

1.2 Chemistry Far and Wide

Guide for Reading

Key Concepts

- What impact do chemists have on materials, energy, medicine, agriculture, the environment, and the study of the universe?

Vocabulary

macroscopic
microscopic
biotechnology
pollutant

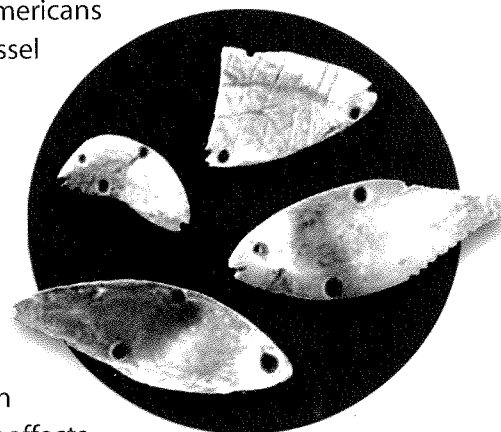
Reading Strategy

Monitoring Your Understanding


After you read this section, identify something you learned that is important to your life and explain why it is important to you.

Connecting to Your World

The first tools were objects such as a stone with a sharp edge. In time, people learned to reshape these objects to produce better tools. Native Americans in what is now Illinois drilled holes in mussel shells and carved lines onto the shells to make them look like small fish. The shells were likely used as lures for ice fishing. People also began to produce materials that did not exist in nature. By weaving plant fibers together, they made cloth, which is softer and dries more quickly than animal skins. Chemistry plays a key role in the production of new materials. In this section, you will learn how chemistry affects many aspects of modern life.

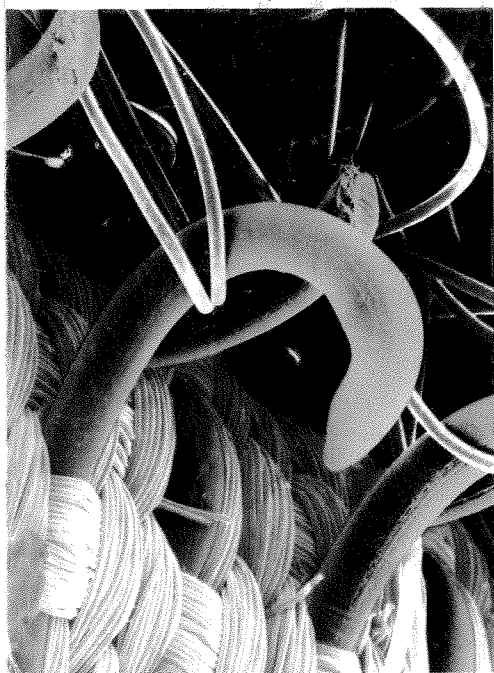


Materials


The search for new materials continues.  **Chemists design materials to fit specific needs.** Often they find inspiration in nature. In 1948, while hiking through the woods of his native Switzerland, George de Mestral took a close look at the pesky burrs that stuck to his clothing. When he looked at the burrs under magnification, he saw that each burr was covered with many tiny hooks that could latch on to tiny loops in the woven cloth of his clothing. George had a weaver make two cloth tapes. On the surface of one tape were hooks, and on the surface of the other tape were loops that the hooks could fit into, as shown in Figure 1.6. In 1955 George patented the design for his hook-and-loop tapes. These tapes are used as fasteners for items such as shoes and gloves.

This story illustrates two different ways of looking at the world—the macroscopic view and the microscopic view. The burrs that George de Mestral used as a model for his tapes are small compared to many objects in nature. However, they were large enough for George to see. Burrs belong to the **macroscopic** world, the world of objects that are large enough to see with the unaided eye. George needed more than his own vision to see the hooks on a burr. The hooks belong to the **microscopic** world, or the world of objects that can be seen only under magnification.

Figure 1.6 This is a magnified view of hook-and-loop tape. Color was added to the photo to highlight the structures. **Classifying** *Does the photograph show a macroscopic or a microscopic view of the tape? Explain.*



Energy

Energy is necessary to meet the needs of a modern society. It is used to heat buildings, manufacture goods, and process foods. It is used to transport people and goods between locations. With population growth and more industrialization around the globe, the demands for energy continue to increase. There are two ways to meet the demand for energy—conserve energy resources and produce more energy.  **Chemists play an essential role in finding ways to conserve energy, produce energy, and store energy.**

Conservation One of the easiest ways to conserve energy is through the use of insulation. Much of the energy consumed is used to keep houses warm and freezers cold. Insulation acts as a barrier to heat flow from the inside to the outside of a house or from the outside to the inside of a freezer. The foam used in drink cups provides excellent insulation because it contains pockets of trapped air. One of the most exciting modern insulation materials devised by chemists is SEAgel, which is a foam made from seaweed. SEAgel is very lightweight. In fact, SEAgel is so light that it can float on soap bubbles, as shown in Figure 1.7.

Production The burning of coal, petroleum, and natural gas is a major source of energy. These materials are called fossil fuels because they formed from the remains of ancient plants and animals. Scientists are always looking for new sources of energy because the supply of fossil fuels is limited. One intriguing possibility is fuels obtained from plants. Oil from the soybeans shown in Figure 1.8 is used to make biodiesel. Regular diesel fuel is a petroleum product that produces an irritating black exhaust when it burns. When biodiesel burns, the exhaust smells like French fries!

Storage Batteries are devices that use chemicals to store energy that will be released as electric current when the batteries are used. Batteries vary in size, power, and hours of useful operation. For some applications, it is important to have batteries that can be recharged rather than thrown away. One application that benefits from rechargeable batteries is cordless tools. These tools were first developed for NASA. Astronauts in the Apollo program needed a way to drill beneath the Moon's surface to collect samples. Other devices that use rechargeable batteries are digital cameras, wireless phones, and laptop computers.

 **Checkpoint** *What plant is a source of biodiesel?*

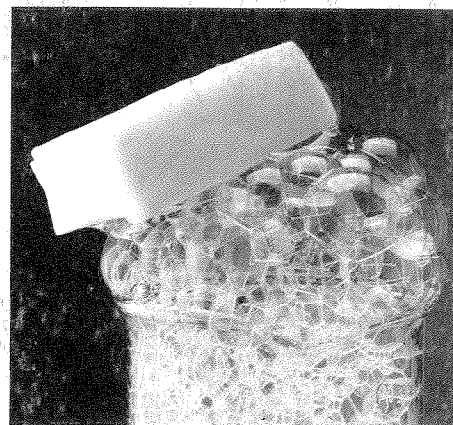


Figure 1.7 This insulation is light enough to float on soap bubbles yet is very effective at preventing heat transfer.

Figure 1.8 Oil from soybeans can be used in a substitute for regular diesel fuel.
Predicting *The supply of diesel fuel is limited. Is the supply of soybeans limited?*



Medicine and Biotechnology

No field has benefited more from advances in chemistry than medicine. **Chemistry supplies the medicines, materials, and technology that doctors use to treat their patients.** Work in the field of medicine is often done by biochemists. Their overall goal is to understand the structure of matter found in the human body and the chemical changes that occur in cells. To accomplish their goal, they work with biologists and doctors.

Medicines There are over 2000 prescription drugs. They are designed to treat various conditions including infections, high blood pressure, and depression. Other drugs, such as aspirin and antacids, can be sold without a prescription. Many drugs are effective because they interact in a specific way with chemicals in cells. Knowledge of the structure and function of these target chemicals helps a chemist design safe and effective drugs.

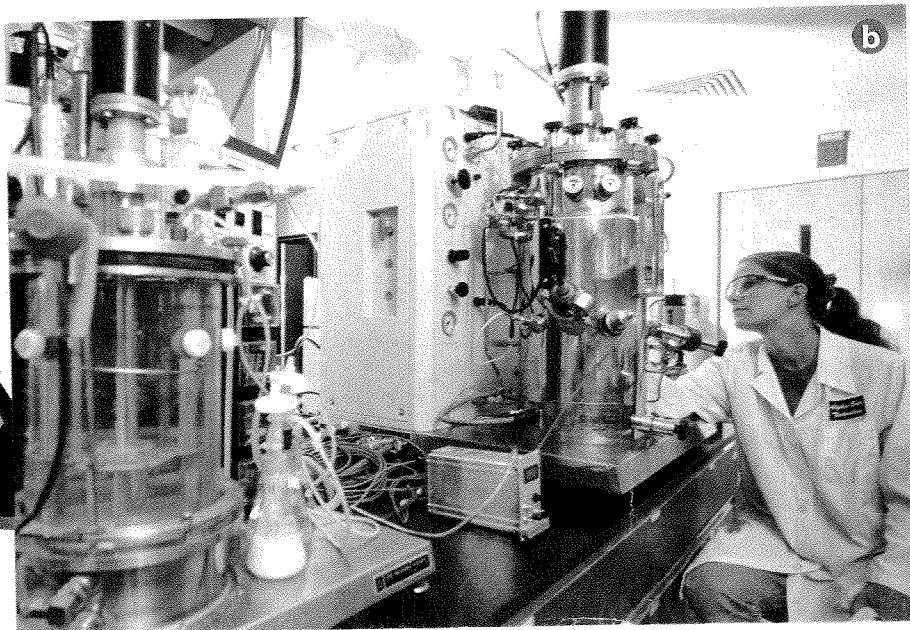
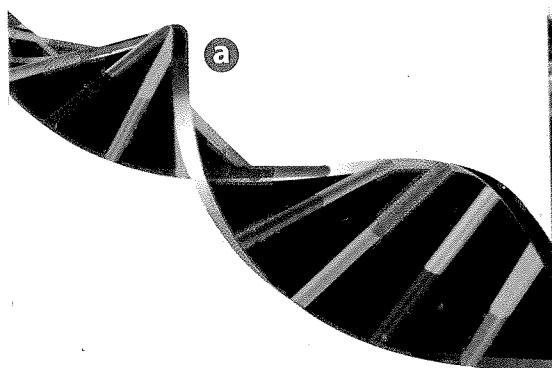
Materials Chemistry can supply materials to repair or replace body parts. Diseased arteries can be replaced with plastic tubes. Artificial hips and knees made from metals and plastics can replace worn-out joints and allow people to walk again without pain. Burn patients may benefit from a plastic “skin” that can heal itself when the plastic cracks. Chemicals that repair the damage are released from tiny capsules in the plastic.

Biotechnology Figure 1.9a shows a model of a small piece of DNA. Segments of DNA called genes store the information that controls changes that take place in cells. From 1990 to 2003, scientists worldwide worked on the Human Genome Project. They identified the genes that comprise human DNA—about 30,000. They determined the sequence of the genes in DNA. Some tools these scientists developed are used in biotechnology.

Biotechnology applies science to the production of biological products or processes. It uses techniques that can alter the DNA in living organisms. It may depend on the transfer of genes from one organism to another. When genes from humans are inserted into bacteria, the bacteria act as factories. They produce chemicals of importance to humans, such as insulin, which is used to treat some types of diabetes. Production takes place in large versions of the bioreactors in Figure 1.9b. In the future, scientists expect to use gene therapy to treat some diseases. A gene that is not working properly would be replaced with one that will work properly.

Figure 1.9 The discovery of the structure of DNA led to the development of biotechnology.

a This computer graphics model shows a small segment of DNA. **b** The conditions in a bioreactor are controlled so that the bacteria produce as much of the product as possible.



Agriculture

The world's population is increasing, but the amount of land available to grow food is decreasing. Land that was once used for agriculture is now used for homes and industries. So it is important to ensure that land used for agriculture is as productive as possible. 🧪 **Chemists help to develop more productive crops and safer, more effective ways to protect crops.**

Productivity One way to track productivity is to measure the amount of edible food that is grown on a given unit of land. Some factors that decrease productivity are poor soil quality, lack of water, weeds, plant diseases, and pests that eat crops. Chemists can help with many of these problems. They test soil to see if it contains the right chemicals to grow a particular crop and recommend ways to improve the soil. They use biotechnology to develop plants that are more likely to survive a drought or insect attack.

Chemists can also help to conserve water. In many regions, water is not an abundant resource. Finding reliable ways to determine when a crop needs water is important. The jellyfish in Figure 1.10 has a gene that causes it to glow. If that gene is inserted into a potato plant, the plant glows when it needs to be watered. These altered plants would be removed from the field before the rest of the crop was harvested.

Crop Protection For years, farmers have used chemicals to attack insect pests. In the past, these chemicals were nonspecific; that is, a chemical designed to kill a pest could also kill useful insects. Today, the trend is toward chemicals that are designed to treat specific problems. These chemicals are often similar to the chemicals that plants produce for protection.

Chemists sometimes use chemicals produced by insects to fight insect pests. Female insects may produce chemicals that attract male insects. This type of chemical has proved effective in combating pinworms. The worms leave holes and black blotches when they tunnel into tomatoes. Pinworms mate when they are in the moth stage of development. The plastic tube wrapped around the stem of the tomato plant in Figure 1.11 contains the chemical that a female pinworm moth emits to attract male moths. When the chemical is released from these tubes, it interferes with the mating process so that fewer pinworms are produced.

✓ **Checkpoint** *What jellyfish gene did scientists transfer to a potato?*

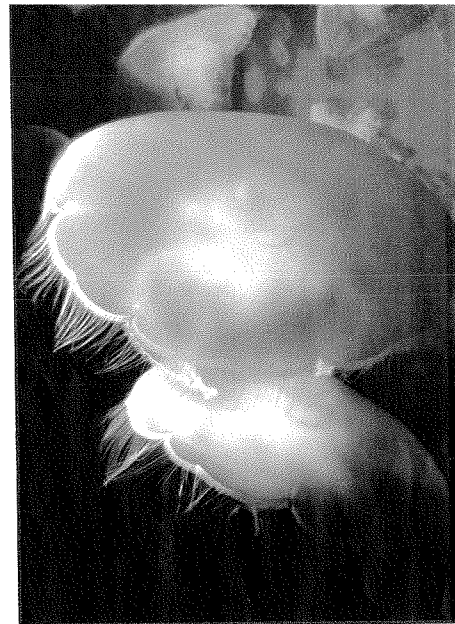
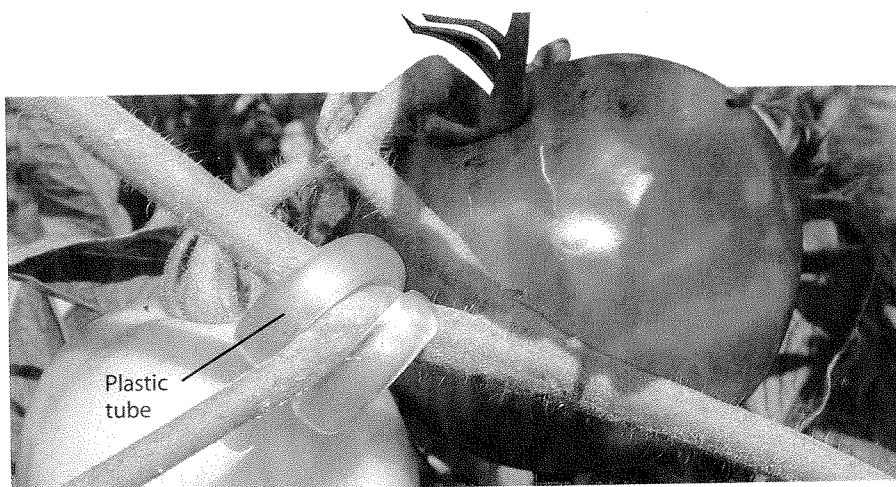


Figure 1.10 If genes from this jellyfish (*Aequaria victoria*) are transferred to a potato plant, the plant glows when it needs to be watered. **Predicting** *How does the modified plant help a farmer to conserve water?*

Figure 1.11 In the plastic tube wrapped around the tomato stem, there is a chemical that attracts male pinworm moths. This process reduces the rate of mating between female and male moths, and the number of pinworms produced.

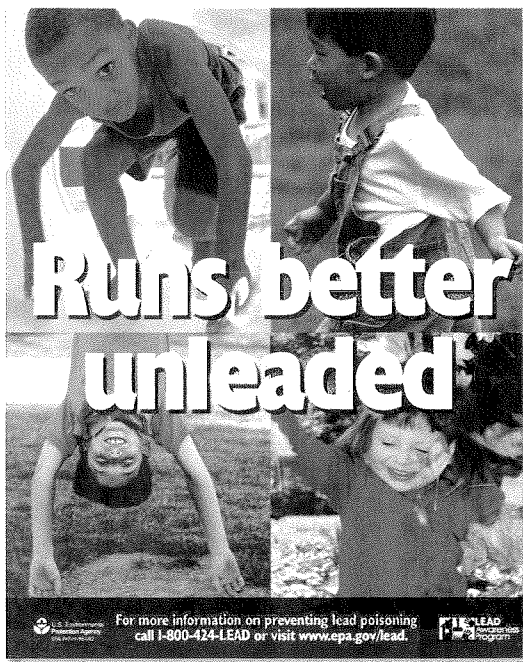



Figure 1.12 This poster was used to warn people about the danger to children from lead-based paint.

The Environment

One unintended consequence of new technologies is the production of pollutants. A **pollutant** is a material found in air, water, or soil that is harmful to humans or other organisms.  **Chemists help to identify pollutants and prevent pollution.**

Identify Pollutants Lead is a pollutant with a long history. The Romans used lead pipes for plumbing and stored their wine in lead-glazed vessels. Brain damage from lead poisoning may have caused Roman rulers to make bad decisions, which led to the fall of the Roman Empire. Until the mid-1900s, lead was used in many products, including paints and gasoline. A study done in 1971 showed that the level of lead that is harmful to humans is much lower than had been thought, especially for children. Low levels of lead in the blood can permanently damage the nervous system of a growing child. This damage causes many problems, including a reduced ability to learn.

Prevent Pollution The use of lead paint in houses was banned in 1978. Using lead in gasoline and in public water supply systems was banned in 1986. Today, the major source of lead in children is lead-based paint in about 39 million homes built before 1978. When children play with flakes of peeling paint or touch surfaces covered with paint dust, they can transfer the paint to their mouths with their fingers. The strategies used to prevent lead poisoning include testing children's blood for lead, regulation of home sales to families with young children, and public awareness campaigns with posters like the one in Figure 1.12. The graph in Figure 1.13 shows the results of these efforts.


 **Checkpoint** When was the use of lead paint in houses banned?

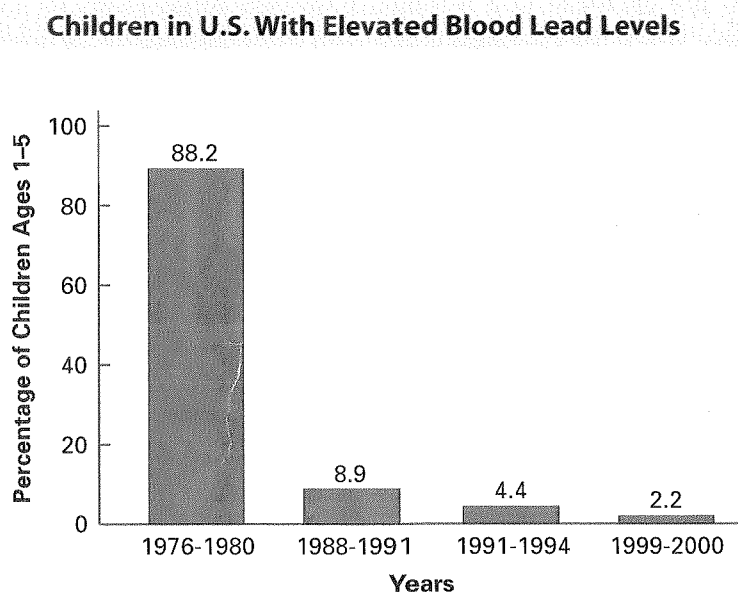
Figure 1.13 This graph shows data on children in the United States with higher than acceptable levels of lead in their blood.

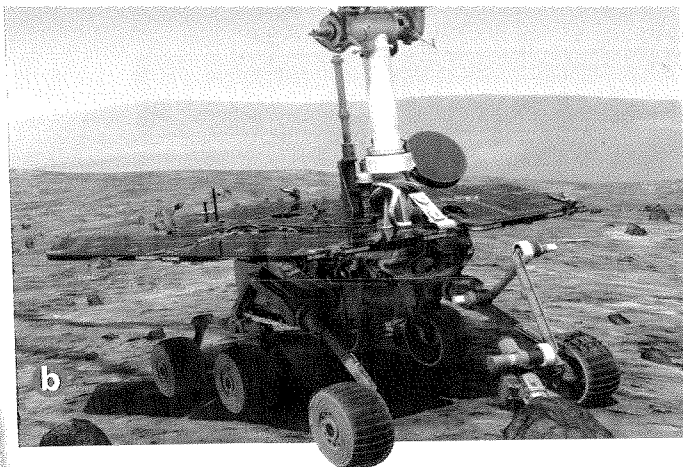
INTERPRETING GRAPHS

a. Analyzing Data What percent of children had elevated lead levels in the 1970s?

b. Calculating If a percentage point equals 200,000 children, how many children had elevated lead levels in 2000?

c. Drawing Conclusions Explain the dramatic drop in the percentage of children affected by lead poisoning between 1980 and 1988.





The Universe

Scientists assume that the methods used to study Earth can be applied to other objects in the universe. ➡ **To study the universe, chemists gather data from afar and analyze matter that is brought back to Earth.**

In the early 1800s, scientists began to study the composition of stars by analyzing the light they transmitted to Earth. In 1868, Pierre Janssen discovered a gas on the sun's surface that was not known on Earth. Norman Lockyer named the gas helium from the Greek word *helios*, meaning "sun." In 1895, William Ramsay discovered helium on Earth.

Because the moon and the planets do not emit light, scientists must use other methods to gather data about these objects. They depend on matter brought back to Earth by astronauts or on probes that can analyze matter in space. Chemists have analyzed more than 850 pounds of moon rocks that were brought back to Earth. The large rock in Figure 1.14a is similar to rocks formed by volcanoes on Earth, suggesting that vast oceans of molten lava once covered the moon's surface. Figure 1.14b is a drawing of the robotic vehicle *Opportunity*. The vehicle was designed to determine the chemical composition of rocks and soil on Mars. Data collected at the vehicle's landing site indicated that the site was once drenched with water.

Figure 1.14 With help from NASA, chemists study matter from other bodies in the solar system. **a** Apollo astronauts brought rocks from the moon back to Earth. **b** This artist's drawing shows the robotic vehicle *Opportunity* on the surface of Mars.

1.2 Section Assessment

8. ➡ **Key Concept** When chemists develop new materials, what is their general goal?
9. ➡ **Key Concept** Name three ways chemists help meet the demand for energy.
10. ➡ **Key Concept** How do chemists help doctors treat patients?
11. ➡ **Key Concept** What role do chemists play in agriculture?
12. ➡ **Key Concept** How do chemists help protect the environment?
13. ➡ **Key Concept** Describe two ways that chemists study the universe.
14. Use lead as an example to explain the meaning of the term *pollutant*.

15. Use an example to compare and contrast the terms *macroscopic* and *microscopic*.

Elements

Handbook

Cleaning Up Pollutants Read about phytoremediation on page R44. Write a paragraph summarizing this method for dealing with pollutants. Explain how it could be used to clean up soil containing high levels of lead.

Interactive Textbook

Assessment 1.2 Test yourself on the concepts in Section 1.2.

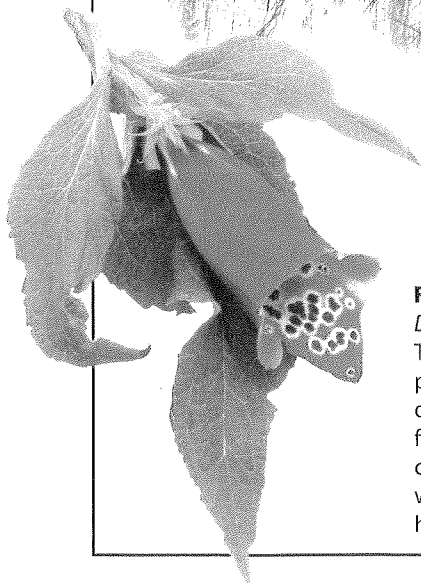
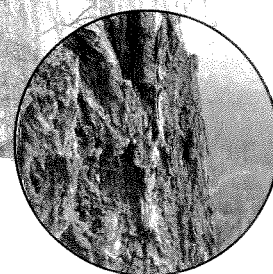
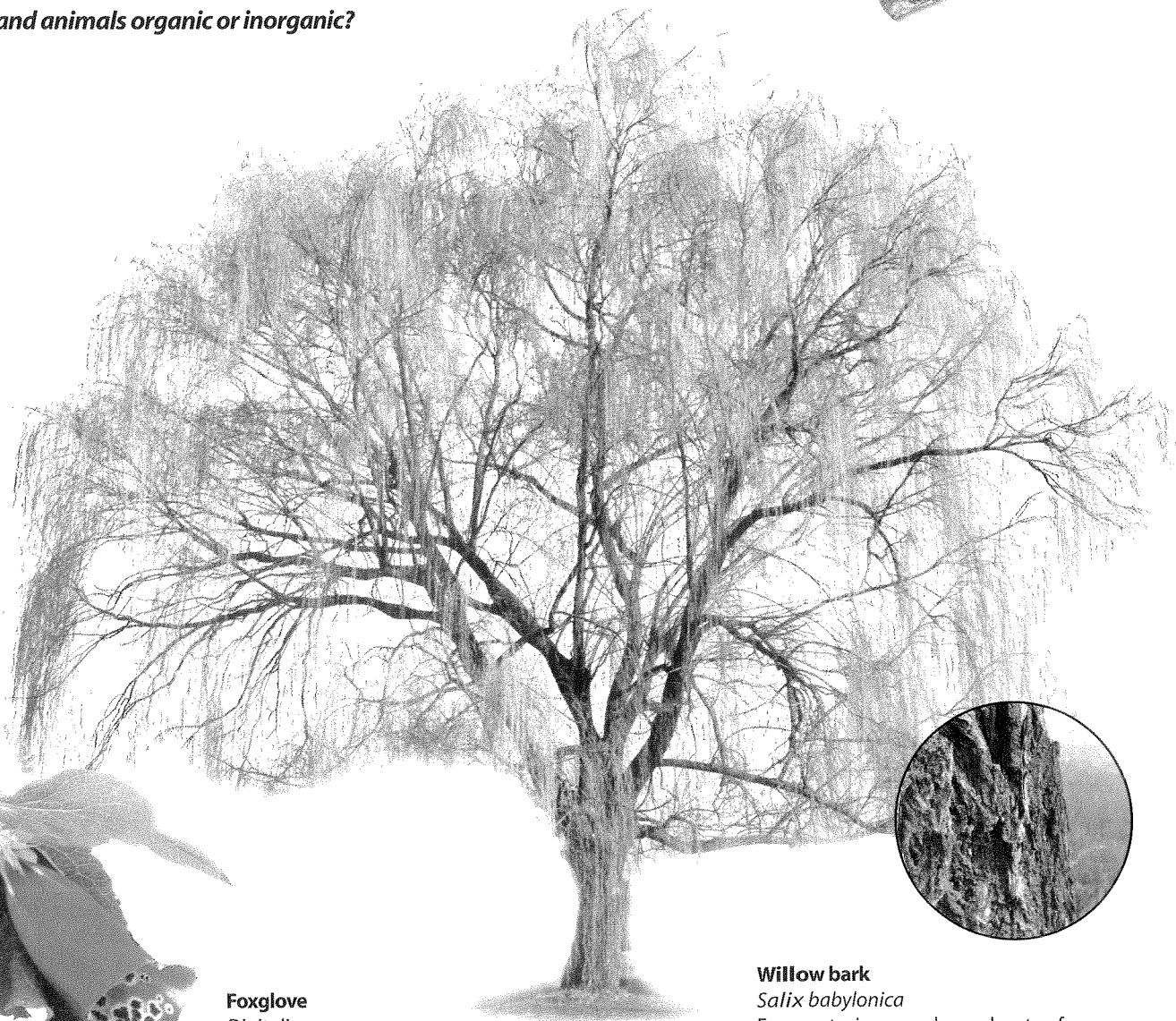
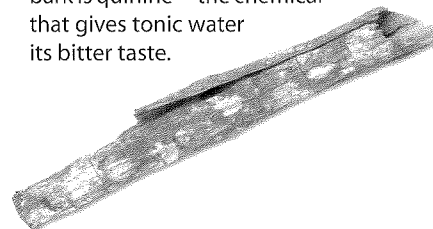
with ChemASAP

Nature's Pharmacy

About 40 percent of all modern medicines come from chemicals produced by plants or animals. With any source, chemists must first identify the effective, or active, ingredient. Then they must purify the chemical and show that it is safe for human use. Chemists often modify a chemical to make it more effective or less toxic.

Applying Concepts *Are the chemicals derived from plants and animals organic or inorganic?*

Cinchona tree
Cinchona succirubra
Bark from this tree was used for centuries to treat malaria, a disease with recurring bouts of fever and chills. The active ingredient in the bark is quinine—the chemical that gives tonic water its bitter taste.



Foxglove
Digitalis purpurea
The poison produced by this plant (digitalis) is used in small doses to treat congestive heart failure. It causes heart muscle cells to contract with more power, which increases the ability of the heart to pump blood.

Willow bark
Salix babylonica
For centuries, people made a tea from willow bark to treat headaches and other ailments. By 1828, chemists had isolated the active ingredient in willow bark. For the next 70 years, chemists worked to produce the most effective drug based on this chemical. What they produced is aspirin (acetylsalicylic acid).