Chapter Highlights

- Tools and machines increase our mechanical advantage and our ability to get work done.
- Tools and machines are used to change materials, information, and energy into products and services.
- The many different types of tools and machines perform a variety of operations.
- Tool and machine safety is important to your health and safety.

Test Your Knowledge

1. Why are tools the earliest forms of technology?
2. Why are a stone ax and a laser both considered tools? Explain.
3. "Tools increase our mechanical advantage." What does this statement mean?
4. What type of operation does a ruler perform?
5. What type of operation does a pencil sharpener perform?
6. What type of operation does a calculator perform?
7. What do we call the group of tools that are usually powered by humans?
8. In which group of machines does a factory robot belong?
9. List three personal safety rules that you must follow when you use machines.
10. Do safety rules apply when you are using power gardening equipment? Explain your answer.

Correlations

SCIENCE

1. Power = Force × Distance, divided by Time. Calculate the horsepower you use to go up a flight of stairs. First, multiply your weight (in pounds) by the vertical height of the stairs (in feet). Then divide by the time (in seconds) that it took to climb the stairs. Note: 1 horsepower = 550 foot pounds per second.

MATH

1. The two most widely used measuring systems are the customary and the metric systems. One customary inch equals about 2.5 metric centimeters. About how many centimeters equal one foot?

LANGUAGE ARTS

1. Write directions for using a tool you have at home. Be sure your directions include safety rules for use.

SOCIAL STUDIES

1. When Samuel Slater came to the U.S. in the late 1700s, he began the factory system as we know it today. Compare the power tools used in the factories of the early 1800s with the power tools used in today's factories.

CHAPTER 5

Material Resources

Introduction

All technologies depend on materials. Materials are the "stuff" that things are made of. Early products were limited by the material resources available. Today, products are created from thousands of combinations of materials.

During the Stone Age, people chipped the first tools from rocks. The first metal tools were made during the Bronze Age (3000 B.C.). Bronze tools were stronger than tools of stone and wood, and they could be made in more shapes and sizes.

During the Iron Age, a period beginning about 1200 B.C., people learned to remove iron from iron ore and create tools that were even stronger than bronze tools.

After reading this chapter, you should be able to

Describe and give examples of the different categories of materials.
Discuss the basic principles of material science.
Describe some properties of materials.

Words you will need

natural resources
raw materials
renewable resources
synthetic materials
hardwoods
softwoods
alloy
ferrous
ceramics
polymers
thermoplastics
thermoset plastics
composite
molecule
plasticity

Types of Materials

Today, people who create products can choose from thousands of kinds of materials. Some are found in nature, and others have been developed by humans. Fig. 5–1. Materials that are found in nature are called **natural resources**. Natural resources include land, water, air, plants, animals, and minerals. Fig. 5–2. From these natural resources, we obtain the **raw materials** we need to create products. Wood, oil, cotton, animal hides, and iron ore are some of the raw materials we process from our natural resources.

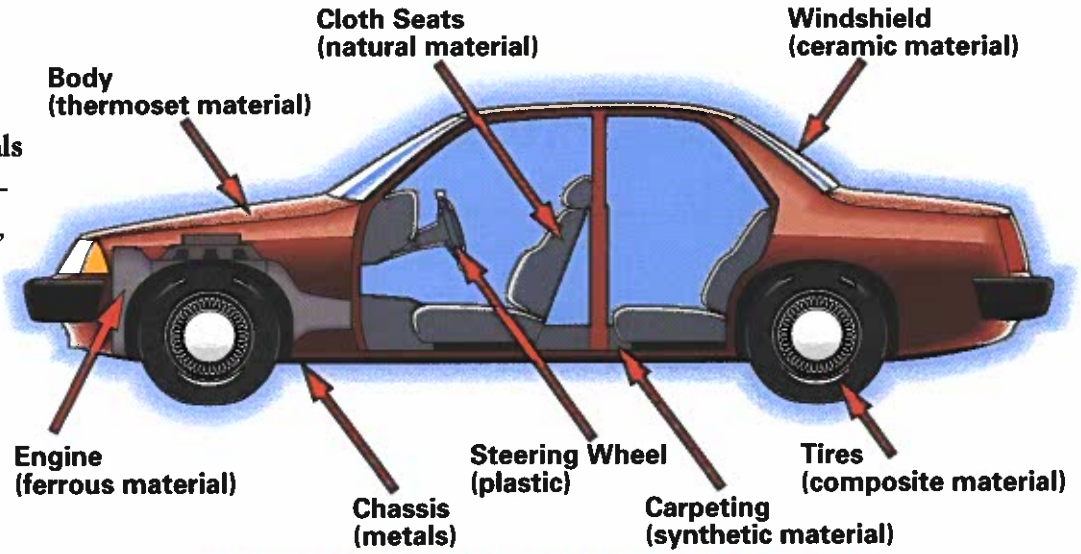


Fig. 5-1. Modern technology depends on thousands of material resources. Each material is selected based on its properties, cost, and availability.

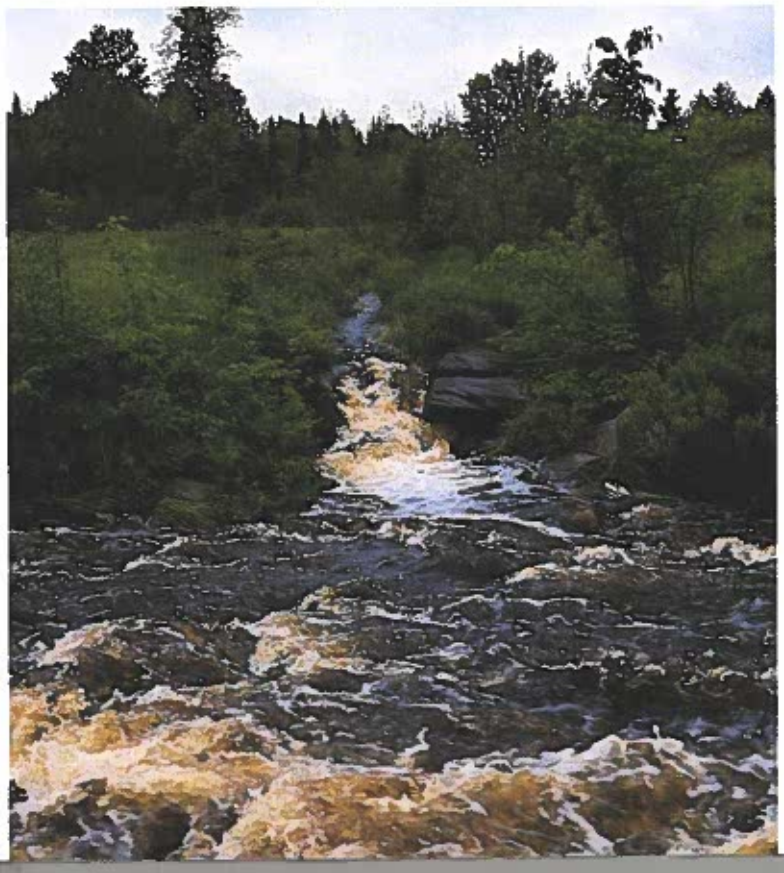


Fig. 5-2. Nature provides many of the raw materials we use in technology. People must help protect our environment by carefully managing our nonrenewable resources.

IMPACT

Europeans might never have come to America if Spain had more silver and gold mines. In the 15th century, Spain needed silver and gold for its treasury. One reason the Spanish king and queen financed the voyages of Columbus was that they hoped he would find new gold and silver mines in Asia. He never reached Asia, but he did discover silver, gold, and a new land that he claimed for Spain.

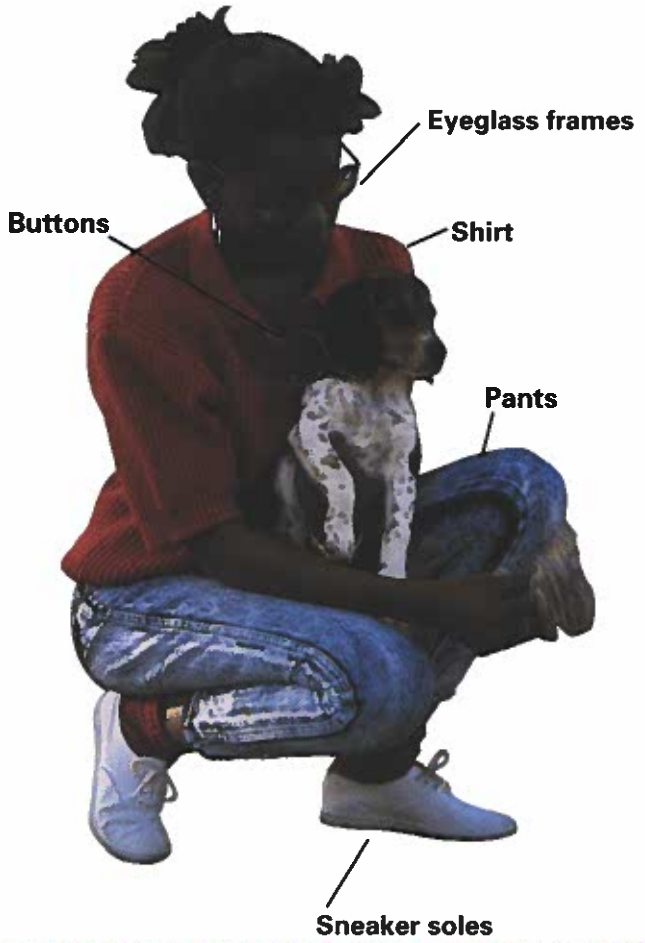


Fig. 5-3. Synthetics have replaced natural materials in many products because they are cheaper, lighter, and easier to care for.

Some raw materials are replaceable after they are removed from nature. We can grow or raise new trees, plants, and animals to replace the ones we use. These raw materials are called **renewable resources.**

Unfortunately, we cannot easily replace many raw materials. Coal, oil, and water are examples of nonrenewable raw materials. When these resources are used up or ruined, they are gone forever.

Synthetic materials are not found in nature. People make them from chemicals. (The chemicals are made from raw materials, such as oil.) Chances are, you are wearing clothing made with synthetic fibers. Fig. 5–3. Look at the labels. Perhaps your shirt is made of 50% cotton and 50% polyester. The cotton is a natural material and the polyester is a synthetic material.

Synthetics are created to improve upon the qualities of natural materials. Synthetics can be made stronger, lighter, and longer-lasting than the materials they are replacing. Synthetics can also be used instead of nonrenewable raw materials.

▶▶▶ FOR DISCUSSION ◀◀◀

1. Look around the room. List the materials you see as natural or synthetic. If the material is natural, what synthetic material might be able to replace it?
2. It seems that water should be a renewable resource, but it's not. Dead rivers result from pollution. What are some of the impacts resulting from water pollution?

Classification of Materials

Technology is dependent on thousands of different materials. Most of these materials can be arranged into five groups:

- wood
- metals
- ceramics
- plastics
- composites

Wood

Wood is a natural material that has been a valuable resource for thousands of years. Many raw materials are obtained from trees. Wood is the most obvious, of course, but some of the materials used in making paper, turpentine, varnishes, and even plastics also come from trees.

Wood can be grouped in two categories: hardwoods and softwoods. The classifications have nothing to do with how hard the wood is. Instead, they refer to the type of tree the wood comes from. **Softwoods**, such as pine and cedar, come from conifer trees (trees that have needles and cones rather than leaves). **Hardwoods** come from trees that have broad leaves, such as maple and oak trees. Fig. 5–4.

Figure 5–5 shows a cross-section of a tree trunk. Wood fibers are held together by a natural glue called *lignin*. The color and shape of these fibers give the wood its natural beauty.

Fig. 5-4. In most areas, hardwood, or deciduous, trees lose their leaves in the fall. Softwood trees keep their needles all year.

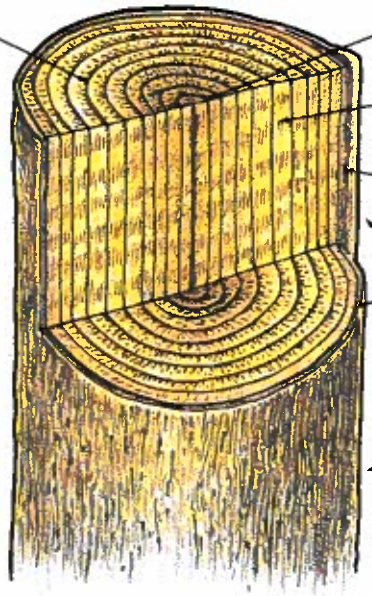


Fig. 5-5. Each year, trees grow new cells that form tubes like bundles of straws that allow food and water to travel up the tree into the branches and leaves.

Metals

Scientists have discovered 107 different simple substances called *elements*. Different materials are created by combining these elements. Of the 107 elements, 70 are metals. When two or more metals are mixed, a new metal is produced. This new metal is called an **alloy.** The chart in Fig. 5–6 shows some common metals and alloys and their uses. People try to create alloys that have more useful properties than the individual metals they are created from. So far, people have created more than 70,000 alloys.

Metals and alloys can be divided into two families: ferrous and nonferrous. The word **ferrous** means "containing iron." Any metal or alloy that contains iron is a ferrous material. Steel is an example of a ferrous alloy.

Metal	Classification	Raw Material	Common Uses
Aluminum	Nonferrous Metal	Bauxite	Airplanes, Foils, Cookware
Copper	Nonferrous Metal	Chalcocite	Wires, Pipes, Coins
Iron	Ferrous Metal	Hematite	Steel Making
Brass	Nonferrous Metal Alloy	Copper & Zinc	Musical Instruments
Stainless Steel	Ferrous Metal Alloy	Iron, Chromium, Nickel	Sinks, Utensils, Knives, Forks
Nichrome	Ferrous Metal Alloy	Nickel, Iron, Chromium, Manganese	Heating Element in a Toaster

Fig. 5-6. Common metals and alloys.

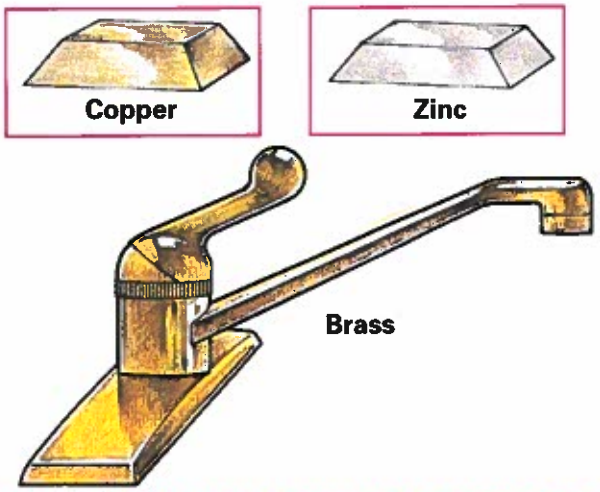


Fig. 5-7. Why is brass a better choice than copper for faucets?

Steel is made up of the elements iron, carbon, and oxygen. By changing the amount and type of element, we can change the properties of the material. For example, if we increase the amount of carbon, the steel becomes harder. When we add chromium and nickel, we create stainless steel.

Nonferrous metals and alloys contain no iron. Aluminum, copper, and tin are nonferrous metals. When we mix the elements copper and zinc, we get a nonferrous alloy called *brass*. Fig. 5–7. Brass is harder than copper and zinc and lasts longer in water than most other metals.

Ceramics

Ceramic materials are natural materials that have been used for centuries. **Ceramics** are made from minerals called *silicates*. Silicates make up one of the most abundant classes of materials found on earth. The sand, clay, and quartz you can find on beaches and river banks are all examples of silicates.

Silicates can be combined with other elements to form a variety of ceramic materials. Clay, glass, cement, plaster, abrasives, and refractory bricks are a few of the more common ceramics.

Most ceramic materials require heat to harden them. After they have been hardened, ceramics are usually strong materials that are resistant to being "eaten away" by other chemicals. Many are also resistant to the flow of electricity. Ceramics are used in a wide variety of products, from cookware and bricks to heat-absorbing tiles and memory chips.

Plastics

Plastics, sometimes called **polymers**, are synthetic materials. Most plastic materials are made from carbon obtained from petroleum and natural gas. Plastic materials have been developed to replace many natural materials. Plastics are cheaper, lighter, and stronger than most metals. Plastics last longer than wood products, especially outdoors.

All plastics can be formed easily using heat. Plastic materials can be divided into two groups based on their behavior when heated: thermoplastics and thermoset plastics. **Thermoplastics** can be repeatedly reheated and reshaped. **Thermoset plastics**, once formed, cannot be reheated and reshaped. Fig. 5–8.

TECHNOLOGY TRIVIA

In 1862, the first plastic articles—made from "Parkesine," invented by Alexander Parkes—were exhibited in London.

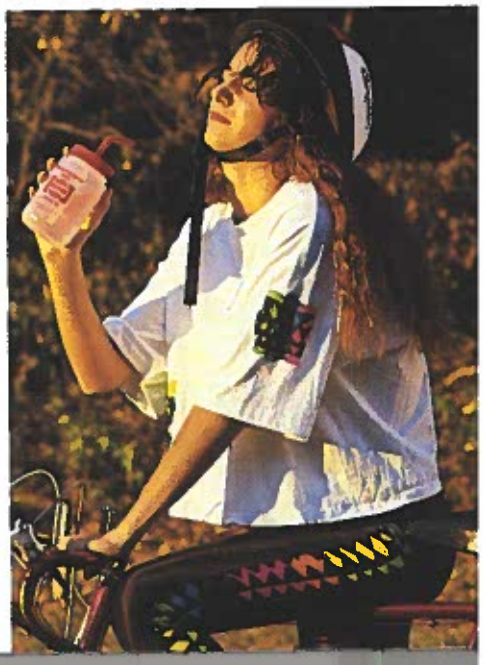


Fig. 5-8. This girl is drinking from a squeeze bottle made of a thermoplastic. Why is it important that the bottle be able to bend?

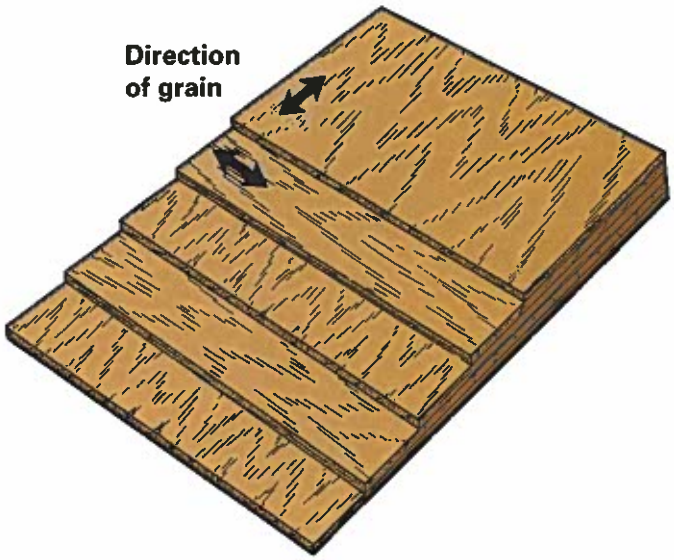


Fig. 5-9A. Each layer of wood in a piece of plywood is glued so that its grain is at a 90-degree angle to the surrounding layers.

Composite Materials

When two or more different kinds of materials are combined or mixed, a new material called a **composite** is formed. For example, you might love chocolate and like to eat peanuts. If so, a chocolate bar with peanuts is a composite that's hard to beat. The chocolate and peanuts have not changed, but the composite tastes even better.

Plywood is a composite material. Layers of wood are held together with a strong glue. The composite is stronger than the materials that make it up, but the wood layers and glue still have their own qualities. Fig. 5–9 A, B, and C.

▶▶▶ FOR DISCUSSION ◀◀◀

1. An automobile is made up of many different materials. Give examples of each of the classifications of materials discussed in this chapter.
2. If you were to build a shelter beneath the ocean, what kinds of materials would you select and why?

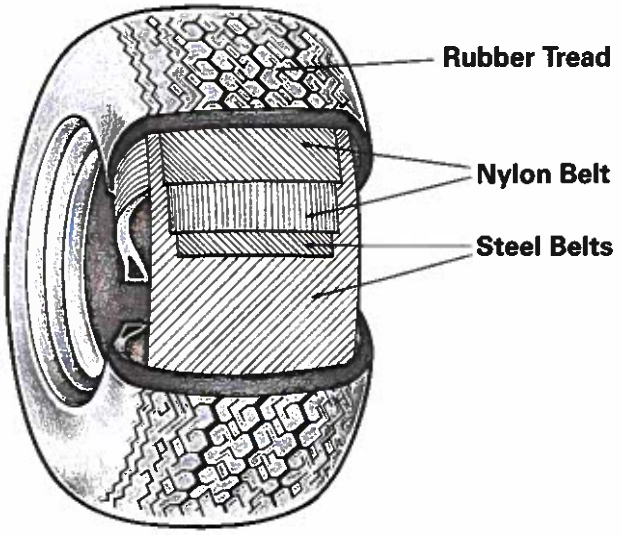


Fig. 5-9B. A tire is a composite made up of layers of rubber, nylon, and steel.

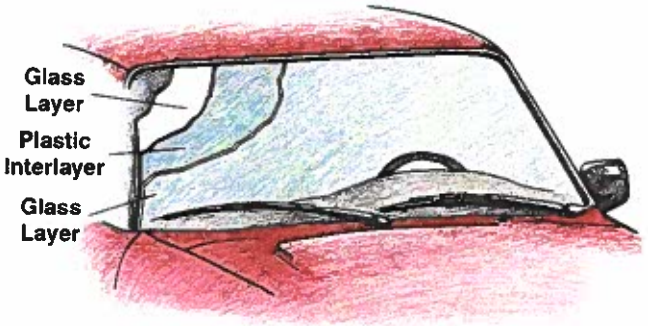


Fig. 5-9C. An automobile windshield is made of laminated glass. This consists of a layer of plastic sandwiched between two layers of glass. The plastic layer is often tinted to filter out some of the sun's rays.

Material Science

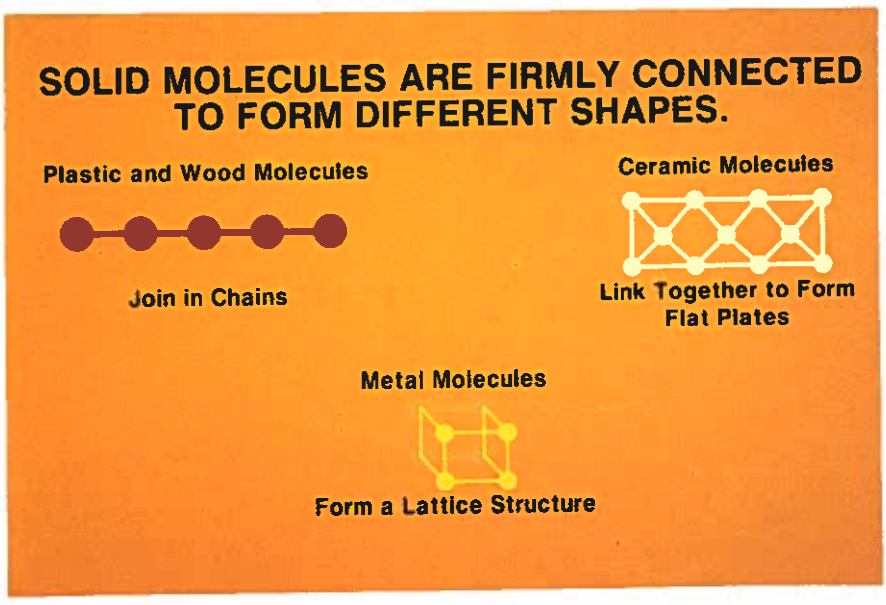
People who design and create new materials are called *material scientists*. Material scientists study the chemical structure of materials and their properties.

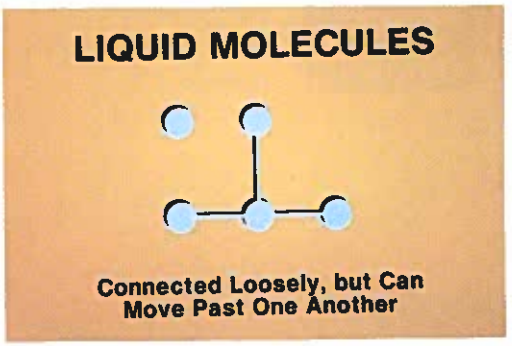
All materials are made up of atoms. The atoms determine a material's structure. In turn, atoms combine to form molecules. A **molecule** is the smallest part of a substance that still has the properties of that substance. Fig. 5–10. If you were to take a splinter of wood and continue to split it, the smallest piece of wood there could be is called a molecule of wood. Material scientists create new materials by combining the molecules of different elements.

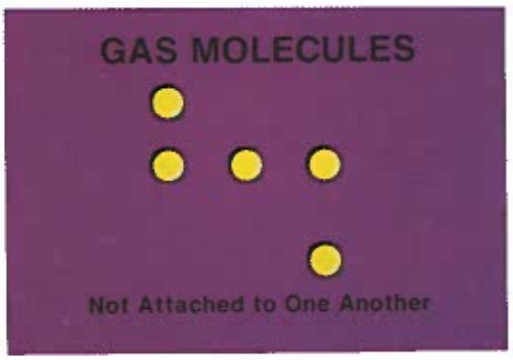
Each different kind of material has unique properties. The properties of a material tell how the material is expected to perform. Fig. 5–11. For

Fig. 5-10. One molecule of water contains one atom of oxygen and two atoms of hydrogen. Material scientists study how materials combine so that they can create new combinations of materials.

Fig. 5-11. The properties of materials are determined in part by how their molecules are linked. Gases expand or contract to fill different containers. Liquids take on the shape of their containers. Solids do not change their shape or size unless acted on by some force (such as a hammer blow).







example, the microscopic molecules of clay form flat plates that easily slide over each other. This gives clay the property of **plasticity**, or the ability to be formed into shape easily and to stay in that shape.

TECHNOLOGY TRIVIA

There are at least as many molecules in a teaspoon of water as there are teaspoons of water in the entire Atlantic Ocean.

▶▶▶ FOR DISCUSSION ◀◀◀

1. Describe a situation in which a company might need to employ a material scientist.
2. What information can a material scientist gain by studying the chemical properties of a material?

■ **Make a display of samples of various materials available in your laboratory.**

Properties of Materials

Designers and engineers select materials very carefully. All materials have advantages and disadvantages. One way to determine whether a material is appropriate is to study its properties.

After determining how a material reacts under certain conditions, engineers may or may not use that material for a given project. For example, glass is a brittle material that has very little flexibility. Would you recommend that a manufacturer build a skateboard from a pane of window glass?

▶▶▶ FOR DISCUSSION ◀◀◀

1. Many natural body parts can now be replaced by artificial parts. What material properties would a metal knee joint have to possess?
2. Describe what happens to the molecules of frozen water when the ice melts and becomes a liquid.

■ **If you were to build a model of a structure, what materials might you use?**

Chapter Highlights

- Materials have always been an important resource for the development of new technologies.
- Natural materials are found in nature; synthetic materials are made by people.
- Not all natural resources are renewable.
- Most materials can be organized into the following groups: wood, metals, ceramics, plastics, and composites.
- New materials are developed by material scientists to meet new needs.
- The properties of materials determine how they will react when they are used.

Test Your Knowledge

1. Why was iron an important advancement over bronze in material science?
2. List three renewable and three nonrenewable materials.
3. List three natural resources and the raw materials with which they provide us.
4. Define *synthetic*.
5. Balsa wood is a very soft wood, but it is classified in the hardwood family. Explain this.
6. What are the two broad classifications of metals?
7. Define *alloy*.
8. How are thermoplastics and thermoset plastics different?
9. What is a molecule?
10. Explain the property of plasticity.

Correlations

SCIENCE

1. Carbon fiber composite is a very lightweight material. What are some practical uses for this material?

MATH

1. A two-ounce "Choc-o-nuts" candy bar claims to be 25 percent nuts. How many ounces of nuts are in the candy bar?

LANGUAGE ARTS

1. In a paragraph compare and contrast the use of raw materials with synthetic materials for clothing. Keep in mind cost, cleaning process, and durability.

SOCIAL STUDIES

1. Find out what natural resources Americans used to run their homes in the 1800s. How many of these natural resources do we still use today? How do we use natural resources differently than we did one hundred years ago?

CHAPTER 6

Information Resources

Introduction

Each of the four families of technology (communication, transportation, production, and biotechnology) consumes and produces large amounts of information. When we create technology, this information directs what we do and how we do it.

Information resources are needed to produce all products and services. This chapter will continue your study of the importance of information resources to technology.

After reading this chapter, you should be able to

Discuss the role of information as a resource for technology.

Define information technology.

Give examples of how information is gathered, stored, and moved.

Describe how a computer processes information.

Words you will need

data
data processing system
information technology
input
output
program
network
terminal
database
central processing unit (CPU)
binary code