Lesson 4

The Product Life Cycle

ATTENTION

This lesson assumes familiarity with the origins of manufactured materials. See background information and Internet resources in the Resource Guide for assistance and for a case study that shows how one company approaches sustainable manufacturing.

The student discussion worksheet assumes familiarity with manufacturing processes and material separation methods. If students are not familiar with these processes, consider

- researching manufacturing processes for athletic shoes (see Internet resources listed in Resource Guide)
- arranging a tour at the community materials recycling center

FOCUS

To explore how product life cycles would change if products were designed with the Earth in mind and according to principles for sustainability.

CONCEPTS

- Like nature, products have life cycles and are part of a complex system of supply and demand.
- Businesses can change design and manufacturing processes so that product life cycles work with, rather than against, the earth's systems for sustainability. Working towards sustainability means choosing materials and manufacturing processes that respect four natural laws (rules of *the game*)
  - ··· Matter and energy cannot be created or destroyed.
  - ··· Matter and energy tend to disperse.
  - ··· The concentration and structure of matter determine how it can be used. In products, it is that functionality that we use up. "Stuff" cannot disappear, but its functionality can.
  - ··· Photosynthesis is the main process that regulates "order" on the earth.

  and *four Winning Principles* (strategies) for achieving sustainability:

1. Societies do not subject nature to continually increasing concentrations of substances taken from the Earth's crust.
2. Societies do not produce substances that build up and "overwhelm" nature's ability to cope with them.
3. Individuals do not physically damage nature faster than it can rebuild.
4. Human needs are met worldwide.

LEARNING OBJECTIVES

Students

- assess the design and manufacture of household items and athletic shoes in terms of their impact on Earth's systems (see Lessons 2 and 3); and
- suggest ways to produce consumer goods that honor principles of sustainability.

PREP TIME: 5-10 MIN. (previous day)
Gather a number of common household items and place in box.

PREP TIME: 15 MIN.
Duplicate copies of the student worksheet.

CLASS TIME:

Day 1	10-15 MIN. for Procedure 1 30-35 MIN. for Procedures 2-6
Day 2	40-45 MIN. (students consider discussion questions as a homework assignment and report answers the following day)
Optional:	10 MIN. for Reuse-A-Shoe video

Subject Areas:

Science

Social Studies

Language Arts

Visual Arts

Economics

Skills:
Discussion, research, analysis, teamwork, creative thinking

Materials:

- Common household items, e.g., potato peelers, vegetable brushes, toothbrushes, doorknobs, plates, drinking glasses, pencil, TV remote control, etc.
- Poster "The Life Cycle of a Shoe," included in teacher kit.
- Copies of team discussion sheets (5 different teams)
- List of Internet resources (see Resource Guide)
- *Enrichment Activity:* Copies of Teacher's Reference Sheet, "Design Your Own Shoe"

Key Vocabulary:
Sustainable, downcycling, recycling, source reduction, regrind, Nike Grind, renewable resource, nonrenewable resource, petrochemicals

The Natural Step Framework

The "Rules"

1. Matter and energy cannot be created or destroyed.
2. Matter and energy tend to disperse.
3. The concentration and structure of matter determine how it can be used. In products, it is that functionality that we use up. "Stuff" cannot disappear, but its functionality can.
4. Photosynthesis is the main process that regulates "order" on the earth.

The "Winning Principles" (Strategies): In sustainable societies

Societies do not subject nature to continually increasing concentrations of substances taken from the Earth's crust.

Societies do not produce substances that build up and "overwhelm" nature's ability to cope with them.

Individuals do not physically damage nature faster than it can rebuild.

Human needs are met worldwide.

NATURAL AND SYNTHETIC CYCLES

Living systems perpetually convert energy and material into different forms. The decay of one organism is the source material for the growth of another. Energy from the sun drives the energy-to-matter conversion. The loop is "closed," i.e., no functionality is destroyed, no matter or energy is wasted (*Sustainability Report*; Interface, Inc.; 1997).

In synthetic cycles, such as manufacturing, humans

- convert raw resources into new materials,
- make these materials into products,
- use them, and then
- reuse, recycle, or ultimately discard the products.

Take, Make, Waste

Unlike in natural cycles, products discarded in landfills are not reborn into new forms. Often, product life cycles come down to "take, make, waste": take resources, make product, waste materials. The question of who is responsible for creating this "open" rather than "closed" loop is beginning to have two answers: consumers and industry.

Consumers want high-quality, high-performance products that are a good value. But consumers also want environmentally friendly products. Corporations are realizing that their reputation for being environmentally responsible and sustainable can influence consumers' buying decisions. Consequently some businesses have altered production cycles so that they work with, rather than against, Earth systems. (Staci Bonner, *Apparel Industry Magazine*, February 1997; Asia Environmental Forum, Nike, Inc., 1997; D. Conti, N. Haas-Dehejia, and R. Calahan Klein, "Creating Value and Sustaining Growth." San Francisco, CA: Business for Social Responsibility, October 1997; The Natural Step, *http://www.thenaturalstep.org*, July 2000.)

NATURAL AND SYNTHETIC CYCLES *(continued)*

Some Approaches to Sustainability, and Related Challenges	
Source Reduction	Reusing products Lessening the quantity or toxicity of materials used during manufacturing Using manufacturing or packaging processes that create less environmental impact Minimizing product damage through effective packaging Designing packaging from fewer materials
Companies intent on practicing source reduction ask these or similar questions:	Where are the most significant waste and emission streams from our current operations? How can we eliminate waste before it is even created? Can we lower costs and risks by eliminating waste at the source or by using it as useful input? (Stuart L. Hart, "Strategies for a Sustainable World," Harvard Business Review, Jan.-Feb. 1997; J. Winston Porter, Ph.D., "Trash Facts IV." Leesburg, VA: Waste Policy Center, 1997.)
Life Cycle Analysis (LCA)	Applies source reduction to each step of the product cycle. Shows that "nothing is free," not even recycling. Example: the benefits of recycling paper may not outweigh the costs of energy used in transporting the paper from its collection point to its recycling destination.
Companies that practice LCA ask these or similar questions	What resource does this product deplete? What are the environmental effects? What are the health effects? How much energy is used in each part of the process? What changes can be made in the system?
Challenges in the Footwear Industry	Reliance on nonrenewable, petrochemical-based products (products made from petroleum, a limited non-renewable resource) to manufacture key footwear components such as nylon, polyurethane, and synthetic rubber. Manufacturing processes use water and energy. Even "natural" footwear components such as leather require powerful chemicals like chromium, which contributes to toxic waste. Waste-handling processes could be invented, but such an approach further complicates an already complex system. (Robert Frenay, "Biorealism: Reading Nature's Footprints," *Audubon*, Sept-Oct 1995).
How Consumers Can Practice Sustainability	Recycling used products Purchasing products whose manufacture or use results in reduced environmental impact – for example, • products designed such that their components can be used again at the end of their life cycle (design for disassembly); • products that are marketed using environmentally innovative or minimal packaging; products that are part of systems created to take back or recycle used commodities. • shift from using products to buying the services their products provide. For example, Interface has a product line called Evergreen Lease, which allows the customer to lease carpet flooring from the company. When finished with the flooring, Interface will take it back, which helps promote closed loop manufacturing.

background

PRODUCT LIFE CYCLE ANALYSIS (LCA)

Using the principle of source reduction as a guide, companies can make decisions about designing products differently by exploring how to minimize environmental impact at each stage of the product life cycle. The ultimate goal is to close the product loop by making new products from old products. Assets in the form of valuable materials stay in a closed loop system instead of being discarded as waste, and the rate at which virgin materials are extracted from the environment decreases.

Some industries use life-cycle analysis (LCA) to give consumers or governments environmental data, or to help an industry to identify how to improve processes that have negative environmental impact. According to the World Resource Foundation (WRF), LCA must be used cautiously: In most situations, it's impossible to prove that one product or process is better in general terms than any other. Yet LCA, when consulted at the design stage of new products, can be a useful tool for guiding consumer and manufacturer choices.

Today, businesses and consumers generally agree that good economics and planning depend on being reasonably concerned about the environment – and that the cure to waste is profitable, creative, and practical. "Sustainability" is emerging as a key concept in global solutions toward environment-related problems. (John F. Disinger, "Environmental Education for a Sustainable Future," ERIC/SMEAC Environmental Education Digest #1, ERIC Document ED 320765 90; *Sustainability Report*, Interface, Inc., 1997.)

RESOURCES: WHAT PRODUCTS ARE MADE OF

This table offers some examples of everyday products and their origins.

Resource	Renewable (∞) or Non-Renewable ( )	Products
Petrochemicals: any of a large group of chemicals (as distinct from fuels) derived from petroleum and natural gas and used for a variety of commercial purposes.		plastics, soaps and detergents, solvents, drugs, fertilizers, pesticides, explosives, synthetic fibers and rubbers, paints, epoxy resins, and flooring and insulating materials. Petrochemicals are found in products as diverse as aspirin, luggage, boats, automobiles, aircraft, polyester clothes, and recording discs and tapes.
Sand		glass
Metals: *Aluminum:* chemical element, a lightweight, silvery-white metal. Aluminum is the most abundant metallic element in the Earth's crust.		bikes, cans, tent frames, jewelry, cookware, aluminum foil
Iron: makes steel, an alloy of iron and carbon in which the carbon content amounts to about 2% or less. Carbon makes the iron hard and strong.		bikes, cars, building frames (rebar), knives, cookware, etc.
Trees: woody plant that renews its growth every year (called a perennial); most plants classified as trees have a single self-supporting trunk containing woody tissues.	∞	paper, cardboard, furniture, jewelry, medicine, etc.
Plants: life forms that use photosynthesis, in which chemical energy is produced from water, minerals, and carbon dioxide.	∞	fibers (cotton, jute, linen, etc.); medicines; food products, cardboard, etc.

Teachers may want to ask students to make their own table of products and origins. Students can research websites (see below) or even hardback encyclopedias.

background

RESOURCES: WHAT PRODUCTS ARE MADE OF *(continued)*

LINKS:

- http://www.ecomall.com/class/menu.htm (environmentally friendly alternatives to source materials)
- http://www.Encyclopedia.com
- http://www.Infoplease.com
- http://www.Letsfindout.com (specifically for kids)
- http://www.encarta/msn.com
- http://www.britannica.com

Teacher Tip

Bring a collection of common household items to school (see examples given in Materials section).

Procedure

Day One

1. Talk about a household item in terms of its life cycle.
   Example: I'm looking at X, and I'm wondering what it's made of (ask students if they can state the raw materials), and continue this process by having them think about and discuss
   - where it came from (region, country, or place in/on the Earth or Earth's crust – [substances from the crust would be any metals or petrochemicals, i.e., chemicals made from petroleum. If the item contains any visible plastic parts, it contains petrochemicals.])
   - which plant- or animal-derived materials were used in its construction.
   - what might have happened next…how did it get from the manufacturer to the consumer…how did it get there…what impacts this may have had on Earth, e.g., air or water pollutants. *For instance, trucks might have taken it to the store, so carbon dioxide was released into the air. If packaging was used, the extra weight makes the truck use more fuel, and ultimately packaging is used once and then thrown away… Perhaps new roads or warehouses were built, which potentially affected some habitats…Maybe a ship transported it from another country, so the quality of ocean water may have been affected, etc…*
   - what designers were intending when they designed the product (purpose or goal)…
   - whether the manufacturer thought about the ultimate disposal of this item, whether it was designed to last a long time.
2. Tell the class that they are going to think about the life cycle of another household product from the box you've brought to school. Have students work in small groups, pick one product to evaluate, and go through the exercise as you did, above. Have them share information with the class.
3. Now tell students that they're going to examine the life cycle of another product – an athletic shoe. Ask whether the shoe was designed keeping people, product, and planet in mind:
   a. Would consumers want to buy it?
   b. Is it produced in a way that is sustainable (in a manner that is least harmful to the earth's systems and in a way that preserves resources for future generations)?
   c. Was it designed to last a long time?
4. Briefly refer to the Product Life Cycle poster with the class. Point out the stages in the life cycle and ask students to discuss what kind of questions must be considered at each step of the cycle. Discuss and compare the concepts of downcycling and recycling.
5. Divide students into five groups, one for each stage of the life cycle process. (Assign group roles, such as discussion leader, recorder, spokesperson, time monitor, etc.) Ask one person from each group to use an athletic shoe as the subject for study.
6. Provide list of Internet resources. Ask students to suggest additional sources for research.
7. Distribute the group discussion sheets. Instruct students to work with their team to answer questions. Allow students to take them home and discuss them with adults or if possible research some of the answers. (You may want to allow students a few days to complete this activity.)

Day Two

1. Ask group spokesperson to report key points of the group discussion. ***Note to teachers***, with respect to team 5 discussion of phase 5, downcycling: On the product cycle poster, "closing the loop" is shown as a dotted line, signifying an ideal that has not yet been achieved. Address this aspect in your follow-up discussions of the activity.
2. Share with the class that some companies (for example, Nike, Stonyfield, Inc., FedEx Kinko's, and others) use this same process to design their products. ***Note to teachers:*** See the chart below for examples of how companies can produce products with "people, product, and planet" in mind.

Evaluation/Wrap-up

Base some of your assessment of students' understanding on their ability to successfully participate in the team and follow-up discussions. Then have them apply what they've learned in one of these activities:

1. How could the household item each team studied be redesigned and remanufactured to change its life cycle in ways that work with, rather than against, Earth systems?
2. Design an Earth-friendly life cycle for a product used everyday. Refer students to websites listed in the Resource Guide.

Enrichment

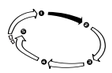
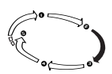
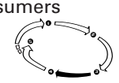
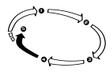
Have students complete the following activity:

Imagine you have been chosen to design an athletic shoe.

- What will it be designed to do?
- What will your athletic shoe look like?
- What kind of customer would be interested in your shoe? Why?

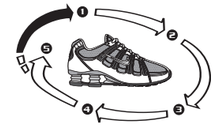
Draw your shoe and label each of the following components: laces, upper, midsole, and outsole.

- Decide which materials you will use to make your shoe, and list the resources that go into each of your materials.
- What other products use these materials?
- What impact does your choice of materials have on the environment?
- Do materials exist that function and perform for their intended use AND work with, rather than against, natural laws so as to be compatible with Earth system conditions for sustainability? (***Note to teachers:*** see Teacher Reference Sheet #1, "Design Your Own Shoe," *Air to Earth Teacher's Guide*, available at *http://www.airtoearth.com*, for additional information.)

Product Phase	Examples
Research and Design 	Designing products so that their individual parts can be easily disassembled for recycling. Working to design a product that is entirely recyclable. Interface, Inc.'s, floor covering product (Solenium) "zips" apart so threads and backing can be recycled.
Manufacturing 	Using organically grown textiles or other products in manufacturing. Using only water-based solvents in production or finishing. (Nike uses water-based solvents to construct athletic shoes in at least 85% of their products and incorporates 3% organic cotton into T-shirts. Nike is working with organic cotton farmers nationwide to increase the supply of organic cotton grown so more organic cotton can be incorporated into T-shirts.)
Retail/Packaging 	Packaging products in recyclable containers that use no adhesives or heavy metal inks, using soy-based inks or dyes, recycled products, etc. (See box containing kit contents. This shoe box uses soy-based dyes, recycled content cardboard and no adhesives.) Foregoing packaging altogether.
Consumers 	Recycling products through a "return product for disposal or refill to manufacturer" programs (such as printer toner cartridges). Buying products based on identified needs.
Downcycling 	Using ground-up materials in new or different products. Examples: Nike uses Nike Grind for playground fall protection surfaces. Interface, Inc., developed a way to lay floor-covering fibers across rather than up and down; this cuts down on the amount of source material needed per carpet and the amount of energy needed in the manufacturing process.

Lesson 4

Student Worksheet



Product Life Cycle Team Discussion Sheets

TEAM ONE

 PHASE 1: *Research and Design*

1. What kind of customer was the designer thinking about when this shoe was designed?
2. Why was each material chosen for that part of the shoe? (What advantages does that material give the shoe in terms of performance or quality?)
3. Think about the Winning Principles (strategies):
   a. What resources are used to make the various parts of this shoe (laces, uppers, midsoles, outsoles)? Are these resources renewable or nonrenewable?
   b. Were any substances introduced into nature (for example, air or water pollutants) as a result of the manufacture of this shoe?
   c. Was some part of nature destroyed or harmed as a result of the manufacture of this shoe?
   d. Based on your knowledge, were energy and natural resources used efficiently and appropriately to produce this shoe?
4. Can you think of any other materials that could be used to produce this shoe
   a. so that the original design intention and qualities could be preserved AND
   b. so that the resources and production processes work with, rather than against nature?
5. Is this shoe designed to last a long time? Could it be? How?

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Lesson 4

Student Worksheet

Product Life Cycle Team Discussion Sheets

TEAM TWO

 PHASE 2: *Manufacturing*

1. How is this shoe put together? (Glued, stitched?)
2. Are there other ways to put the shoes together?
3. How could waste be prevented in the manufacture of this shoe?
4. Is it possible to use manufacturing waste for other things? (i.e., reusing scrap, etc.)
5. Think about the Winning Principles (strategies):
   a. What resources are used to make the various parts of this shoe (laces, uppers, midsoles, outsoles)? Are these resources renewable or nonrenewable?
   b. Were any substances introduced into nature (for example, air or water pollutants) as a result of the manufacture of this shoe?
   c. Was some part of nature destroyed or harmed as a result of the manufacture of this shoe?
   d. Based on your knowledge were energy and natural resources used efficiently and appropriately to produce this shoe?

Lesson 4

Student Worksheet

Product Life Cycle Team Discussion Sheets

TEAM THREE

PHASE 3: *Retail/Packaging*

1. How is this product presented to the consumer? (Does it come in a box, in a bag, placed on a shelf?)
2. What are the benefits of packaging?
3. Think about the Winning Principles:
   a. What resources are used to make this packaging? Are these resources renewable or nonrenewable?
   b. Were any substances introduced into nature (for example, air or water pollutants) as a result of the manufacture of this packaging?
   c. Was some part of nature destroyed or harmed as a result of the manufacture of this packaging?
   d. Based on your knowledge, were energy and natural resources used efficiently and appropriately to produce this packaging?
4. Can you think of other ways to package this shoe
   a. so that the original reasons for packaging (protection from dirt, ease of storage, etc.) could be preserved AND
   b. so that the resources and production processes work with, rather than against nature?
5. Is the packaging too much, too little, or just right? Explain
6. What do consumers do with packages after they've opened them?
7. Can you suggest other uses for this packaging?

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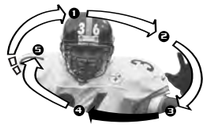
Lesson 4

Student Worksheet



Product Life Cycle Team Discussion Sheets

TEAM FOUR

PHASE 4: *Consumers*

1. What reasons do consumers give for buying certain athletic shoes?
2. Do consumers care if the materials in the shoe are recycled? recyclable?
3. What do consumers do with old shoes when they're finished using them?
4. What options are there for disposing of used shoes?
5. What happens to shoes after they're thrown away?
6. Is there a place to recycle old shoes?
7. How would you find out how to recycle your old shoes?
8. Think about the Winning Principles (strategies):
   a. What resources did consumers use when they shopped for and purchased these shoes? Are these resources renewable or nonrenewable?
   b. Were any substances introduced into nature (for example, air or water pollutants) as a result of the purchase of this shoe?
   c. Was some part of nature destroyed or harmed as a result of the purchase of this shoe?
   d. Based on your knowledge, were energy and natural resources used efficiently and appropriately by the consumer to purchase this shoe?
9. Do consumers care if a company manufactures its products to work with nature? Explain what you think "vote with your dollars" means?

Lesson 4

Student Worksheet

Product Life Cycle Team Discussion Sheets

TEAM FIVE

PHASE 5: *Downcycling*

1. What is the difference between downcycling and recycling?
2. If the materials were used again, what advantages or disadvantages would that give the new product in terms of performance or quality?
3. Do the materials have to be separated out before they're made into a new product, or could they be combined to make different products?
4. If they have to be separated, how could that be done? Are there different methods? What are the advantages and disadvantages of each separation method?
5. What happens to downcycled products after they have been used?
6. Are there examples of downcycled products in our school or community?
7. Do downcycled shoes "close the product cycle loop"?
8. What would "closing the loop" for a shoe mean?

Nicolas Vouilloz:

"When it comes to recycling, everyone needs to be involved."