

# Vermicomposting

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garden and kitchen wastes, many more use both types of composting, and thousands of households without gardens use neat and unobtrusive worm boxes indoors to compost their kitchen scraps (as well as newspapers and cardboard boxes), reducing their garbage by up to a third and providing their own organic soil for pot plants and container gardens on balconies and roofs to grow their own healthy food.

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## Vermicompost and plants



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Worm casts -- the best soil there is

it -- they consume it, sure enough, but what they derive their nourishment from is all the micro-organisms that are really eating it. And yet -- mystery! -- their casts contain eight times as many micro-organisms as their feed! And these are the micro-organisms that best favour healthy plant growth. And the casts don't contain any disease pathogens -- pathogenic bacteria are reliably killed in the worms' gut. This is one of the great benefits of vermicomposting.

Worm casts also contain five times more nitrogen, seven times more phosphorus, and 11 times more potassium than ordinary soil, the main minerals needed for plant growth, but the large numbers of beneficial soil micro-organisms in worm



casts have at least as much to do with it. The casts are also rich in humic acids, which condition the soil, have a perfect pH balance, and contain plant growth factors similar to those found in seaweed. There's nothing better to put in your garden!

Chinese spinach seedlings grown with (from left) chemical fertilizer, powdered horse manure, vermicompost, and nothing.

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## The worms

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These are not the usual big burrowing earthworms that live in garden soil. Called red worms, tiger worms, brandlings, angle worms, manure worms, or red wrigglers, they occupy a different ecological niche, living near the surface where there are high concentrations of organic matter, such as on pastures or in leaf mould, or under compost piles.

Two breeds are used in vermicomposting: *Eisenia foetida* or *Lumbricus rubellus*. Many garden centres now supply them, and in most countries they can be bought by mail order from worm farms. Some sellers advertise special high-performance breeds or specially developed hybrids, but don't believe them -- they'll be one of these two breeds. There's no such thing as a hybrid worm.

You'll need 1,000 worms (1 lb) to start a worm box, maybe twice that if you want to process your garden wastes too -- they breed very fast in the right conditions, but starting with more will give the system a good start.

## Breeding

Worm populations double each month. In ideal conditions they can reproduce much faster than that: 1 lb of worms can increase to 1,000 lbs (one million worms) in a year, but in working conditions 1 lb will produce a surplus of 35 lbs in a year, because hatchlings and capsules (cocoons or eggs) are usually lost when the vermicompost is harvested.

Mature redworms make two or three capsules a week, each producing two or three hatchlings after about three weeks. The hatchlings are tiny white threads about half an inch long, but they grow fast, reaching sexual maturity in four to six weeks and making their own capsules. Three months later they're grandparents!

This rapid breeding rate means the worm population easily adjusts to conditions in the worm box according to the feed supply and the proportion of worm casts to feed and bedding -- their casts are slightly toxic to them, and as the box gets "full" they'll either leave, if there's anywhere for them to go, or they'll die off.

This is an important consideration -- if you only want the vermicompost for the garden it doesn't much matter if the worms die off, as long as you've kept some aside to set a new box going. It also makes it easier to harvest the castings, and you'll have a higher proportion of pure castings.

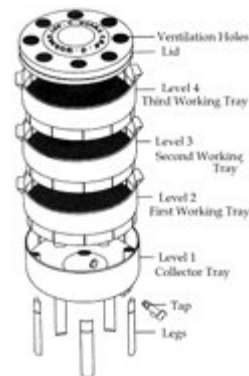
But if you want to produce excess worms as well, to extend your worm system, for sale as fishing bait, or to feed to poultry or fish (they really thrive on wormfeed), you'll need to separate them from the vermicompost before the proportion of castings gets too high. See below, [Harvesting](#).

## Worm boxes

This section mainly applies to using worms to compost kitchen wastes. For garden wastes, the same basic principles apply, with a few cautions: see below, [Garden wastes](#).

There's a good range of specialized worm composting units that you can buy: Can-O-Worms, Worm Factory, Worm-a-way, Eliminator, Worm-A-Roo, Tiger Wormery and others -- you'll find details at [Vermicomposting resources](#).

Or you can easily build one yourself. In fact many people advise it, saying that wood is better than plastic -- the commercial models are usually made of plastic, which doesn't "breathe", while wood is porous and allows for better ventilation.



ReIn's three-tray  
Can-O-Worms

## Dimensions

The size of the unit should be geared to your household's production of kitchen scraps.

One or two people usually produce about 4 lb of food waste a week: use a 2ft x 2ft box 8" deep. For three people make it 12" deep, for more, 2ft x 3ft x 12" deep -- or two 2-person boxes might be better, because bigger boxes can be too heavy to move when they're full.

Use exterior-grade 1/2" plywood. Don't use chemically-treated wood. Treat the wood with a non-toxic wood preservative, or paint it with vegetable oil, or linseed oil. Use galvanized nails. Drill at least a dozen 1/2" holes in the bottom for aeration, and arrange it so that two opposite sides are half-an-inch deeper so that the bottom stands off the ground. Stand the box in a tray, because it will probably leak a bit.

Once filled, cover the surface with black plastic sheeting (a garbage bag) slightly smaller than the surface area; this will keep the moisture in, and the

surface area: this will keep the moisture in, and the worms will work right up to the surface. If this makes it too wet, use a couple of newspapers instead. Make a lid for the box. Keep it anywhere convenient.

## Bedding

Fill the box with moist bedding for the worms to burrow in and to bury the food scraps in. You need about 6 lb (dry weight) for a 2ft x 2ft x 8" box. Worms will eat the bedding as well as the food scraps, so you'll need to top it up in a few months.

Any inert, non-toxic, fluffy material that holds moisture and allows air to circulate will do. Don't use anything that will decompose too rapidly when you moisten it and get hot, like manure that's not aged enough or hay, especially alfalfa hay. Mixed bedding is better, but no need to be too complicated: 2/3 corrugated cardboard and 1/3 sphagnum [peat moss](#) or [coco peat moss](#) is a good mixture, or sphagnum peat moss, shredded leaves and sawdust; or just cardboard and/or newspaper.



Adding new bedding  
(Greater Vancouver  
Regional District)

- Cardboard cartons (corrugated): cut them up into strips an inch wide and a few inches long. Don't use the shredded cardboard sold for insulation because it's treated with toxic chemicals.
- Newspaper: tear it into 1" strips -- it's easy to tear with the grain. Black ink is non-toxic, avoid glossy paper.
- Shredded computer paper.
- Autumn leaves: spread them thickly in the driveway and drive over them with the car a few times to break them up, or shred them with a lawnmower. Or moisten them, sprinkle some lime, ground limestone or wood ash over them and bundle them up in a garbage bag, tie the top closed, and in a few months they'll have broken down enough to be excellent worm bedding. Or just use them as is, though it'll take a bit longer for the worms to break them down.
- Aged manure, or composted manure: cow, horse, rabbit.
- Sphagnum [peat moss](#): use Canadian peat moss, soak it in water for 24 hours, squeeze it out and sprinkle some lime on it.
- [Coco peat moss](#) or coir (coconut fibre): comes in compressed bricks, soak in water and they swell up -- no need to add lime.

- Chopped-up straw or other dead plant material, spoiled hay, yard clippings, dried grass clippings: any plant material "aged" beyond the green stage.
- Sawdust, wood shavings: from non-aromatic wood, avoid treated wood, about a quarter to a third of the bedding mixture.

Add a couple of handfuls of soil or sand -- it helps the worms grind up the food in their gizzards. Sprinkle a bit of lime, ground limestone or wood ash over the bedding (not too much!). Ground limestone is best.

Worm bedding and feed can be wetter than compost material: 75%, compared with 65% maximum for compost. Dry bedding usually needs a bit less than three times its weight in water (a pint of water weighs a pound, a litre weighs a kilogram).

Once it's all suitably shredded, mixed and moist, put it in the box and add the worms (about 1lb -- 1,000 worms). Leave it for two or three days to let the worms settle in before adding wastes.

## Feeding

No metal, foil, or plastic. Use vegetable and fruit scraps, coffee grounds (including paper filters), tea bags (remove the staple), eggshells (best dried and crushed first, then sprinkled over the surface), stale bread, houseplant trimmings. Chop up big chunks. Some people advise against citrus, and also onion and garlic, others use them: try small quantities first. Not too much vegetable oil, be cautious at first with dairy products, meat and fish -- small amounts chopped fine, well-dispersed and well-covered with bedding should be okay. Broken chicken bones are okay, bigger bones won't break down but shouldn't cause problems either -- they'll be picked clean.

It's best to collect food scraps in a small bucket with a lid and add them to the worm box every couple of days (or more often in hot weather -- don't let it go rotten). Bury them in the bedding in a corner of the box. Next time, bury the new scraps near the first scraps. You can have about nine burial sites in a 2x2ft box: by the time you've used the ninth one, you can go back to the first site again, the worms will have cleared it.

You'll be surprised how much feed you can put in that box -- the worms and micro-organisms reduce it more than you'd think possible.

The box will need emptying every 3-6 months.

Best tool for burying feed: a three-pronged hand-cultivator (hand-fork).

## Harvesting

If it's mainly the worm casts you want to use as garden compost, any of the following methods will do. If you value production of worms as well as casts, use the light separation method or a wire mesh screen.

### Some hassle -- light separation

Dump the finished material from the box onto a big piece of plastic (eg, an opened-out garbage bag) on the floor or on a table under a 100W light, or outside in the sun.

Form it into eight or nine mounds. Worms are sensitive to light and immediately burrow beneath the surface. Wait a few minutes, and meanwhile put fresh bedding in the box.



Keith harvests a worm box

A handbrush and dustpan are useful for this. Lightly brush the top off each mound until the worms are revealed, then wait for them to burrow deeper and do it again. Eventually you're left with a squirming mass of worms all trying to get under each other to avoid the light. Quickly put them in the new bedding in the box with a fresh supply of feed.



Worm spaghetti!

This leaves you with a rich harvest of worm castings and a lot of capsules, which you lose (the hatchlings won't survive in garden soil), but the worms in the bin will soon replace them. Store the castings for a

week or two before using them in the garden.

Kids love this -- if you have any tame children around you can usually talk them into doing it for you.

### Less hassle -- sideways separation

SHIRT all the material in the box to one side and fill the other side with fresh bedding; put your kitchen scraps and feed only in the fresh bedding side. In the next week or two the worms will migrate from the finished vermicompost into the fresh bedding. In the meantime the capsules will hatch and most of the hatchlings will also move across, so you won't lose them, which is an advantage over the dump-and-sort method.

## **Even less hassle -- vertical separation**

Get a piece of nylon or mesh window screening a bit bigger than the surface of the box and lay it flat on the surface of the vermicompost. It should be big enough to flatten against the sides and leave some overlap at the top. Fill the box up with fresh bedding on top of the screen and continue feeding it with kitchen scraps. The worms will migrate up through the screen into the new bedding as the food runs out below.

When the top part is ready for harvesting, use the overlap to lift the screen from the box, vermicompost, worms and all. Set it aside and empty the box -- it will have a very high concentration of worm castings and few if any worms, hatchlings or capsules.

Dump the wormy material that was on top of the screen into the bottom of the box and put the screen back on top of it, with fresh bedding on top of the screen.

Check the condition of the screen each time you empty the box, and replace it before it gets rotten enough to rip just as you're removing it, spilling everything back into the box.

## **No hassle**

This method will give you lots of trouble-free castings, but no extra worms. Go on feeding kitchen scraps to the box for up to four months, and then start a second box -- prime it with fresh bedding and a supply of worms from the first box. Just leave the first box until the second box is full, by which time the first box will contain a very high proportion of fine castings, and very few worms.

To make sure there are enough worms for both boxes, you can prepare the second box about a month earlier, adding some worms to it every time you add feed to the first box.

## Screening

The vermicompost might need screening, especially if you've used rough stuff (sticks etc.) in the bedding that takes time to break down. A circular gardener's sieve with a 3/16" mesh will work best. Try to get one with stainless steel mesh, it'll do the job much quicker, the worm castings won't stick to the mesh, and it won't rust.

This is also a good way of separating the worms from finished vermicompost, though capsules and hatchlings are lost.

## Problems

Flies and smells -- there shouldn't be any, but sometimes it happens. Worm casts have a pleasant, earthy smell, like forest soil. If the worm bin starts to smell, there's too much feed in it, more than the worms can process -- you've overloaded the system. Stop feeding the worms, add more dry bedding, a little sprinkled lime, and stir the bin with the hand cultivator (hand-fork). Repeat until the smell vanishes.

Fruit flies (actually vinegar flies) can get into the box, but they do no harm. Lots of them mean too much feed -- cut down the feeding rate and cover the surface with a damp newspaper.

The bin can also have an influx of soldier fly maggots, up to an inch long (they're a favourite with fishermen). Vinegar fly larvae are much smaller. Actually the maggots benefit the composting process, but if you don't like them, add more bedding and lime and stir as above, or put a chunk of bread soaked in milk on the surface. In a couple of days it will be infested with larvae; take it out and get rid of it (give it to a fisherman or a chicken).

## Garden wastes

Outdoor boxes can be bigger. The simplest way of all is a 12-inch-deep trench in the soil about 2ft wide or more with 8" of bedding and/or compost to put the worms in. Red worms can't survive long in ordinary garden soil so they won't crawl away. Add garden wastes as they come, putting it in a different part of the trench each time, and cover with a sprinkling of soil and lime. Bury kitchen wastes at the bottom, under the garden wastes.

Fresh garden wastes might get hot, but the worms will have a place to escape to until it gets cool enough for

have a place to escape to until it gets cool enough for them to handle.

To keep moles away, line the trench with 1/2" chicken wire or wire mesh.

Or make a four-sided wooden box with four 18" by 36" boards (or nail narrower planks together), treat it with vegetable oil or linseed oil, and stand it on a layer of bricks on top of the soil. Put 6" or so of bedding in the bottom and put the worms in it. Add wastes to the corners in succession. Shake the soil off clumped roots. Chop up big bits with the edge of a spade. Add more bedding as necessary. Bury kitchen scraps.

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## Using vermicompost

Use like compost -- dig it lightly into the topsoil around your plants. In composting growing beds or preparing new beds, vermicompost generally goes about twice as far as ordinary (aerobic) compost, so use half as much. But each garden is different (and so is each gardener!) -- some people have good results simply dumping large amounts of the stuff on top of their beds (6" a year in one case), others with very little.

Vermicompost gives seedlings a really good start in life.

In pots and containers, don't use pure vermicompost. About 25% of the growing mixture seems to be about ideal, but experiment -- it might vary according to what you mix it with.

You can also use vermicompost to make "compost tea" liquid fertilizer. Mix two tablespoons of vermicompost with a litre of water and let it stand for a day, shaking it occasionally, then sprinkle under the plants. One-litre drinking water bottles make good sprinklers: drill a few small-diameter holes in the lid, point and squeeze.

For transplants, especially bare-root transplants, spray them with an even more dilute solution of "tea", or stand them in it for awhile -- it'll help to prevent transplant shock. (Liquid seaweed solution is excellent for this.)

Don't let the vermicompost dry out before using it -- it loses a lot of its value and resists wetting. If you store it, don't use an airtight container. It will keep for a year or more.

See [Vermicomposting resources](#) for more information.

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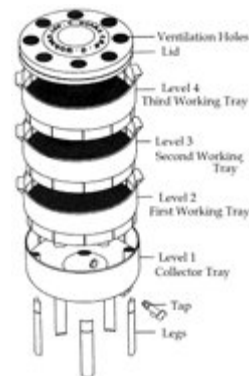
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Once it's all suitably shredded, mixed and moist, put it in the box and add the worms (about 1lb -- 1,000 worms). Leave it for two or three days to let the worms settle in before adding wastes.

## Feeding

No metal, foil, or plastic. Use vegetable and fruit scraps, coffee grounds (including paper filters), tea bags (remove the staple), eggshells (best dried and crushed first, then sprinkled over the surface), stale bread, houseplant trimmings. Chop up big chunks. Some people advise against citrus, and also onion and garlic, others use them: try small quantities first. Not too much vegetable oil, be cautious at first with dairy products, meat and fish -- small amounts chopped fine, well-dispersed and well-covered with bedding should be okay. Broken chicken bones are okay, bigger bones won't break down but shouldn't cause problems either -- they'll be picked clean.

It's best to collect food scraps in a small bucket with a lid and add them to the worm box every couple of days (or more often in hot weather -- don't let it go rotten). Bury them in the bedding in a corner of the box. Next time, bury the new scraps near the first scraps. You can have about nine burial sites in a 2x2ft box: by the time you've used the ninth one, you can go back to the first site again, the worms will have cleared it.

You'll be surprised how much feed you can put in that box -- the worms and micro-organisms reduce it more than you'd think possible.

The box will need emptying every 3-6 months.

Best tool for burying feed: a three-pronged hand-cultivator (hand-fork).

## Harvesting

If it's mainly the worm casts you want to use as garden compost, any of the following methods will do. If you value production of worms as well as casts, use the light separation method or a wire mesh screen.

### Some hassle -- light separation

Dump the finished material from the box onto a big piece of plastic (eg, an opened-out garbage bag) on the floor or on a table under a 100W light, or outside in the sun.

Form it into eight or nine mounds. Worms are sensitive to light and immediately burrow beneath the surface. Wait a few minutes, and meanwhile put fresh bedding in the box.



Keith harvests a worm box

A handbrush and dustpan are useful for this. Lightly brush the top off each mound until the worms are revealed, then wait for them to burrow deeper and do it again. Eventually you're left with a squirming mass of worms all trying to get under each other to avoid the light. Quickly put them in the new bedding in the box with a fresh supply of feed.



Worm spaghetti!

This leaves you with a rich harvest of worm castings and a lot of capsules, which you lose (the hatchlings won't survive in garden soil), but the worms in the bin will soon replace them. Store the castings for a

week or two before using them in the garden.

Kids love this -- if you have any tame children around you can usually talk them into doing it for you.

### Less hassle -- sideways separation

SHIRT all the material in the box to one side and fill the other side with fresh bedding; put your kitchen scraps and feed only in the fresh bedding side. In the next week or two the worms will migrate from the finished vermicompost into the fresh bedding. In the meantime the capsules will hatch and most of the hatchlings will also move across, so you won't lose them, which is an advantage over the dump-and-sort method.

## **Even less hassle -- vertical separation**

Get a piece of nylon or mesh window screening a bit bigger than the surface of the box and lay it flat on the surface of the vermicompost. It should be big enough to flatten against the sides and leave some overlap at the top. Fill the box up with fresh bedding on top of the screen and continue feeding it with kitchen scraps. The worms will migrate up through the screen into the new bedding as the food runs out below.

When the top part is ready for harvesting, use the overlap to lift the screen from the box, vermicompost, worms and all. Set it aside and empty the box -- it will have a very high concentration of worm castings and few if any worms, hatchlings or capsules.

Dump the wormy material that was on top of the screen into the bottom of the box and put the screen back on top of it, with fresh bedding on top of the screen.

Check the condition of the screen each time you empty the box, and replace it before it gets rotten enough to rip just as you're removing it, spilling everything back into the box.

## **No hassle**

This method will give you lots of trouble-free castings, but no extra worms. Go on feeding kitchen scraps to the box for up to four months, and then start a second box -- prime it with fresh bedding and a supply of worms from the first box. Just leave the first box until the second box is full, by which time the first box will contain a very high proportion of fine castings, and very few worms.

To make sure there are enough worms for both boxes, you can prepare the second box about a month earlier, adding some worms to it every time you add feed to the first box.

## Screening

The vermicompost might need screening, especially if you've used rough stuff (sticks etc.) in the bedding that takes time to break down. A circular gardener's sieve with a 3/16" mesh will work best. Try to get one with stainless steel mesh, it'll do the job much quicker, the worm castings won't stick to the mesh, and it won't rust.

This is also a good way of separating the worms from finished vermicompost, though capsules and hatchlings are lost.

## Problems

Flies and smells -- there shouldn't be any, but sometimes it happens. Worm casts have a pleasant, earthy smell, like forest soil. If the worm bin starts to smell, there's too much feed in it, more than the worms can process -- you've overloaded the system. Stop feeding the worms, add more dry bedding, a little sprinkled lime, and stir the bin with the hand cultivator (hand-fork). Repeat until the smell vanishes.

Fruit flies (actually vinegar flies) can get into the box, but they do no harm. Lots of them mean too much feed -- cut down the feeding rate and cover the surface with a damp newspaper.

The bin can also have an influx of soldier fly maggots, up to an inch long (they're a favourite with fishermen). Vinegar fly larvae are much smaller. Actually the maggots benefit the composting process, but if you don't like them, add more bedding and lime and stir as above, or put a chunk of bread soaked in milk on the surface. In a couple of days it will be infested with larvae; take it out and get rid of it (give it to a fisherman or a chicken).

## Garden wastes

Outdoor boxes can be bigger. The simplest way of all is a 12-inch-deep trench in the soil about 2ft wide or more with 8" of bedding and/or compost to put the worms in. Red worms can't survive long in ordinary garden soil so they won't crawl away. Add garden wastes as they come, putting it in a different part of the trench each time, and cover with a sprinkling of soil and lime. Bury kitchen wastes at the bottom, under the garden wastes.

Fresh garden wastes might get hot, but the worms will have a place to escape to until it gets cool enough for

have a place to escape to until it gets cool enough for them to handle.

To keep moles away, line the trench with 1/2" chicken wire or wire mesh.

Or make a four-sided wooden box with four 18" by 36" boards (or nail narrower planks together), treat it with vegetable oil or linseed oil, and stand it on a layer of bricks on top of the soil. Put 6" or so of bedding in the bottom and put the worms in it. Add wastes to the corners in succession. Shake the soil off clumped roots. Chop up big bits with the edge of a spade. Add more bedding as necessary. Bury kitchen scraps.

See **"Friend Earthworm: Practical Application of a Lifetime Study of Habits of the Most Important Animal in the World"** by George Sheffield Oliver for more information -- online at the Journey to Forever [Small Farms Library](#).

## Using vermicompost

Use like compost -- dig it lightly into the topsoil around your plants. In composting growing beds or preparing new beds, vermicompost generally goes about twice as far as ordinary (aerobic) compost, so use half as much. But each garden is different (and so is each gardener!) -- some people have good results simply dumping large amounts of the stuff on top of their beds (6" a year in one case), others with very little.

Vermicompost gives seedlings a really good start in life.

In pots and containers, don't use pure vermicompost. About 25% of the growing mixture seems to be about ideal, but experiment -- it might vary according to what you mix it with.

You can also use vermicompost to make "compost tea" liquid fertilizer. Mix two tablespoons of vermicompost with a litre of water and let it stand for a day, shaking it occasionally, then sprinkle under the plants. One-litre drinking water bottles make good sprinklers: drill a few small-diameter holes in the lid, point and squeeze.

For transplants, especially bare-root transplants, spray them with an even more dilute solution of "tea", or stand them in it for awhile -- it'll help to prevent transplant shock. (Liquid seaweed solution is excellent for this.)

Don't let the vermicompost dry out before using it -- it loses a lot of its value and resists wetting. If you store it, don't use an airtight container. It will keep for a year or more.

See [Vermicomposting resources](#) for more information.

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## WORM BINS

### PURPOSE

Thousands of schools around the world use worm bins to teach students about recycling organic wastes and to involve them in investigations of worm biology and behavior. Vermicomposting (from the Latin *vermis*, for worm) is also used in large-scale industrial applications, with waste streams including sewage sludge, animal manure, and food wastes. Unlike thermophilic composting, vermicomposting does not get hot. In fact, temperatures above 35°C would kill the worms. In all types of composting, microorganisms play the key role in decomposition. In vermicomposting, worms help by physically breaking down the organic matter and chemically altering it through digestion. The end product, vermicompost, contains plant-available nutrients and compounds that enhance plant growth.

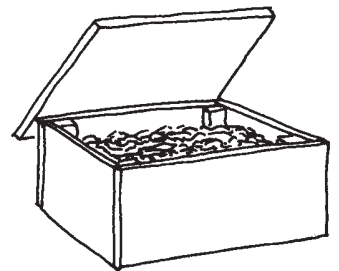
Vermicomposting provides a wealth of opportunities for student research on topics such as worm behavior, life cycles, feeding preferences, and effects of worms and other invertebrates on decomposition. For more information on the biology and ecology of worms, see Chapter 1 (pp. 22–26).

### MATERIALS

- a worm bin (see Steps 1 and 2, below)
- bedding (see Step 3, below)
- red worms (see Step 4, below)
- food (see Step 5, below)

### CONSTRUCTION

1. **Decide on the bin size:** If you plan to use your worm bin for classroom observation and scientific investigation, but not for recycling of a set amount of food scraps, then any size bin will do. It can be as small as a shoe box or as large as you'd like to make it. However, if you plan to put in a set amount of food, such as all the non-meat lunch scraps from your classroom, then you will need to calculate the size of the bin based on the amount of food you plan to compost. Conduct a waste audit by collecting food scraps for a week and then weighing how much has accumulated. The rule of thumb is that roughly a square foot of bin space is needed for every pound of waste composted per week. (Since red worms are surface dwellers, surface area rather than volume is used for this calculation).
2. **Prepare the bin:** Many different types of containers are successfully used for vermicomposting. Wooden boxes, Styrofoam coolers, and plastic tubs all are possibilities. Whatever type of container you use, providing adequate ventilation is the key to success. Worm bins usually have a tight-fitting lid, with many small ventilation holes drilled through the bin sides for ventilation. The most fail-proof design uses drain holes in the bottom, with the bin propped up on blocks so that excess moisture can drain into an underlying tray. (Most food scraps are wet, and without drainage the bedding can become mucky and



anaerobic.) If you want to build a self-contained unit, it is possible to maintain proper moisture conditions without bottom drainage, as long as you are willing to keep a watchful eye on the moisture level and mix in dry bedding whenever the compost mixture begins to look soggy. (You want the mix to be moist but without puddles.)

Some commercially available worm bins use a tiered system of stacking bins. When the worms have depleted the food in the bottom bin, they crawl upward through holes or mesh into the next higher bin, where fresh food scraps have been added. Students may want to design a system such as this, using a stack of mesh-bottomed trays or boxes.

3. **Prepare the bedding:** The bedding holds moisture and contains air spaces essential to worms, and it gets eaten along with the food wastes. Common types of bedding include strips of newspaper, office paper, corrugated cardboard, or paper egg cartons. Machine-shredded paper or cardboard is ideal if available. If not, paper or cardboard will need to be torn into strips 1–3 cm wide. Other popular bedding materials include leaves, sawdust, peat moss, and shredded coconut fiber, which is similar in consistency to peat moss and is available from companies that sell red worms.

Whatever type of bedding you choose, you will need to soak it until saturated, then drain off any excess water. Place the damp bedding in the bin, filling it to a depth of about 20 cm. Do not pack the bedding down—leave it loose to provide air spaces for the worms. You may wish to add a couple of handfuls of sand or crushed egg shells to provide the grit that worms use to grind their food.

4. **Add the worms:** The species most commonly used for vermicomposting is *Eisenia fetida*, commonly called red worms, red wigglers, manure worms, or tiger worms. You will need a pound or two (1000–2000 worms) to get started, after which the worms will replace themselves as long as conditions remain suitable for their reproduction and growth. If you can't obtain *Eisenia fetida* from a composter or worm farm in your community, you can mail-order them.<sup>1</sup> *Lumbricus terrestris*, the common night crawlers found in gardens, will not thrive in worm bins because they are adapted to burrowing deep into soil. In contrast, *Eisenia fetida* are surface dwellers, adapted to living in organically rich surface soils and the overlying layers of decomposing leaves and organic debris.

5. **Add food:** Bury a few handfuls of fruit and vegetable scraps in the bedding. Wait several days for the worms to acclimatize, then gradually increase the amount of food based on how quickly it is disappearing. You can add food every day, or you can leave the bin untended for a week or even up to a month once it has become established.

Any food that humans eat can be fed to worms, but some types are more suitable than others for indoor worm bins. Vegetable and fruit scraps are ideal, such as carrot peels, melon rinds, and apple cores. Coffee grounds, tea bags, bread crusts, and pasta all are suitable. If you add a large amount of citrus fruits or other acidic foods, it would be a

good idea to monitor the pH to make sure it does not drop below the 6.5 to 8.5 range that is ideal for worms (see **pH**, below). It is best to limit the quantities of foods such as onions and broccoli, which tend to have strong odors as they decompose. Avoid meats, fats, and dairy products because these foods decompose slowly and may attract pests. You may want to cut or break large food scraps into small pieces for faster decomposition.

6. **Cover the bin** with a lid made of plastic, wood, or fabric to provide shade and conserve moisture.
7. **Locate the bin** in an area where it will not be exposed to extreme heat or cold. Red worms thrive at room temperature (15–25°C). They can survive in colder locations, but their rate of feeding will be reduced. They will die if they freeze or are subjected to temperatures above about 35°C. Avoid placing bins on surfaces that vibrate, such as the surface of washing machines, because the vibrations may trigger the worms to try to leave the bin.

## MAINTENANCE

Maintaining a worm bin is simple. No mixing or turning is needed. All you need to do is to keep an eye on the amount of food, the moisture level, and possibly the pH, and to harvest the worms once the composting process is completed.

**Food:** Monitor the bin and add more food once the first scraps have started to disappear. How much food should you add? Red worms can eat up to half their weight per day, so a simple calculation based on their initial weight will provide a guideline for the appropriate amount of food. But, it is important not to rely on numbers alone—instead, check once a week or so to see if the food is disappearing, and adjust feeding levels accordingly.

**Research Possibilities:** *Worm feeding provides many opportunities for experimentation. Which types of food disappear the fastest, and which decompose slowly? Which foods tend to attract large groups of worms, and which ones do the worms avoid? Does the initial size of food particles affect how quickly they disappear?*

**Moisture:** If the bedding appears dry, add moist food scraps or lightly spray with water. If the bedding becomes soggy, add dry newspaper strips or other dry bedding material, and avoid adding wet food scraps until the moisture is back in balance.

**pH:** Although not essential, periodic pH measurements are useful in monitoring the conditions in your worm bin. Simply insert pH paper into damp vermicompost, or follow one of the other measurement techniques described on p. 54. *Eisenia fetida* do best at a pH around neutral or slightly alkaline, in the range of 6.5 to 8.5. If conditions become acidic, mix in a sprinkling of crushed egg shells or powdered lime ( $\text{CaCO}_3$ , *not* hydrated lime).



**Bedding:** Within several months, most of the original bedding will have been replaced with brown, soil-like castings. At this point, it is time to remove the completed vermicompost and harvest the worms to start a new batch. This can be done all at once or through a gradual process (see *Harvesting the Worms*, p. 39).

## TROUBLESHOOTING

**Escaping Worms:** When you first put worms into fresh bedding, they may initially try to escape. If you keep the lid on, they will gradually get acclimatized and remain in the bin even when it is uncovered. Once your vermicomposting is underway, worms attempting to escape is a signal that conditions in the bin are not favorable. The bedding may be too moist, which you can solve by mixing in some dry bedding. Or, the conditions may have become too acidic (see **pH**, p. 37). Another possibility is that the worms are not getting enough to eat. If all of the food and bedding have decomposed, the remaining castings will not continue to adequately nourish the worms, and it is time to harvest them and begin again with fresh bedding.

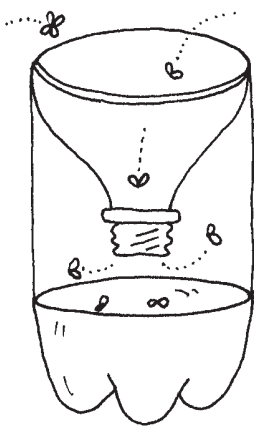
**Worm Mortality:** In a properly maintained worm bin, worms will continually die and decompose without being noticed, and the population will replenish itself through reproduction. If you notice many dead worms, there is a problem. Either the mixture has become too wet or dry, too hot or cold, or available food supplies have become depleted (see remedies listed under **Escaping Worms**, above).

**Fruit Flies:** Although fruit flies do not pose any health hazards, they can be a nuisance. To avoid breeding flies in worm bins, make sure to bury all food scraps in bedding. Monitor the decomposition of food that you add, and hold off on adding more if the scraps are sitting longer than a few days before disappearing. Keep bedding material moist but not too wet, since overly wet conditions encourage the proliferation of fruit flies.

If a fruit fly problem does develop, stop adding food until the worms have had a chance to catch up with the existing supply, and add dry newspaper strips if the bedding appears soggy. If the outdoor weather is suitable, you might want to air out the bin by leaving it uncovered outside for a few hours.

You can build a simple but effective fruit fly trap that can be placed either right in the worm bin or anywhere in the classroom where flies congregate. Take a soda bottle and remove the lid. Cut the bottle in two, with the top part slightly shorter than the bottom part. Pour cider vinegar into the bottom part to a depth of about 2 cm. Then, invert the top of the bottle into the bottom, forming a funnel leading into the bottle. Fruit flies will be attracted to the vinegar, and they will drown or get trapped.

**Other Invertebrates:** Many types of soil invertebrates can inhabit worm bins without causing problems. If you use leaves for bedding or if you add soil for grit, you are likely to introduce into the bin a variety of invertebrates such as millipedes, sowbugs, slugs, and springtails (see



pp. 19–21 for a description of common soil invertebrates). These organisms are decomposers and will aid in making compost. You may notice some tiny white worms in your vermicompost. These often are mistaken for baby red worms but can be distinguished by their white rather than pink coloration. They are potworms, or enchytraeids (see p. 19). Potworms will not harm red worms, and they will aid in decomposition, but if you have many of them in your bin it may indicate that conditions have become acidic. Mites usually are present in worm bins but rarely present a problem. However, if your vermicompost becomes too moist or acidic, it may become infested and appear to be swarming with mites. At this point, it is a good idea to harvest the worms, rinse them, and start over with new bedding and food in a clean bin.

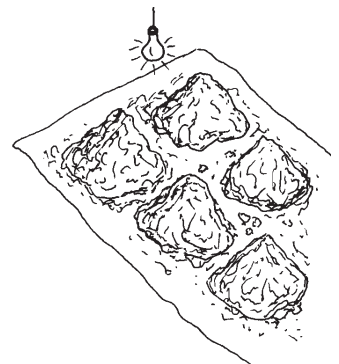
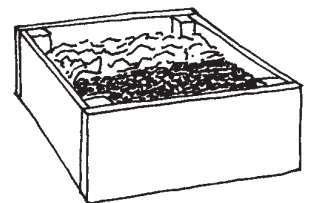
**Odors:** A properly functioning worm bin will not have a noticeable odor. If unpleasant smells do develop, there are several possible reasons. The bedding may have become too wet or may not be getting enough air. Another possible source of odors is food such as onions or broccoli that are naturally smelly as they decompose, or foods such as dairy products that turn rancid because they are not eaten rapidly by worms. To correct a problem of this sort, simply remove and dispose of the offending foods.

## HARVESTING THE WORMS

If you want to use the compost on plants, and reuse the worms to make more compost, you will need to harvest the worms. This is generally done after three or more months, when the bin is filled with compost and very little bedding remains. Two methods are commonly used to separate worms from the castings. In the slower but easier method, you simply push all of the worm bin contents to one-half of the bin. In the empty half, start a new batch of compost by providing fresh bedding and food scraps. Over the next several weeks, the worms will move to the side with new food, conveniently leaving their castings behind in the other section. After this occurs, you can remove the finished compost and replace it with fresh bedding.

A faster but more labor-intensive method of removing worms involves dumping the entire contents of the worm bin onto a sheet of plastic or paper in a sunny or brightly lit location. Shape the compost into several cone-shaped piles. The worms will burrow downward to avoid light. Scoop the top layer off each pile, wait a few minutes for the worms to burrow farther, and then remove the next layer of compost. Repeat this process until the worms have become concentrated at the bottom of each pile. Collect the worms, weigh them (to compare with your initial mass of worms), and put them back in the bin with fresh bedding.

**Research Possibility:** Design some experiments to find a better way of separating worms from compost. Are there any chemical or physical factors that will cause the worms to migrate, without impairing the beneficial properties of finished vermicompost?



## USING VERMICOMPOST

Once the food and bedding have fully decomposed, vermicompost can be used in the same way as other types of compost, either mixed into the soil or added to the surface as a top dressing. By mixing vermicompost with water, you can make a compost tea solution that enriches plants as they are watered. Many claims are made about the growth-inducing properties of vermicompost. See Chapters 6 and 7 for ideas about experiments to test the effects of various types of compost on plant growth.



**Research Possibility:** *How does vermicompost compare with thermophilic compost in plant growth experiments?*