The Life Cycle of Everyday Stuff

by

Mike Reeske
Shirley Watt Ireton

Featuring sciLINKS®—a new way of connecting text and the Internet. Up-to-the-minute online content, classroom ideas, and other materials are just a click away. Go to page xiii to learn more about this new educational resource.
## Introduction

Why Investigate the Life Cycle of Products? ........................................................ viii
What Is Life Cycle Assessment? ............................................................................... ix
How to Use This Book .............................................................................................. x
- Instructional Design and Science Standards .................................................... x
- Unit Overviews ................................................................................................. xi
- Group Work .................................................................................................... xii
- Using a Journal ................................................................................................ xii
- Life Cycle of a Pencil poster insert ................................................................. xiii
- Assessment ..................................................................................................... xiii
sciLINKS ................................................................................................................ xiii
About the Authors .................................................................................................. xiv
Acknowledgments .................................................................................................. xiv

## Unit One: What Is a Life Cycle?

Summary ................................................................................................................... 1
Objectives .................................................................................................................. 1
Time Management .................................................................................................... 2
Materials .................................................................................................................... 2
Preparation ................................................................................................................ 2
Teaching Sequence .................................................................................................... 2
Learning Goals .......................................................................................................... 4
Resources ................................................................................................................... 5
Student Sheet 1.1
  Introduction to Life Cycles—Matter and Energy Transformations ................ 7
Student Sheet 1.2
  What's in a Product and Where Does It Go? ................................................... 8

## Unit Two: Dissecting a Telephone—Design

Summary ................................................................................................................... 9
Objectives .................................................................................................................. 9
Time Management .................................................................................................. 10
Materials .................................................................................................................. 10
Preparation .............................................................................................................. 11
Teaching Sequence .................................................................................................. 12
Learning Goals ........................................................................................................ 15
Resources ................................................................................................................. 16
Student Sheet 2.1
  The Structure and Materials of a Telephone ..................................................... 17
Student Sheet 2.2
  The Functions and Design Rationale of Telephone Components ................... 18
Student Sheet 2.3
  Life Cycle of a Product—Expert Roles............................................................. 19
### Unit Three: Raw Materials—Acquisition and Processing

- **Summary**: 21
- **Objectives**: 21
- **Time Management**: 22
- **Materials**: 22
- **Preparation**: 22
- **Teaching Sequence**: 22
- **Answers to Student Sheets and Suggestions for Class Discussion**: 25
- **Learning Goals**: 26
- **Resources**: 27
  - **Student Sheet 3.1**: 29
    - Raw Materials—Expert Roles
  - **Student Sheet 3.2**: 31
    - Processing Copper from Chalcopyrite Ore
  - **Student Sheet 3.3**: 33
    - Simulating Mining and Extraction of Copper from Ore

### Unit Four: Manufacturing a Product

- **Summary**: 35
- **Objectives**: 35
- **Time Management**: 36
- **Materials**: 36
- **Preparation**: 36
- **Teaching Sequence**: 36
- **Learning Goals**: 39
- **Resources**: 40
  - **Student Sheet 4.1**: 41
    - Test Sheet: Chill Out!
  - **Student Sheet 4.2**: 43
    - Design Rationale Form
  - **Student Sheet 4.3**: 44
    - Post-Build Questions
  - **Student Sheet 4.4**: 45
    - Manufacture of a Food Wrapper—Expert Roles

### Unit Five: The Useful Life of a Product

- **Summary**: 47
- **Objectives**: 47
- **Time Management**: 48
- **Materials**: 48
- **Preparation**: 48
- **Teaching Sequence**: 48
- **Answers to Student Sheets and Suggestions for Class Discussion**: 50
Unit Six: A Tale of Two Cups—Disposal and Reuse

Summary ................................................................................................................. 61
Objectives ................................................................................................................ 61
Time Management .................................................................................................. 62
Materials .................................................................................................................. 62
Preparation .............................................................................................................. 62
Teaching Sequence .................................................................................................. 62
Answers to Student Sheets and Suggestions for Class Discussion ....................... 65
Learning Goals ........................................................................................................ 68
Resources ................................................................................................................. 69
Student Sheet 6.1
Disposal ............................................................................................................ 73
Student Sheet 6.2
A Tale of Two Cups .......................................................................................... 77
Student Sheet 6.3
Where Does a Telephone Go When It Dies? ................................................... 79

Unit Seven: Redesigning a Product

Summary ................................................................................................................. 81
Objectives ................................................................................................................ 81
Time Management .................................................................................................. 82
Materials .................................................................................................................. 82
Preparation .............................................................................................................. 82
Teaching Sequence .................................................................................................. 82
Answers to Student Sheets and Suggestions for Class Discussion ....................... 84
Learning Goals ........................................................................................................ 85
Student Sheet 7.1
A New Life for an Old Phone .......................................................................... 87
Student Sheet 7.2
Class Presentation Guide and Scoring Rubrics .............................................. 91

Appendix A

Reproduction of the Life Cycle of a Pencil Poster ............................................. 95
The Life Cycle of Everyday Stuff
**Why Investigate the Life Cycle of Products?**

The National Science Teachers Association (NSTA), using a grant from the Environmental Protection Agency (EPA), designed these instructional units to help you and your students explore a new tool—*life cycle assessment*. Parallel to living things, material products also have a “birth, life, and death”—a life cycle. For a material product, these steps include design, raw materials, manufacturing and distributing, useful life, and disposal or reuse. Life cycle assessment is a relatively new tool for science and economics. A life cycle assessment (LCA)—also called a *cradle-to-grave analysis*—looks at the environmental impact of the total life of a product. Its goals are to minimize the product’s negative or unplanned effects and maximize the product’s usefulness and profit. With these goals, the design of the product ultimately affects each stage of its life cycle. This book uses common products, such as the telephone, to illustrate how LCA works.

Examination of the life cycle of a product also offers a systematic way to look at the flow of energy and matter through the Earth’s system—a physical science parallel to food webs. In the context of life cycles, these units use central science concepts to explore the energy, raw materials, and waste issues that are part of the history of any manufactured product. As students consider the trade-offs made at each life cycle step, they will learn to recognize the decisions made by the producer to balance economic, environmental, and developmental needs. In addition, they’ll have opportunities to make parallel decisions about products they design and use.

These trade-off decisions are necessary in the goal of sustainable development. What is sustainable development? According to the President’s Council on Sustainable Development (1997): “A sustainable United States will have a growing economy that provides equitable opportunities for satisfying livelihoods and a safe, healthy, high quality of life for current and future generations. Our nation will protect its environment, its natural resource base, and the functions and viability of natural systems on which all life depends.” This goal of sustainable development calls upon educators to expand American students’ conceptual awareness and take a systems view of what we use, how we use it, and how it is disposed.

As this country becomes more technologically advanced, it is essential for students to clearly see the important connections between a relatively small group of the Earth’s raw materials and the products we value. For example, petroleum powers the industries of our planet. However, few students understand that plastics are synthesized from refined petroleum. Nor do they understand that the energy to produce nitrogen fertilizers is mostly generated from fossil fuels—a non-renewable resource.

Life cycle assessment gives students the opportunity to see these important connections in natural and human-made systems. It allows them to make informed decisions about the allocation of limited natural resources in the future, as these resources diminish in size and their dollar costs escalate. These types of decisions, based on the best science available, are the foundations of science literacy in our high school curriculum. It is our hope that the use of these materials in your classroom will contribute to the goals of science literacy for the 21st century.

---

**Sustainable Development**

In 1990, the World Commission on Environment and Development, a group developed by the United Nations, defined sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their needs.” Sustainable development is a process that balances both industrial and economic growth. It takes a broad systems view of what sustains economies, the environment, and human life. It looks at ways to sustain the quality of life for all people of the Earth at a level that will allow a balance between economic health, environmental health, and societal health. Life cycle assessment uses the goals of sustainable development and applies them in a practical way to the design, manufacturing, use, and end-of-life options of any product to make it more “environmentally friendly” and, in the end, more sustainable both now and in the future.

**SCILINKS®**

**THE WORLD’S A CLICK AWAY**

Topic: sustainable development

Go to: www.scilinks.org

Code: LCS01
What Is Life Cycle Assessment?

Life cycle assessment originated in the early 1960s as workers tried to develop materials and energy inventories to estimate the environmental impacts of product manufacture. During the 1980s, Europe’s Green Movement reawakened interest in LCAs. The Green Party called for a complete restructuring of social, cultural, and political life, especially in the developed countries. Today, it looks at important issues from the standpoint of the environment. The result—European manufacturers now routinely take back and reuse or recycle products such as cars. According to the Green Movement, examining life cycles is an important part of understanding the relatedness of all issues.

Around the same time in the United States, several consulting firms conducted landmark studies on solid waste. They analyzed the lives of common products such as foam and paper cups, disposable and cloth diapers, and plastic and paper grocery bags, using a cradle-to-grave analysis of energy and waste impacts at each stage of the product’s life.

These studies included some surprising answers to hotly debated environmental issues related to organic versus synthetic products. They found that plastic cups, because they were uniformly made of a single material—polystyrene—are less energy consuming and easier to recycle than the paper cup. They also produce less total waste.

Life cycle assessment is now an important tool for technology and planning, as our solid waste disposal options dwindle and energy prices continue to increase. LCA is only one type of this increasingly popular method of sustainable design. Other processes include eco-balance, resource analysis, and Environmental Impact Assessment (EIA). However, LCA goes one step further and evaluates the inventory. This step provides a quantitative catalog of the inputs (energy and raw materials) and outputs (including environmental releases) for a specific product, process, or activity. These are then used to evaluate such things as environmental effects, site selection for manufacturing and distribution, habitat alteration, good management practices, worker health concerns, community relations, and public perception. Once an evaluation is complete, the company or agency rates the results and develops an action plan to sustain economic growth while also sustaining the environment.

Why a Systems View?

Within a given system, the components are related to each other in defined ways. Until recently, students examined each separate component, but rarely were given the opportunity to look at the overarching relationships between them. Science teaching was based on memorizing facts. In the early 1990s, an emerging consensus among science educators brought about the implementation of more thematic and integrated science programs. These programs emphasized the relationships between the major scientific disciplines by using such broad concepts as energy, evolution, and systems and interactions. In a parallel fashion, the concept of sustainable human development emerged.
How to Use This Book

The chapters in this book are organized around the stages in the life cycle of a product:

Instructional Design and Science Standards

The authors assembled the units of *The Life Cycle of Everyday Things* using a “backwards” instructional design based on a process developed by Jay McTighe and Grant Wiggins and published by the Association for Supervision and Curriculum Development as *Understanding by Design*. Using this method, the authors evaluated the levels of knowledge that the units could address. In nearly any topic, in any area of study, there is typically far more content than can or should reasonably be presented to students. This design method provides a method to discriminate among three levels of content: Enduring Understandings, Important to Know and Do, and Worth Being Familiar With. These three levels established the curricular priorities—the Learning Goals—on which to build the units.

The Enduring Understandings identified for each unit are core to the *National Science Education Standards* and the *Benchmarks for Science Literacy*, and are required for understanding of each stage of a product’s life cycle. These enduring understandings are the ones that have value beyond the classroom, and that are transferable to new situations.

As a second level of content, the authors identified the important knowledge (facts, concepts, and principles) and skills (processes, strategies, and methods) that students should master in order to understand the content of the unit. The Objectives for each unit are derived from these first and second levels of content.

As a third level of content, the authors identified content that was just worth being familiar with, perhaps that added perspective or detail. Content worth being familiar with was built into the units in a broad-brush way: included as sidebars or extensions.

Once the authors identified the relevant content for each life cycle unit, the instructional methods for each unit were established. The authors built the instructional delivery methods to account for a variety of learning styles. The constructivist principles of identifying what students understand, and providing students with opportunities to challenge and modify these preconceptions as they learn, were used in each unit, and in the overall design of the book.
The Learning Goals for each unit are at the end of the teacher sections, accompanied by the relevant National Science Education Standards and Benchmarks for Science Literacy. Most state or district science standards are correlated to these standards, and you’ll find online correlations on several Web sites. These standards may guide your selection of when to use The Life Cycle of Everyday Stuff with your classes, and provide pointers toward using the concepts of life cycle assessments with other science instruction.

**Unit Overviews**

The activities in this book are suitable for secondary Earth science, environmental science, physical science, or integrated science classes. Unit Three may also be suitable for chemistry classes.

**Unit One: What Is a Life Cycle?** introduces the concepts of a life cycle using the *Life Cycle of a Pencil* poster. Through class discussion, the class extends the ideas of this visual depiction to other common items and learns that all products have origins and fates—a life cycle. They then focus on the matter and energy transformations at each life cycle step—a process that develops student ability to see a product as part of a cycle. Students will explore what they already know about product life cycles, and complete a pretest of their current understanding that they will revisit and modify in the final unit.

In **Unit Two: Dissecting a Telephone—Design**, students discover that a simple product (e.g., a polystyrene cup) and a complicated product (e.g., a computer) each must have a design that relates structure and function. This design is the result of the synthesis of several perspectives: historical developments in the use of the product or products with a similar function, energy expenditure, environmental impact, and product economics. Students consider the structure and function of major telephone components. They are then introduced to the roles they will use throughout the remaining units to develop a way of understanding how the design process influences every stage in the life cycle of a product.

Students next answer two questions about telephones and, indirectly, about all products: What are they made of, and why? **Unit Three: Raw Materials—Acquisition and Processing** examines the second stage in the life cycle—raw materials, and uses a literature search to explore various aspects of three of the main materials in a telephone: plastic, metals, and silicon chips. Through a laboratory experiment, students model the extraction of metal from ore.

**Unit Four: Manufacturing a Product** discusses the step in the life cycle that creates final products out of raw materials. Students make a protective package for a frozen dessert and then consider materials and design options. They then weigh the energy, economic, and environmental impacts of their package to highlight the trade-offs and decision-making needed at each stage of the life cycle of a product.

**Unit Five: The Useful Life of a Product** explores the fourth stage in a product’s life cycle. Students examine issues of durability, depreciation, and waste as they evaluate this part of a product’s life cycle. The class will use mathematical and economic concepts to illustrate the useful life of some common household products. As an optional extension activity, students can conduct original research by following the useful life of a school telephone.

What happens to a product when it no longer works and its useful life is over? The last stage in a product’s life cycle is disposal or reuse—called the *end-of-life* stage. **Unit Six: A Tale of Two Cups—Disposal and Reuse** has students examine the trade-offs involved in selecting one drinking cup over another. They investigate what
would happen to each type of cup as a waste and review the concept of life cycles as a way to consider waste management issues. Students then analyze the end-of-life stage for a telephone. What happens to each component of a phone?

How can materials be redesigned to incorporate economic and environmental criteria into their life cycle? In Unit Seven: Redesigning a Product, students examine the strengths and weaknesses of the life cycle assessment tool to incorporate different values in the design of a product. They use a telephone to examine the practice of sustainable design and then develop their own criteria for evaluating a product. This unit is an embedded assessment of student learning. Student teams present the results of their research that began in Unit One. By analyzing how the design of the telephone relates to each stage of its life cycle, students are able to synthesize the basic concepts of this book.

**Group Work**

In *The Life Cycle of Everyday Stuff*, much of the student work will be done in teams. Science is a cooperative endeavor, and teamwork allows students to engage in that mix of individual thought and cooperative exchange that is real scientific investigation.

Also, the team approach offers an opportunity for students to explore viewpoints and debate ideas. There are several non-contradictory ways to view each stage of a product life cycle, and each viewpoint has a particular value at each stage. Units Two, Three, Four, and Five have “Expert Roles” handouts for students. These handouts provide questions to guide a member of each team to examine how History, Design, Energy Flow, Environmental Impact, and Economics play a role at each stage of a manufactured product’s “life.” Student journals provide a record for answers, and team/class discussions and team presentations provide the forum for exchange of practical ideas.

The teacher’s role during much of the group work will be as facilitator. You may wish to circulate among the teams as they are working together, providing suggestions for resources and perhaps changing the direction of a discussion.

**Using a Journal**

A lab journal will help students organize, analyze, and interpret the information they collect throughout the course of their investigations. The journal will not only provide students with a record of how their knowledge grows, but will provide you with a mechanism for assessing student performance, understanding, and application of knowledge. Journals enable students to organize information as they gather it, to share it with peers, and to integrate class information toward successful participation in the culminating activities. Writing also helps students develop ideas, think through problems, make decisions, and determine what remains to be discovered.

Students can use a separate notebook or a section of a three-ring binder for their journals. This allows for organization and for containment of single sheets that can be easily turned in for grading. Organization is a critical learning skill for all students, and journals must be organized to be useful and meaningful. You may want students to number each page and construct a table of contents for their journals.
Assessment

The units have a mix of instructional techniques—class discussion, group discussion, group and individual assignments, group and individual presentations, homework questions, lab work, and independent research projects. Build rubrics to measure what your students are learning based on your own instructional goals and on the "Enduring Understandings" and "Important Facts and Skills" guides at the end of each Teacher Section. Unit Seven, Redesigning a Product, concludes with group presentations of their design work, and includes a multi-trait rubric to share with students to guide their presentation development. You may wish to use Unit Seven as a summative assessment of student learning in the previous units.

Assessments are the techniques to analyze student accomplishment against the Enduring Understandings and Important Facts and Skills curricular priorities of the unit. Many of the student tasks in *The Life Cycle of Everyday Stuff* serve as authentic assessments—they are designed to have students simulate or replicate important real-world challenges. In Unit Four: Manufacturing a Product, for example, students design, build, test, and redesign a simple product, gaining first-hand knowledge of the challenges and illustrating their mastery of the process.

Journals are also important tools for assessment. Students should record all observations and activity results and include the separate student worksheets in their journals. In addition to answering specific questions, encourage students to record any thoughts related to the issues covered in this book. You can use the journals to assess students’ abilities to conduct the activities, their knowledge of the significance of the activities, their understanding of the results and what they have learned, and their abilities to use this information. Students will record their pretest of their life cycle knowledge in their journals in Unit One. You may wish to encourage students to revisit this pretest to have them concretely mark their gains of understanding throughout the course of these units.

*Life Cycle of a Pencil* Poster Insert

Several units of *The Life Cycle of Everyday Stuff* suggest using the *Life Cycle of a Pencil* poster, included with this book, as a visual reference of the parts of a life cycle. This poster was initially designed for, and included with, *Science Scope*, NSTA’s journal for middle level science teachers. Use it to broaden students’ awareness of product life cycles. A small black and white version of the poster is included as an appendix.

**sciLINKS**

*The Life Cycle of Everyday Stuff* brings you sciLINKS, a creative project from NSTA that blends the best of the two main educational “drivers”—textbooks and telecommunications—into a dynamic new educational tool for all children, their parents, and their teachers. This sciLINKS effort links specific textbook and supplemental resource locations with instructionally rich Internet resources. As you and your students use sciLINKS, you will find rich new pathways for learners, new opportunities for professional growth among teachers, and new modes of engagement for parents.

In this sciLINKed text, you will find an icon near several of the concepts you are studying. Under it, you will find the sciLINKS URL (http://www.sciLINKS.org/) and a code. Go to the sciLINKS Web site, sign in, type the code from your text, and you will receive a list of URLs that are selected by science educators. Sites are chosen for accurate and age-appropriate content and good pedagogy. The underlying database changes constantly eliminate dead or revised sites or simply replace them with better selections. The text may dry on the page, but the science it describes will always be fresh.
The site selection process involves four review stages:

1. First, a cadre of undergraduate science education majors searches the World Wide Web for interesting science resources. The undergraduates submit about 500 sites a week for consideration.

2. Next, packets of these Web pages are organized and sent to teacher-Web watchers with expertise in given fields and grade levels. The teacher-Web watchers can also submit Web pages they have found on their own. The teachers pick the jewels from this selection and correlate them to the National Science Education Standards. These pages are submitted to the sciLINKS database.

3. Then scientists review these correlated sites for accuracy.

4. Finally, NSTA staff approves the Web pages and edits the information provided for accuracy and consistent style.

Who pays for sciLINKS? sciLINKS is a free service for textbook and supplemental resource users, but obviously, someone must pay for it. Participating publishers pay a fee to NSTA for each book that contains sciLINKS. The program is also supported by a grant from the National Aeronautics and Space Administration.

About the Authors

Mike Reeske has taught science in high schools for over 30 years and currently teaches Chemistry and Integrated Science at Vista High School in Vista, California, where he is the Science Department Chairman. He was the former Director of Education for the Orange County Marine Institute and is currently a teacher-developer for the Science Education for Public Understanding Program (SEPUP) at the Lawrence Hall of Science, University of California at Berkeley. He has co-authored many SEPUP modules and several books including Issues, Evidence and You and Science and Sustainability, from which his current interest in life cycle assessment has come.

Shirley Watt Ireton is Director of the National Science Teachers Association Press and NSTA’s Environment Education Coordinator. For the past 16 years she has developed and managed science education projects with EPA, USGS, NASA, National Park Service, USDA, Medtronic Corporation, Abbott Laboratories, and many others. The results of these projects have been numerous award-winning publications for science educators. Her interests are conveying leading-edge science to educators in classroom-ready ways, and modeling innovative teaching techniques in the development of science education publications.
Summary

Just as living things go through a series of developmental stages from birth to death, products must also complete a life cycle—from design to disposal. However, the cycle does not stop with the end of life. In nature, living things die and serve as energy for animals, plants, and bacteria. Likewise, used products can be recycled into new products, or simply discarded as waste. In both cases, matter and energy are conserved.

Unit One introduces these concepts using the *Life Cycle of a Pencil* poster. Through class discussion, you’ll extend the ideas on this visual depiction to other common classroom items to emphasize that all products have origins and fates—a life cycle. As a class, and then as homework, students review and apply their knowledge of the properties of matter and energy to the series of transformations that make up the life cycle of a product.

Objectives

- To introduce the concepts of life cycles
- To emphasize that all products have a life cycle
- To apply knowledge of the properties of matter and energy to the series of transformations that make up the life cycle of a product
Preparation

Before class begins, place the objects on a table where students can clearly see them as they enter the room. You may substitute other objects, but keep the telephone. Display the Life Cycle of a Pencil poster. Duplicate enough copies of Student Sheet 1.1, Introduction to Life Cycles—Matter and Energy Transformations, and Student Sheet 1.2, What’s in a Product and Where Does It Go? You may need to do some research in advance for the questions on Student Sheet 1.2, but this sheet is a starting point record for students’ thinking about product life cycles.

Teaching Sequence

Day One

Step One: Ask the class to analyze the objects on the table according to the following three criteria: Where did the raw materials come from to make this object? How long is the product useful? What happens to it when humans don’t find it useful any longer? This should be a quick discussion, recording opinions on the board or on an overhead. (Use the following table as a format, but the short discussion should focus on the life cycle process, not on filling in the cells.)

Step Two: Use the Life Cycle of a Pencil poster as a guide. Hold up the pencil and have students examine their own pencil. Ask students what they think the pencil is made of, and fill in student answers in the Raw Materials column. The sidebar, “There’s No Lead in Pencils!” provides some background for the discussion. Ask students where the pencil’s raw materials come from, how the pencil arrived in the student’s possession, and where the pencil will end up. Students should realize that some products have many origins, and that even a simple product like a pencil can be the result of a variety of natural resources and human labor from all over the world. Use the poster to elicit and reinforce student contributions.

Students should realize that the time they spend interacting with an object is only a portion of the “life span” of that object.

<table>
<thead>
<tr>
<th>Product</th>
<th>Raw materials</th>
<th>Useful life</th>
<th>Then what?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pencil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T-shirt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soda can</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newspaper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telephone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phone book</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disposable diaper</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Step Three: When the level of discussion indicates that students are comfortable with the idea of a pencil having a life cycle, draw attention to life cycles in nature. Ask students for examples of life cycles in nature (humans, animals, plants). Record their answers on the board or an overhead.

Use the plant to illustrate a parallel flow with raw materials (seed, water, root support); manufacturing (sunlight, nutrients, water); useful life (continued growth, seed production); end-of-life (death); and reuse (decomposition and return to nutrients that may be used by other organisms). You may wish to sketch the cycle of the plant to guide the discussion.

In an Earth science context, continue this parallel with the water cycle, nitrogen cycle, or carbon cycle. In a biology or environmental science context, revisit what students already know about composting, or more explicitly, food webs. Students should realize that life cycles are pervasive in the world around them.

Step Four: Distribute Student Sheet 1.1, Introduction to Life Cycles—Matter and Energy Transformations.

Introduce the Law of Conservation of Matter: In all physical and chemical changes, matter is neither created nor destroyed, but it may be converted from one form to another.

Relate this to the First Law of Thermodynamics—the Conservation of Energy: In all physical and chemical changes, energy is neither created nor destroyed, but it may be converted from one form to another.

Finally, further the idea of energy flow by introducing the Second Law of Thermodynamics—when energy is changed from one form to another, some of the useful energy is always degraded to lower-quality, more-dispersed, less-useful energy. Students will revisit these concepts throughout The Life Cycle of Everyday Stuff as they consider energy flow as part of each stage of the life cycle of an object.

Have students reproduce the Life Cycle of a Pencil in their lab journal. As directed in Student Sheet 1.1, students write a sentence describing the changes in energy and matter at each stage of the cycle.

Day Two
Step Five: As a class, review the homework. Assess student’s general understanding of matter and energy transformations in their diagrams by checking to see if they have shown the following at each stage: 1) energy inputs; 2) material inputs; 3) waste outputs; and 4) waste energy as heat. Look for broad, general categories. Suggest to the class that energy is lost at each stage. Where does this happen? Develop the idea of heat loss and have them add arrows to their diagram to show this.

Step Six: Draw students’ attention again to the telephone. Hand out Student Sheet 1.2, What’s in a Product and Where Does It Go? Students should examine the telephone in groups as they each fill out Student Sheet 1.2. Have them keep both sheets in their lab journal.

These short questions are a pretest to the life cycle material and a guide for students to apply the thinking they have just done on the life cycle of a pencil to the life cycle of a telephone. Students should realize there are no right or wrong answers to these questions.

Use student answers to gauge where you need to place your emphasis in teaching the rest of Life Cycle. Students should keep this sheet in their lab journal. After completing Unit Seven, students can review their answers to Student Sheet 1.2 to see what they have learned.

There’s No Lead in Pencils!

Contrary to popular belief, pencils do not contain lead. Lead was used in pencils throughout the 19th century, but was abandoned because it was too soft and left only a light mark on the writing surface. Lead is also a toxic heavy metal that can be hazardous to human health. In 1820, Joseph Dixon developed a process of mixing clay with graphite to make the writing cores pencils still use today. The graphite-clay mixture is blended and extruded into pencil-sized “leads.” The leads are baked at 982°C to make the material smooth and hard.

The wooden part of a pencil is made by cutting a block of cedar wood into slats. The slats are stained on one side and grooves are cut into one surface. The leads are placed into the grooves, a second cedar slat is placed on top, and the two slats are glued together. This “pencil sandwich” is milled to separate the individual pencils. Each pencil is painted and lettered. A metal band called a ferrule is crimped onto the end, and the eraser is crimped into the ferrule to finish the pencil. The eraser was once made of rubber, but vinyl plastic and synthetic rubber mixed with pumice has replaced the rubber.
Learning Goals

Unit One has been constructed to guide student understanding of the following Learning Goals.

Enduring understandings

• Life cycles are parallel in living and non-living things.
• Matter has characteristic properties that are related to composition and structure.
• In all physical and chemical changes, matter and energy are neither created nor destroyed, but may be converted from one form to another.
• When energy changes from one form to another, some of the useful energy is always degraded to lower-quality, more-dispersed, less-useful energy.
• Materials from human societies affect both the physical and chemical cycles of the Earth.

Important facts and skills

• Products can be categorized by their raw materials and by what happens to those raw materials.
• The five basic areas of life cycle assessment are: design; materials acquisition; manufacture and transportation; use and maintenance; and recycling and waste disposal.
• Energy, human impact, and waste production are part of a complex system that influences each step of the cycle.

These Unit One Learning Goals contribute to student learning of the following National Science Education Standards and Benchmarks for Science Literacy.

National Science Education Standards

Unifying Concepts and Processes
Systems, order, and organization
Physical Science: Content Standard B
Structure and properties of matter
Conservation of energy
Interactions of energy and matter
Life Science: Content Standard C
Matter, energy, and organization in living things
Earth and Space Science: Content Standard D
Geochemical cycles
Science in Personal and Social Perspectives: Content Standard F
Natural resources
Environmental quality: Material from human societies affects both physical and chemical cycles of the Earth
Benchmarks for Science Literacy

4 The Physical Setting
  4D Structure of matter
  4E Energy transformations
5 The Living Environment
  5E Flow of matter and energy
7 Human Society
  7E Social trade-offs
8 The Designed World
  8B Materials and manufacturing
  8C Energy sources and use
II Common Themes
  II A Systems

Resources

LIFE CYCLES

Publications


Web Sites


PENCILS

Web Sites
The General Pencil Company: http://www.generalpencil.com/
The Tennessee Pencil Company: http://www.tennesseepencil.com/

TELEPHONES

Publications

Web Sites
Antique Telephone History: http://www.cybercomm.net/~chuck/phones.html
Private Line’s Telephone History: http://www.privateline.com/TelephoneHistory/History1.htm
Tribute to the Telephone: http://hyperarchive.lcs.mit.edu/telecom-archives/tribute/

Note: Web sites current as of August, 2000.

Videos
Biography: “Alexander Graham Bell: Voice of Invention” AAE-14146 (available through http://store.biography.com/)
Biography: “Modern Marvels: The Telephone” AAE-12230 (available through http://store.biography.com/)
PBS Home Video: “The American Experience: The Telephone” 2447-WEBHV (available through PBS Home Video at http://shop.pbs.org/MDTQvsVN7s/products/A2447/)
Introduction to Life Cycles—Matter and Energy Transformations

Law of Conservation of Matter
In all physical and chemical changes, matter is neither created nor destroyed, but it may be converted from one form to another.

(Its all still here.)

First Law of Thermodynamics
In all physical and chemical changes, energy is neither created nor destroyed, but it may be converted from one form to another.

(You can't get something for nothing.)

Second Law of Thermodynamics
When energy is changed from one form to another, some of the useful energy is always degraded to lower-quality, more-dispersed, less-useful energy.

(You can't break even.)

Directions
On a separate sheet of paper in your Lab Journal, draw a circle and fill in the stages from the Life Cycle of a Pencil poster. At each stage of its life cycle the product is changing. Its matter may be converted from one form to another, energy may be added to the product, and energy may be released. Based on what you know of the life cycle of a pencil, write a paragraph describing the changes in matter and energy at each stage of its life cycle.
What's in a Product and Where Does It Go?

The study you are about to begin will challenge you to examine the social and natural resource issues related to the design and use of a common product—the telephone. This is your initial look at the issues, a reference point for you to use to gauge your own intellectual growth. These questions ask about your current knowledge of the material in this unit. Record your answers in your lab journal.

Consider a telephone.

1. List as many materials as you can think of that might be part of a telephone.

2. For the materials you listed in Question 1, are there other materials that could have been substituted for them 10 years ago? Fifty years ago? One hundred years ago?

3. Raw materials are either grown or taken from the Earth. For example, copper is a raw material; wire is not. List as many of the raw materials as you can that might have been used to make the materials you listed in Question 1.

4. What energy may have been used to make these materials?

5. Was energy used to get the telephone from its manufacturing point to where it is now?

6. How long does a telephone last before it is disposed of?

7. What could happen to this telephone if it breaks?

8. Does the telephone have pieces that could be recycled or reused?

9. What pieces would produce the most waste if they were thrown away? How long will it take to decompose?

10. Using the life cycle of a pencil as a model, sketch the components in the life cycle of a telephone.