
# Composting Indoors

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# Composting Indoors

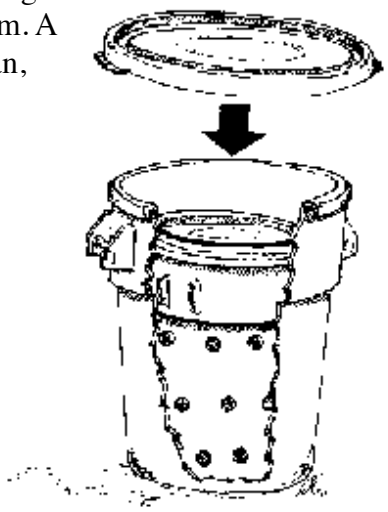
When you think of composting, chances are you envision one of a variety of bins or holding systems that are used for composting outdoors. For fastest composting, these bins need to provide adequate moisture, heat retention, and air flow to facilitate aerobic, heat-producing decomposition of organic matter. Composting can also be carried out right in the classroom, in containers ranging in size from soda bottles to garbage cans. Because these units are so much smaller than the outdoor bins, they need to be carefully designed to provide proper conditions for aerobic, heat-producing composting to occur.

Three types of composting vessels, or bioreactors, are described here:

## Building a Two-Can Bioreactor

### Purpose

Two-can bioreactors are designed to be used as small-scale indoor composting units for families, and for composting as an educational tool in the classroom. A two-can Bioreactor will process enough organic matter to fill a 20-gallon can, producing finished compost within two to three months.



**Materials**

- 32-gallon plastic garbage can
- 20-gallon plastic garbage can
- drill
- brick
- spigot (optional)
- duct tape (optional)
- insulation (optional)

**Construction**

1. Using a drill, make 15 to 20 holes (0.5" to 1" diameter) through the bottom of the 20-gallon can. Next drill three rows of holes through the sides of this can, six to eight inches apart with four to five inches between rows, ending about two inches below where the can expands at the top.
2. Place a brick or some other object in the bottom of the 32-gallon can. This is to separate the leachate from the compost and allow for its measurement and addition back into the compost pile. The leachate, often referred to as "compost tea," is rich in nutrients which may be in a form readily usable by plants. If not used right away on growing plants, pour the leachate back into the

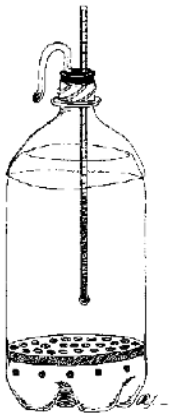
compost. Excessive leachate can be responsible for foul smells. If your system produces enough leachate to cause odor problems, your initial compost mixture was probably too wet.

3. Variations on the design:
    - Add insulation to the barrels (inner and outer) with duct tape.
    - Include a spigot to draw off the leachate.
    - Add a layer of old compost, wood chips, or soil inside the outer barrel. This will allow the leachate to be absorbed and may cause fewer leachate/odor issues.

**Note:** A system of 10-gallon plastic garbage cans that can fit inside 20-gallon cans can be substituted if space is a problem. The smaller system may operate at lower temperatures. This should not affect the final product; it will just take longer before the product can be used.

The composting process in the cans will take from three to five weeks. After this period, you can transfer the compost to other containers or an outdoor pile for several weeks of curing while starting up a new batch of compost in the 2-can system.

## Building a Soda Bottle Bioreactor



**Purpose**

Soda bottle bioreactors are designed to be used as tools for composting research. They are small and inexpensive enough to enable students to design and carry out individualized research projects, comparing variables such as reactor design, moisture content, and nutrient ratios of mixtures to be composted.

The design described here is meant to be used as a starting point only -- please improvise and allow your students to use their own ideas in designing and building their bioreactors.

**Materials (per student or group of students)**

- two 2-liter or 3-liter soda bottles
- one smaller container, about 5-cm high, that fits inside the soda bottle
- one Styrofoam plate or tray
- drill or nail for making holes
- duct tape or clear packaging tape
- utility knife
- insulation materials such as sheets of fiberglass or foam rubber, or Styrofoam peanuts
- fine-meshed screen or fabric large enough to cover top of soda bottle and air holes in bottom half
- thermometer that will fit into the top of the soda bottle and be long enough to reach down into the center of the compost
- chopped vegetable scraps such as lettuce leaves, carrot or potato peelings, and apple cores, or garden wastes such as weeds or grass clippings

- bulking agent such as wood shavings or 1-2 cm pieces of paper egg cartons, cardboard, or wood
- optional: hollow tubing to provide ventilation

**Construction**

1. Using a utility knife or sharp-pointed scissors, cut the top off one soda bottle just below the shoulder and the other just above the shoulder. Using the larger pieces of the two bottles, you will now have a top from one that fits snugly over the bottom from the other.
2. Place a smaller container (roughly 4-5 cm high) upside down into the bottom of the soda bottle. This will form a stand to support the tray that will hold the compost. You can use any plastic container that will fit inside the bottle and provide adequate support for the styrofoam stand and overlying compost.
3. The next step is to make a styrofoam circle. Trace a circle the diameter of the soda bottle on a styrofoam plate or try and cut it out, forming a piece that fits snugly inside the soda bottle. Use a nail to punch holes through the styrofoam for aeration.
4. Assemble the bottom of your bioreactor by placing the stand into the soda bottle, then resting the styrofoam circle on top of the stand. Make a mark on your bottle to indicate where the styrofoam circle sits. Above this point is where the compost will be, and below it is where you want to make air holes.
5. Make air holes in the sides of the soda bottle in the area below the mark that you made. This can be done with a drill or by carefully heating a nail and using it to melt holes through the plastic. Avoid making holes in the very bottom of the bottle unless you plan to use a tray underneath to collect whatever leachate may be generated during composting. Reassemble the bioreactor pieces, making sure that you have provided sufficient air holes to allow air to enter the bottle and flow up through the stand and styrofoam circle.
6. Fill the bioreactor with the mixture you wish to compost. A variety of materials will work, but in general you want a bulking agent to provide air flow plus some vegetable scraps to provide food

| Bulking Agents | Food for the Microbes |
|---|---|
| Wood shavings | Lettuce scraps |
| Small wood chips | Carrot peelings |
| Newspapaer strips | Apple cores |
| Pieces of paper egg cartons | Bread crusts |
| Chopped straw | Banana peels |
| | Weeds |
| | Grass clippings |

for the microbes (see following table for some possibilities). In these mini-bioreactors, composting proceeds best if the bulking agent and food scraps are cut or chopped into roughly 1-2 cm pieces. Soak the bulking agent in water until thoroughly moist, then drain off excess water.

7. Mix roughly equal amounts of bulking agent and food scraps, then fill your reactor. Remember that you want air to be able to diffuse through the pores in the compost, so make sure to keep your mix light and fluffy and do not pack it down.
8. Put the top piece of the soda bottle back on and seal it in place with tape.
9. Cover the top hole with a piece of screen or nylon stocking, rubber banded into place. Alternatively, if you are worried about potential odors you can ventilate your bioreactor using rubber tubing out the top. Simply use the screw-on soda bottle cover with a hole drilled through it for a piece of rubber tubing, which leads out the window or into a ventilation hood.
10. If you want to eliminate the possibility of flies becoming a problem, you can cover all air holes with a piece of nylon stocking or other fine-meshed fabric.
11. Insulate the bioreactor, making sure not to block the ventilation holes. (Because these soda bottle bioreactors are much smaller than the typical compost pile, they will work best if insulated to retain the heat that is generated during decomposition.) You can experiment with various types and amounts of insulation.

Now you are ready to watch the compost process at work! You can chart the daily progress of your compost by taking temperature readings, inserting a thermometer down into the compost through the top of the soda bottle. Using temperature charts, you can compare variables such as the types of compostable materials, moisture levels, amounts of air flow, and insulation systems. Because the bottles are so small, you may not end up with a product that looks as finished as the compost from larger piles or bioreactors. You should find, though, that the volume shrinks by 1/2 to 2/3 and that the original materials are no longer recognizable. You can let the compost age in the soda bottles for several months, or transfer it to other containers for curing while starting up a new batch of compost in the soda bottles.

## High-Tech Bioreactors

A bioreactor is a name given to an enclosed composting vessel. The difference between a bioreactor and a typical composting system is that more parameters of the composting process can be measured and controlled in bioreactors. Even though the degradation of organic wastes has been happening since the introduction of life on our planet, it still is not completely understood. Using a bioreactor enables students and teachers to study and manipulate composting parameters inside a classroom or lab setting.

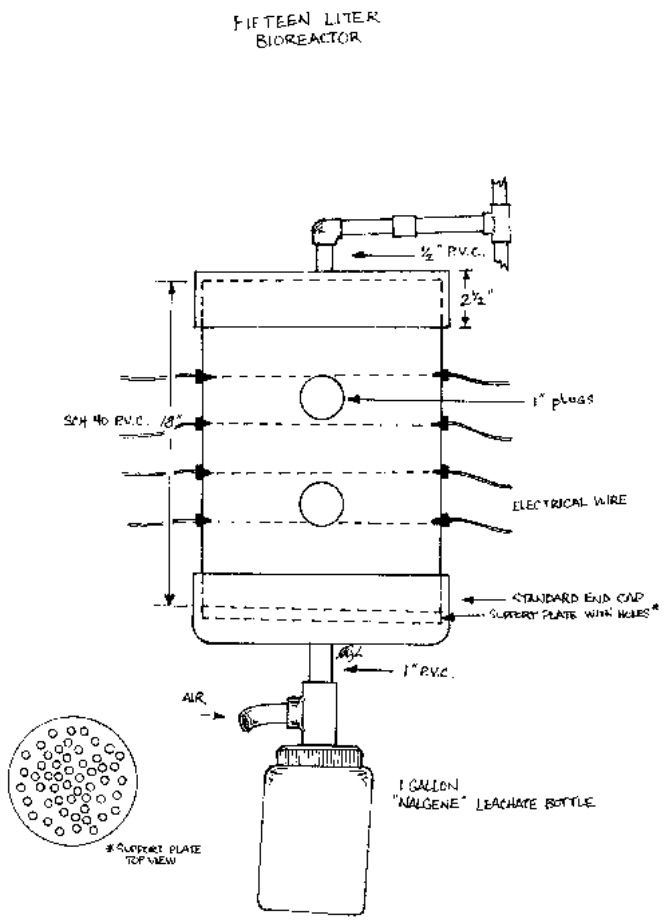
This is a complicated construction project, and access to a machine shop is highly recommended. For simpler classroom composting systems, try Soda Bottle Bioreactors or Garbage Can Bioreactors (above).

**Materials**

- 18" length of 12" diameter PVC plastic sewer pipe
- 1 PVC end cap for 12 PVC pipe
- 1/4 to 3/8 inch thick plastic plate (2' x 2')
- PVC fittings:

- 3.5" x 3" nipple
- 1.5” threaded elbow
- threaded 0.5" coupler
- 2.5" x 6” nipple
- 1.5" threaded T
- 1" x 3" nipple
- 1” threaded T
- 1" x 6" nipple
- 1" to 0.25"reducer
- 1.25" nozzle
- two 1" plugs

- Epoxy for PVC pipe (small can)
- roll of Teflon tape
- tube of silicon caulk
- 1 gal. Nalgene bottle with cap
- thermocouple wire and male and female connectors (T type-constantine/copper)
- thermocouple reader
- clear plastic tubing:
  - 5 to 6 feet 3/4"
  - 4 feet 3/8"
- basic tools: crescent wrenches, permanent markers, power drill, drill bits, etc.




**Procedure**

**Building the Bioreactor**

1. On a band saw, cut 3" off the end cap. Save this ring as it will be used to make the top cap.
2. Drill a hole in the center of the end cap large enough for a 1" tap. With a 1" tap thread hole for 1" PVC nipple.
3. Using the same drill bit, drill two holes in the side of the 18" of PVC pipe. The first one should be 7 inches from the edge and the other should be 14 inches from the same edge directly above the first. Using the 1" tap, thread the hole. These are where the 1" plugs will be placed.
4. Using the ring formed from the cut on the end cap, draw the outline of the outer diameter on the plastic plate with the permanent marker. Cut this out with a band saw or jig saw. Glue this to the ring using the epoxy (&laqno;DO THIS OUTSIDE OR IN AN AREA WITH PLENTY OF VENTILATION!) Allow to dry overnight. Drill a hole in the center of this plate large enough for a 1/2" tap. With a 1/2" tap, thread this hole.
5. Place the 18" section of PVC pipe upright on the plastic plate. Using the marker, draw on the plate the inside diameter of the PVC pipe. Cut this plastic plate using the same equipment used in #4. With a drill press, drill 1/4" holes uniformly over the entire plate. {how many?, spacing?}
6. Using a band saw, cut 1" off the 18" section of PVC pipe. This will be used as your support for the plate you made in #5. Cut a section out of this ring so that it will fit snugly inside the remaining 17" of

PVC pipe. (It will be an inside ring.) Using the epoxy, glue this ring inside the remaining 17" of PVC pipe so that the bottom edge is flush with the bottom of the pipe.
7. Glue the bottom end cap with epoxy to the 17" section on the side with the plate ring. Use excess epoxy for a tight seal.
8. Using a hand drill with a 1/8" drill bit, drill four holes on each side of the reactor body directly across from one another. These should be arranged so that you can obtain temperature readings from above, the top 1/3, the center, and the bottom 1/3 of the composting material.

**Constructing the Exhaust and Condensate Collection System**

1. Put Teflon tape on all threaded fittings.
2. Thread a 1/2" x 3" nipple into 1/2" elbow, thread a 1/2" x 6" nipple into other end of elbow, put a coupler onto this 6" nipple, and to this coupler add a 1/2" x 6" nipple. To this nipple, thread on the 1/2" T at the middle junction and to each side of the T, add the other two 1/2" x 3" nipples.
3. Thread the nipple closest to the elbow into the top of the reactor. The 6" nipples should be in a position perpendicular to the floor. To the 6" nipple facing down, put a condensate collection bottle. (This doesn't have to be air tight). To the 6" nipple, pointing upward, place the 3/4" tubing over the top and the other end will be put outdoors.

**Constructing the Leachate Collection and Air Input Systems**

1. Drill a hole in the top of the nalgene bottle large enough for the 1" tap. (It's easier if cap is left on the bottle during drilling.) Using a 1" tap, thread the hole.
2. Thread the 1" x 3" nipple into the end of the 1" T, the reducer into the middle port of the T, the 1/2" nozzle into the reducer, the 1" x 6" nipple into the top of the T.
3. Connect the 6" nipple to the bottom of the end cap and the gal. Nalgene bottle to the 3" nipple. (These must be airtight; use silicon caulk.)

A reactor stand is recommended, but its design is up to the individual. The only criteria are that it be near an outside wall for the ventilation of the exhaust gases from the reactor and that it hold the reactor high enough for the leachate bottle to be installed.

You are now ready to begin composting and experimenting!

## Worm Bins

Worm Bins are another form of indoor composting. Here the decomposition is accomplished by redworms as well as microorganisms, and the temperatures do not get as high as in the bioreactors above. Worm bins are popular in elementary school classrooms, where the students use them for activities ranging from scientific measurement to story writing.

### Worm Composting Basics

by Jen Fong and Paula Hewitt

**What is worm composting?**

Worm composting is using worms to recycle food scraps and other organic material into a valuable soil amendment called vermicompost, or worm compost. Worms eat food scraps, which become compost as they pass through the worm's body. Compost exits the worm through its' tail end. This compost can then be used to grow plants. To understand why vermicompost is good for plants, remember that the worms are eating nutrient-rich fruit and vegetable scraps, and turning them into nutrient-rich compost.

**Materials to use (and avoid) in a classroom worm bin**

For millions of years, worms have been hard at work breaking down organic materials and returning nutrients to the soil. By bringing a worm bin into the classroom, you are simulating the worm's role in nature. Though worms could eat any organic material, certain foods are better for the classroom worm bin.

We recommend using only raw fruit and vegetable scraps. Stay away from meats, oils and dairy products, which are more complex materials than fruits and vegetables. Thus, they take longer to break down and can attract pests. Cooked foods are often oily or buttery, which can also attract pests.

Avoid orange rinds and other citrus fruits, which are too acidic, and can attract fruit flies. Try to use a variety of materials. We have found the more vegetable matter, the better the worm bin. Stay away from onions and broccoli which tend to have a strong odor.

**Setting up a worm bin**

Setting up a worm bin is easy. All you need is a box, moist newspaper strips, and worms. To figure out how to set up a worm bin, first consider what worms need to live. If your bin provides what worms need, then it will be successful. Worms need moisture, air, food, darkness, and warm (but not hot) temperatures. Bedding, made of newspaper strips or leaves, will hold moisture and contain air spaces essential to worms.

You should use red worms or red wigglers in the worm bin, which can be ordered from a worm farm and mailed to your school. The scientific name for the two commonly used red worms are Eisenia foetida and Lumbricus rubellus.

**Containers**

When choosing a container in which to compost with worms, you should keep in mind the amount of food scraps you wish to compost, and where the bin will be located. A good size bin for the classroom is a 5- to 10- gallon box or approximately 24" X 18" X 8". The box should be shallow rather than deep, as red wigglers are surface-dwellers and prefer to live in the top 6" of the soil..

Whether you choose a plastic, wooden or glass container to use as a worm bin is a matter of personal preference based primarily on what is available. Some teachers have extra aquariums available. Some have wooden boxes which they would like to reuse. Others may prefer to buy or reuse a plastic container, such as commercially manufactured storage bin (e.g. "Rubbermaid," "Tucker," "Sterilite").No matter what material you choose, make sure to rinse out the container before using. For wooden bins, line the bottom with plastic (e.g. from a plastic bag or old shower curtain). Cover the bin with a loose fitting lid. This lid should allow air into the bin.

**Harvesting**

If you take care of your worms and create a favorable environment for them, they will work tirelessly to eat your "garbage" and produce compost. As time progresses, you will notice less and less bedding and more and more compost in your bin. After 3-5 months, when your bin is filled with compost (and very little bedding), it is time to harvest the bin. Harvesting means removing the finished compost from the bin.

After several months, worms need to be separated from their castings which, at high concentrations, create an unhealthy environment for them.

To prepare for harvesting, do not add new food to the bin for two weeks. Then try one of two methods for harvesting:

Push all of the worm bin contents to one half of the bin, removing any large pieces of undecomposed food or newspaper. Put fresh bedding and food scraps in empty side of bin. Continue burying food scraps only in freshly bedded half.

Over the next 2-3 weeks, the worms will move over to the new side (where the food is), conveniently leaving their compost behind in one section. When this has happened, remove the compost and replace it with fresh bedding. To facilitate worm migration, cover only the new side of the bin, causing the old side to dry out and encouraging the worms to leave the old side.

**Hands-On Method:**

Dump the entire contents of the worm bin onto a sheet of plastic or paper. Make several individual cone-shaped piles. Each pile will contain worms, compost and undecomposed food and bedding. As the piles are exposed to light,, the worms will migrate towards the bottom of the pile. Remove the top layer of compost from the pile, separating out pieces of undecomposed food and newspaper. After removing the top layer, let pile sit under light for 2-3 minutes as the worms migrate down. Then remove the next layer of compost. Repeat this process until all of the worms are left at the bottom of the pile. Collect the worms, weigh them (for your record keeping) and put them back in their bin with fresh bedding.

Regardless of which method you choose, the compost you harvest will most likely contain a worm or two, along with old food scraps and bedding. If you are using the compost outdoors, there is no need to worry--the worms will find a happy home and the food scraps and bedding will eventually decompose. If you are using the compost indoors, you may want to remove old bedding and food scraps for aesthetic purposes and ensure that there are no worms in the compost. Though the worms will not harm your plants, the worms may not like living in a small pot.

For both methods, you may continue to compost your food scraps after harvesting. Just add fresh bedding and food scraps. If, for some reason, you do not want to continue composting, please offer the setup to another teacher or to someone who will take the worm bin home. Anyone with a garden will find the worm compost extremely valuable. As a last resort, if you cannot find anyone who wants good worm compost, you may add the worms to a garden bed.

**Using worm compost**

You can use your compost immediately, or you can store it and use it during the gardening season, or whenever. The compost can be directly mixed with your potting soil or garden soil as a soil amendment,

which helps make nutrients available to plants. Or, the compost can be used as a top dressing for your indoor or outdoor plants.

You can also make "compost tea" with your compost. Simply add 1-2" of compost to your water can or rain barrel. Allow compost and water to "steep" for a day, mixing occasionally. Then water plants as you normally would. The resulting "tea" helps make nutrients already in the soil available to plants.

**Biology of worms**

Worms can live for about one year in the worm bin. If a worm dies in your bin, you probably will not notice it. Since the worm's body is about 90% water, it will shrivel up and become part of the compost rather quickly. New worms are born and others die all the time.

Worms are hermaphrodites, which means they are both male and female at the same time. In order to mate, they still require two worms. The worms line up in opposite directions near their band (or clitellum), which contains some of the sexual organs. The worms are attached for about 15 minutes while they exchange sperm cells. Several days later, eggs come in contact with the sperm cells and form a cocoon, or egg case. The cocoon separates from the worm, then fertilization takes place. Inside the cocoon, 2-5 baby worms may be found.

The baby worms live in the egg case for at least 3 weeks, sometimes longer depending on the surrounding conditions. For example, in the winter time, baby worms may stay in the cocoon for many weeks until the temperature warms up again. When the baby worms eventually crawl out, they are the thickness of a piece of thread and possibly 1 cm 1/4" long. Usually the worms appear white, as they have not yet developed pigmentation, or do not have enough pigmentation (or blood) to be seen.

Successful vermicompost projects

Many schools have been successfully composting with worms over the past few years. Some elementary school classes keep worm bins as part of an environmental unit, others for science. In most cases, teachers find a variety of multidisciplinary ways to use a worm bin. For example, one class called their room the "Worm World." Writing assignments, math lessons and art work focused on worms as a theme.



## Six Easy Steps to Setting Up a Worm Bin

by Jen Fong and Paula Hewitt

Once you have worms and a bin, follow these six easy steps to set up a worm bin. Soon worms will be recycling food scraps into a healthy, nutrient-rich soil amendment called compost.

1. Acquire a bin. Reuse an old dresser drawer or fish tank, build a box out of wood or find/buy a plastic bin. The approximate size is 16" x 24" x 8" or 10 gallons. Make sure the bin is clean by rinsing it with tap water to remove any residues which may be harmful to the worms. For wooden bins, line the bottom and sides with plastic (an old shower curtain or plastic garbage bag works well).
2. Prepare the bedding. Instead of soil, composting red worms live in moist newspaper bedding. Like soil, newspaper strips provide air, water, and food for the worms.
   - Using about 50 pages, tear newspaper into 1/2" to 1" strips. Avoid using colored print, which may be toxic to the worms.

- Place newspaper strips into a large plastic garbage bag or container. Add water until bedding feels like a damp sponge, moist but not dripping. Add dry strips if it gets too wet.
- Add the strips to the bin, making sure bedding is fluffy (not packed down) to provide air for the worms. Bin should be 3/4 full of wet newspaper strips.
- Sprinkle 2-4 cups of soil in bin, which introduces beneficial microorganisms. Gritty soil particles also aids the worms' digestive process. Potting soil, or soil from outdoors is fine.

3. Add the worms. Before adding the worms, find out how many worms you are starting with. The easiest method is to weigh the worms. If you do not have access to a scale, determine the worms' volume. The amount of worms is important for knowing how much food to feed them and for record keeping.
4. Bury food scraps under bedding. Feed the worms fruit and vegetable scraps that would normally be thrown away, such as peels, rinds, cores, etc. Limit the amount of citrus fruits that you place in the bin. NO MEATS, BONES, OILS OR DAIRY PRODUCTS.
   - Cut or break food scraps into small pieces--the smaller, the better.
   - Measure the amount of food. Feed worms approximately 3 times their weight per week. Monitor the bin every week to see if the worms are or are not eating the food. Adjust feeding levels accordingly. (If you start with one pound of worms, add 3 pounds of food per week.)
   - Bury food scraps in the bin. Lift up bedding, add food scraps, then cover food with bedding.
5. Place a full sheet of dry newspaper on top of the bedding. This will help maintain the moisture balance, keep any possible odors in the bin, and help prevent fruit flies from making a home in the bin. Replace this sheet frequently if fruit flies are present, or if bin gets too wet.
6. Cover and choose a spot for the bin. Cover the bin with a lid made of plastic, plywood or cloth, but leave the lid ajar so the bin receives some air. If desired, you may drill holes into the bin. Place the bin away from windows and heaters.
7. FEED, WATER and FLUFF!!! To keep worms happy, feed them about once a week. If bedding dries up, spray with water. (If bedding gets too wet, add dry newspaper strips.) Fluff up bedding once a week so the worms get enough air.



## More About Worms... And Related Classroom Activities

by Jen Fong and Paula Hewitt
(Adapted from Cornell Cooperative Extension)

1. Worms can eat their weight in soil each day. Over 1 million worms may be present in one acre of soil, and these worms can produce 700 pounds of castings each day. Two thousand red worms in a worm bin can produce 7 pounds of castings in one month.
   - ❖ *Ask children to estimate how much food waste they produce each day. What happens to it? What ways can food waste and other waste be recycled?*

2. Worms do not have teeth. Their food is softened by moisture or by microorganisms which break it down. Food is further broken down in the worms' gizzard, which contains hard particles and muscles which grind ingested food.
   - *Observe which food wastes decompose the fastest, and try to explain why. What are your worms' favorite foods? Do worms like dry or wet garbage best? Why?*
3. Worms are not the only living organisms in the worm bin. All sorts of microorganisms (in fact, billions of them) live in a worm bin. These microorganisms are introduced to the bin from the skin of the worm and from soil added to the bedding. Added garbage introduces more microorganisms, as do fungal and bacterial spores that land in the bin from the air.
   - *Are other creatures besides worms present in your classroom worm bin? Look for composting critters outside, in piles of decaying leaves. Where else can you find them?*
4. Worms do not have eyes, but they can sense light, especially at their front end. They move away from light, and will become paralyzed if exposed to light for too long (approximately one hour). If a worm's skin dries out, it will die.
   - *Observe worms' reactions to light. Why do worms stay inside your covered worm bin?*
5. While worms need moisture to survive, too much moisture will kill them. Have you ever noticed worms on the sidewalk after a rainstorm? This happens because the worms' homes in the soil got flooded, and the worms came to the surface in search of less soggy conditions. Once on the pavement, worms often get disoriented and cannot find their way back to the soil. They then dry up and die when the sun comes out.
   - *After a heavy rainstorm, go out on a worm hunt. What should you do when you see worms on the pavement? (Stepping on them is not the right answer!) Be a worm rescuer- put them back in the soil where they belong and can survive. Why do we want worms to survive?*
6. Worms are hermaphrodites; each worm has both male and female organs. Worms mate by joining their clitella (the swollen area near the head of a mature worm) and exchanging sperm. Then each worm forms an egg capsule in its clitellum; after 7-10 days, this is shed into the castings. Egg capsules are lemon-shaped and about the size of a match head. After 14-21 days baby worms hatch from the eggs. One to five worms emerge from each egg. In 60-90 days, the young worms are mature.
   - *Try to find mature worms, young worms and worm eggs in your worm bin.*
7. Worms can live as long as four years. When worms die in the bin, their bodies decompose and are recycled by other worms, along with the food scraps. Worm castings are toxic to live worms. After all the food scraps in a bin are recycled, the worms will eat their own castings which will poison them.
   - Why should a worm bin be harvested every few months? Harvest your worm bin when it is filled with compost.
8. Contrary to popular belief, worms cannot reproduce by being cut into small pieces. However, they do have amazing healing powers. If you cut a worm in half, both sides will continue wiggling. The portion with the head may grow a new tail if the cut is after the segments that contain vital organs. The tail portion will continue to wiggle until the nerve cells die. The tail end will not grow a new head.
   - *What other animals can regenerate parts of their bodies?*
9. Worm castings contain nitrogen and other nutrients necessary for plant growth. When added to soil, worm compost increases nutrient availability and improves soil structure and drainage.
   - *Transplant a few plants, seedlings or seeds in a potting mix with worm compost added, and transplant other plants or seeds into pure potting mix. Observe what plants grow the best, and try to explain why.*

10. In addition to making soil, worms are natural soil tillers. They mix layers of soil while producing tunnels in the soil to help air and water to reach plant roots. Tiny feeler-like bristles, called setae, on the bottom of worms help worms to move through the soil.
    - ❖ *Put worms into a glass container with soil, and watch them make tunnels in the soil. Put layers of different types of soil into the glass container, and watch the worms mix the soil.*
11. There are over 3000 species of earthworms in the world. Red worms (Eisenia foetida) are best for a worm bin because they are natural surface feeders that do not burrow as nightcrawlers do. Thus, living in a worm bin is not as confining to red worms as it would be to nightcrawlers. Red worms for worm composting can be purchased from worm farms. Composting worms are usually sold by the pound.
    - ❖ *Look for worms in garden soil, vacant lots, etc. How many kinds of worms did you find? Where did you find the most worms? Research worms from around the world. Where in the world kind you find worms several feet long?*
12. Many people mistakenly believe that garbage sent to landfills decomposes quickly, like it does in a worm bin or compost pile. However, this is not at all true because the key ingredients of air and moisture are missing in a landfill environment. Additionally, worms and other important decomposers can not live or function in such conditions.
    - ❖ *Put some worm food in an air tight bag. Compare what happens to this food to what happens to food in a worm bin.*



## Potential Cross-Curricular Applications of a Worm Bin For the Elementary School Classroom

by Jen Fong and Paula Hewitt

**Language Arts:**

- read/write stories about worms
- vocabulary development
- worm bin journals
- worm puppet shows
- create newsletter/information sheet on worm composting
- library work to find out information/books about worms and recycling
- write to Department of Sanitation requesting information on recycling

**Math:**

- count worms
- measure and weigh worms, food scraps
- sort worms (by size, color, etc.)
- metric measurements/conversions
- graph worm information such as population increase, amount of food eaten
- measure bin, three dimensional measuring, calculate area and volume
- ratios (worms to garbage, big worms to small worms, etc.)
- averages (how much food per day, week, month)

**Science:**

- worm anatomy
- worm needs and adaptations

- worm life cycle and reproduction
- scientific method/ worm experiments
- organic vs. non organic
- decomposition, mold, fungi
- food chain, food webs, ecology
- scientific classification and different species of worms
- other worm bin organisms (e.g., sowbugs, ants, mites, millipedes, centipedes)

**Geography and Social Studies:**

- climate and worms (red worms are native to the South)
- farming techniques/ crops around the world
- garbage around the world (how much do other countries produce?)

**Horticulture:**

- soil composition
- compost, compost piles
- plant parts/needs
- planting lessons and experiments (do plants grow better in compost?)

**Other Potential Topics:**

- waste reduction: reduce, reuse, recycle
- landfills



## Troubleshooting Worm Bins

by Jen Fong and Paula Hewitt

**Fruit Flies**

Though fruit flies do not pose any health hazards, these little creatures can be a nuisance in the classroom. To help prevent these potentially prolific pests, do the following:

1. Avoid putting rotting or rotten food in your worm bin. Fly larvae are more likely to be present on rotten food.
2. Cut food scraps into small pieces. Worms will be able to eat smaller pieces more quickly, thereby limiting the possibility of fruit flies thriving on decomposing food.
3. Don't overfeed worms. Ripe food that sits around in the bin attracts (and may contain) flies.
4. Bury food. Burying the food will help keep unwanted pests and pets from intruding on your bin.
5. Keep bedding material moist, but not too wet. Overly wet conditions encourage the proliferation of fruit flies. Wet conditions might also cause an odor problem, as anaerobic bacteria thrive when it is too wet.
6. Feed worms a varied diet. If citric foods dominate the bin, the bin may become too acidic, which may attract fruit flies.
7. Loosely place a piece of plastic or a sheet of newspaper inside the bin on top of the worm bin contents. This plastic or newspaper cover will create another barrier to help prevent flies from getting in (or out) of the bin.
8. Limit citrus fruits.

To help control an existing fruit fly problem, try the following:

1. Remove rotten food from the bin when fruit flies are present. Fruit flies often lay their eggs on decomposing food.

2. Tape or staple flypaper strips on the inside of the bin lid, and/or hang a strip near the bin. Flypaper strips can be purchased cheaply at most hardware stores.
3. Create a fly trap to put in the bin. A bowl of apple cider vinegar with a drop of dish detergent, placed near the bin, will attract and kill flies. Change liquid regularly to keep fly trap potent.
4. Place a whole sheet of newspaper on top of bin contents. Change this sheet regularly as flies tend to congregate on the newspaper.
5. Sprinkle lime in the bin to neutralize excessively acidic conditions.
6. For temporary relief, take bin outside and leave uncovered for up to four hours to air out the bin (out of direct sunlight).

If the problem cannot be controlled, have your class analyze the problem, and speculate about what is causing it. The best solution may be to harvest the worms and start a new bin from scratch, using what you have learned from your past experience to create a better bin.

**Odor Problem**

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

1. Bin is too wet. Solve the problem by not adding any water or foods with a high percentage of water (e.g., melons) and by adding more dry bedding.
2. Bin does not get enough air. Anaerobic bacteria (bacteria which thrive without air) is smelly. To aerate, add fresh bedding and mix bin contents daily.
3. The food in bin is naturally smelly. For instance, we have found that onions and broccoli do not smell very pleasant when they decompose in the worm bin. Simply remove any food source that smells bad from the bin.
4. Bin contains non-compostables. Meat, bones, dairy and oily products should not be fed to the worms because these items become rancid when decomposing.

**Worm Death**

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

1. Bin is too wet and worms are drowning.
2. Bin is too dry and worms dry out.
3. Bin does not get enough air and worms suffocate.
4. Worms do not get enough food. Once the worms devour all of their food and newspaper bedding, they will start to eat their own castings which are poisonous to them. TIME TO HARVEST
5. The bin is exposed to extreme temperatures. The worms thrive in temperatures from 55 to 77 degrees 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.



## Frequently Asked Questions About Worms in Composting

by Jen Fong and Paula Hewitt

- **Do I need to add worms to my compost pile?**

You do not need to add worms to your compost pile. Outside, composting happens with and without the help of earthworms. Worms will usually find their own way to a compost pile.

- **What can I do with my coffee grounds?**
  Coffee grounds, as an organic material, can be added to your compost pile. Worms like coffee grounds, so you may want to put a layer of coffee on the bottom of your pile to attract worms.

- **How often do I have to turn the pile?**
  The more you turn the pile, the quicker you will produce compost. Many people would rather let their pile sit and let nature do her work over a several month period. If you turn your pile frequently, you may produce compost in one month. If you turn your pile once in a while, you may produce compost in 3-6 months.

- **Should I add compost activator to my bin?**
  Most commercially sold compost bioactivators contain microorganisms which will help your pile start composting. However, similar microorganisms are readily available in a handful of soil or finished compost.

- **Won't rats be attracted to my compost pile?**
  With proper management, rats and other pests should not be a problem. Rats are attracted to food odors. By avoiding odiferous foods such as meats, dairy and oil, and mixing in or covering with a good layer of brown material (dry leaves, wood shavings, crumpled or shredded paper) odors will be filtered out.

- **Are the worms used in a worm bin the same as earthworms?**
  When most people think of "earthworms", they usually mean "nightcrawlers," which can be 8-10" long and 1/2" in diameter. These nightcrawlers are different from red wigglers, although both may be called "earthworms" since they both are found in the earth. Nightcrawlers are soil-dwellers, thus they like to burrow several feet below the surface. By burrowing, the nightcrawlers mix different layers of the soil, while creating tunnels which aerate the soil. On the other hand, red wigglers are surface-dwellers and prefer to live within the top 6" of the soil (which is why red wigglers prefer shallow boxes as homes). Red wigglers are often found among the fallen leaves of the forest floor, as well as in manure piles.

- **Can worms bite?**
  Worms do not have teeth, therefore they cannot bite you. Do not be afraid to hold a worm. Most people find that the worms are soft and ticklish.

- **What is the yellow liquid which the worm releases?**
  The yellow liquid is not urine, which many people first guess. The yellow liquid, called coelomic fluid, is released when the worm is stressed, which often happens when students touch the worm. When a worm is placed on a student's dry hand, the worm's body will begin to dry out. The worm will start wiggling, trying to find its' way back to the soil or bin, then release a yellow liquid in order to make its' body moist again. Exposure to light also triggers the release of the coelomic fluid. This yellow liquid may smell like garlic, hence the scientific name Eisenia foetida. Foetida means smelly.

When conducting experiments with worms, you may want to gently spray the worms with water every few minutes.

- **What happens if you cut a worm in half?**
  Almost everyone wants to know the answer to this question. Some species of worms can regenerate, or re-grow, a new tail, if their tail is cut off. However, a worm cut too closely to its' head will have difficulty growing a new tail. Most worms will not regenerate a head.
  Generally, we tell students that if you cut a worm in half, you will most likely end up with two dead pieces of worms. However, if you are lucky, the piece with the head may grow a new tail, so you will have one alive worm and one piece of dead worm.
  Some worms have a natural reflex, in which they will eject their tail when the tail is pulled. For example, when a bird catches the tail end of a worm, the worm would eject or sever its' tail from the rest of its' body. Thus, the worm remains alive and safe, while the bird gets only part of the worm.

- **Why is worm compost so good for plants?**
  Worm compost makes nutrients available to plants. When compost is mixed with water, it has the ability to hold many positively-charged mineral ions (cations), or nutrients, which can then be taken up by plants. Also, as worms process (digest) the food scraps, the nutrients in the food are changed into forms which can then be used by plants.