Section 1
Thinking like a Scientist

Key Concept Scientific progress is made by asking meaningful questions and conducting careful investigations.

What You Will Learn
- The habits of mind that scientists use include curiosity, skepticism, openness to new ideas, creativity, intellectual honesty, and ethical responsibility.
- Studying science can help you become a better-informed consumer.
- Most scientists follow a code of ethics so that no living thing is subjected to unnecessary harm.

Why It Matters
Thinking like a scientist can help you ask questions and solve problems in your everyday life.

You are preparing a gelatin dessert. You mix the gelatin with pineapple. You then put the mixture in the refrigerator to set overnight. In the morning, you find just a pan of liquid with pineapple in it! What happened?

To answer this riddle, you need to think like a scientist. Ask yourself the following questions: Did I mix the gelatin enough? Was the water too hot or too cold? Or did the pineapple ruin my dessert? After some research, you find out that pineapple has an enzyme that prevents gelatin from setting!

Scientific Habits of Mind
Although scientists work in many fields, they share certain habits of mind. Scientists are curious, skeptical, openness to new ideas, creative, and ethical. And they learn from their mistakes. The inventor Thomas Edison once said that he never failed; he just found 10,000 ways that did not work.

Curiosity
Scientists are curious about the world around them. **Figure 1** shows a scientist named Jane Goodall. Goodall was very curious about where chimpanzees lived, what they ate, and how they interacted. Curiosity led Goodall to study chimpanzees for more than 30 years. Goodall's

questions, research, and writings changed what scientists know about chimpanzees and other primates.

Figure 1 Jane Goodall has studied chimpanzees for more than 30 years. Her curiosity helped her make many discoveries about chimpanzees.

Skepticism

Skepticism is the practice of questioning accepted ideas or claims. Skepticism helps scientists question the assumptions that influence how we see the world. Skepticism helped one scientist discover a major threat to the environment. Rachel Carson, shown in **Figure 2,** was a biologist in the 1950s. At the time, scientists were developing many new kinds of pesticides to kill insects. The companies that made the chemicals said that the chemicals would not harm animals other than insects. Carson did not believe these claims. She questioned whether chemicals that killed insects would also harm other living things.

Figure 2 Rachel Carson was skeptical of the claims made by pesticide manufacturers. Her research

helped bald eagles recover from the effects of pesticides in the environment.

After much research, Carson wrote a book, *Silent Spring.* The book started debates about the use of pesticides in the United States. Some chemical companies threatened to sue Carson and tried to discredit her. But she stood by her findings, and her work led to controls on pesticide use. In particular, *Silent Spring* led to the banning of a chemical called *DDT.* DDT had threatened bald eagle populations in the United States. By being skeptical and asking questions, Carson encouraged others to think about the world around them.

Openness to New Ideas

Keeping an open mind means considering new ideas. However, this process may be harder than it sounds. Often, people make assumptions about the world based on what they are used to. Scientists in particular should be open to new ideas, even if these ideas differ from their own beliefs. Sometimes, considering an opposing idea can lead to a breakthrough that is the basis of a new discovery.

Imagination and Creativity

As well as being curious, skeptical, and open minded, scientists need to be creative and imaginative. Being creative helps scientists think about the world in new or different ways. **Figure 3** shows a scientist who used his imagination to connect earthquakes with music! Andy Michael is a seismologist, a scientist who studies earthquakes. Michael also plays the trombone, and he wrote a piece of music called "Earthquake Quartet #1." When the piece is played, the trombone sounds like the stress that builds up inside Earth before an earthquake. Michael also adds earthquake sounds to the music. He says that writing earthquake music helped him think about earthquakes in a different way. He realized that seismologists often do not notice tension building up in Earth's crust because, like the rhythm in a song, the tension is always present.

Figure 3 Creativity helped Andy Michael write "Earthquake Quartet #1." He says that writing the music changed how he thinks about earthquakes.

Intellectual Honesty

Scientists also must demonstrate honesty. Imagine what would happen if you lied about the results of your experiments and other scientists thought that your results were true. Something like this happened in 1989. Two groups of scientists were researching cold fusion. The goal of *cold fusion* is to join the nuclei of two atoms at low temperatures. If cold fusion were achieved, it would create cheap, limitless energy for the world. One group feared that the other group would publish its results first and become famous. So, members of the first group wrote an article claiming that they had achieved cold fusion even though they had not.

The scientific community was excited at first. But no one could repeat the group's results. In short, the scientists were discredited. To ensure honesty, scientists have their work reviewed by other scientists before it is published. This process, which is called *peer review,* is very important in science. Whether scientists are working in a research lab, for a business, or for the government, they must be honest.

Ethical Responsibility

Scientists must never subject anyone's property or any living thing to unnecessary harm. Ethics help guide scientists as they do research. Scientists must use compassion when they care for animals used in research. If scientists use people in research, the scientists must first explain the risks that people may face. When people are informed of risks and choose to participate, this process is known as *informed consent.* Many groups monitor ethics in science. The American Association for the Advancement of Science (AAAS), develops ethics guidelines for scientific research.

What Does a Scientist Look Like?

What do you think of when someone says the word *scientist?* Do you picture a man who has crazy white hair and who wears glasses? Is he also wearing a white lab coat? There are many different scientists. They come from various countries and backgrounds, as shown in **Figure 4.**

Figure 4 The Faces of Science

A Mae Jemison was a NASA mission specialist. Now, she is adapting space technology to improve the lives of people in West Africa.

B David Ho is a researcher who developed new treatments for the virus that causes AIDS.

C Stephen Hawking is a theoretical physicist who has taught us about black holes in space.

Standards Check Who can be a scientist?

Scientific Literacy

The goal of science education is to improve scientific literacy. **Scientific literacy** is the understanding of the methods of scientific inquiry, the scope of scientific knowledge, and the role of science in society.

Logic and Analysis

Although you may not become a scientist, learning science and becoming scientifically literate give you skills to use in your daily life. Science teaches you how to ask questions and how to find answers. Science helps you make careful observations. Science teaches you to think logically about information and teaches you how to decide if information is true. Studying science will help you become a better-informed consumer. For example, look at the acne products shown in **Figure 5.** How many of the claims made on the packages can be proven scientifically?

Figure 5 You should carefully analyze marketing claims. Advertisers may distort science to convince you to buy their products.

Critical Thinking and Science

Scientists have good critical-thinking skills. When you think critically about something, you think clearly, logically, practically, and realistically. You also gather information, ask questions, make

inferences, and try to be objective.

The key to critical thinking is studying the information that you find and asking yourself if the information makes sense. Ask yourself if the person who presents the information is trying to persuade you. Find out how the information was gathered. Ask yourself if the research was done scientifically. Also, find other sources. Find out if they back up the claims being made. Finally, analyze how your opinions might influence how you interpret information. Critical thinking is very important when you are gathering information from the Internet. Many Web sites attempt to influence how you feel about a certain topic or product.

Science in Our World

Every day, ordinary people make important contributions to the advancement of science. People can help scientists in many ways. For example, people have discovered comets and helped plant trees. And because science affects everyone, people and communities speak out on scientific issues that concern them. These issues may be the research funded by governments, the ethical questions raised by scientific research, or global environmental conditions.

Scientists as Citizens

Scientists have a public place in society, and they use their knowledge and skills to help improve our world. Mario Molina, shown in **Figure 6,** has worked hard to protect Earth's ozone layer. When he was a graduate student in the 1970s, Molina studied chemical compounds called *CFCs,* or chlorofluorocarbons. These chemicals were widely used in aerosol sprays and as refrigerants. Molina discovered that these chemicals could damage the ozone layer of Earth's atmosphere. The ozone layer protects living things on Earth from the sun's harmful ultraviolet (UV) radiation.

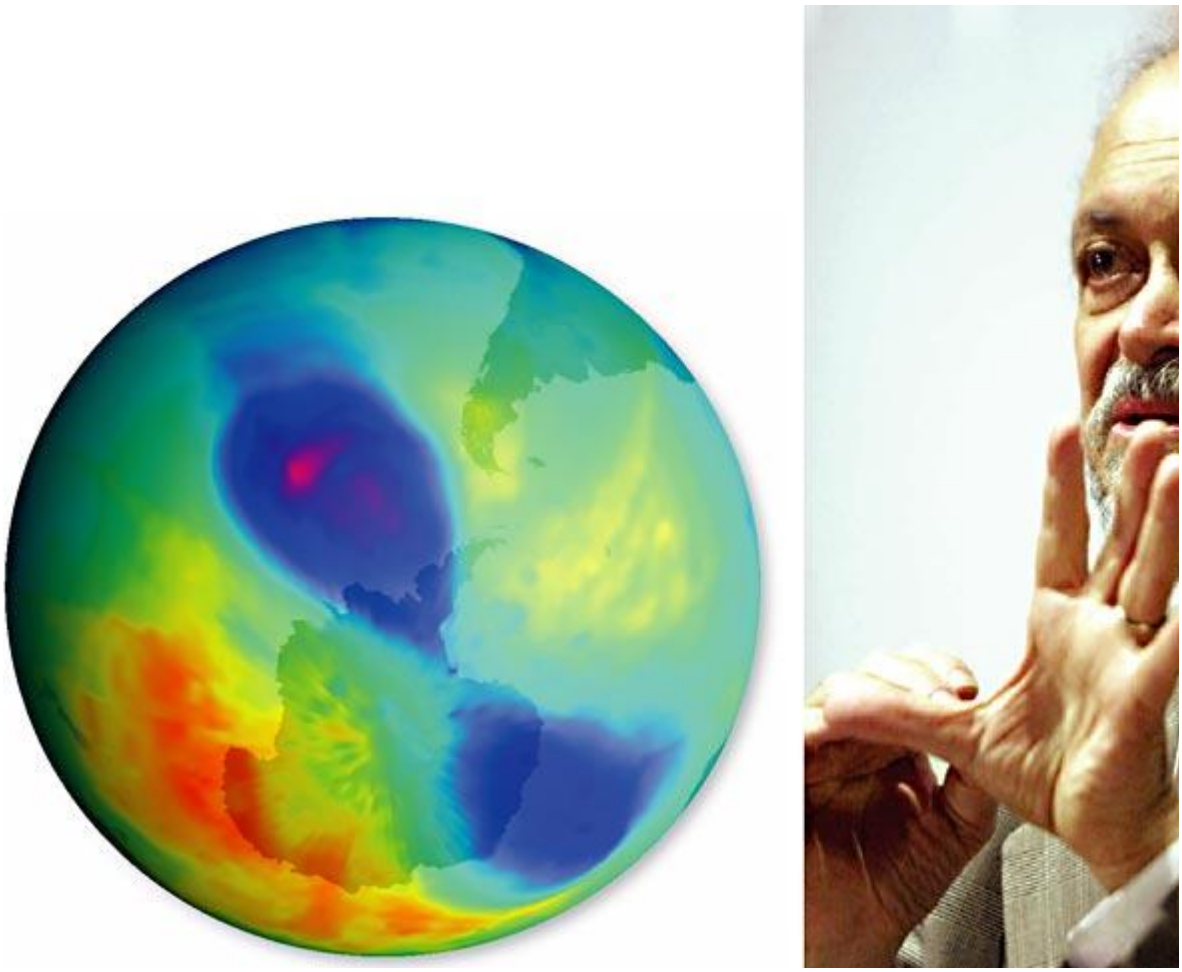

Figure 6 Mario Molina was awarded the Nobel Prize for his efforts to find the link between CFCs and ozone destruction. In the computer-modeled image of Earth to the left, the Antarctic ozone hole is shown in purple.

Molina warned scientists and others about his discovery, but it took a long time for some people to believe him. He worked for many years to teach people about the link between CFCs and ozone destruction. Finally, in the 1990s, the use of CFCs was banned in most of the world. Today, Molina continues to research ways to help lower the effects of harmful pollutants in the atmosphere.

Standards Check How did Mario Molina contribute to the understanding of the ozone hole?

From the Classroom to the World

In science, the world is your classroom. If you are interested in science, there are many ways to become involved. There are no limits to what you can do.

Special Science Programs

Students, such as the students in **Figure 7,** can build scientific literacy and learn the skills used by scientists by taking part in special science programs. These skills are questioning, observing, problem solving, and critical thinking. In science programs, students can take part in exciting, hands-on activities, such as exploring tide pools and whale watching. Students can also navigate the ocean by using an ROV, or remotely operated vehicle. Students not only can learn to "fly" an ROV but also can design and build their own ROV! These activities are just a few examples of fun activities in which students can participate at special science programs in California.

Figure 7 These students are learning to think like scientists by studying the geology of Mt. Diablo in a special science program.

Classroom Collaboration

Your class can also take part in science projects that connect classrooms

around the world. One such project is the JASON Project. Each year, scientists working on the project lead students, teachers, and other scientists on a virtual two-week research trip. Students talk online with researchers, take part in digital labs, and keep notes in online journals. If your class cannot take part in online projects, you can do a science project at your school. You can volunteer or be an intern in the education department of a local museum. At the museum, you can build skills that may get you a job as a scientist someday!

Section Summary

- Scientists are curious, creative, skeptical, and open to new ideas.
- It is important for scientists to be honest and ethical in their treatment of humans and other living things.
- People from diverse backgrounds have made many contributions to the advancement of science.
- Increasing scientific literacy and developing critical-thinking skills are goals of science education.
- Scientists always evaluate the credibility of information that they receive.
- Scientists can have public roles in society. In addition to explaining scientific concepts to the media, scientists work to improve the quality of people's lives.
- There are many opportunities to participate in science programs in your community.