Lesson 1

It's a Closed System

FOCUS

To help students visualize the consequences of a product life cycle that ends with disposal rather than with recycling or downcycling. To introduce the concept of a closed system, and the understanding that the earth is a closed system: Practically nothing comes in, with the exception of energy in the form of heat and light from the sun, and nothing leaves except heat and reflected light.

Note to teachers: It is true that meteors do fall to Earth and some cosmic dust enters our atmosphere, but this is nearly negligible; in general, the principles of a closed system apply.

CONCEPTS

- Life cycles (birth decay raw material for new life) are an integral part of Earth systems: groups of interacting, interrelated, or interdependent elements that form a complex whole.
- The earth and its systems are closed to matter: i.e., matter can change form (the system is open to energy), but resources are finite.
- There is no away.
- Because the earth is a closed system, disposing of products at the end of their useful life can waste usable materials.
- Preserving resources for future generations means embracing the idea of sustainability.

LEARNING OBJECTIVES

Students

- explore the concept of systems,
- examine a system familiar to them that is open,
- define the characteristics of one that is "closed,"
- compare the needs of a closed system to those of an open system,
- identify Earth as a closed system,
- describe how product cycles (in this case, shoe design, manufacturing, retailing, consumer use, and disposal) impact Earth systems (environments and societies), and
- suggest ways to reduce, reuse, or recycle resources in the life cycle for a shoe product.

PREP TIME: 5 MIN.

Draw a large outline of a house on the chalkboard or whiteboard. Distribute several sheets of self-sticking notepaper to students.

PREP TIME: 10 MIN.

Arrange desks into U-shape (you're creating floor space for visualizing consequences of shoe disposal). Make copies of student worksheet A (optional).

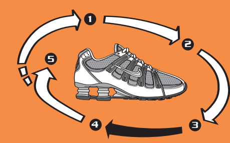
CLASS TIME: 45 MIN.

background

THERE IS NO AWAY

Resources taken from the Earth and manufactured into human-made products remain in Earth's system – but generally in a highly altered form. First we call the "form" a product; then when we've used it up, we call it garbage. Garbage – or municipal solid waste – does not return to the Earth's crust to feed new life forms, as would occur in natural cycles.

The Environmental Protection Agency (EPA) estimates that in 2001, U.S. residents, businesses, and institutions produced more than 229 million tons of MSW, which is approximately 4.4 pounds



Subject Areas:

Science

Social Studies

Math

Language Arts

Economics

Skills:

Diagramming (mapping a physical construct), discussion, creative thinking, classifying, estimating, comparing, charting/graphing, research (optional)

Materials:

- Large plastic garbage bags
- Copies of Student Worksheet A (optional)
- Chalkboard or whiteboard
- Chalk or nontoxic dry erase markers
- Drawing paper for students; art and writing instruments (crayons, pens, markers, etc.)
- Self-sticking notepaper
- Photograph of Earth taken from outer space (optional; may be found on the Internet)
- Jar or beaker filled with water
- Dark food coloring or ink
- Ball of twine, strong yarn, or yellow construction tape for human pie chart
- Scales and rulers (optional)

Key Vocabulary:

system, open system, closed system, resources, waste materials, sustainable, sustainability

THERE IS NO AWAY (continued)

of waste per person per day, up from 2.7 pounds per person per day in 1960. The agency recommends these strategies, in order of preference, for managing municipal solid waste (MSW):

- source reduction
- recycling and composting
- disposal in landfills or waste combustors

Though source reduction is the preferred strategy for working towards sustainability, recycling also provides environmental benefits: in 2001, recycling diverted 68 million tons of material away from landfills and incinerators. Typical recyclable materials include batteries, recycled at a rate of 94%, paper and paperboard at 45%, and yard trimmings at 57%. These materials and others may be recycled through curbside programs, drop-off centers, buy-back programs, and deposit systems. The number of landfills is steadily decreasing (8,000 in 1988 to 1858 in 2001), although their capacity has remained relatively constant. New landfills are much larger than in the past.

By 2001, the recycling rate for MSW was 29.7%. The EPA supports reaching a national goal of at least 35% recycling.

(***Source:*** Background Press Information, EPA's Recycling Goal. United States Environmental Protection Agency, last updated October 27, 2004. [Online.] *http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/recbkgnd.pdf*

Basic Facts, Municipal Solid Waste. United States Environmental Protection Agency, last updated April 27, 2004. [Online.] *http://www.epa.gov/epaoswer/non-hw/muncpl/facts.htm)*

MUNICIPAL SOLID WASTE (MSW)

The collective term for waste discarded by a community is Municipal Solid Waste (MSW). According to 2001 figures published by the EPA, 16.3 million tons of this waste (7% of all waste by weight) consists of rubber, leather, and textiles – the components of clothing and shoes. Here's a snapshot of MSW (this information can be passed on to students when the class compares "actual" shoes thrown away to "estimates" of shoes thrown away):

WASTE	229 MILLION TONS (BEFORE RECYCLING)
• rubber, leather, and textiles	7.1% of all MSW by weight
• paper	35.7%
• yard trimmings	12.2%
• glass	5.5%
• metals	7.9%
• plastics	11.1%
• wood	5.47%
• food scraps	11.4%
• other	3.4%

(***Source:*** Basic Facts, Municipal Solid Waste. United States Environmental Protection Agency, last updated April 27, 2004. [Online.] *http://www.epa.gov/epaoswer/non-hw/muncpl/facts.htm*)

Much of this waste ends up in landfills (***Note to teacher:*** in countries other than the United States, landfills may not be available and waste disposal options may vary). Recycling materials can reduce the amount of landfill space needed for MSW. More importantly, recycling can recover still-useful materials for use in another product.

TO RECYCLE OR NOT TO RECYCLE

The list of recyclable materials is long – and exceptions to it longer still. You may wish to do the following activity with your students:

1. Collect the following objects:
   glass container, plate, Pyrex, light bulb
   newspaper, rubber band
   empty metal can, empty aluminum can, can of paint
   plastic stamped #1 or #2 on the bottom, bottle cap from plastic type #3, 4, 5, 6, or 7 (often the bottle caps are of a different type of plastic and should be tossed)
   plastic bags marked #2 or 4, unmarked plastic bag
   mixed paper: junk mail, magazines, photocopies, computer printouts, cereal boxes, corrugated cardboard, stickers, napkin, milk carton, food-stained paper
   scrap aluminum such as a lawn chair or window frame or pot, nonmetal part
   motor oil
   rechargeable battery
   paint, pesticides, or cleaners
   computers, computer floppy disk (limited; however, consumers can reuse)
   eyeglasses
2. Arrange the objects on a table in front of the room, or divide them evenly among four groups.
3. Ask students to group the objects into "recyclable" or "nonrecyclable" and state the reasons for their choice.
4. Discuss the following question: Is there recycling in their community?
5. Have students verify their choices by seeking information on the Internet or from local libraries. Have them explain what new facts they've learned about recycling and ask if they want to do more recycling, given what they've learned. What kind of items would they recycle? What choices do they have as individuals? What factors might affect those choices?

Note to teacher: italicized items are recyclable; non-italicized items are generally unable to be recycled, even though they appear to fall into the recyclable category.

LINKS to Sources (Internet):

The World's Shortest Comprehensive Recycling Guide
http://www.obviously.com/recycle/guides/shortest.html

The Consumer Recycling Guide: Commonly Recycled Materials
http://www.obviously.com/recycle/guides/common.html

Recycling Myths (*source:* Institute for Local Self-Reliance, Washington, DC)
http://envirosystemsinc.com/myths.html

Textile Fiberspace (Secondary Materials and Recycled Textiles Association)
http://www.textilefiberspace.com/assn/rs000201.html

THE SHOE INDUSTRY IN THE UNITED STATES

Factoids	Source/Comments
59.128 million pairs of shoes produced in the U.S. in 2002	··· Shoe Stats 2003, Apparel and Footwear Industries, July 2003. *http://www.apparelandfootwear.org/data/shoestats2003.pdf*
Total pairs of footwear consumed in 2002 nearly doubled (1.927 billion; 98.5% of these are imported) from the number of pairs consumed in 1997: 1,100.8 million. Number of athletic shoes consumed in 2002: 360 million; in 1997: 342 million pairs (most are produced in Asia). Nike, about 40% of the market, produces 150-200 million shoes annually. Number of athletic shoes Nike recovered for recycling in 1997 through its Reuse-A-Shoe Program: 2.1 million pairs. In 1998-1999, Nike recovered 2.5 million pairs. (Number of shoes discarded annually is unknown.)	··· Trends, American Apparel & Footwear Association, First Half 2003. American Apparel & Footwear Association *http://www.apparelandfootwear.org/data/trends2003Q2.pdf* ··· Footwear Industries of America, *Shoe Stats 1998* ··· Nike's Consumer Insights Research Dept. Report, November 1997
1998 U.S. Nonrubber Footwear Consumption: 1.583 billion pairs of shoes. (Compare this to 2000: 1.452 billion pairs)	The term "nonrubber footwear" includes men's work shoes, women's footwear, juvenile shoes, athletic shoes, and slippers. ··· Trends, A Semi-Annual Compilation of Statistical Information on the U.S,. Apparel and Footwear Industries. First Half 2003. American Apparel & Footwear Association *http://www.apparelandfootwear.org/data/trends2003Q2.pdf*

As with all markets, a delicate balance exists between the supply of raw materials and the demand for products. In emerging recycled markets, balancing the supply of raw materials and the demand for recycled goods is a challenge.

Shoes are made of materials that come from natural resources, many of them considered nonrenewable. Instead of disposing of shoes and their usable materials, some companies are developing ways to use them for other purposes and thereby save primary source material, By considering alternatives to disposal, the useful life (and material properties) of a resource could be extended and maximized.

One alternative, reuse, can be implemented when a child's shoe, for example, has been outgrown but is still usable. The shoe can be given to another family member, to charity, or to consignment shops before it is ultimately discarded. Another alternative is to repair the item in order to get the maximum life from it. For example, some shoes can be resoled.

While recycling newspapers, bottles, and cans is quite familiar, recycling of used consumer products is a new phenomenon. Some companies have collection programs to downcycle shoes at the end of their useful life. Athletic shoes, for example, can be ground up and their materials made into a variety of new products such as basketball and tennis courts, synthetic grass fields, playground fall protection, and carpet underlayment and retail store flooring.

BIOSPHERE: AN EXPERIMENT IN SUSTAINABILITY

LINKS:
Footwear Industries of America, *http://www.fia.org*

BIOSPHERE: AN EXPERIMENT IN SUSTAINABILITY

Who: Four men, four women

What: lived sealed in a 3.15-acre, airtight, metal and glass greenhouse for two years. They relied on the outside only for energy (electricity and sunlight) and information. Inside, more than 3,500 plant and animal species existed in replicas of 5 ecosystems (desert, grassland, marsh, ocean, and rainforest).

There were two separate phases to the project: Biosphere 1, in which the eight residents tried to create a self-sustaining system, and Biosphere 2, which is research oriented and managed by Columbia University in New York.

When: Biosphere 1 – September 26, 1991-September 26, 1993
Biosphere 2 – 1994 through today

Where: Oracle, AZ (35 miles north of Tucson); 3,960 feet above sea level

Why: Originally scientists wanted to test whether a space colony could be self-sustaining. Now the biosphere is a center for environmental research.

How: Sensors monitor temperature, light, humidity, carbon dioxide (CO_2), and air and soil quality. In the beginning of the project, excess CO_2 became a problem, because Biosphere designers had placed highly organic soils in the agro-forestry and rainforest biomes. Oxygen was pumped in to restore the balance. Humans adjust sensor readings so that they mimic ecosystem conditions, allowing them to learn more about sustainability in nature.

BIOSPHERE 2: FROM FICTION TO FACT

The idea of a Biosphere – an artificial environment constructed by advanced extraterrestrials (ET) – was first described by Olaf Stapleton in his 1937 science fiction novel *Starmaker.* About 20 years later, physicist Freeman Dyson proposed the idea that very advanced ET civilizations might construct large artificial shells around a "parent star" and thereby capture all of the star's energy for their own use.

Today, this "large artificial shell" exists, though it is not built around a "parent star" nor is all the energy captured for use by the inhabitants. Instead, this shell, named Biosphere 2, is in Arizona, near the Santa Catalina Mountains. By using the biosphere as a model, researchers hope to learn more about Earth systems and ultimately how they can be sustained.

Human-Made Ecosystems at Close Range

Columbia University student Myvonywnn Hopton spent five months investigating greenhouse gases in Biosphere 2. She lived outside the structure, in nearby housing, and swiped a specially coded access card through a card reader while a video camera recorded her entrance.

background

BIOSPHERE 2: FROM FICTION TO FACT *(continued)*

"I walked through an airlock and into a maze of pipes and cement. On my right, the ocean was like a huge swimming pool, but the waves were made by machine," Hopton says. "I went through another airlock to get to the rainforest. There's no way you can forget this creation is manmade: you always hear the huge industrial fans (temperatures near the glass ceiling can reach 120°-130°F)."

Every day, before exiting, Hopton had to place her shoes into a bleaching solution to eliminate nematodes. "These microorganisms in the soil were imported and are foreign to Arizona. It's a question of the Biosphere contaminating Arizona rather than Arizona contaminating the Biosphere," she says.

Connecting to Place: A Key to More Informed Policy-Making

Hopton relishes the sense of place she developed in Arizona. And the more she travels, the more she wants to know everything about the place she calls home – right now, that's New York City.

"Connections to place [and between different bodies of knowledge] are so important," she says. "You look at the soil. You try to figure out what kind of rocks it came from, and more importantly, how humans have changed the natural environment." These stresses, she says, have occurred at such lightning speed that the landscape cannot easily respond to or recover from them.

Hopton's program at Columbia places a strong focus on how science and society connect. "If we study them together instead of separately, we have a chance of achieving more informed policy making," she says.

LINKS to Sources (Internet):

Biosphere 2, *http://www.Encyclopedia.com*

"Biosphere 2 Center Virtual Tour," *http://www.bio2.edu/virtualtour/lung.htm*

"Its Lessons Learned, Biosphere 2 Seeks Niche as Teaching Center," *http://www.bio2.edu/fromsite/41798.htm*

"Research at Biosphere 2," *http://www.bio2.edu/Research/new resentry.htm*

"The Ultimate Biospheres," *http://seds.lpl.arizona.edu/nodes/NODEv4n3-10.html*

"Welcome to Columbia University's Biosphere 2 Center," *http://www.bio2.edu/visitor/home_ent_new.htm*

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TEACHER TIP

You may wish to bring in a sample athletic shoe… or invite students to wear athletic shoes to class for this lesson.

Procedure

A. Warm-up: 15 minutes

1. Introduce "system" by giving examples of *body systems*:

- ***a.*** circulatory (heart, veins, arteries, capillaries are interdependent elements that work together to pump blood throughout the body)
- ***b.*** respiratory (nose, cilia, mouth, trachea, lungs, bronchi, alveoli are interconnected elements that work together to bring "clean" air into the body [oxygen for blood and brain] and to expel carbon dioxide, which is then used by plants in the process of photosynthesis).

and *Earth systems:*

- ***c.*** weather
- ***d.*** water purification (algae, oxygen, etc.) in rivers, oceans, streams

- ***e.*** nutrient cycles (***example:*** leaf decays, which could be considered waste, except that this "waste" becomes food for the next life cycle)
- ***f.*** ecosystems (the interaction between all organisms in a given habitat; for instance, one organism may serve as food for another. Most ecosystems consist of four components: producers, consumers, decomposers, and non-living matter. [Source: Environmental Protection Agency. 1997, September. Appendix C: Understanding Ecosystems. In Community-Based Environmental Protection: A Resource for Protecting Ecosystems and Communities. Washington, DC: EPA.])

2. *DEMO: SHOE PILE-UP*

What happens if disposal is our only option for the end of a product's life?

- ***a.*** Note that product cycles are part of a complex business system of product design, manufacturing, acquisition by consumers, and recycling or disposal.
- ***b.*** Ask students where shoes go when they reach the end of their useful life.
- ***c.*** List answers on the board, each in its own column. Possible answers: charity, trash, consignment shop, and relative or family member.
- ***d.*** Ask which destinations could be considered "reduction," "reuse," "recycling," or "disposal." (Ask what each term means to students, and how consumers might participate in these actions. For example, though we might not "reduce," i.e., stop wearing, shoes, we might make purchases based on identified needs.)

- ***e.*** Have students place their shoes on the floor, in a column that corresponds to shoe destinations you've listed on the board (you will be automatically creating a bar graph).
- ***f.*** Ask what happens to shoes after they've gone to each destination. (For example, after they've been given to a younger brother or sister, shoes might then go to a charity or to the garbage.) Physically move the shoes from their original piles to their final destination piles. Eventually most shoes will end up in the "garbage" pile (note that even if shoes go to charity, this is ultimately disposal – and a waste of resources).
- ***g.*** Place "discarded" shoes into a trash bag and pass it around – you want students to see and feel the "weight" of the disposal issue, and reflect that this is just their classroom's group of shoes. What if the whole school threw away their shoes? Their town? State?

B. Closed vs. Open Systems: 20 minutes

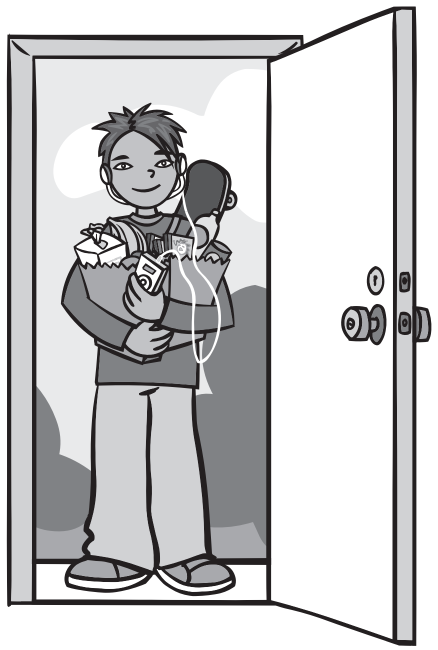
1. Point out the diagram of the house to the students. Ask them to name things that enter our homes (food, water, toys, clothing, shoes, people, air, etc.) and write their answers on self-adhesive notepaper. Let them place their answers on the board, inside the house diagram.

2. Now ask students to name things that leave our houses (people, air, garbage, wastewater, etc.). As students mention items already listed on the notepaper on the board, remove these notepapers.

3. Explain that things enter and leave our houses because they are open systems. Things can move in and out of an open system.

4. Now ask students to imagine that their house is a closed system: this means that nothing can enter (with the exception of heat and light from the sun) or leave (with the exception of reflected heat and light). Things already in our houses are the only resources we have. Waste materials produced by the people living in the house must stay there. (***Teacher:*** Younger students may enjoy hearing Shel Silverstein's poem, "Sarah Cynthia Sylvia Stout," in his collection, *Where the Sidewalk Ends*. See Resources section for publication information.)

5. Have students diagram their own houses on drawing paper (i.e., create one like the one on the chalkboard). Tell them, "Imagine that starting today nothing will be able to enter or leave your house. What would happen inside the house? Draw it!"



6. Students will quickly realize that life inside the house would be impossible. They may suggest ways to make such a house livable (*examples:* using plants as sources of food and oxygen or installing water reclamation systems). Encourage such brainstorming if it occurs.
7. Explain that planet Earth is a closed system, just like the homes in their drawings. (If you have a photograph of the earth taken from outer space use it as a visual aid.)
8. Only sunlight enters the earth's systems. There is no way to entirely "get rid of" materials or substances found on earth. As some people put it, "There is no away."
9. Students may suggest sending trash into outer space. Even trash (debris from space missions and disabled satellites) can fall back into Earth's atmosphere. Students may also suggest using the moon or an asteroid as a dumping ground. Allow students to discuss the plan's positive and negative consequences. Explain that materials taken from the Earth's crust (oil, minerals) can never be returned to the crust in original form or original quantity (because everything disperses [see Lesson 2]).
10. Discuss the implications of living in this closed system:
    a. What are some of the waste materials that humans introduce into the earth's systems?
    b. What effects do these wastes have? (*Examples:* water and air pollution.)

C. Demo: Water and Ink – 10 minutes
The difficulty in controlling the materials we release into the environment and the impossibility of returning material to its virgin state.

1. Fill a glass jar or beaker about ¾ full with water.
2. Shake 1-2 drops of dark food coloring or ink into the water.
3. Ask students to predict what will happen to the ink. (Eventually the color will disperse throughout the water.)
4. Now ask students if they can get the color out of the water or if the food coloring can be returned to its concentrated form. (Students may suggest boiling the water or filtering it to remove the color.) If you have the necessary equipment and wish to do so, allow students to try; however, even without trying, students will realize it is extremely difficult to remove the color.
5. Say, "This is similar to what happens when materials used to make the products we consume are removed from the earth's crust. Some of them enter the earth's systems and are very difficult or impossible to completely collect again (for example, the difficulty of recapturing smog – i.e., gasoline byproducts created during combustion of car engines. When gas is used as fuel, there are byproducts that combine with other substances in the air and disperse. How do you recapture the gasoline and turn it back to oil?). Thus we must be very careful about the materials we take from the earth's crust and very careful about how we use them."
6. Discuss examples of these products and materials – e.g., refer to athletic shoe: What is it made of? Where did the materials come from?
7. Ask students to brainstorm ways in which humans can work to keep our closed system livable. List student suggestions on the chalkboard or whiteboard.
8. Explain that keeping our closed system livable, especially for future generations, is called "sustaining the earth," or "sustainability." Air to Earth lessons will explore how businesses and consumers are trying to practice sustainability in their communities. In particular the lessons will address steps that some companies, including shoe manufacturers, are taking to make their products in ways that try to protect our closed system.

Evaluation/Wrap-Up

1. Have students make a diagram of their school building (like the first house diagram you drew on the board). Ask students to explain why a school *is* or *is not* a closed system.
2. Ask students to explain, in their own words, the concept of a closed system, and why Earth is considered a closed system.
3. Suppose their school were a closed system. What routines and practices would change in order to keep the school "sustainable"?

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Enrichment

Choose from the following activities:

1. Complete Student Worksheet A, based on activities in Part A: Warm-up. Choose whichever variation of calculating percentage (below) is appropriate for your students.
    a. *For older/advanced students:* Use an overhead transparency to work some problems together with the class and let students work the others on their own. Chart the results as a bar or line graph.
    b. *For younger learners:* Create a human pie chart.

    Materials: Strong yarn or yellow construction tape works well.

    Purpose: To determine the percentages of shoes in various categories of "disposal," i.e., after students have determined what they do with their shoes when they are finished wearing them (landfill, closets, donations, hand-me-down, etc.).

    To create a human pie chart (to demonstrate percentages in a graphic way), have all students who throw their shoes away form a circle. Next, all students who donate shoes join and expand the circle, making sure they stand together in their category. Next, all students who store them in the closet join and expand the circle and so on until all of the students are standing together in a circle in their chosen categories. Students should be standing very close together in the circle for the best results. Ask one student to stand in the middle of the circle.

    Using the yarn or tape, begin by having the student in the center hold one end of the yarn. String the yarn from the center to the first student in the landfill category and follow along the line distributing yarn to each student in that category. When you come to the end of the landfill category, string the yarn to the student in the center. Wrap the yarn around the student's hand and return with the yarn to the first student in the next category. Pass the yarn along the line until the end of that category and return the yarn to the student in the center again. Continue in this manner until all of the categories have been defined and each student is holding yarn. You will have 5-6 categories and the circle should look like a pie chart.

    Now begin to discuss disposal and the various options the students selected knowing that eventually the students will realize that shoes finally end up in the landfill.

    What happens to shoes after they have been donated or handed down? (They eventually end up in the landfill.) As the students realize that almost all shoes end up in the landfill, drop the yarn from the center in their category, making a bigger piece of the pie representing landfill. Continue in this manner until you have discussed each of the disposal categories and have determined that eventually all shoes end up being thrown away. By that time, the student in the center should have no yarn in his/her hands and the students in the circle should be holding a full yarn circle with no pieces of pie.

    Have students discuss other options for shoe disposal.
2. Ask students to discuss the possible consequences (pro and con) of shoe disposal. Have them suggest ways to reduce, reuse, or recycle resources in the life cycle for a shoe product. Can they suggest any other uses for the materials in used shoes? Create a poster or advertising campaign to get the word out.
3. Students may want to research the space station currently under construction or the Biosphere projects. Are they closed or open systems? How are oxygen and water supply, waste removal, etc., accomplished in these systems? (*Teacher:* see background information.)
4. Have students pick a partner or a team and consider the following scenario. Students will need to do some research in the library or on the Internet. What are some recommended solutions?

"THERE IS NO AWAY."

Even though trash is compacted in landfills, we appear to be running out of room. For example, Fresh Kills Landfill (Staten Island, NY) is closing because it is too big.

When this happens, some states, like New York, ship trash to other states (for a fee). Pennsylvania and Virginia, for example, import the largest amount of out-of-state trash. Others have suggested that trash be shipped to outer space rather than put back into the Earth.

Suppose you were chosen to be on a special committee to decide how excess trash in your community is to be handled. What would you recommend? As you brainstorm, consider the following questions:

- What are the positive and negative consequences of shipping trash out of state?
- What are the positive and negative consequences of shipping trash to outer space?
- Are there other ways to take care of trash? What are they? What are their advantages and disadvantages?
- What resources are available in your community for trash disposal?
- What impact will each proposed method of trash disposal have on
  ··· your community,
  ··· your environment (or the environment to which you choose to send the trash), and
  ··· your local economy (will it create more jobs, fewer jobs, etc.)?
- What do you recommend to solve the problem of excess trash in your community?
- *Use these or similar questions after you have drafted your recommendations.*
  ···Was it easy or difficult to design a plan?
  ···Were you able to design a plan that had minimal impact on earth systems? on the economy? Or did you have to make trade-offs? What were they?
  ···Would you ever consider volunteering to be on a policy-making body (like this one) in your community? Why or why not?

5. To get a quantifiable picture of a trash disposal issue, pick an "average" shoe and have students work in teams on the following activities:

a. *Calculate total weight of shoe "waste":* for your classroom, for the whole school.

b. *Calculate linear feet (meters) or miles (kilometers) of shoe "waste."* Calculate for your classroom and your school. Make an analogy: How many times could this line of shoes circle a track, for instance, or go back and forth across the gymnasium or classroom floor?

Extension: How many shoes do you throw away annually, if any? Do the calculations, above, again, using data based on estimates of classmates' experiences with throwing shoes away. (***Hint:*** use an "average" number for the number of pairs of shoes you imagine are discarded.) Survey your classmates to find the actual number of shoes discarded, and calculate the "waste" again. Compare your answers. Is the amount of shoes actually discarded more or less than the ones they imagined were discarded? What do you think about this?

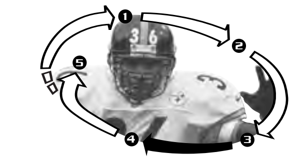
c. Advanced: Calculate the volume of shoe "waste." Compare the amount of space taken up by discarded shoes to the volume of the classroom. *Note:* this activity is intended to give you another way to imagine the amount of resources that could be used over again if they weren't thrown away. It is not intended to suggest that disposed-of shoes would take up this much space in a landfill: landfills are compacted. For further information, look up "landfill" in the glossary or dictionary.

d. Calculate estimated weight of shoe waste over a lifetime.

6. Have students poll their family to discover how many shoes their family buys annually. Have them interview parents or caregivers to discover what options exist for shoe disposal. About how many pairs of used shoes do they discard each year? What did they learn about what happens to used shoes in their house? Have them write up the results of their research.

Lesson 1

Student Worksheet A



Destination	Predicted Percent of shoes at each destination	Actual Total Number of shoes at each destination	÷	Total Number of shoes in class	x 100 =	Actual Percent of shoes at each destination
			÷		x 100 =	
			÷		x 100 =	
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Jerome Bettis:

Starting NFL running back for the Pittsburgh Steelers who is nicknamed "The Bus" because of his size and speed.