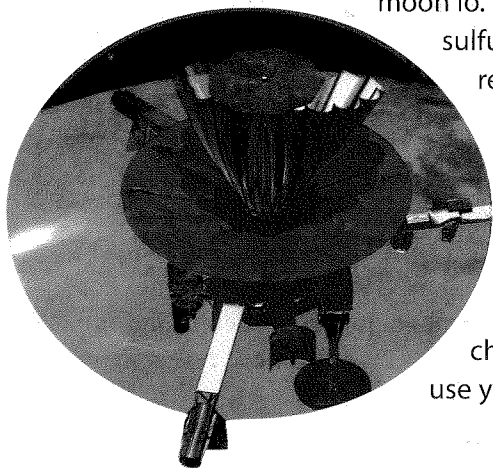


# 1.1 Chemistry

## Connecting to Your World

The *Galileo* spacecraft was placed in orbit around Jupiter to collect data about the planet and its moons. Instruments aboard *Galileo* analyzed the atmosphere of the moon Io. They found large amounts of sulfur and sulfur dioxide. These chemicals are usually released when volcanoes erupt on Earth. So the presence of these chemicals verified that the volcanoes on Io's surface are active. Chemistry helped scientists to study the geology of a distant object in the solar system. In this section, you will learn about chemistry in general and ways you can use your knowledge of chemistry.



## What Is Chemistry?

In autumn thousands of visitors travel to New England to view vivid colors like those in Figure 1.1. These colors appear as the trees approach the winter months when growth no longer takes place. The bright pigments are produced by a complex chemical process, which depends on changes in temperature and hours of daylight. The color pigments in leaves are an example of matter. Matter is the general term for all the things that can be described as materials, or “stuff.” **Matter** is anything that has mass and occupies space. You don't have to be able to see something for it to qualify as matter. The air you breathe is an example of “invisible” matter.

**Chemistry** is the study of the composition of matter and the changes that matter undergoes. ➡ **Because living and nonliving things are made of matter, chemistry affects all aspects of life and most natural events.** Chemistry can explain how some creatures survive deep in the ocean where there is no light, or why some foods taste sweet and some taste bitter. It can even explain why there are different shampoos for dry or oily hair.

## Guide for Reading

### Key Concepts

- Why is the scope of chemistry so vast?
- What are five traditional areas of study in chemistry?
- How are pure and applied chemistry related?
- What are three general reasons to study chemistry?

### Vocabulary

matter  
chemistry  
organic chemistry  
inorganic chemistry  
biochemistry  
analytical chemistry  
physical chemistry  
pure chemistry  
applied chemistry  
technology

### Reading Strategy

**Relating Text and Visuals.** As you read, look closely at Figure 1.2. Explain how this illustration helps you to understand the traditional areas of study in chemistry.

**Figure 1.1** Chemical changes that occur in leaves can cause brilliant displays of color.



## Areas of Study

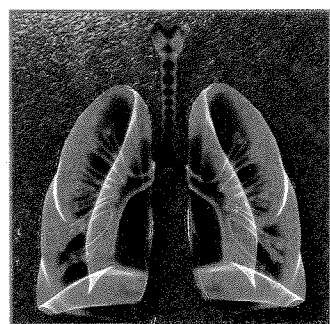
Because the scope of chemistry is vast, chemists tend to focus on one area.

☞ **Five traditional areas of study are organic chemistry, inorganic chemistry, biochemistry, analytical chemistry, and physical chemistry.**

Most of the chemicals found in organisms contain carbon. Organic chemistry was originally defined as the study of these carbon-based chemicals. Today, with a few exceptions, **organic chemistry** is defined as the study of all chemicals containing carbon. By contrast, **inorganic chemistry** is the study of chemicals that, in general, do not contain carbon. Inorganic chemicals are found mainly in non-living things, such as rocks. The study of processes that take place in organisms is **biochemistry**. These processes include muscle contraction and digestion. **Analytical chemistry** is the area of study that focuses on the composition of matter. A task that would fall into this area of chemistry is measuring the level of lead in drinking water. **Physical chemistry** is the area that deals with the mechanism, the rate, and the energy transfer that occurs when matter undergoes a change.

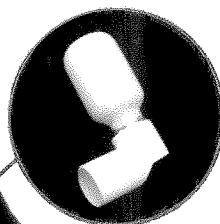
The boundaries between the five areas are not firm. A chemist is likely to be working in more than one area of chemistry at any given time. For example, an organic chemist uses analytical chemistry to determine the composition of an organic chemical. Figure 1.2 shows how research in these areas of study can be used to keep humans healthy.

**Figure 1.2** Chemists study structures and processes in the human body. **Inferring Does a bone contain mainly organic or inorganic chemicals?**



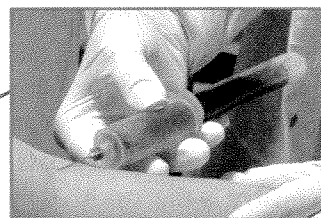
### Physical Chemistry

A physical chemist might study factors that affect breathing rates during exercise.



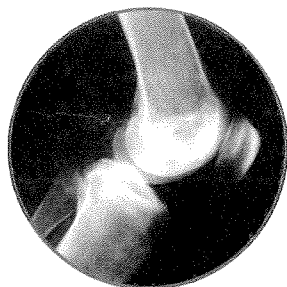
### Organic Chemistry

Athletes inhale chemicals developed by organic chemists to control symptoms of asthma.



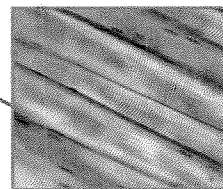
### Analytical Chemistry

Analytical chemists develop tests to detect chemicals in the blood. The tests help to show if organs in the body are working properly.



### Inorganic Chemistry

An inorganic chemist might explain how a lack of calcium can affect the growth and repair of bones.




### Biochemistry

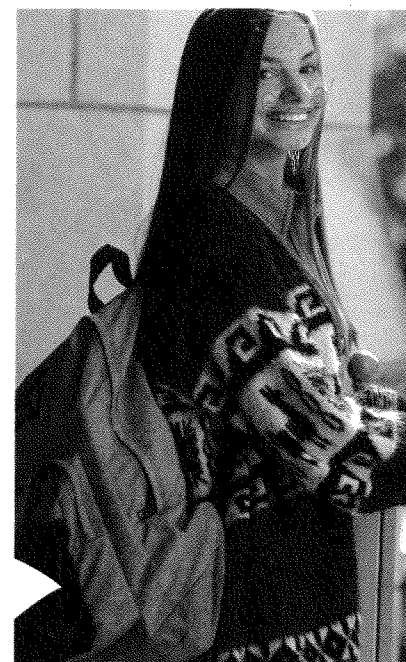
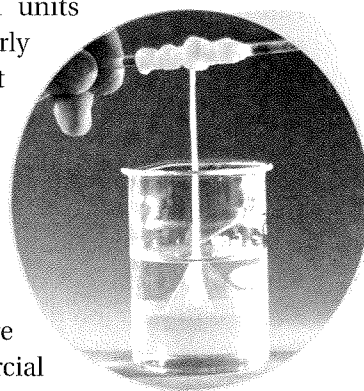
A biochemist might study how the energy used for the contraction of muscles is produced and stored.



## Pure and Applied Chemistry

Some chemists enjoy doing research on fundamental aspects of chemistry. This type of research is sometimes called pure chemistry. **Pure chemistry** is the pursuit of chemical knowledge for its own sake. The chemist doesn't expect that there will be any immediate practical use for the knowledge. Most chemists do research that is designed to answer a specific question. **Applied chemistry** is research that is directed toward a practical goal or application. In practice, pure chemistry and applied chemistry are often linked.  **Pure research can lead directly to an application, but an application can exist before research is done to explain how it works.** Nylon and aspirin provide examples of these two approaches.

**Nylon** For years, chemists didn't fully understand the structure of materials such as cotton and silk. Hermann Staudinger, a German chemist, proposed that these materials contained small units joined together like links in a chain. In the early 1930s, Wallace Carothers did experiments to test Staudinger's proposal. His results supported the proposal. During his research Carothers produced some materials that don't exist in nature. One of these materials, nylon, can be drawn into long, thin, silk-like fibers, as shown in Figure 1.3. Because the supply of natural silk was limited, a team of scientists and engineers were eager to apply Carothers's research to the commercial production of nylon. By 1939, they had perfected a large-scale method for making nylon fibers.



**Figure 1.3** Long, thin nylon fibers are woven into the fabric used in this backpack. Other objects that can be made from nylon are jackets, fishing lines, toothbrush bristles, and ropes.

**Aspirin** Long before researchers figured out how aspirin works, people used it to relieve pain. By 1950, some doctors began to recommend a low daily dose of aspirin for patients who were at risk for a heart attack. Many heart attacks occur when blood clots block the flow of blood through arteries in the heart. Some researchers suspected that aspirin could keep blood clots from forming. In 1971, it was discovered that aspirin can block the production of a group of chemicals that cause pain. These same chemicals are also involved in the formation of blood clots.

**Technology** The development of nylon and the use of aspirin to prevent heart attacks belong to a system of applied science called technology. **Technology** is the means by which a society provides its members with those things needed and desired. Technology allows humans to do some things more quickly or with less effort. It allows people to do things that would be impossible without technology, such as traveling to the moon. In any technology, scientific knowledge is used in ways that can benefit or harm people and the environment. Debates about how to use scientific knowledge are usually debates about the risks and benefits of technology.

 **Checkpoint** *Which material found in nature does nylon resemble?*

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## Why Study Chemistry?

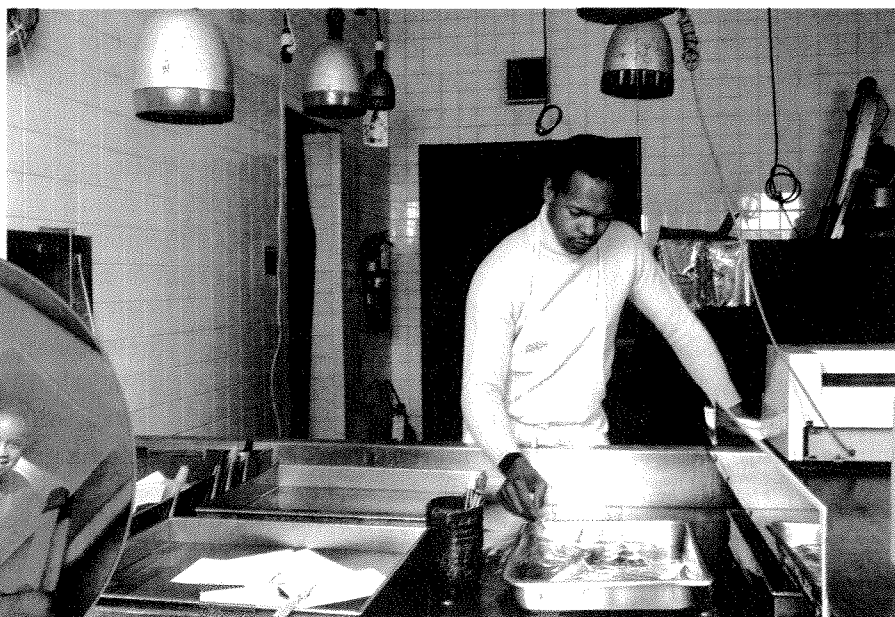
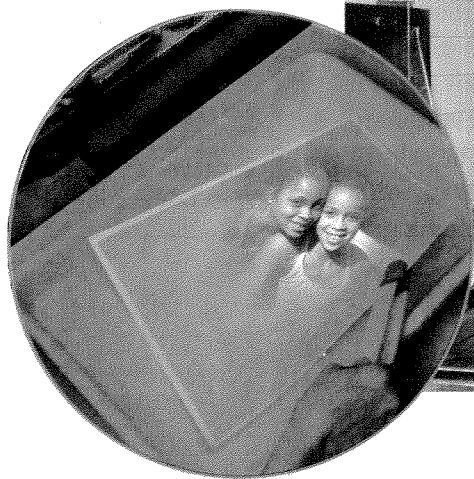
Should you use hot water or cold water to remove sunblock from a shirt? How could studying chemistry help you to be a better nurse, firefighter, reporter, or chef? If your local government wanted to build a solid waste incinerator in your town, what questions would you ask about the project? Chemistry can have an impact on all aspects of your life. 📖 **Chemistry can be useful in explaining the natural world, preparing people for career opportunities, and producing informed citizens.**

**Explaining the Natural World** You were born with a curiosity about your world. Chemistry can help you satisfy your natural desire to understand how things work. For example, chemistry can be seen in all aspects of food preparation. Chemistry can explain why peeled apples turn brown upon exposure to air. It can explain why the texture of eggs changes from runny to firm as eggs are boiled or scrambled. Chemistry can explain why water expands as it freezes, sugar dissolves faster in hot water, and adding yeast to bread dough makes the dough rise. After you study this textbook, you will know the answers to these questions and many more.

**Preparing For a Career** Being a chemist can be rewarding. Section 1.2 will present some examples of how chemists contribute to society. In this book, you will find features on careers that require knowledge of chemistry. Some of the choices may surprise you. You do not need to have the word *chemist* in your job title to benefit from knowing chemistry. For example, a firefighter must know which chemicals to use to fight different types of fires. A reporter may be asked to interview a chemist to gather background for a story. Turf managers are admired for the patterns they produce on a ball field while mowing grass, but their more important task is keeping the grass healthy, which requires an understanding of soil chemistry. A photographer, like the one in Figure 1.4, uses chemical processes to control the development of photographs in a darkroom.

**Figure 1.4** Even after the invention of the digital camera, many photographers still work with film. They use chemical processes to develop film and produce prints in a darkroom.

**Inferring** *Why isn't film developed under natural light conditions?*





**Being an Informed Citizen** Industry, private foundations, and the federal government all provide funds for scientific research. The availability of funding can influence the direction of research. Those who distribute funds have to balance the importance of a goal against the cost. Because there is a limit to the money available, areas of research often compete for funds.

For example, space exploration research could not take place without federal funding. Critics argue that the money spent on space exploration would be better spent on programs such as cancer research. Those who support space exploration point out that NASA research has led to the development of many items used on Earth. These include smoke detectors, scratch-resistant plastic lenses, heart monitors, and flat-screen televisions. What if all the money spent on space exploration was used to find a cure for cancer? Are there enough valid avenues of research to take advantage of the extra funding? Would there be qualified scientists to do the research?

Like the citizens shown in Figure 1.5, you will need to make choices that will influence the development of technology. You may vote directly on some issues through ballot initiatives or indirectly through the officials you elect. You may speak at a public hearing or write a letter to the editor or sign a petition. When it comes to technology, there is no one correct answer. But knowledge of chemistry and other sciences can help you evaluate the data presented, arrive at an informed opinion, and take appropriate action.



**Figure 1.5** By registering to vote, these citizens in Chicago, Illinois, can have a say in the decisions made by their government. Those decisions include how much money to provide for scientific research.

## 1.1 Section Assessment

- Key Concept** Explain why chemistry affects all aspects of life and most natural events.
- Key Concept** Name the five traditional areas into which chemistry can be divided.
- Key Concept** Describe the relationship between pure chemistry and applied chemistry.
- Key Concept** List three reasons for studying chemistry.
- Workers digging a tunnel through a city find some ancient pots decorated with geometric designs. Which of the following tasks might they ask a chemist to do? Explain your answer.
  - Determine the materials used to make the pots.
  - Explain what the designs on the pots represent.
  - Recommend how to store the pots to prevent further damage.
- Would a geologist ask a biochemist to help identify the minerals in a rock? Explain your answer.
- Explain how knowledge of chemistry can help you be a more informed citizen.

### Writing Activity

**Describing Technology** Pick one activity that you can do faster or with less effort because of technology. Write a paragraph in which you describe the activity, identify the technology, and explain how the technology affects the activity.



**Assessment 1.1** Test yourself on the concepts in Section 1.1.

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