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.

Section Resources

Print

- **Guided Reading and Study Workbook,** Section 1.1
- **Core Teaching Resources,** Section 1.1 Review, Interpreting Graphics
- **Transparencies,** T1–T2

Technology

- **Interactive Textbook with ChemASAP,** Assessment 1.1
- **Go Online,** Section 1.1

1.1

1 FOCUS

Objectives

1.1.1 **Identify** five traditional areas of study in chemistry.
1.1.2 **Relate** pure chemistry to applied chemistry.
1.1.3 **Identify** reasons to study chemistry.

Guide for Reading

Build Vocabulary L2

Paraphrase Help students translate the definition of *technology* into their own words. For example, *means* might be "a way that something gets done" as in "means to an end."

Reading Strategy L2

Summarize Have students write a summary of this section and then check the summaries to see if the summaries answer the key concepts questions on p. 7.

2 INSTRUCT

Connecting to Your World

Have students study the photograph and read the text that opens the section. Ask, **Why would large amounts of sulfur and sulfur dioxide be a sign that the volcanoes on Io's surface are active?** *(These chemicals are usually released when volcanoes erupt on Earth.)* On September 21, 2003 *Galileo's* mission ended when its supply of propellant was almost depleted. Without propellent, *Galileo* couldn't point its antenna toward Earth or avoid a collision with Jupiter's moon Europa. Scientists programmed *Galileo* to collide with and disintegrate in Jupiter's atmosphere.

What Is Chemistry?

Discuss L2

To find out if students understand the scope of the category *matter*, ask them to classify items as matter or non-matter.

Areas of Study

Discuss

L2

Ask students to consider their activities during a single day. Ask them to give examples of things they do that involve chemical processes or contact with chemicals. Then, ask if they can think of four items or activities that do not in some way involve chemistry. *(It will be hard to find any that do not! Students could consider what they eat, what they wear, the products they use for personal hygiene, their normal mode of transportation, and their residence.*

FYI

The area that is most difficult to describe at the start of a chemistry course is physical chemistry, which is highly theoretical. Physical chemists investigate the underlying scientific principles behind the changes that occur in matter. A physical chemistry course includes topics such as quantum mechanics, thermodynamics, kinetic molecular theory, and reaction mechanisms.

Address Misconceptions

Based on how the term *chemical* is used in the media (and how it is defined in most dictionaries), students may assume that the term *chemical* refers exclusively to harmful materials. Explain that *chemical* describes all types of matter, including life-sustaining substances, such as water and oxygen.

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?***

Differentiated Instruction

Gifted and Talented

L3

Challenge students to conduct research on the traditional areas of study in chemistry. Encourage students to set up an interview with a chemist at a nearby college or local research laboratory. They could also search for information online. Ask students to share their research with the class.

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.

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.

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 Carother's research to the commercial production of nylon. By 1939, they had perfected a large-scale method for making nylon fibers.

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?***

Go Online NSTA SciLinks
For: Links on Applied Chemistry
Visit: www.SciLinks.org
Web Code: cdn-1011

Facts and Figures

Aspirin

In the late 1940s, Dr. Lawrence Craven observed that gum containing aspirin, which was used to relieve pain after the removal of tonsils, caused excessive bleeding in children. He hypothesized that aspirin prevented the blood from clotting. He then began to prescribe aspirin to prevent heart attacks.

In 1985, the FDA approved aspirin for patients who had suffered a heart attack. In 1996, the FDA proposed using aspirin during a suspected attack. In 1997, an advisory committee recommended daily low doses of aspirin for people at high risk of a heart attack.

Pure and Applied Chemistry

Use Visuals L1

Figure 1.3 Have students study the photographs. Ask, **What is the connection between the photographs?** *(The backpack is made of nylon, which is the material in the beaker.)* Then point out that the study of the underlying structure of fibers was an example of pure chemistry, which led to an example of applied chemistry—the commercial production of nylon. (Nylon is discussed as an example of a condensation polymer in Section 23.4. There is a demo for making nylon on p. 751.)

Relate L2

The public's perception and expectations of science have changed dramatically over the last two hundred years. Advances in technology can lead to increased public concern about the role that science plays in shaping the future. These societal concerns are reflected in the work of 19th- and 20th-century novelists such as H. G. Wells, Edward Bellamy, Jules Verne, George Orwell, and Mary Shelley. Have students select a novel by one of these novelists and critically examine it to determine how the author addressed the role of science, technology, and society in his or her era.

Go Online NSTA SciLinks

Download a worksheet on **Applied Chemistry** for students to complete, and find additional teacher support from NSTA SciLinks.

Answers to...

Figure 1.2 Students should infer that a bone contains mainly inorganic materials.

Checkpoint Silk

Why Study Chemistry?

TEACHER Demo

Explaining the Natural World L1

Purpose Students see that chemistry is involved in many natural processes.

Materials slides showing events or structures such as a volcanic eruption, a forest fire, a limestone cave, a flood, lightning, a plowed field, a fireworks display, someone skateboarding, pizza being removed from an oven, someone pumping gasoline

Advance Prep Collect a set of slides that show a wide variety of events or structures. Pick slides for which you can make a connection to chemistry without having to supply details that students will study later. Public libraries and visitor-information bureaus often have slides that can be borrowed.

Procedure Run through the set of slides once without discussion. Discuss the common thread among the images. Then go through the slides a second time and explain the connection to chemistry.

Relate L2

Ask students to volunteer to talk about careers they are considering. Have each volunteer briefly describe what kinds of activities are involved in each career. Challenge the class to think of ways that knowledge of chemistry would be helpful for each career.

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.

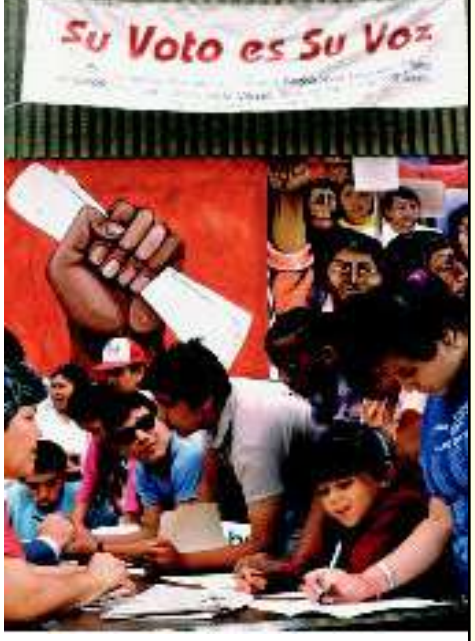

Figure 1.5 By registering to vote, these citizens in Chicago, Illinois, can have a say in the decisions made by their government. Those decisions include how much money to provide for scientific research.

1.1 Section Assessment

1. **Key Concept** Explain why chemistry affects all aspects of life and most natural events.
2. **Key Concept** Name the five traditional areas into which chemistry can be divided.
3. **Key Concept** Describe the relationship between pure chemistry and applied chemistry.
4. **Key Concept** List three reasons for studying chemistry.
5. 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.
   a. Determine the materials used to make the pots.
   b. Explain what the designs on the pots represent.
   c. Recommend how to store the pots to prevent further damage.
6. Would a geologist ask a biochemist to help identify the minerals in a rock? Explain your answer.
7. 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.

Interactive Textbook

Assessment 1.1 Test yourself on the concepts in Section 1.1.

with ChemASAP

Section 1.1 Assessment

1. Living and nonliving things are made of matter, and chemistry is the study of matter.
2. organic chemistry, analytical chemistry, biochemistry, physical chemistry, and inorganic chemistry
3. Pure research can lead directly to an application; an application can exist before research is done to explain how it works.
4. explaining the natural world, preparing people for career opportunities, and producing informed citizens
5. a and c
6. No, a biochemist studies processes that take place in organisms.
7. A possible answer is that knowledge of chemistry helps a citizen evaluate data and arrive at an informed opinion about a public issue that involves technology.

CLASS Activity

Chemistry in the News L2

Have students scan local and national newspapers for current news stories related to chemistry. Ask students to cut out one article and prepare a short presentation on the content of the article and how it relates to chemistry.

3 ASSESS

Evaluate Understanding L2

To determine students' understanding about the field of chemistry, ask, **In your own words, how would you define chemistry?** *(Chemistry is the study of the composition of matter and the changes it undergoes.)* **What do chemists do?** *(Chemists study the composition and behavior of matter.)*

Reteach L1

Point out that learning about the principles of chemistry will enable students to better understand the modern world. Ask students what is essential in their lives, and make a short list on the board. Have students think of one or two examples of how chemistry plays a part in each essential product or activity.

Writing Activity

Students' answers will vary, but should reveal an understanding of the definition of technology.

Interactive Textbook

If your class subscribes to the Interactive Textbook, use it to review key concepts in Section 1.1.

with ChemASAP

Answers To . . .

Figure 1.4 Students may infer that natural light causes unwanted changes to the film.