

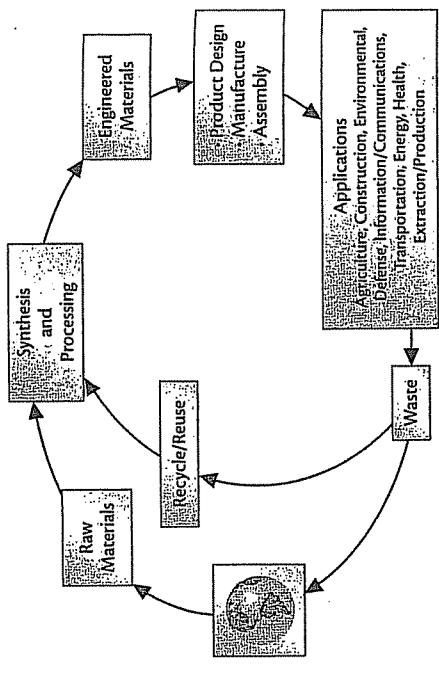


## THE LIFE CYCLE OF A MATERIAL

In designing a new product for human use, proper evaluation must include consideration of the full life cycle of the materials involved. Such a life cycle has several distinct stages. Raw materials are first obtained and then refined and synthesized into the desired material. That material is then used to make the product designed for a particular use. When the product is no longer useful, the materials may be recovered and reused, or they may end up scattered in landfills. Figure 22 illustrates this general life cycle.

In every step of the cycle, energy and resources are used. Laboratory Activities B.2 (Converting Copper) and C.5 (Retrieving Copper) are good examples of this fact. Recall that heat energy and chemical resources (hydrochloric acid and zinc metal) were used first to convert the copper metal to other substances and then to recover the copper metal. Because energy use and resource use impact economics as well as the environment, each step in the life cycle of a material becomes a factor to consider when a new product is designed.

The next activity will allow you to model this process for a familiar material—copper.



Life cycle of materials.

## COPPER LIFE-CYCLE ANALYSIS

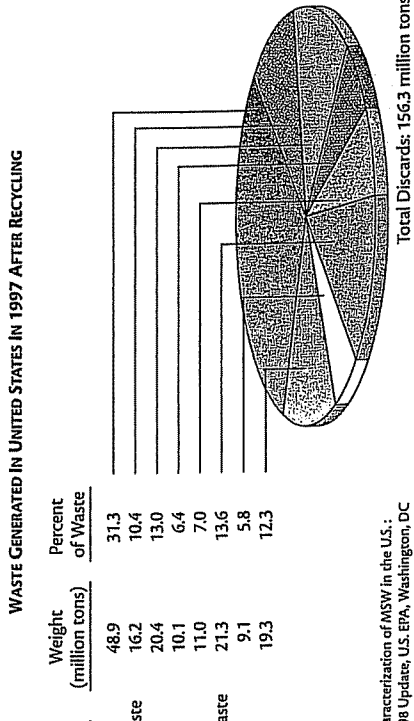
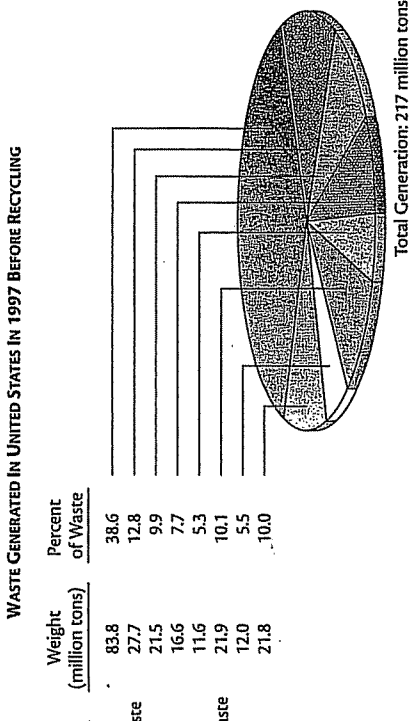
Imagine that you are involved in designing copper water pipes. Use Figure 11 (page 115) and Figure 22 to conduct a life-cycle analysis for the copper metal in your pipes. Consider how each step in the life cycle of copper will affect your final design by answering the following questions.

1. Which life-cycle steps consume significant quantities of energy?
2. Which steps (such as the reduction of a mineral in an ore to produce the metal) require the use of other materials?
3. How will you obtain the copper for your pipes?
4. Consider the transportation of materials in each step. How might this influence the design of your copper pipes?
5. Copper pipes may someday no longer be in use.
  - a. What will happen to the copper in them?
  - b. How can this issue be addressed when designing the pipes?
6. Consider your answers to each of the previous questions. How does each decision influence the cost of your copper pipes?

The market for recycled paper is limited. Because this leaves a high amount of combustibles in the waste stream, waste-to-energy plants become an attractive option. More than 120 waste-to-energy plants now operate in the United States, burning about 97 000 tons of solid waste each day. Each ton of garbage that serves as "fuel" in these plants produces about a third of the energy released by a similar quantity of coal.

Although waste-to-energy plants produce some fly ash and solid residue, such plants can allow the recycling of materials that otherwise would be disposed of as part of an unwanted product. In addition, waste-to-energy plants tend to increase recycling, both on-site and in the communities where they are located.

Recycling, landfilling, and combustion for energy production are three options for the final step in the life cycle of a material—



Characterization of MSW in the U.S.: 1988 Update, U.S. EPA, Washington, DC