three and can be seen with the naked eye. Soil sand however must be small enough to hold some water, unlike gravel for paths. Even so, most of the water will readily drain out along with nutrients, leaving lots of air space.

Silt soil is much smaller than sand - will need a microscope to see individual particles. Silt soil holds more water and has the appearance of flour, yet still contains air spaces.

Clay soil on the other hand is much, much smaller. In fact you will need an electron microscope to see a single clay particle. Clay holds lots of water, is slippery when wet, rock hard when dry and has little air space between the particles.

In the book *Teaming With Microbes* the following illustration is given. “If a clay particle was the size of a marigold seed, a silt particle would be the size of large radish, a sand particle would be the size of a large garden wheelbarrow.”

Of the three soil types, clay is by far the best soil for gardening, containing large amounts of minerals which plants need.

However, many gardeners will disagree because the clay is difficult to cultivate and is so compacted that it provides little air to plant roots.

When mixed with clay soil, Coir breaks up the clay particles, adds air space and loosens the soil making it easy to till. It also adds porosity to the mix similar to garden compost. However, coir stays in the soil mix for many years, unlike garden compost which breaks down quickly.

Coir also improves sandy soil by adding texture, water retention, and nutrient storage and retention.

Gardeners report amazing results converting their home soil into useful medium for soil mixes and container plant growing. These characteristics make Coir an ideal soil amendment.

Coir as a seed starting mix

For many gardeners starting seeds is a challenge prone to failure.

Garden writers suggest two important things to consider:

1. A disease free growing medium.
2. A medium that retains moisture but avoids becoming wet or soggy.

Garden soil is never recommended for seed starting for many reasons. Many advise making a soil mix using peat moss or sphagnum, a wetting agent and limestone to correct the pH of peat. Coir however, is free of weed seeds, diseases, and pathogens. Coir is easy to wet, holds seven times its weight in water, cannot be compacted, fosters root development and does not waterlog.

Coir replaces all other recommended soil amendments for creating your own seed starting soil, including peat moss, rockwool, vermiculite, perlite and wetting agents like polymers. There is also no need to place the starts in a pan of water in an attempt to manage moisture as some recommend. Since coir retains moisture so well.

Remember seeds don’t require fertilizer for germination, begin to add fertilizer once the plant’s leaves have developed.

Starting seeds

Use moist Coir. Add moisture using a fine spray as the top surface dries out. Make sure there is sufficient light.

Once your seeds have reached 3” or 4” in height and have true leaves, it is time to transplant into a container which has fertilizer or add fertilizer to the container your plants are in.

Transplants

When transplanting any size plant adding Coir is recommended below the plant. Example: fill the bottom 1/3 of your container with Coir, and fill the rest of the area around the plant with potting soil. Coir builds strong root structures and will insure your transplanted plant will adapt its roots into the new location.

Worm composters

Adding a handful or two of Coir to each new tray will speed up the compost process and produce a much higher quality of finished worm compost for your garden.

Coir in not an essential ingredient to operate a worm composter, however, if available, it is highly beneficial.

Available Sizes

5kg

250g

650g

GET THE MOST FROM YOUR VERMICOMPOST!

The UrBin Grower™ provides endless organic vegetables by facilitating growth through a mixture of all natural soil amendments, and a patent pending self-watering reservoir design. Simply mix in the amendments with your soil, and plant your vegetables. Grow your own nutrient rich fresh organic vegetables at your own home, even if you don't have a garden!

One cup of SoilKey™ will multiply the millions of living organisms already found in vermicompost. The results produce an advanced soil medium which is organic.

Contact your retailer to learn more about other great products like these from Nature's Footprint!

Connect with other Worm Factory® 360 Users Online At:

WWW.NATURESFOOTPRINT.COM/COMMUNITY

You Tube @WormFactory nature's footprint CHANGE YOUR IMPACT