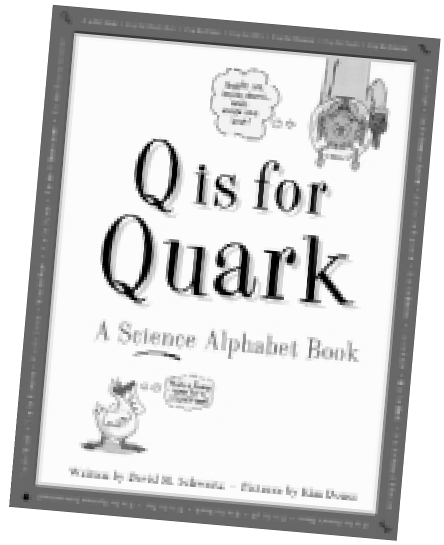
Tricycle Press

Q IS FOR QUARK
A Guide for Teachers

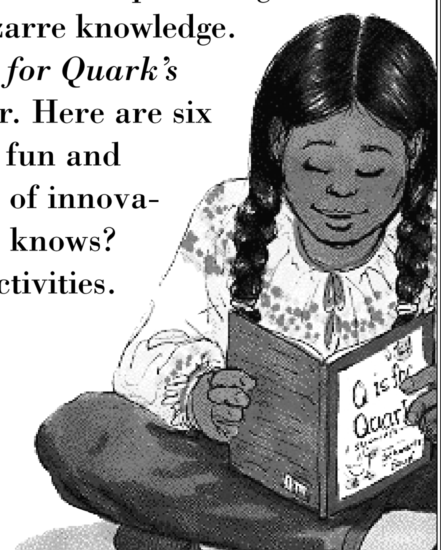
Based on the book
Q is for Quark: A Science Alphabet Book
by David M. Schwartz
Illustrated by Kim Doner



ABOUT THE BOOK AND THE TEACHERS' GUIDE

Q is for Quark: A Science Alphabet Book is the companion book to David Schwartz's *G is for Googol: An Alphabet Math Book*. What *G is for Googol* did for math, *Q is for Quark* does for science—providing laugh-out-loud introductions to both basic and bizarre knowledge.

If you're looking for ways to implement *Q is for Quark's* science lessons in your classroom, look no further. Here are six in-class activities in the spirit of *Q is for Quark's* fun and accessible approach to science, offering a variety of innovative ways to use the book as a teaching tool. Who knows? You may be inspired to create your own in-class activities. (Q is for Quantum? Quasar? Quadruped?)



SUGGESTIONS FOR TEACHING

Before beginning the in-class activities, share the book with your class, perhaps spending a few minutes daily going through selected sections of *Q is for Quark: A Science Alphabet Book*. Though the activities fulfill grades 5 though 8 National Science Education Standards, most activities can be easily adapted for lower grades. In addition, suggestions for more challenging activities are provided where appropriate. Helpful Web sites have been included, but access to the Internet is not crucial and information can alternately be found in your school or community library.

F is for Fault

Purpose:
To investigate why earthquakes occur in the outer layer of earth's crust.

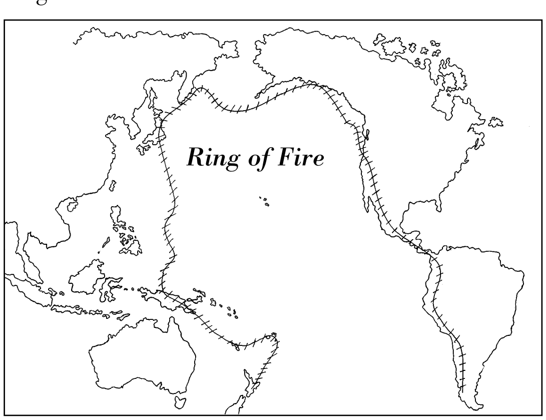
Materials:
- spongy foam balls (Nerf®)
- balls of clay
- wooden craft sticks
- chalk or dry-erase board
- paper and pencils

Time:
60 minutes

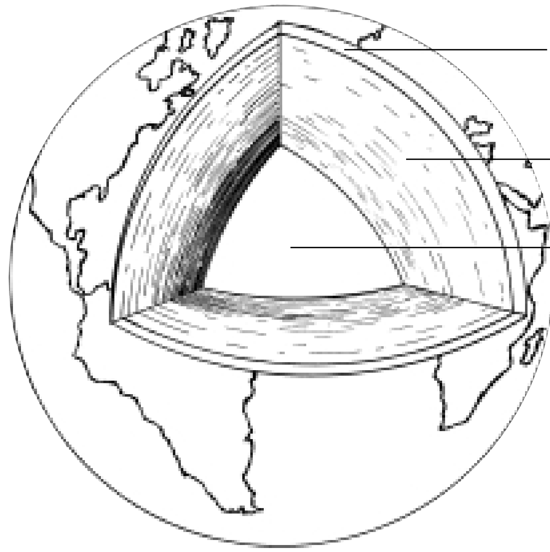
National Science Education Standard:
Earth and Space Science, Grade 5–8, Structure of the Earth System: "The solid earth is layered with a lithosphere; hot, convecting mantle and dense, metallic core. Lithospheric plates… constantly move. Major geological events, such as earthquakes,…result from these plate motions."

Extension:
Have students research the Ring of Fire, the area around the edge of the Pacific Ocean where many earthquakes and volcanoes occur. How do the locations of these earthquakes and volcanoes correspond to the locations of the tectonic plates in that area? Why are areas prone to earthquakes often the same as those prone to volcanic activity? Have students create maps of the Ring of Fire and label the oceans and countries that surround it.

Students can begin their research at the PBS Web site for the television series *Savage Earth* (www.thirteen.org/savageearth/). Have them click on The Ring of Fire sidebar under "Hell's Crust: Our Everchanging Planet" to see a map of the ring and read more about it.



Procedure:
- As students learned in "F is for Fault", earthquakes occur along faults, or cracks in the earth's rocky crust, or lithosphere. What do they think affects where faults occur in the lithosphere?
- Give each group of students a foam ball, a ball of clay, and a solid plastic craft stick. Explain that these three materials represent different rock types in the earth's crust. One type of rock is found near the top of the crust, another is found near the middle of the crust, and the third is found toward the bottom of the crust (near the mantle).
- Draw the following cross-sectional view of earth on the board.



  Remind students that the earth is hottest at its core, and gets cooler as you move toward the surface.
- Review with students the fact that materials in the earth's crust are subjected to stress, including bending and squeezing forces. Have students bend and squeeze the three "rock" materials and record how each responds to the stress. (The foam ball collapses when squeezed but resumes its original shape when released. The clay ball changes shape when squeezed but doesn't return to its original shape when released. The plastic stick cracks when bent.)
- Now, introduce and define the terms **elastic, inelastic,** and **brittle**. Have them categorize each of their rock types as belonging to one of these groups. (The foam ball is elastic; the clay ball is inelastic; the plastic stick is brittle.) Explain that some rocks in the earth's crust are elastic, some are inelastic, and others are brittle.
- Now explain that warmer rocks are more elastic while colder rocks are more brittle. Challenge them to identify which of their rock materials is found near the surface of earth's crust. (The brittle rock.)
- Have students write a paragraph summarizing what they learned in this activity. Then have them infer why earthquakes only occur in the top 10 km of earth's crust. (The rock is brittle there. When subjected to stress, it breaks instead of bending. This results in earthquakes.)

L is for Light

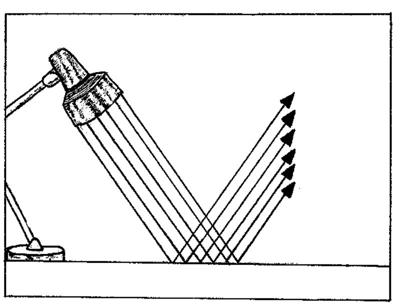
Purpose:
To investigate how light is reflected from mirrored surfaces.

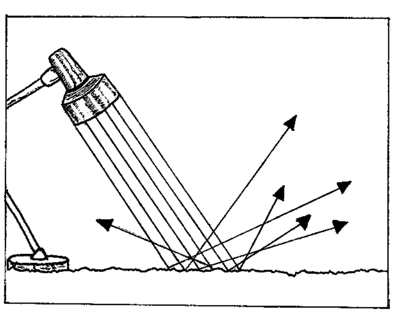
National Science Education Standard:
Physical Science, Grades 5–8, Transfer of Energy: "Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection)."

Time:
40 minutes

Materials:
- small flashlights (penlights work well)
- pocket mirrors (approximately 2 × 3 inches)
- large cardboard boxes or blocks or textbooks
- masking tape
- scissors

Safety Information:
Check to see that the edges of the pocket mirrors are not sharp. Cover the edges with masking tape as needed to prevent cuts.





Procedure:
- Review with students what they learned about how light travels in "L is for Light." (It travels as waves.) Tell them that today they will learn more about how light travels and what happens to it when it strikes a mirrored surface.
- Distribute a pocket mirror and a flashlight to each student or pair of students. Have them try shining lights on the mirrors in as many ways as they can and record what they learn about how light reflects off mirrors.
- Hold a discussion about what students learned in their investigations. As a class, come up with a list of rules that describe how light behaves. (Light bounces off a mirror at the same angle it strikes the mirror.) Introduce the Law of Reflection, and the terms **angle of incidence** and **angle of reflection.**
- Now challenge students to use what they learned about how light waves travel to design a maze for light to travel through. (They can use wooden blocks or heavy books to prop up the mirrors, or cut cardboard pieces to fit like walls inside a cardboard box.) By placing mirrors in the corners on the maze, students can direct the light through a complicated course.
- Have students draw maps of their mazes, showing the locations of the mirrors and the approximate angles of incidence and reflection. Ask students to explain their mazes and the paths of reflected light.
- Judge the mirror mazes according to the grade level of your class. Older students may be able to construct mazes with more mirrors than younger students.

Extension:
Have students research what it is about mirrors than allows them to reflect the images of objects placed in front of them. (Light shined on a surface will always be reflected back at the same angle at which it hits the surface. [See the top illustration at the left.] This is called the law of reflection. You see yourself in a mirror because all the light rays are reflected at the same angle. Reflection from a smooth surface is called **specular reflection**. Reflection of light from a rough surface, on the other hand, is called **diffuse reflection**. When light shines on a rough or dull surface, the light rays still get reflected back at the same angle at which they struck the surface, but since the surface is made up of many small uneven surfaces, the light bounces off of it at many different angles. [See the bottom illustration at the left.] Since the light is reflected at many different angles, it cannot form an image. This is why rough and dull surfaces cannot be used as mirrors.)

M is for Music

Purpose:

To investigate how echoes are formed and how they can be used to calculate distance.

National Science Education Standard:

Physical Science, Grades 5–8, Transfer of Energy: "Energy is a property of many substances and is associated with…sound…."

Time:

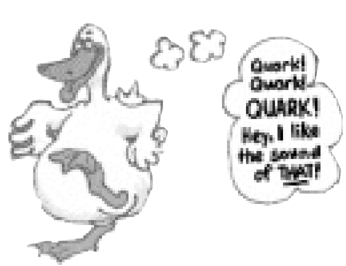
30 minutes

Materials:

- paper
- pencils
- calculators

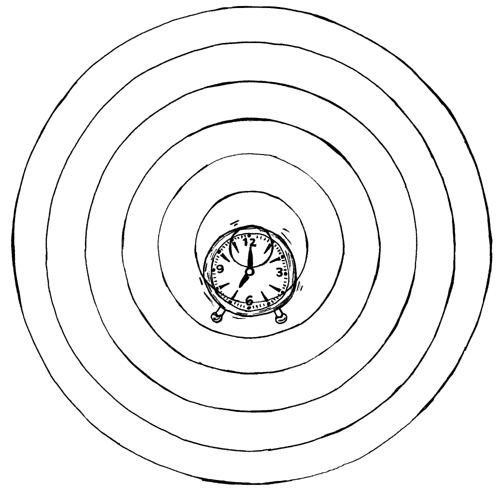
Extension:

Have students research the construction of amphitheaters, both ancient and modern. What materials are used to improve the sound quality? What structural issues are considered? Where is the audience placed in relation to the orchestra? Do all seats experience the same sound?



Procedure:

- Review with students what they learned in "M is for Music" about how sound travels. (Sound moves as waves. It travels away from a vibrating object in every direction.)



- Ask if anyone knows what the speed of sound is. (It varies with temperature, pressure, and medium, but for this activity, we'll say it moves through air at 335 m/sec.) Write "335 m/sec" on the board. Explain that this is the approximate speed at which sound travels through air.
- Now explain that while sound waves pass through air, they bounce off solid surfaces. Some of this bounced sound is reflected back toward the source.
- Knowing these facts, challenge students to explain why it is that a hiker in the mountains will hear several echoes of a word she utters a single time. (The sound waves bounce off several mountains at different distances from the yeller, and so return to the yeller at different times. In limited cases, the sound may also be bouncing from one mountain to another before returning to the yeller.)
- Explain to students that they can use echo time to calculate how far away a mountain is from a hiker. Pose the following problem: A hiker yells the word "hi" from a mountain on one side of a valley across to a mountain on the other side. She hears the word echoed back 1.2 seconds later. How far away is the mountain on the other side of the valley? (Remind students that distance = rate × time. You may want to write this equation on the board.)
- Help students as needed to solve the problem:
  335 m/sec × 1.2 sec = 402 m ÷ 2 = 201 m
  (Note that in the final step the total distance must be divided by two since the sound travels back and forth in the 1.2 seconds.)
- Create other math problems using the speed of sound, echo time, and distance between person and mountain. Or have pairs of students develop their own word problems and challenge their partners to solve them.

N is for Natural Selection

Purpose:

To investigate the biological adaptations that produced the modern-day whale.

National Science Education Standard:

Life Science, Grades 5–8, Diversity and Adaptations of Organisms: "Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment."

Time:

120 minutes (including research time)

Materials:

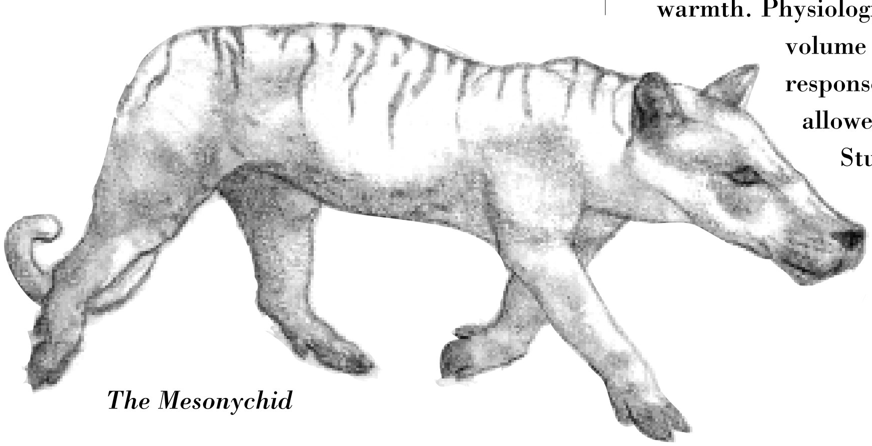
- paper
- pencils
- research materials (including access to the Internet)

Extension:

Have students research the difference between toothed and baleen whales. Which evolved first? (Toothed.) What pressure might have led to the evolution of baleen whales? (Abundance of plankton as a food source.)

Procedure:

- Review with students what they learned in "N is for Natural Selection" about how natural selection favors some characteristics over others and how it can affect populations of organisms over time.
- Show students a picture of a whale, toothed (including dolphins) or baleen. Explain that, like most animals, whales evolved from an ancestor that bore little resemblance to the organisms we see today.
- Have students research what evidence suggests is the ancestor of today's whales, both toothed and baleen. Students might check out Enchanted Learning.com (www.enchantedlearning.com) and click "Zoom Whales" and then "Whale Evolution." Or go to Darwin Day Web (fp.bio.utk.edu/darwin/) and search for "whale." Then click "Whale Transitional Fossil Evidence."
- Students should encounter the animal Mesonychid in their research. Have students list the physical, behavioral, and physiological characteristics of Mesonychid. Then have them create a list of the same characteristics for their favorite modern whale.
- Once students have completed their research, tack pictures of both the Mesonychid and examples of modern whales (toothed and baleen) on the board as a visual reference for students as they begin step 6.
- Challenge students to describe a scenario whereby the Mesonychid could have evolved step by step over millions of years to become a modern whale. Which structures and behaviors would have to change and how would they change? (As the species began spending more time in the water and less on land, their bodies became more streamlined. Eventually the species developed fleshy appendages, including a dorsal fin and horizontal fluke, to help them swim better. Rear appendages were no longer needed, and arm and hand bones shortened and thickened into paddles. The vertebral column became less stiff so it could undulate. Two nostrils became one, and moved to the top of the head so the animal could breathe while swimming along the water's surface. The animal developed blubber to keep it warm and a sleek skin as hair was no longer needed for warmth. Physiological adaptations included an increased blood volume and a suspension of the automatic breathing response experienced by most mammals. Both adaptations allowed the animal to make deeper, longer dives.) Students may want to create labeled diagrams of modern whales showing each of these adaptations.
- Finally, have students speculate as to why the Mesonychid might have returned to the sea after having evolved from it originally. (Mostly likely, the animal returned to the sea for the abundance of food it provided.)



The Mesonychid

X is for Xylem

Purpose:
To investigate how capillary action pulls water up plant xylem cells.

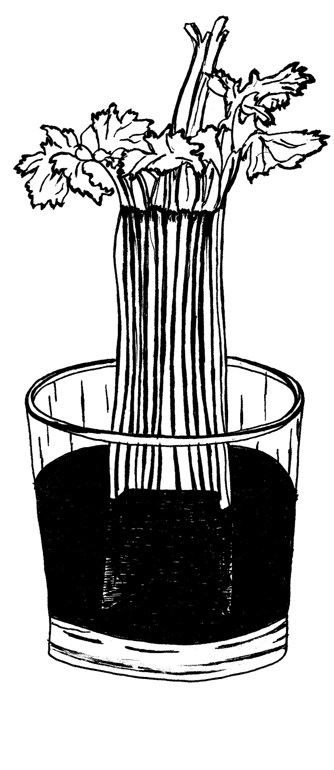
National Science Education Standard:
Life Science, Grades 5–8, Structure and Function in Living Systems: "Specialized cells perform specialized functions in multicellular organisms. Groups of specialized cells cooperate to form a tissue…."

Time:
Setup time: 15 minutes
Observation and discussion: 20–30 minutes a few hours later

Materials:
- plastic knives
- celery stalks with leaves
- red food coloring
- clear plastic tumblers
- paper and pencils
- white carnations (optional)

Extension:
Have students research the difference between primary and secondary xylem. Which one is found primarily in woody plants? (Secondary xylem.) Which primitive member of the grass family is widely used in Asia as a source of wood? (Bamboo.) How does this woody plant differ from a tree? (It is hollow in the center, and does not taper toward the top.) Students may want to research the unusual reproductive pattern of bamboo. (It grows from underground stems called rhizomes, but also reproduces sexually at regular but well-spaced intervals—usually 30, 60, or 120 years.)

Procedure:
- **Warn students to use caution when handling the plastic knives.** Have students use a plastic knife to cut the bottom 1/2 inch from a stalk of celery and place the stalk in a tumbler of colored water. Ask them to record their predictions of what will happen to the celery-water system in a few hours.
- After a few hours, have students observe the celery stalks again. (They will see that the red color has moved up the stalk and into the leaves.) Students should record their observations. Older students might want to record the rate at which the red liquid moves through the stalk, using the equation rate = distance/time.
- Have students discuss what conclusions they can draw from their observations. (Water moves from the bottom of the celery, through long tubes, to the top of the celery.)
- Review with students what they learned about the function of xylem in "X is for Xylem." (It is responsible for moving water and dis solved minerals from the roots to the upper regions of the plant.) Have students describe what happened in the celery stalk using the term **xylem**.
- Now ask students how they think the water was able to move against the pull of gravity. Record their ideas on the board.
- Define the movement of water upward through small tubes as **capillary action.** Explain that Leonardo da Vinci was the first to describe capillary action back in 1490. Capillary action is based on the fact that water molecules are attracted to one another (cohesion) and to other materials (adhesion). In plants, as water evaporates from the leaves, water molecules are pulled up the xylem tubes, and these in turn pull the molecules behind them.
- Students might enjoy using their understanding of capillary action in xylem tubes to color white carnation petals using food coloring and water. (Flowers placed in colored water will eventually draw the colored water up to the petals, tinting them the color of the dye.)



R is for Rot

Purpose:

To investigate how decomposers turn garbage into valuable compost and to demonstrate the role of decomposers in an ecosystem.

National Science Education Standard:

Life Science, Grades 5–8, Populations and Ecosystems, "Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food."

Time:

80 minutes (for construction of composter, plus several weeks of observations)

Materials:

- plastic garbage can with lid or a large box with lid
- organic soil
- yard trimmings (grass clippings, decaying leaves, straw, or hay), food wastes (vegetable and fruit peelings, used tea bags and coffee grounds, nutshells)
- water (optional)
- earthworms (optional)
- pitchfork
- student journals

Extension:

Have students compare how quickly bread with preservatives rots compared to bread made without preservatives. Have them set up an experiment, complete with controls, that compares growth rates of mold on moist slices of bread placed in resealable plastic bags and left in a cool dark place. Encourage them to present their findings in a written report.

Procedure:

- If you have the time and space to construct a class composter on school grounds, follow the directions as described. If you are not able to construct a composter, use the information provided to discuss with students how one is constructed then have them design one on paper, label the parts, and describe the decomposition process occurring within. Alternately, you can have students do research themselves and use the information provided as a reference. Students can create a detailed diagram of a composter and perhaps bring it home to share with their families.
- Ask students to list the things they throw out in the garbage every week. (Students may name food scraps, paper products, plastic, etc.) Tell students that about 20 percent of the garbage thrown away by people in the Unites States is organic, meaning "once alive." Review with students what they learned about what happens to living things that have died in "R is for Rot." (They are broken down by decomposers, like bacteria and fungi, into materials that can be used again by plants.)
- Ask students if they know what a composter is. Most will know that a composter (or compost pile) is a collection of organic material that, when left to decomposers, produces rich soil that can be used in the garden.
- Brainstorm a list of materials students think could go into a composter. (Yard trimmings, food wastes—see materials list.) Also discuss things that should *not* go in the composter. (Meat and animal bones as they attract dogs and cats.) Then discuss how the pile should be set up. (It needs to be contained in something, maybe a box or can; it should contain some soil to supply the right decomposing microorganisms; it needs air for the microorganisms to live.) Discuss the best way to arrange these components in a composter. (They should be arranged in thin, loose layers so air can circulate.)
- If feasible, construct a composter with the class. You may choose to bring in the yard and food scraps yourself, or solicit student participation. You might consider involving your own cafeteria and grounds department in collecting the organic wastes.
- Poke holes all over the garbage can and its lid to allow air to circulate. The holes should be about 1/4 inch in diameter. Then add thin layers of organic soil, shredded yard waste, and shredded food waste. (Shredding helps speed up the decomposition process.) If the material seems dry, add a small amount of water. You may choose to put some earthworms in the can as well. Earthworms are considered "shredders," not decomposers. But they play a very important role as they shred waste materials into smaller pieces that bacteria and fungi can then decompose more quickly.

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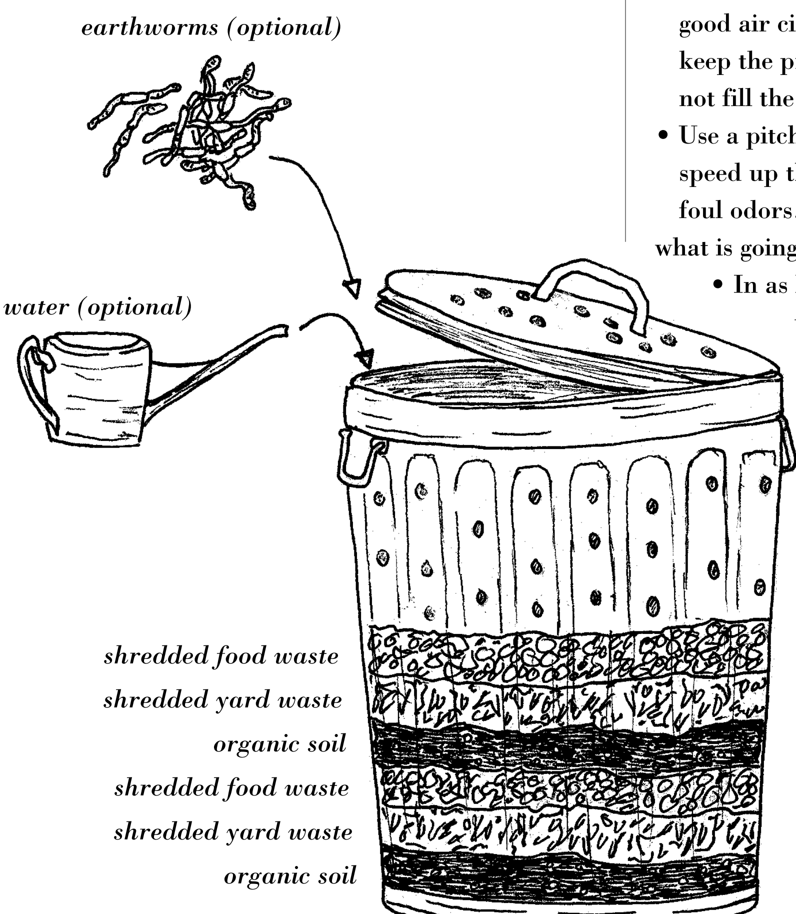
R is for Rot *(continued)*



- Put the lid on the can and place the can in a sunny spot where there is good air circulation. Add more layers as you collect wastes, trying to keep the proportions of yard and food materials roughly equal. (Do not fill the can more than 3/4 full.)
- Use a pitchfork or other garden tool to mix the layers regularly. This will speed up the decomposition process and keep the can from producing foul odors. Have students record in a journal (both drawing and text) what is going on inside their composter as the weeks pass.
- In as little as 3 weeks, your compost might be ready to use. Good compost will be dark and crumbly. Use the compost in a school garden, or give each student a bagful to bring home to their families.
- Review with students the role of decomposers in a food chain and in an ecosystem.

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$2.95

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ISBN 1-58246-049-3

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Q is for Quark: A Guide for Teachers written by Sarah Martin
Illustrations © 2001 by Kim Doner from the book
Q is for Quark: A Science Alphabet Book
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