

MORE COMMONLY ASKED QUESTIONS

How do worms help the soil?

1. They mix up the different layers of the soil.
2. They add nutrients to the soil by depositing their waste products or “castings” into the soil.
3. They help to decompose dead plant and animal material into simpler parts that can be used again by new organisms.

How does compost benefit the soil?

Compost improves soil structure, texture and aeration and increases its water-holding capacity. Compost loosens clay soils and helps sandy soils retain water. Adding compost to soils aids in erosion control, promotes soil fertility and stimulates healthy root development in plants.

Helpful Hints:

Pocket folders make the best journal.

If you cut or mash your food scraps and keep them damp while you store them, your worms will eat them faster.

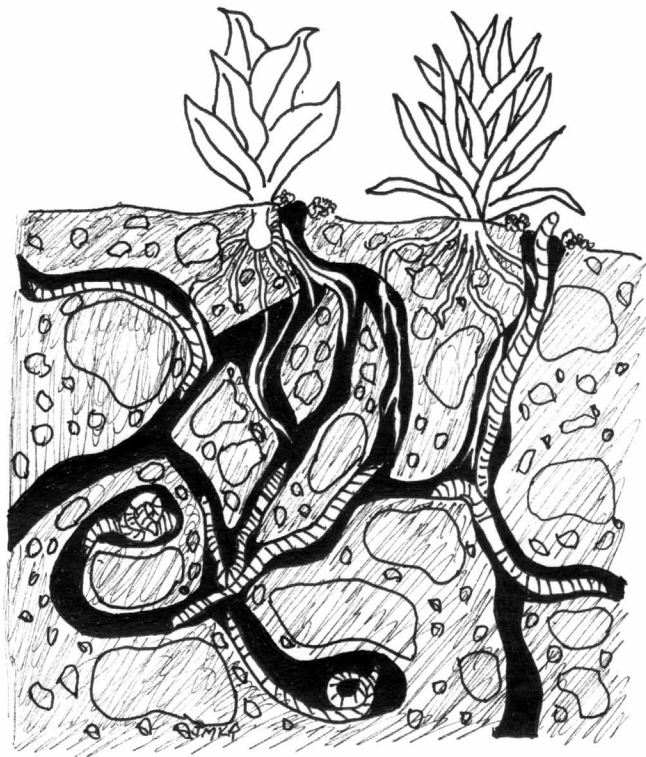
Don't forget to prepare the individual group bins from gallon containers before Lesson Four (Worm Population Growth).

Refer back to The Properties of Good Soils, p.69, Lesson One, Grades 4-6.

Resources:

Teacher's Pet Project, Population Education Training. n.d. Earth: The Apple Of Our Eye. Developed by Audrey Brainard.

Kalman, B. and J. Schawb. 1992. *Squirmy Wormy Composters*. NY: Crabtree. ISBN 0-86505-581-5



VERMICOMPOSTING LOG

DATE	Quadrant used	Name of worm manager	Types of food put in bin	Temperature and moisture level	Observations

THINGS TO THINK ABOUT FOR YOUR “OBSERVATION” COLUMN

1. Moisture

Are there puddles of water? Is liquid draining from holes?
Do worms have glistening skin? Is bedding dry?
Are casting and bedding stuck to worms?

2. Decomposition

Does food look fresh? Is food black and slimy? Is there fuzzy mold on food?
Is only the fibrous food left? Is the bedding disappearing?
Are castings piling up?

3. Reproduction

Are there only a few worms left?
Are there a few baby worms or many baby worms?
Are there worms joined together in mating?
How many worms can you see?

4. Air circulation

Does the bin smell fresh and earthy like the forest?
Does the bin smell rotten? Are food and bedding matted in large clumps?
Are there puddles in the bin? Do a few areas smell rotten?
Can spaces be seen in between the bedding?

5. Other decomposers

Are there any little white worms, slugs or snails, sow bugs, fruit
flies, ants, mites, others....????

THINGS TO THINK ABOUT FOR YOUR “QUADRANT USED” COLUMN

1. Food scrap placement

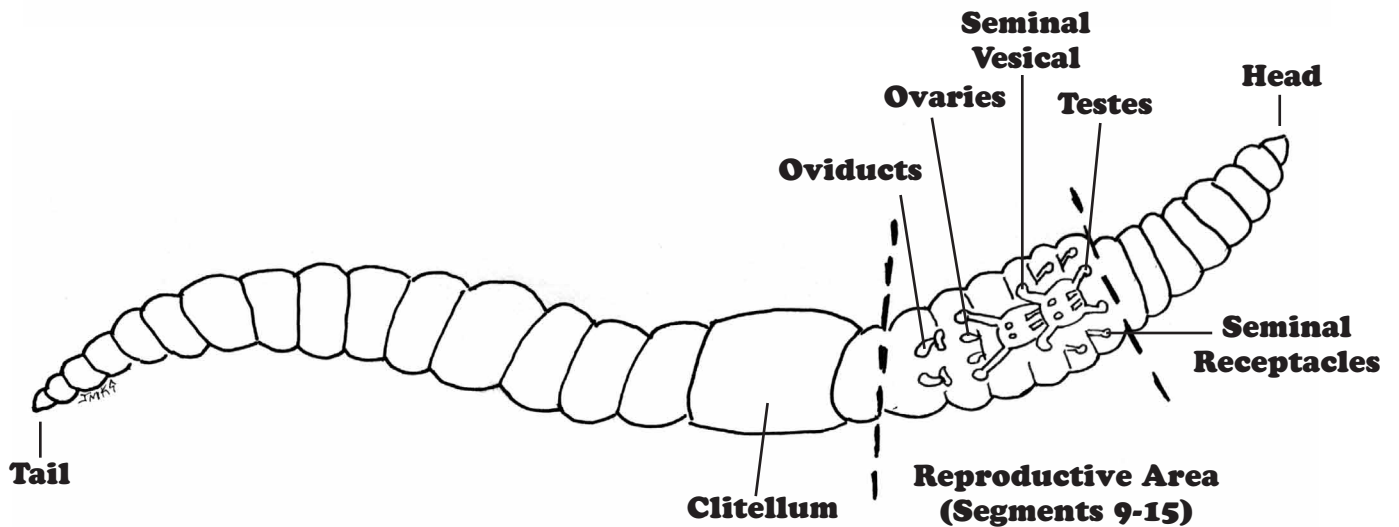
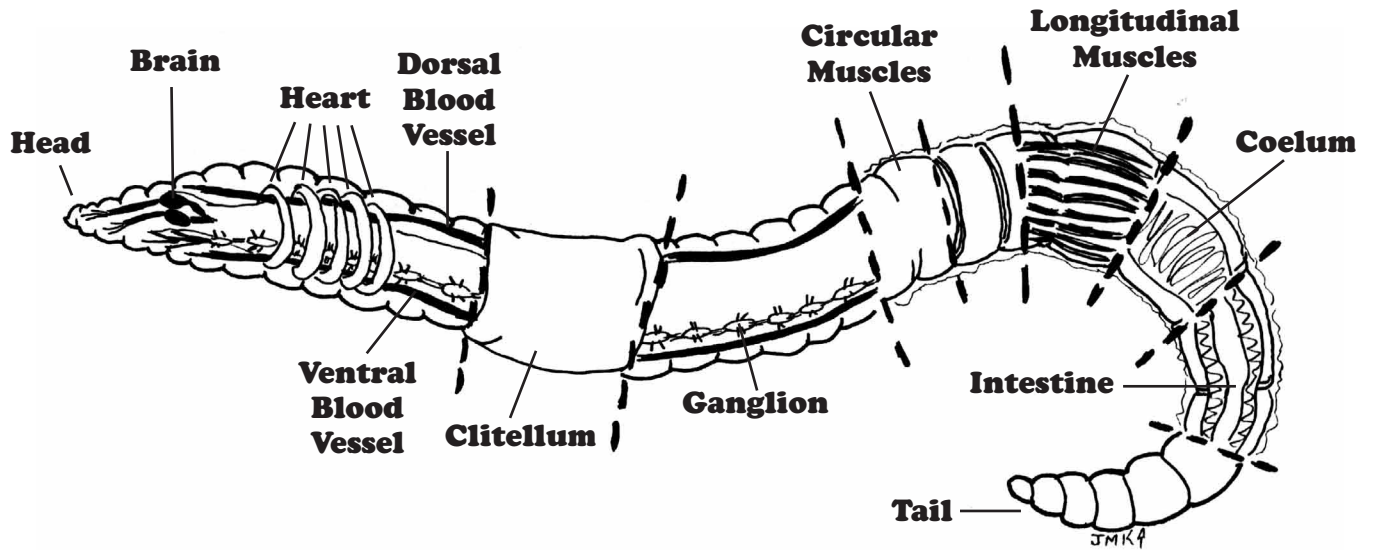
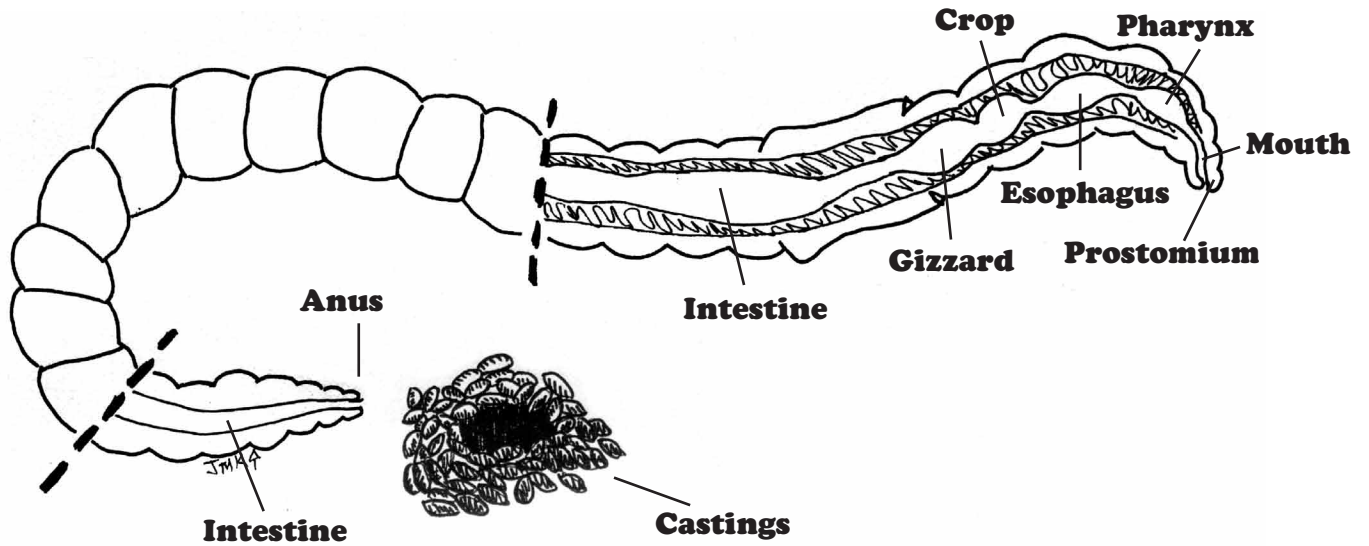
Indicate whether you added food scraps to your bin today.
If so, indicate by noting which one of the quadrants you used to place the scraps.

2. Types of Food

Do you notice foods that aren't being consumed?
If so, note the size and type of food.

Source: Adapted from *Composting Across The Curriculum: A Teacher's Guide To Composting*. Marin County Division of Waste Management. 1993. San Rafael, CA: Marin County Hazardous And Solid Waste Management Authority.

WORM ANATOMY

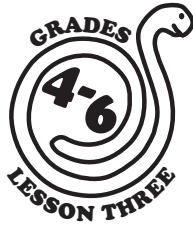


I liked making our worm bins because learning about soils and seeing how the worm body works because it is interesting to me. I like seeing how worms behave and how they make vermicomposting.

I learned worms breathe through their skin (like us). I also learned worms have five hearts or heart channels. I think its neat worms can eat half their weight in one day. I also learned about different ways of vermicomposting from around the world. I learned that worms have blood and some kinds can breathe under water.

Will Ladd, Cornish Elementary School, Grade 6





Community Vermicomposting

GEOGRAPHY STANDARDS

Essential Elements:

Environment and Society, The World In Spatial Terms

Content Standard 14:

How human actions modify the physical environment.

Organizing Standard 3:

How to use maps and other geographical representations, tools, and technologies to acquire, process and report information from a spatial perspective.

Knowledge Statements:

- Student knows and understands the consequences of human modification of the physical environment.
- Student knows and understands how to display spatial information on maps and other geographic representations.

Geographic Skills:

- Asking geographic questions about geographic issues relating to land use (replenishing soil) and climate effects on life.
- Organizing geographic information by using maps to show areas of world where vermicomposting is practiced.

Focus question:

What cities of the world practice vermicomposting?

Objectives:

- After examining a simple climate map of the world, students will compare climatic conditions in different regions of the world, taking into consideration factors such as distance from the equator, temperature, seasons, elevation, etc.
- Given information about vermicomposting practices of various world cities, students will discuss the reasons and possible effectiveness of the vermicomposting practices.
- Given a world map, students will plot location of world cities practicing vermicomposting and identify each location relative to its climate zone.

Materials:

World map (overhead); world climate map (overhead); country clues; vermicomposting facility descriptions—Cities That Vermicompost; sticky dots; worm scales; eyedroppers or spray bottle.

Preparation before lesson:

1. Have students gather around classroom worm bin.
2. Ask each student to check moisture of worm bin by placing finger into the bedding material; if the finger feels moist, then worm bin should not need water. If water is needed, add a few eyedroppers full to bedding mixture.
3. Students add food scraps (half of worms' body weight) to worm bins. Add scraps in different location each time.

Time Needed:

One hour.

THE LESSON PLAN

List of Procedures:

1. Give descriptions of world cities
2. Plot world cities using vermicomposting on map
3. Discuss vermicomposting practices
4. Compare different climate zones
5. Identify each city location relative to its climate zone
6. Closure

Connection to Science Standards (Grades 5-8):

Standard F: Change in environments can be natural or influenced by humans.

Connection to Math Standards (Grades 3-5):

Geometry: Students will use visualization and spatial reasoning to develop a spatial sense of world climatic regions.

VOCABULARY

barrier A geographic zone such as an ocean, desert, or glacier which would prevent the migration of an earthworm. Barriers may be different for other kinds of animals.

climate The prevailing or average weather conditions of a place over a period of years.

biosolids The solid residue from a wastewater treatment system.

leachate The liquid produced in a compost pile as a result of decaying foods and moisture.

vermicompost Mixture of partially decomposed organic waste, bedding, worm castings, cocoons and worms. As a verb: to carry out composting with worms.

Body of Lesson:

1. **Descriptions of world cities (in small work groups)**
 - a. From “Cities That Vermicompost”, students read each description of vermicomposting for the following cities: Canberra, Australia; Havana, Cuba; Newcastle, New South Wales, Australia; Pinar del Rio, Cuba; Pune, India; Wellington, New Zealand.
 - b. Have students draw pictures of what they envision the systems to look like based on the verbal description.
2. **Plot on map**
 - a. Each group presents their vermicomposting system description and drawings then locates the city on a world map by placing a sticky dot on the city.
 - b. When all groups have made their presentation, use the overhead of world map (Vermicomposting Cities) with the above cities located.
3. **Discuss vermicomposting practices**
 - a. Discuss reasons why each city practices vermicomposting.
 - b. Examine variety of composting bins used by each city.
4. **Compare different climate zones**
 - a. Display world climate map and highlight the following regions or areas: deserts, moist areas, high mountains, cold regions, warm regions, and hot regions. If appropriate, teacher may wish to use simple icons (thermometers, raindrops, etc.) to attach to map that represent each of the climate regions. See page 41, Lesson Three, Grade 1-3.
 - b. Discuss that redworms do not live in: deserts, oceans, high mountains, cold temperatures (lower than 50° F). Worms do live underground, in moist areas, gardens, warm temperatures (no higher than 80° F).
5. **Identify each city location relative to its climate zone**
 - a. Compare dot location to climate map: Are cities located in areas conducive to establishing worm habitats?
 - b. Have students identify a neighborhood need for vermicomposting (e.g., a neighborhood park’s need for good soil for its flower beds, soil needed for neighborhood community garden, etc.).
 - c. Examine a variety of ways to construct a large-size bin that can provide a pre-determined amount of soil.
6. **Closure**
 - a. Introduce use of journals to record changes within compost bin.
 - b. Review “Earth: The Apple of Our Eye”, Lesson Two,

MORE VOCABULARY

vermiculture The raising of earthworms under controlled conditions.

windrow A half-circular mound of compost that extends length-wise on the ground to however long the creator wants it to be.

worm bin Container designed to accommodate a vermicomposting system.

COMMONLY ASKED QUESTIONS

Will the earthworm bin smell up the basement, garage, or storage shed?

Surprisingly, there is no odor from the worm bins in spite of the highly odoriferous feed they receive. A handful of earthworm compost held close to the nose smells like rich, loamy, topsoil.

Grades 4-6. (Ask students how class project of creating soil can contribute to protecting Earth's limited soil resources.)

- c. Discuss potential impact of individual classroom bin on ability to conserve land resources.

Extension Activities:

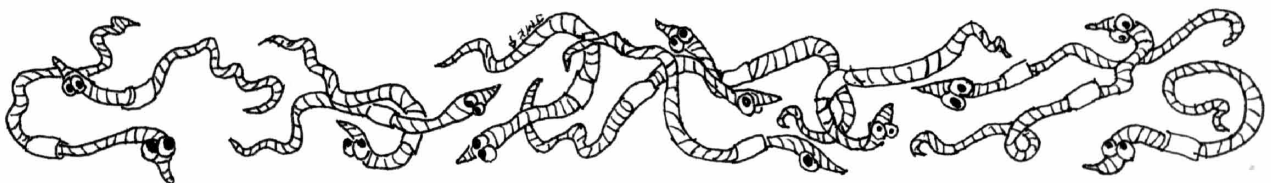
Examine social and political characteristics of the cities that vermicompost.

Contact an agency in the cities that vermicompost and share projects. It may be possible to obtain an actual photo of the described system.

Have each group build a mini model of their city vermicomposting system.

Helpful Hints:

Students may need help defining some of the more technical terms in "The Cities That Vermicompost" worksheet.



CITIES THAT VERMICOMPOST

Canberra, Australia:

This city has a project underway which is vermicomposting 39 cubic yards per week of pre-processed food scraps. This takes place in covered brick beds on a concrete slab inside a shed. They will probably use the castings as an agricultural fertilizer.

Havana, Cuba:

Here they have an innovative system for home use, called the "Sanitary Box System." It consists of two boxes designated for stacking on top of one another. Kitchen scraps are added to the first box and wetted daily until the feedstock reaches a height of 15cm. Waste paper can be added up to 20 - 40% of the volume of space. The earthworms are added at a rate of 1 kg/meter² and fed in the first box until it is full.

The second box, slatted on the bottom, is then placed on top of the first and food provided. As worms move up through the slats to the fresh food, they separate themselves from the finished vermicompost. There are currently 300 or more sanitary boxes in use in Cuba.

Newcastle, New South Wales, Australia:

Vermicomposting occurs for about 33 cubic yards per week of biosolids and vegetable scraps. The windrows are underlain by a plastic ground sheet and watered with an overhead system. A windrow is a half-circular mound of vermicomposting that extends length-wise (on the ground) to however long the creator wants it to be. About 40% of the input is harvested weekly as vermicastings, which are bagged, marketed and sold to major supermarkets in Melbourne and Sydney.

Pinar del Rio, Cuba:

Windrows are formed with a tractor-drawn manure spreader, under the shade of large mango trees. A windrow is a half-circular mound of vermicomposting that extends length-wise (on the ground) to however long the creator wants it to be. The first layer of a new windrow is 10 - 15 cm. high. The worms are put into the windrow at the rate of 1kg/meter² and they feed from the bottom to the top of the bed. Once the worms seem to be at the top, another 7-10 cm layer of feedstock is added.

Pune, India:

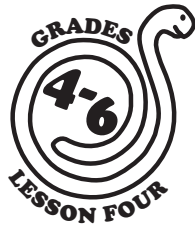
Both solid waste and sewage from a colony of 500 homes are being processed with vermiculture at the Indian Aluminum Co.

One system consists of seven concrete block bins (one for each day of the week) measuring 7m by 20m or roughly 21ft by 60ft, which receive all compostable garbage.

The colony's sewage is fed to a 600ft square vermifilter. The filter usually has a 30cm deep bed of vermicastings and selected earthworms and selected plants. The filter helps to purify the water.

Wellington, New Zealand:

The city has a volunteer project working to create low-cost, small-scale techniques for turning food scraps into vermicasting. Materials are hauled to two sites where several designs of outdoor worm beds are being tested. The beds have lids and are constructed flat to harvest the vermicasting, and also incorporate a leachate collection system made of plastic sheeting.



Worm Population Growth

GEOGRAPHY STANDARDS

Essential Elements:

Physical Systems, The Uses of Geography

Content Standard 8:

The characteristics and spatial distribution of ecosystems on Earth's surface.

Organizing Standard 18:

How to apply geography to interpret the present and plan for the future.

Knowledge Statements:

- The student knows and understands how physical processes produce change in ecosystems.
- The student knows and understands how the interaction of physical and human systems may shape present and future conditions on Earth.

Geographic Skills:

- Acquire geographic information by observing systematically the changes in worm population over time.

Connection to Science Standards (Grades 5-8):

Standard C: Students should develop an understanding of structure and function in living systems; reproduction and

Focus question:

How quickly does the population of earthworms increase within the compost bin?

Objectives:

Given several worms, students will observe and draw similar and different characteristics of worms.

After drawing the worms, students will identify the clitella and cocoon of the worm.

After observing individualized bins of mature worms over a period of time, students will maintain a count of the population growth occurring within the bin.

Materials:

Mature worms; hand lenses; journals for making observations; aluminum pie plates for 2-3 children; overhead diagram of worm; gallon jug containers for group bins, one for each group of four students; moist paper towels; "Worm Population Growth" chart.

Preparation before lesson:

1. Have students gather their individual worm bins begun in Lesson Two.
2. Ask each student to check moisture of worm bin by placing finger into the bedding materials; if finger feels moist, then worm bin should not need water. If water is needed, add a few eyedroppers full to bedding mixture.
3. Students add chopped food scraps to worm bins. Be sure to place food in different corner each time.

THE LESSON PLAN

List of Procedures:

1. Distribution of mature worms
2. Draw worms
3. Identification of worm characteristics
4. Closure

Time Needed:

1.5 hours.

heredity; regulation and behavior; populations and ecosystems; diversity and adaptations of organisms.

Connection to Math Standards (Grades 3-5):

Data Analysis and Probability: Students will formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them by using tables or charts.

VOCABULARY

anterior Toward the front.

anus The posterior opening of the alimentary canal.

clitellum A swollen region containing gland cells which secrete the cocoon material. Sometimes called a girdle or band, it is present on sexually mature worms.

cocoon Structure formed by the clitellum which protects embryonic worms until they hatch.

hatchlings Worms as they emerge from a cocoon.

mucus A watery secretion, often thick and slippery, produced by gland cells. One function is to keep membranes moist.

posterior Toward the rear, back, or tail.

Body of Lesson:

1. Distribution of mature worms

- a. Prepare aluminum pie plates by placing several worms in each one. (One plate per 2-3 students; be sure to keep worms moist by covering them with moist paper towels.)
- b. Ask students to observe if worms have swollen areas.

2. Draw worms

- a. Students are to draw worms in observation journals and label worm parts with their own descriptive words.
- b. After worms are drawn, ask students to share their drawings with others within their group and students outside of their own groups.

3. Identification of worm characteristics

- a. Show an overhead diagram of worm to illustrate clitella and cocoon; explain purpose of each.
- b. Worms join by mucus from their clitella. Sperm passes from each worm to the sperm storage sacks of the other worm. Later a cocoon forms on the clitellum of each worm. Eggs and sperm are deposited in the cocoon as it passes over openings from ovaries and sperm storage sacs. After being released from the worm the cocoon closes at both ends. Egg fertilization takes place in the cocoon. The worm backs out of the hardening cocoon.

4. Closure

- a. Ask students to predict number of worms that may come from a cocoon and record prediction in journal.
- b. Prepare students (in groups of four) to isolate, in a separate bin, a few mature worms to observe and keep track over time of the population increase within small individualized bins.
- c. Use individual bins that have been created from directions in Lesson Two.
- d. Introduce "Worm Population Growth" worksheet in order for students to maintain a record of what they observe over time.

Extension Activities:

Compare worm population growth to human population growth on world scale or at your state level.

Helpful Hints:

With plenty of food and a good environment, worms can double their population every 90 days.

A worm is old enough to lay eggs at about one year.

The mucus is a yellow slime on the worm.

MORE VOCABULARY

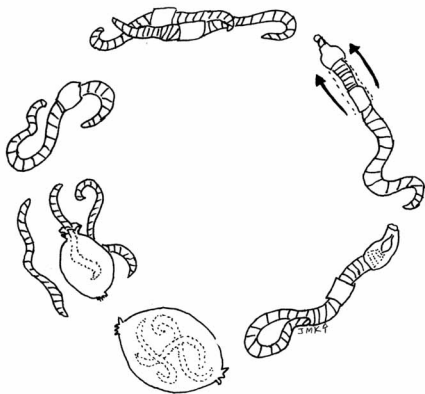
prostomium Fleshy lobe protruding above the mouth of an earthworm.

segments Numerous disc-shaped portions of an earthworm's body bounded anteriorly and posteriorly by membranes. People identify earthworm species by counting the number of segments anterior to the position of structures such as the clitellum, ovaries, or testes. Segmentation is a characteristic of all annelids.

setae Bristles on each segment used in locomotion.

sexually mature Possessing a clitellum and capable of reproducing.

slime Mucus secretion of earthworms which helps to keep skin moist so that gas exchange can take place.



The cocoon is a golden yellow ball the size of an apple seed.

When the cocoon is soft, there are no zygotes in it – it has hatched. A hard cocoon still forming has baby worms in it.

Resources:

Refer to Population Reference Bureau publications and web site: <http://www.prb.org/prb/>

The World Watch Institute offers information on waste management efforts: <http://www.worldwatch.org>

COMMONLY ASKED QUESTIONS

Can worms see?

Worms do not have eyes as we do. They have very sensitive skin cells that detect fluctuations in temperature.

How many baby worms are in a cocoon?

Several pale, whitish wormlets will crawl out of the cocoon after three or four weeks.

Where does the cocoon come from?

When the eggs have reached maturity and have been released, the clitellum secretes a tube of mucus which slips over the front of the worm. The mucus tube receives eggs and sperm cells when it passes over the anterior segments. Fertilization occurs inside the tube as it slides forward until it finally slips off the anterior end. The tube is then sealed and left in the bedding to form a cocoon.

I like how you have to care for them like they are kids. You have to make sure they don't get hurt. You have to feed them. I like how they are slimy.

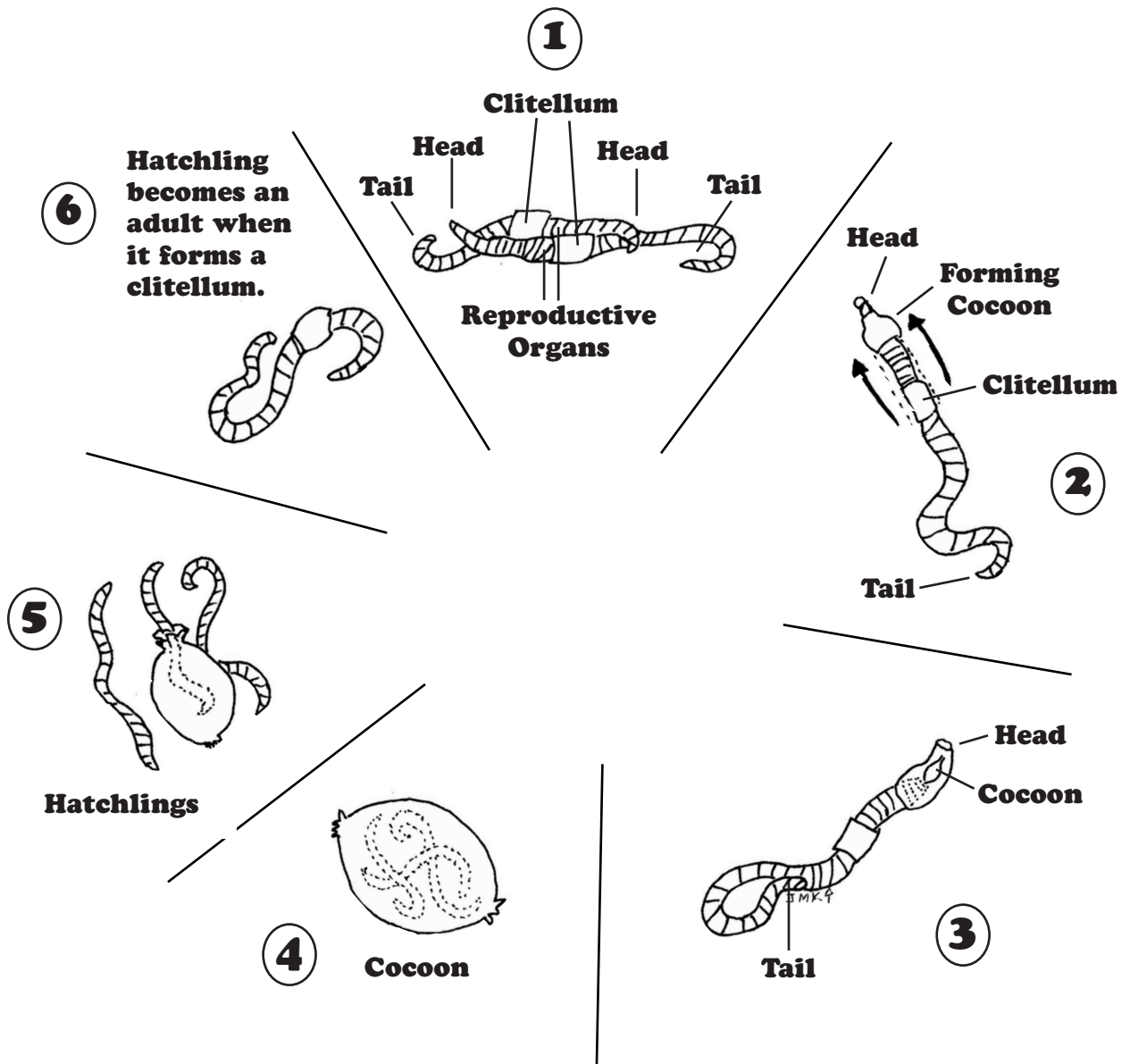
I didn't know how much fun it is to work with worms. I didn't know that worms have hairs under them to make them move.

I can't believe that worms are so much fun and so interesting. I liked working with the worms and I hope I can do it again.

Angela Perron, Cornish Elementary School,
Grade 6

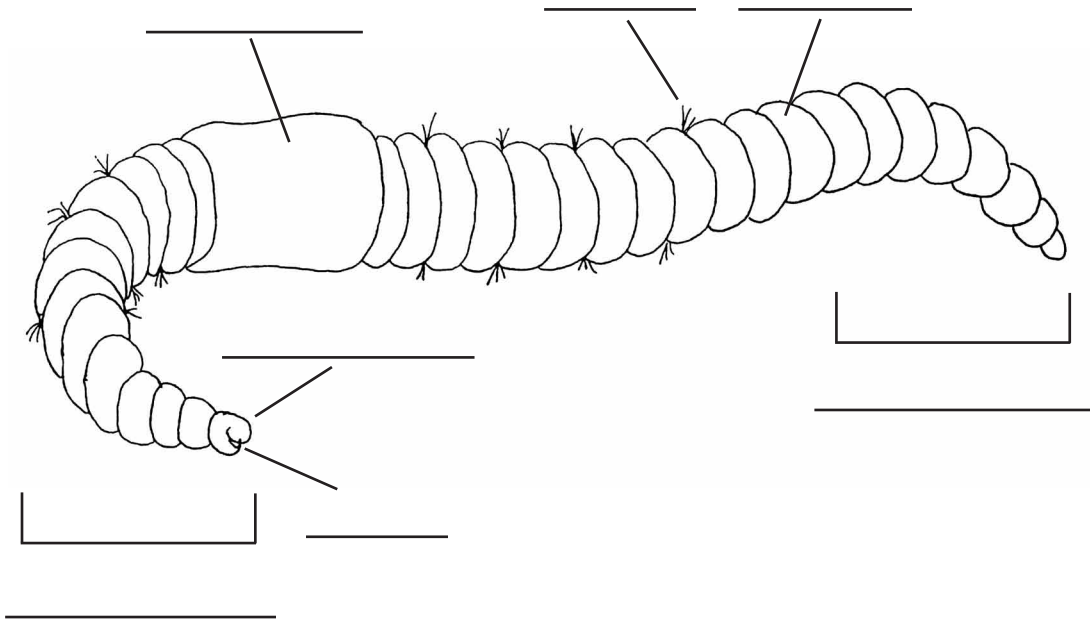


STAGES OF THE LIFECYCLE OF THE REDWORM

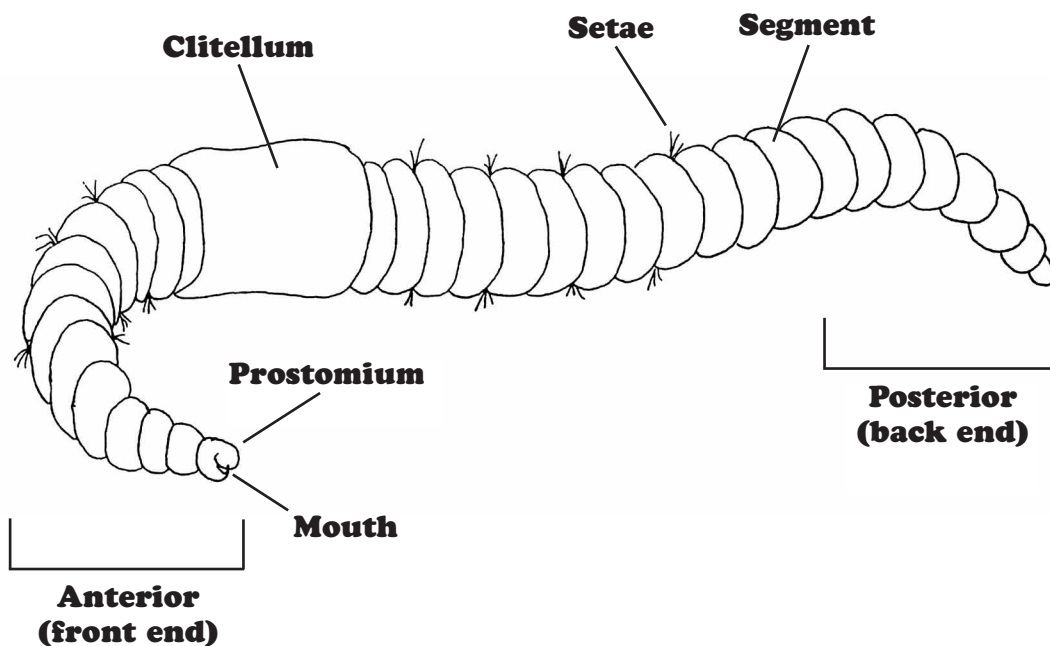


THE EXTERNAL ANATOMY OF THE REDWORM

Can you identify the body parts?

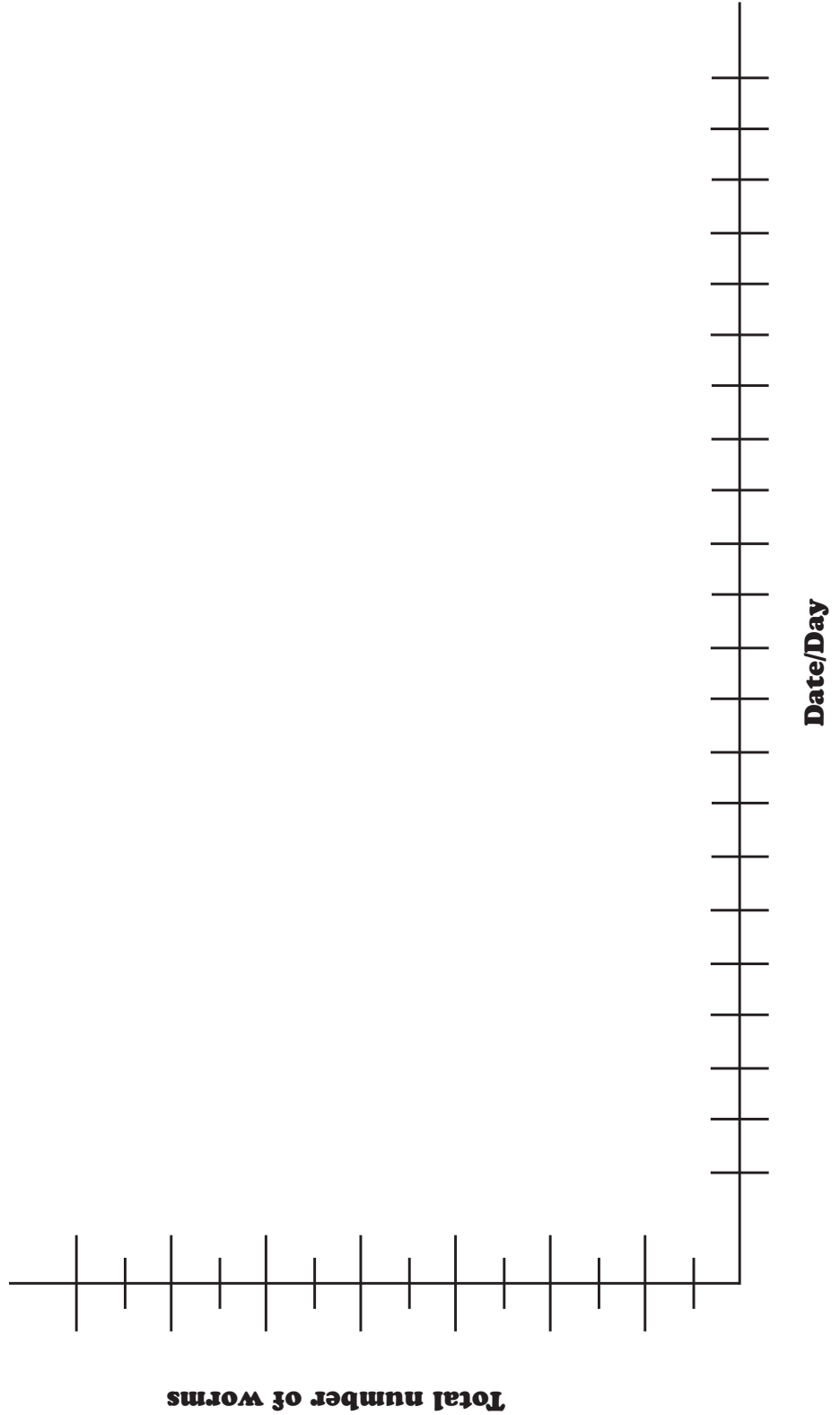


Answers



WORM POPULATION GROWTH

Create a bar or line graph plotting the growth in population of your worms. Plot the total number of worms in your bin for each day that you count. Record date and number of worms.



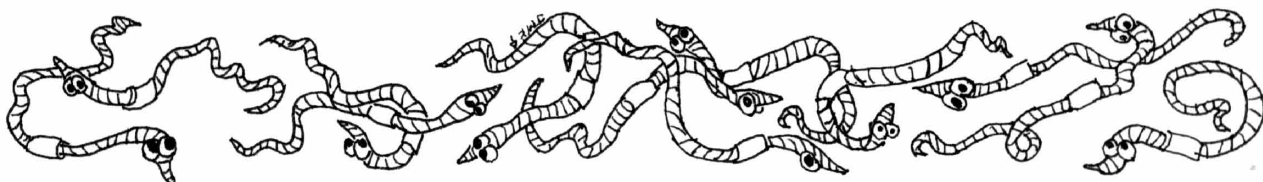
WORM POPULATION GROWTH

Name: _____

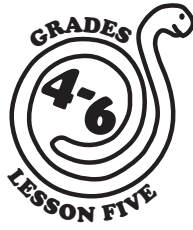
In a few sentences, write a description of your observations. Be sure to include any predictions you may have: number of baby worms to hatch, length of time to grow to full maturity, etc.

Date:

Observation:



Source: Deborah Mendolia



Using Compost to Grow Plants

GEOGRAPHY STANDARDS

Essential Elements:

Physical Systems, The Uses of Geography

Content Standard 7:

The physical processes that shape the patterns of Earth's surface.

Organizing Standard 18:

How to apply geography to interpret the present and plan for the future.

Knowledge Statements:

- Student knows and understands how physical processes influence the formation and distribution of resources.
- Student knows and understands how the interaction of physical and human systems may shape present and future conditions on Earth.

Geographic Skills:

- Answering geographic questions by determining the most efficient use of worm castings for seed germination.

Connection to Science Standards: (Grades 5-8)

Standard C: Students should develop an understanding of structure and function in living

Focus question:

How beneficial are varying amounts of composting in seed germination?

Objectives:

Given soil and varying amounts of compost, students will create an experiment to determine if adding compost to soil has an effect on seed germination.

Materials:

Plastic sandwich baggies; soil; compost; seeds (bean, pea, radish, or lettuce seeds work well); pencils; "Plant Growth – Seeds in Vermicomposting Experiment" worksheet; measuring cups.

THE LESSON PLAN

List of Procedures:

1. Divide the class.
2. Prepare sandwich baggies for seed germination.
3. Organize sandwich baggies onto a bulletin board.
4. Make periodic observations of sandwich baggies and record plant height.
5. Closure.

Time Needed:

One Hour

Body of Lesson:

1. **Divide the class into groups of four.**
 - a. Divide the class into groups of four. Each child within the group will be assigned a specific sandwich baggie identified as either baggie 1, 2, 3 or 4.
 - b. Each child within the group will place his/her name and date on a baggie.

NOTE: If there isn't a bulletin board near sunlight, clear plastic cups can be used and placed on a windowsill.

2. **Prepare sandwich baggies for seed germination.**

- a. To baggie 1, add compost only.
- b. Using a measuring cup, measure one part compost

systems; reproduction and heredity; regulation and behavior; populations and ecosystems; diversity and adaptations of organisms.

Connection to Math Standards (Grades 3-5):

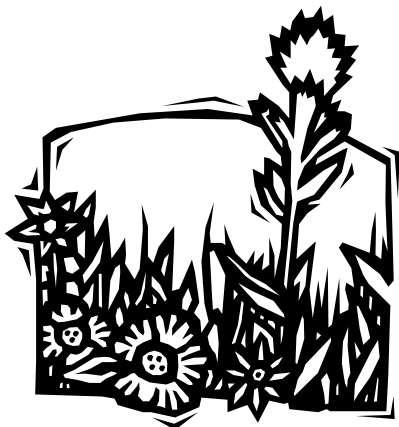
Measurement: Students will understand measurable attributes of length, capacity, volume, and time; develop the process of measuring and concepts related to units of measurement by creating an experiment to measure the effect of compost on plant growth.

VOCABULARY

harvest To gather in or process.

top dressing Nutrient-containing materials placed on the soil surface around the base of plants.

worm casting Undigested material, soil, bacteria deposited through the anus. Worm manure.



and an equal amount of soil to baggie 2. Mix the two together thoroughly.

- c. Using a measuring cup, measure one part compost and three parts soil. Mix together thoroughly. Place in baggie 3.
- d. Fill baggie 4 with 100 percent soil.
- e. Plant three to four seeds of the same species in each baggie. Bean seeds are fast growing and easy to observe.
- f. Water seeds according to instructions on seed packet. It is important that the same amount of water is added to each baggie.

3. Organize sandwich baggies onto a bulletin board.

- a. Create a bulletin board display of the sandwich baggies. Be sure that each baggie is easily accessible by the children.
- b. Arrange the baggies by groupings.

4. Make periodic observations of sandwich baggies and record plant height.

- a. After four or five days, record the number of seeds that have sprouted. Remove extra plants, leaving just one plant per baggie.
- b. Once a week, measure the height of the plant in each bag and record it.
- c. After five weeks, compare the number of surviving plants in the different mixtures of compost and soil.

5. Closure

- a. Discuss the importance of distributing compost in soil wisely.
- b. Too much compost may have the opposite effect to growth, and can kill seeds by promoting the growth of fungus.

Extensions:

Repeat the experiment with a different kind of compost and note any differences.

The experiment can be done in a garden bed by mixing different measured amounts of compost into soil and planting the same seeds in each bed.

Helpful Hints:

Have students blend their soils well. Bury the seeds 1/2 inch into the soil mix, at least one inch apart.

Do not throw away the sprouts picked from the experiment containers. Plant them elsewhere.

COMMONLY ASKED QUESTIONS

How do I harvest my worm bin?

When a worm bin is full, scoop out any undigested food scraps and the material that contains the most worms – usually the top 3 to 4 inches of material. Use the rest as compost. Put the material full of worms back into the bin. Mix it with an equal amount of fresh bedding, and cover with 1 inch of shredded paper.

To remove more worms from the compost, spread a thin layer on a tarp in sunlight, leaving a few small mounds. The worms will gather in the mounds as the material dries. Be careful, because the heat and rapid drying can kill your worms. Another method is to sift the compost gently over a wire screen and save the worms that don't go through it.

Why does the worm bin need to be harvested every six months?

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.

Resources:

Marin County Division of Waste Management. 1993. *Composting Across the Curriculum: A Teacher's Guide To Composting*. San Rafael, CA: Marin County Hazardous And Solid Waste Management Authority.

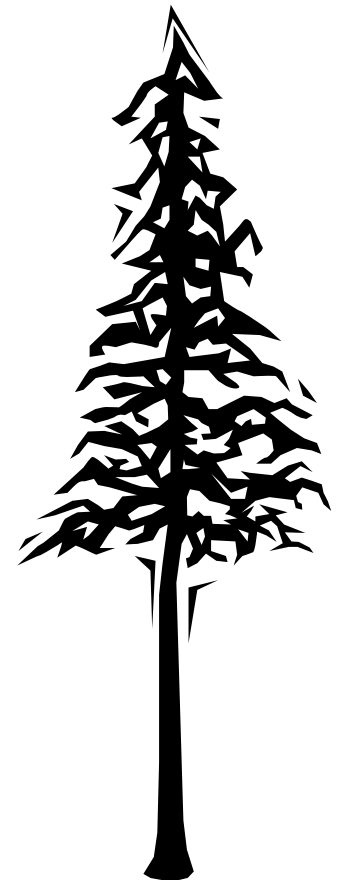
MORE COMMONLY ASKED QUESTIONS

Do worms die in the box?

Worms will die in any home worm bin, but in a properly maintained worm bin, you will rarely see a dead worm.

What conditions make for a good quality of life for my worms?

Keep them at 55° to 70° F, with 65° being a good average temperature of the bedding. Mean humidity should be 55%, and keep the redworms out of the rain. They will drown and/or scatter all over under rainy or very humid conditions. Finally, the pH of the bed should be as close to 6.5 as possible, with 7.0 and 6.0 being the upper & lower pH limits.



PLANT GROWTH - SEEDS IN VERMICOMPOST EXPERIMENT

Bag 1	Soil Type	3 Seeds	Date Planted	Sprouted	First Leaves	Growth in Centimeters					
Bag 1		A									
		B									
		C									
Bag 2		3 Seeds	Date Planted	Sprouted	First Leaves						
		A									
		B									
Bag 3		3 Seeds	Date Planted	Sprouted	First Leaves						
		A									
		B									
Bag 4		3 Seeds	Date Planted	Sprouted	First Leaves						
		A									
		B									
		C									

GLOSSARY

Actinomycetes Microorganisms that have the characteristics of both fungi and bacteria. Actinomycetes create cobweb-like growths throughout the compost and give compost an earthy aroma.

aerobic Pertaining to the presence of free oxygen. Organisms that utilize oxygen to carry out life functions.

anaerobic Pertaining to the absence of free oxygen. Organisms that can grow without oxygen.

anterior Toward the front.

anus The posterior opening of the alimentary canal.

bacteria A one-celled organism which can be seen only with a microscope. Bacteria may be shaped like spheres, rods, or twisted springs. Some bacteria cause decay; others may cause disease. Most bacteria are beneficial because they help recycle nutrients.

barrier A geographic zone such as an ocean, desert, or glacier which would prevent the migration of an earthworm. Barriers may be different for other kinds of animals.

bedding Moisture-retaining medium which provides a suitable environment for worms. Worm beddings are usually cellulose-based, such as newspaper, corrugated cartons, leaf mold, or compost.

bio-degradable Capable of being broken down into simpler parts by living organisms.

biosolids The solid residue from a wastewater treatment system.

carbon An element that is abundant in wood chips, sawdust, straw, and leaves. Carbon provides energy for living things.

climate The prevailing or average weather conditions of a place over a period of years.

clitellum A swollen region containing gland cells which secrete the cocoon material. Sometimes called a girdle or band, it is present on sexually mature worms.

cocoon Structure formed by the clitellum which protects embryonic worms until they hatch.

compost A rich soil-like mixture that is produced when organic matter breaks down.

decompose To decay, to rot; to break down into smaller particles.

decomposer An organism that breaks down cells of dead plants and animals into simpler substances.

decomposition The process of breaking down complex materials into simpler substances. End products of much biological decomposition are carbon dioxide and water.

digestive tract The long tube where food is broken down into forms an animal can use. It begins at the mouth and ends at the anus.

dorsal The top surface of an earthworm.

ecosystem The complex of a community and its environment functioning as an ecological unit in nature.

Eisenia fetida Scientific name for one of several redworm species used for vermicom-

posting. Color varies from purple, red, dark red to brownish red, often with alternating bands of yellow in between segments. Found in manure, compost heaps, and decaying vegetation where moisture levels are high.

enchytraeids Small, white segmented worms common in vermicomposting systems. As decomposers, they do not harm earthworms. Also called pot worms.

environment Surroundings, habitat.

excrete To secrete and to discharge waste.

gland A specialized type of tissue which produces secretions. Glands in a worms' skin produce mucus.

gizzard Structure in anterior portion of digestive tract whose muscular contractions help grind food in the presence of grit.

harvest To gather in or process.

hatchlings Worms as they emerge from a cocoon.

heart Muscular thickening in blood vessels whose valves control the direction of blood flow. Earthworms have several (commonly 5 pairs) of these blood vessels which connect the dorsal to the ventral blood vessels.

humus Complex, highly stable material formed during breakdown of organic matter.

inorganic Being or composed of matter other than plant or animal. Mineral.

immigrate To move into a region.

leachate The liquid produced in a compost pile as a result of decaying foods and moisture.

macroorganism Organism large enough to see by naked eye.

microorganism Organism requiring magnification for observation.

mucus A watery secretion, often thick and slippery, produced by gland cells. One function is to keep membranes moist.

nutrient cycle Cycling of nutrients in the ecosystem or environment.

organic matter Material which comes from something which was once alive.

organism Any individual living thing.

overload To deposit more garbage in a worm bin than can be processed aerobically.

pollute To make foul or unclean, to contaminate.

population The total number of individuals of a single species in a defined area.

population density Number of specific organisms per unit area, e.g. 1000 worms per square foot.

posterior Toward the rear, back, or tail.

prostomium Fleshy lobe protruding above the mouth of an earthworm.

redworms A common name for *Eisenia fetida*. A common worm used for vermicomposting.

segments Numerous disc-shaped portions of an earthworm's body bounded anteriorly and posteriorly by membranes. People identify earthworm species by counting the number of segments anterior to the position of structures such as the clitellum, ovaries, or testes. Segmentation is a characteristic of all annelids.

setae Bristles on each segment used in locomotion.

sexually mature Possessing a clitellum and capable of reproducing.

slime Mucus secretion of earthworms which helps to keep skin moist so that gas exchange can take place.

soil Soil is made up of mineral particles, organic matter, air and water. The mineral particles are called sand, clay, or silt, depending on their size. Sand has large particles and feels gritty. Clay has fine particles and feels sticky or slippery when wet. Silt particles range between clay and very fine sand. Soil types have differing amounts of each of these particles. Loam is a mixture of sandy soil, clay, and organic matter. The organic matter acts like a sponge to hold water.

soil horizon A separate soil layer, of which four primary layers exist.

sow bug A small crustacean with 10 pairs of legs which breathes with gills and lives in organic litter.

subsoil Mineral bearing soil located beneath humus-containing topsoil.

top dressing Nutrient-containing materials placed on the soil surface around the base of plants.

ventral Term for the underside of an earthworm.

vermicompost Mixture of partially decomposed organic waste, bedding, worm castings, cocoons and worms. As a verb: to carry out composting with worms.

vermiculture The raising of earthworms under controlled conditions.

worm bedding The medium, usually cellulose-based, in which worms are raised in culture, such as shredded corrugated cartons, newspaper, or leaf mold.

worm bin Container designed to accommodate a vermicomposting system.

worm casting Undigested material, soil, bacteria deposited through the anus. Worm manure.

windrow A half-circular mound of compost that extends length-wise on the ground to however long the creator wants it to be.

APPENDIX

Ordering Your Worms

You'll need one pound of worms for a 19" x 16" x 12" worm bin.

Impact Earth

32 Probate Street
Keene, NH 03431
(603) 357-3866 Sells worms, offers classes on worm bin composting.

Flowerfield Enterprise

10332 Shaver Road
Kalamazoo, MI 49002
(616) 327-0108 Sells worms, worm bins, and worm bin guides.

Gardener's Supply Company

128 Intervale Road
Burlington, VT 05401
(802) 863-1700 Sells worms, worm bins and worm bin guides.

Real Goods

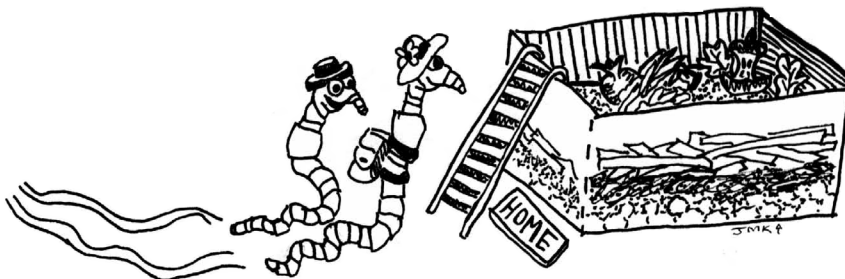
966 Mazzoni Street
Ukiah, CA 95482-3471
1-800-762-7325
Sells worms, worm bins and worm bin guides.

Seventh Generation

49 Hercules Drive
Colchester, VT 05446-1672
1-800-456-1177
Sells worms, worm bins and worm bin guides.

Smith and Hawken

2 Arbor Lane, Box 6900
Florence, KY 41022
1-800-776-3336 Sells worm bins and related supplies, including worm bin guides. No worms for sale. Offers classes on worm bin composting.



Potential Problems and Their Cures

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 citrus 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 inexpensively 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.

Odors

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.

Dying Worms

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°F.

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

How to Prepare Your Own Bin

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.

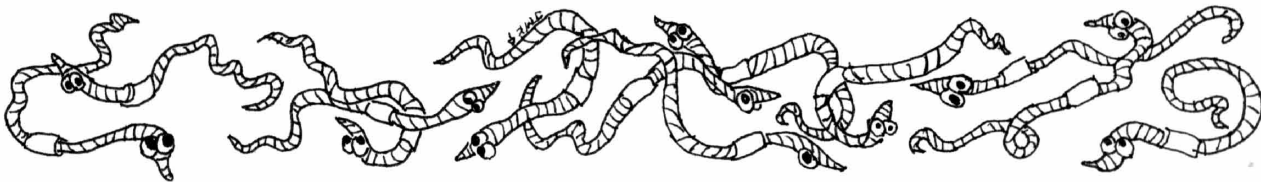
1- Acquire a bin.

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 redworms live in moist newspaper bedding. Like soil, newspaper strips provide air, water, and food for the worms.

1. Using about 50 pages, tear newspaper into 1/2" to 1" strips. Avoid using colored print, which may be toxic to the worms.



2. 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.
3. 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.
4. 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.

1. Cut or break food scraps into small pieces--the smaller, the better.
2. 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.)
3. 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.

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.

How To Build A Wooden Bin

Materials:

- 1 - 4 foot x 8 foot x 1/2" sheet exterior plywood
- 1 - 14 foot construction grade 2" x 4"
- 1 - 16 foot construction grade 2" x 4"
- 1 - lb 4d galvanized nails
- 1/4 lb. 16d galvanized nails
- 2 - 3" door hinges

Tools:

Tape measure, skill saw or rip hand saw, hammer, saw horses, long straight edge or chalk snap line, screwdriver, chisel, wood glue, and drill with 1/2" bit. Use eye and ear protection.

Construction Details:

Measure and cut plywood.

To make base, cut the 14 foot 2" x 4" into five pieces: two 48" and three 20" long. The remaining 12" piece will be used in making the sides as described below. Nail the 2" x 4"s together on edge with two 16d nails at each joint. Nail the plywood piece onto the 2"x 4" frame using the 4d nails.

To build the box, cut three 12" pieces from the 16 foot 2" x 4". Place a 12" 2" x 4" under the end of each side panel so that the 2" x 4" is flush with the top and side edges of the plywood, and nail the boards into place. Nail the side pieces onto the base frame.

To complete the box, nail the ends onto the base and sides.

To reinforce the box, place a nail at least every 3 inches wherever plywood and 2" x 4"s meet. Drill twelve 1/2" holes through the bottom of the box for drainage.

To build the lid, cut the remainder of the 16 foot 2" x 4" into two 51" lengths and two 27" pieces. Cut lap joints in the corners, then glue and nail the frame together. Center the plywood onto the 2" x 4" frame and nail with 4d nails. Lay top on ground with plywood surface touching the ground. Attach hinges to the top and back. Position hinges so the screws go through plywood and 2" x 4"s.

(Note: Contact the Cornell Cooperative Extension for a complete diagram at <http://www.cfe.cornell.edu/compost>)

Foods for Worms

Apples	Coffee Grounds	Molasses	Pizza Crust
Beans	Corn	Oatmeal	Potatoes
Bread	Cream of Wheat	Onion	Rice
Cabbage	Cucumber	Orange	Tea Leaves
Carrot	Egg Shells	Pancakes	Tomatoes
Cauliflower	Grapefruit	Pasta	Turnip
Celery	Grits	Peas	Waffles
Cereal	Lettuce	Pineapple	Watermelon



ADDITIONAL SOURCES OF INFORMATION

BOOKS

Barbarow, Peter. 1990

Give Peas a Chance

Organic Gardening Cartoon - Science. Happy Camp, California: Naturegraph Publishers.

This book covers information by using humorous cartoons and down-to-earth explanations on: how to compost; preparing a soil; the soil chemistry; the fertility of the soil; garden plans; plant propagation; watering plans, and pest control. Chapter one covers composting in a detailed yet easy to comprehend fashion. It explains how to build a compost pile, how to separate it, and what an ammonia smell coming from the pile means. The book gives examples of what could go wrong and how to fix it in the compost pile.

Bruno, Merle. 1971

Teacher's Guide for Earthworms

New York: McGraw-Hill Book Company.

This book features a collection of ideas which have been used in teaching about earthworms. The ideas in this book have been taught in grades three through eight, but could be easily adapted to include lower grades. This wonderful teaching guide includes materials you will need for your class, how to prepare a worm box, how to care for worms, as well as different classroom activities which can be used while studying earthworms.

Coldrey, Jennifer. 1985

Discovering Worms

New York: The Bookwright Press.

This children's book will be useful in any elementary grade (kindergarten through sixth grade). Younger children will benefit from the pictures of different types of worms, as well as having the text read to them. Older readers will enjoy the large, full-color pictures, as well as the text. Close-up pictures of the earthworm (as well as other worms) show students different body parts.

Ezrattu, Kathy. 1993

Composting Across the Curriculum: A Teacher's Guide to Composting

San Rafael, California: Marin County Office of Waste Management.

Teaching worm composting in the classroom helps young students learn more about their environment. This teacher's guide presents ideas on how to incor-

porate activities on waste management in the classroom. It gives teachers information to start a composting project with their class, connects composting with other subject areas, and it discusses why composting is important for the environment and the treatment of waste on our resources. Many of the lessons in this book can be adapted to most grade levels and allow teachers to incorporate many other ideas for enrichment activities.

Fong, Jennifer and Paula Hewitt. 1996.
Cornell Composting: Composting in Schools. Worm Composting Basics.

<http://www.cfe.cornell.edu/compost/worms/basics.html>.

This guide is very beneficial to anyone who wants to try to start their own worm composting bin. It discusses the following topics: 1. What worm composting is. 2. Materials that should and should not be used in a classroom worm bin. 3. How to set up a worm bin. 4. What type of container to use. 5. How to harvest worms. 6. How to make the activities hands-on. 7. What to do with the compost that the worms create. 8. The biology of the worm. The tips and ideas are useful and can make the process of worm composting in a classroom run a lot more smoothly.

Goode, D. 1994
Diane Goode's Book of Scary Stories and Songs

New York: Dutton Children's Books.

Incorporating music into the worm composting curriculum gives children a chance to get up and release their energy. Teachers like to incorporate movement and fun into their teaching. The song "The Worms Crawl In" is found in the book. This tune, taken from "The Hearse Song", allows children to move about. The original version discusses how worms live underground and will crawl into your dead body. The modified version is about worms underground and provides laughter to a classroom of younger students.

Hand, Julia. 1995
The Wonderful World of Wigglers

Montpelier, Vermont: Food Works.

This is a wonderful teacher resource if you are teaching about worms and vermicomposting. Hand includes plays and skits to teach children about worms. Also included are directions to make a vermicompost bin, as well as how to make individual worm houses for each student. Many ideas for teaching about earthworms are given throughout this book. There are also numerous questions to ask children throughout this book, and amazing worm facts. Unfortunately this book is now out of print and can be difficult to locate, unless you get it through a library.

Kalman, Bobbie and Janine Schaub. 1992
Squirmy Wormy Composters

New York: Crabtree.

The book contains many things that a teacher, thinking about vermicomposting in the classroom, would want to know. It provides photographs showing stu-

dents working with the worms and what worms look like. It defines vermicomposting, where the worms like to live and the ideal temperature for them. The book shows how to create a worm bin and how and what to feed the worms. There is a colorful diagram of the worm body parts which is very useful in explanations of the digestive process. There are activities and other great ideas within this book.

Lavies, Bianca. 1993

Compost Critters

New York: Dutton Children's Books.

This children's book helps to describe composting and what insects work to break down the food and other organic materials. The book provides excellent pictures of earthworms, millipedes, and mites that help with the process of composting. These pictures also provide information of body parts. This book is beneficial because students will be able to see that not only earthworms help the process, but they are the best invertebrates to break down the waste.

Rockwell, T. 1973

How to Eat Fried Worms

New York: Dell Publishing.

This chapter book is about two boys who set out to show that eating worms can make a great meal. This book will bring a smile and laughter to any classroom. It is most appropriate for second through fifth grade. This book is too difficult for young students to read on their own, but cassette recordings are available so they can listen to the book on their own. Although it may be a bit off the topic of composting, it can be a great extension activity.

MAGAZINES THAT HAVE ARTICLES ON VERMICOMPOSTING:

Biocycle
Science and Children
The Science Teacher
World Wastes

VIDEOS

Wormania

Mary Appelhoff, Billy B. and the Brennan Kids. Kalamazoo, MI: Flowerfield Enterprises, 1995. 26 minutes.

Geared for younger children, but appropriate for middle school students because of the content and photography. Footage is outstanding, and is highly recommended as an addition to the curriculum.

The Complete Guide to Home Composting Video Guide

Howard Stenn. N.p., Venal Productions, 1993.

An overview of composting by an ecological horticulturist. Topics include: yard waste, compost bins, compost tools, worm composting, trouble-shooting, hot composting, pest control, compost uses and more. Very informative.

Generation Earth

Jeff Barrie. Oakland, CA: The Video Project, Media for Safe and Sustainable World, 1995. 40 minutes.

Highlights innovative environmental education projects being done in schools.

The Rotten Truth

California Department of Conservation, Division of Recycling.

1025 P Street, Rm. 401

Sacramento, CA 95814

(916) 327-8811

An entertaining video for kids and adults discussing waste management and composting.

Worm Bin Creatures Alive Through a Microscope

Warren Hatch. Kalamazoo, MI: Flowerfield Enterprises, 1995. 33 minutes.

All of the microscopic critters that are rarely seen in the worm bin are revealed in this colorful, well-lit and in-focus video. By using a microscope, Warren provides an interesting, concise and informative lesson on worm bin critters. Great for all ages.

WEB SITES

Earthworms: Frequently Asked Questions

<http://www.oldgrowth.org/compost/wormfaq.html>

A must-read for anyone new to vermicomposting!
(Reprinted from the now defunct Green Hut magazine)

Worm Digest

<http://www.wormdigest.org>

A 32-page quarterly newspaper which reports about worms and worm composting on all levels, world-wide. It aims to network people, information and resources in the area of using worms for waste utilization and soil enrichment.

The Burrow

<http://gnv.fdt.net/~windle>

Worm Composting from City Farmer

<http://www.cityfarmer.org/wormcomp61.html>

Backyard Magic! The Composting Handbook

<http://gov.nb.ca/enviromn/comucate/compost/magic.htm>

An excellent, comprehensive guide to the basics of the composting process. Includes information on how to build your own composter, worm composting, indoor composting, FAQs, and more.

Cornell Composting

<http://www.cals.cornell.edu/dept/compost>

Resources, contacts, fact sheets, composting in schools and much more.

Environmental Protection Agency, U.S.

<http://www.epa.gov/epaoswer/non-hw/compost/index.htm>

The Environmental Protection Agency sponsors this page on composting at an individual and municipal level. There is a lot of information on source reduction methods as recycling, plus lots more.

