The photo on the left shows a tiny model of Earth under a magnifying glass. You have probably used a similar tool to study small living things. Of course, you cannot really see the whole Earth through a magnifying glass. However, many scientists do study planet Earth very carefully. Earth is made of many parts that interact, including living things. The result is a constantly changing planet. In Chapter 1, you will learn how living things depend on Earth's environment. You will also find out how scientists study interactions between Earth and its living things.

Organize Your Thoughts

Environment
- Parts of the environment
- Environmental challenges

Environmental science

Science
- Scientific method
- Science and society

Goals for Learning
- To understand that environmental science includes many different areas of study
- To describe the major things that all living things need to survive
- To explain how life on Earth has changed over time
- To describe five major environmental problems
- To list and describe the steps in the scientific method
- To explain why science is important to society
Think about some of the advances in science that have happened in the last decade. Scientists have developed new ways to track organisms, or living things, such as whales and butterflies. They have designed cars that run on both gas and electricity to save energy. They have even discovered new plants and animals that no one has ever seen before. These are just a few examples of what scientists are learning about the earth.

Science and the Environment

All of these discoveries show environmental science at work. Environmental science is the study of how living things, including humans, affect and interact with their environment. The environment is an organism's natural and human-made surroundings. Environmental scientists work to understand the environment in order to solve environmental problems. They also try to prevent new problems from happening in the future.

The environment has two major parts, the natural environment and the built environment. The natural environment is often called nature. The built environment includes what humans have made, such as roads and buildings. The environment also includes the relationships among living and nonliving things. Environmental scientists study both the natural environment and the built environment to understand how they affect each other.

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**Objectives**

After reading this lesson, you should be able to

- define environmental science and applied science
- describe the natural environment and the built environment
- list different areas of study important to environmental science

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**Organism**

A living thing; one of many different forms of life

**Environmental science**

The study of how living things, including humans, interact with their environment

**Environment**

An organism's natural and human-made surroundings

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**Language Arts**

The word environment comes from the French word virer, which means "to turn." The word environ means to encircle, or surround.
Environmental science builds on many other areas of science. These areas include biology, earth science, chemistry, physics, and the social sciences. It explores how people use natural resources, such as water, plants, coal, and soil. Unlike many other sciences, environmental science is an applied science. That means its goal is to provide practical solutions to environmental problems. Environmental scientists look for ways people can interact with the environment without harming it.

**Map Skills: Physical Map of the United States**

One way to learn about the physical environment is through maps. A physical map shows natural features, such as mountains and rivers. It also shows elevation, which is the height above sea level. The colors on the map represent different ranges of elevations. Notice that the units are in meters. Use the map and the legend to answer the questions below.

1. What natural resource is shown in blue?
2. What color represents the highest elevations?

<table>
<thead>
<tr>
<th>LEGEND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Elevation in Meters</td>
</tr>
<tr>
<td>-100 to 700</td>
</tr>
<tr>
<td>701 to 1,200</td>
</tr>
<tr>
<td>1,201 to 2,000</td>
</tr>
<tr>
<td>2,001 to 4,400</td>
</tr>
</tbody>
</table>

3. Which mountains are taller: the Rocky Mountains or the Appalachian Mountains? How do you know?

4. What is the elevation range of most of the southeastern United States?

5. What body of water does the Mississippi River empty into?
There are many kinds of environmental scientists. They have different backgrounds and different points of view. Some are conservation biologists who study living things and how to protect the environment. Others are earth scientists who study air, water, and land systems. Some are social scientists, such as geographers and anthropologists. These scientists look at different cultures, among other things. Cultures are the languages, religions, customs, arts, and dress of a people. All of these things help determine how people relate to the environment.

Different areas of science within environmental science are listed in Table 1.1.1. They are followed by some real-life examples of environmental scientists.

<table>
<thead>
<tr>
<th>Area of science</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>The study of living things</td>
</tr>
<tr>
<td>Ecology</td>
<td>The study of interactions between living things and their environment</td>
</tr>
<tr>
<td>Zoology</td>
<td>The study of animals</td>
</tr>
<tr>
<td>Botany</td>
<td>The study of plants</td>
</tr>
<tr>
<td>Ethology</td>
<td>The study of animal behavior</td>
</tr>
<tr>
<td>Microbiology</td>
<td>The study of microorganisms</td>
</tr>
<tr>
<td>Earth science</td>
<td>The study of the earth over time</td>
</tr>
<tr>
<td>Geology</td>
<td>The study of the solid parts of the earth</td>
</tr>
<tr>
<td>Climatology</td>
<td>The study of climate</td>
</tr>
<tr>
<td>Hydrology</td>
<td>The study of the earth's water systems</td>
</tr>
<tr>
<td>Meteorology</td>
<td>The study of the earth's air and weather</td>
</tr>
<tr>
<td>Paleontology</td>
<td>The study of fossils and prehistoric life</td>
</tr>
<tr>
<td>Chemistry</td>
<td>The study of matter and how it changes</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>The study of the chemistry of living things</td>
</tr>
<tr>
<td>Geochemistry</td>
<td>The study of the chemistry of the earth</td>
</tr>
<tr>
<td>Geography</td>
<td>The study of places, people, and cultures</td>
</tr>
<tr>
<td>Anthropology</td>
<td>The study of human cultures</td>
</tr>
<tr>
<td>Sociology</td>
<td>The study of human societies</td>
</tr>
<tr>
<td>Demography</td>
<td>The study of population dynamics</td>
</tr>
</tbody>
</table>
Wangari Maathai is a biologist. She is the first African woman to win the Nobel Peace Prize. For more than 30 years, she has worked with communities throughout Africa to plant trees. The trees provide resources for communities and help prevent soil from washing away. Her work has also provided jobs for many poor people in Africa. She has shown firsthand how a healthy environment can improve the quality of life.

Figure 1.1.2 In 2004, Wangari Maathai received the Nobel Peace Prize for her work.

Jason Clay is an anthropologist who works to reduce the impact of food production. He is researching ways to grow shrimp and salmon that do not harm the environment. He is also working to protect the fish in oceans and rivers.

Eric Dinerstein is a conservation biologist. He is working to prevent rhinoceroses, tigers, pandas, and other large animals from disappearing. In the past 50 years, the numbers of these large animals have decreased. Dr. Dinerstein is trying to protect the land they need to survive.

Figure 1.1.3 Eric Dinerstein traveled to China to study giant pandas and help preserve their habitat.
All of these scientists ask questions and conduct research to learn how people and the environment interact. They share their findings with others, including other scientists and the public. Scientists build on what others have discovered before them to make new discoveries. In this textbook, you will read about how science helps people learn more about the environment.

### Express Lab 1

**Materials**
- paper
- pencil

**Procedure**

1. Look around your classroom. Observe and write down the things that surround you.
2. Identify which natural resources might have been used to make these things.
3. List all the natural resources that you identified.

**Analysis**

1. Which natural resources are used to construct buildings?
2. Which natural resources on your list will be used up or eaten? One example is an apple someone brought for lunch.
3. Which natural resources do you share with other students? One example is the water in the drinking fountain.
On a sheet of paper, write the words from the Word Bank that complete each sentence correctly.

1. Buildings, roads, schools, and bridges are examples of the _____.
2. The study of how living things interact with their surroundings is _____.
3. A(n) _____ is an area of study designed to help solve practical problems.

On a sheet of paper, write the letter of the correct answer.

4. Which of the following is not a natural resource?
   A soil   B water   C roads   D plants

5. Which of the following areas of science might study a past society’s relationship with the environment?
   A ecology   C chemistry
   B climatology   D anthropology

6. The _____ is often referred to as nature.
   A natural environment   C built environment
   B environmental science   D tropical rain forest

**Critical Thinking**

On a sheet of paper, write the answers to the following questions. Use complete sentences.

7. As an applied science, what is the main goal of environmental science?

8. Name a natural resource and one reason that it is important to people.

9. List three different areas of science that are part of environmental science. How do they each relate to the environment?

10. Give two examples of the types of work environmental scientists do.
Lesson 2 A Living Planet

Objectives

After reading this lesson, you should be able to

- list the things that organisms need to survive
- explain where most of Earth's energy comes from
- describe how water, oxygen, energy, and nutrients are important

Earth is the only planet in the universe known to support life. It is home to gigantic blue whales and bumblebee bats the size of a dime. It is home to tiny mosses and giant redwood trees. All of these organisms need certain things to survive, including water, oxygen, and energy.

The Importance of Water

Sea jellies, often called jellyfish, have bodies that are more than 95 percent water. These creatures live in the ocean, pushed along by currents and wind. They have a bell-shaped body and thin, dangling arms. Unlike true fish, jellyfish do not have backbones. Instead, they are related to corals and sea anemones. Without water, sea jellies could not exist.

Water is important for people, too. Each person needs to drink about 1.9 liters of water every day to stay healthy. In the United States, each person uses about 379 liters each day. This water is used in many ways, such as for drinking, bathing, and flushing toilets. In other areas of the world, there is not enough water available. More than 2 billion people do not have enough water for drinking or cleaning.

Take a Breath

Another thing that organisms need to live is oxygen. When you take a breath, you bring oxygen and other gases into your lungs. The oxygen is picked up by chemicals in your blood. It travels to all of your body's more than seven trillion cells. Cells are the basic units of life that make up all living things. Oxygen helps the cells get the energy they need from food. When you breathe out, you give off carbon dioxide as a waste product.

Oxygen can dissolve, or break apart, in water. Many organisms that live in water, such as fish, use gills to absorb this oxygen. Gills are organs that allow fish to breathe underwater. Like people, fish need oxygen to get energy from food.
The Energy Connection

All life needs energy, which is the ability to do work. Without energy, organisms could not grow, move, think, or heal. Organisms also need energy to reproduce, which means to breed and produce offspring. Organisms get the energy they need from their environment. Where does the earth’s energy come from? Almost all of Earth’s energy comes from the sun. It travels from the sun in waves, such as heat waves and light waves. These waves are types of electromagnetic radiation.

When sunlight strikes the earth, most of it bounces back into space as heat waves. Enough makes it to Earth to provide the energy organisms need to live. Some sunlight is absorbed into the water and ground. Some is absorbed by animals in the form of heat. Plants use some to make food.

Energy is never created or destroyed. It just changes form as it moves through living systems. You will learn more about energy in Chapters 2 and 7.

What We Need to Survive

Living things need water, oxygen, energy, and nutrients, which are chemicals needed for growth. Each species has its own specific set of needs. A species is a group of organisms that can breed with each other. Each species also has different requirements for where it can live. Frogs and willow trees are examples of species that need a wet environment. Some species, such as parrots and orchids, thrive in environments that stay hot all year. Other species, such as tigers and eagles, need a lot of open space to find enough food. Some species, such as snow leopards and snowy owls, do best in cold, snowy weather.

Link to Physics

Electromagnetic radiation moves by electromagnetic waves. Electromagnetic waves are different than many other types of waves. They do not need a medium, such as air or water, to move through. This is how electromagnetic radiation can move through outer space.
Environmental scientists study what organisms need to survive. They explore how living things interact with their environment. They also study how organisms interact with the living and nonliving parts of their environment. For example, farmers use pesticides on their crops. These poisonous chemicals can harm more than just the pests. In many cases, pesticides have poisoned birds and even humans. It is difficult to know exactly how changes in the environment will affect different organisms. That is one of the reasons environmental science is so important.

**Achievements in Science**

**Silent Spring**

At first, the development of the pesticide DDT was celebrated by the public. In fact, a Swiss chemist received a Nobel Prize in 1948 for his discovery of the pesticide properties of DDT. The chemical promised to greatly decrease the populations of disease-carrying mosquitoes. Few people imagined that this chemical could harm the environment.

A biologist named Rachel Carson became concerned about the effects of DDT and other pesticides. She and several other biologists noticed that birds were dying in areas where DDT was being used. These scientists eventually began their own research on the pesticide. In 1962, Carson published the research results in her book _Silent Spring_. The book revealed how DDT was killing many more organisms than anyone had thought. She also explained how destroying large numbers of animals would affect the environment.

_Silent Spring_ made people realize that using chemicals could have negative effects on the environment. In response, the U.S. government investigated DDT and banned its use in 1972. This action helped start the environmental movement. You will learn more about DDT in Chapter 3.
On a sheet of paper, write the word from the Word Bank that completes each sentence correctly.

1. Birds, fish, and trees are all examples of _____.
2. Many different activities, such as dancing and talking, require _____.
3. Farmers use _____ to control unwanted organisms on crops.

Choose the term from Column B that best matches the phrase in Column A. Write the letter of your answer on a sheet of paper.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. these organs help fish get oxygen from the water</td>
<td>A electromagnetic radiation</td>
</tr>
<tr>
<td>5. electric and magnetic waves</td>
<td>B gills</td>
</tr>
<tr>
<td>6. chemicals that help plants and animals grow</td>
<td>C nutrients</td>
</tr>
</tbody>
</table>

Critical Thinking
On a sheet of paper, write the answers to the following questions. Use complete sentences.

7. Describe what would happen if living things ran out of oxygen.

8. What is the relationship between oxygen and food in the human body?

9. Explain where most of Earth's energy comes from and how it travels to Earth.

10. Why is Earth the only planet in the universe with life?
Scientists estimate that the earliest life forms appeared on Earth about 3.5 billion years ago. It took another 3 billion years for human history to begin. Based on recent discoveries, scientists think the first humans emerged more than 100,000 years ago. These early humans, who were called Cro-Magnons, were the first *Homo sapiens*. They made and used tools, created art, and hunted to find food.

From the beginning, humans depended on the environment to survive. They also affected their environment in many ways, just as they do today. Over time, human societies have found three main ways to survive. One way was as hunters and gatherers. Another was by farming the land. A third was by using machines to produce what people need.

**Living Off the Land**

The first humans lived in small groups. As the seasons changed, they moved from one place to another to find food. They were called *hunter-gatherers*. This means they survived by hunting animals and collecting plants to eat. When one place ran out of food, they moved to another area.

People lived as hunter-gatherers for most of human history. Hunter-gatherers knew a lot about their environment. They knew which plants could be eaten and where to catch animals. This information was passed down from one generation to the next.

Many of the early hunter-gatherer tribes were very small in numbers. The effect they had on their environment was limited. As their numbers increased, so did their impact on the environment. Scientists believe that some tribes might have hunted certain species faster than they could reproduce. This could have helped to wipe out giant bison and other large animals.
Today, only a few hunter-gatherer societies exist. However, many people still hunt for food and collect berries and other plants.

**The Agricultural Revolution**

About 11,000 years ago, a huge change took place in hunter-gatherer societies. Some of the tribes started planting seeds and growing crops. They also started raising animals that could provide them with food and clothing. Instead of moving when the seasons changed, people started to stay in one place.

Agriculture, also called farming, allowed people to raise more food. Farming supports around 500 times more people than hunting and gathering, using the same space. With better crops and the invention of the plow, there was enough food to support even more people. The number of humans quickly increased.

Historians call this period of time the **Agricultural Revolution**. The Agricultural Revolution changed people's diets. People started eating grains, such as wheat, barley, rice, and corn. Beans were also an early crop. Many of the grains people eat today came from these early wild plants.

The Agricultural Revolution also changed how people lived. Farming communities began to thrive. People worked together to build cities. However, as more people lived in smaller areas, they faced new problems. For the first time, they had to deal with getting rid of waste and keeping water supplies clean.

The Agricultural Revolution also started a **cycle**, or repeating pattern, of environmental change that continues today. Farming has completely changed the **landscape** in most parts of the world. Chapters 8, 10, and 11 will discuss more about the effects of farming on the environment.
The Industrial Revolution

In the mid-1700s, another revolution took place. This revolution was run by machines. Before that, agriculture and manufacturing were accomplished by people and animals. With the invention of the steam engine, factories could mass-produce clothes, building materials, and equipment. To mass-produce is to produce in large quantities using machines. Machines also helped make farming and transportation more efficient. With motorized farm equipment, more land could be farmed using fewer people.

The Industrial Revolution, as it was called, caused far-reaching changes. On the positive side, fewer people were needed to produce the goods that people needed. Goods are items people buy, like beds, cars, and televisions. These goods also cost less because many could be made at once. Many new inventions made people’s lives easier. Electric lights, automobiles, and computers are just a few examples.

The Industrial Revolution also created new environmental problems. Large-scale farming led to a loss of habitat, or living space, for many wild animals. Pollution from farms and factories increased. Pollution is anything humans add to the environment that is harmful to living things. In cities, air and water pollution became serious problems. Machines required more and more energy and resources. All this has led to a number of environmental problems.

Social Studies

The steam engine is commonly believed to be the invention that started the Industrial Revolution. The first working steam engine was developed by Thomas Savery. This engine used coal to heat water into steam. The force of the steam moved the machine’s different parts. This steam engine, the “Miner’s Friend,” was used to pump water out of coal mines.
One of the biggest side effects of the Industrial Revolution was the increase in population. Since the 1800s, the human population has climbed from 1 billion to more than 6 billion. This has put a number of different pressures on the environment. You will learn more about population problems and solutions in Chapter 6.

Environmental science focuses on solving the environmental problems that have increased since the Industrial Revolution. The timeline in Table 1.3.1 shows how much time has passed since the earth formed. By comparison, the changes humans have caused are recent events.

<table>
<thead>
<tr>
<th>Table 1.3.1 Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6 billion years ago</td>
</tr>
<tr>
<td>3.7 billion years ago</td>
</tr>
<tr>
<td>3.5 billion years ago</td>
</tr>
<tr>
<td>650 million years ago</td>
</tr>
<tr>
<td>500 million years ago</td>
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<tr>
<td>250 million years ago</td>
</tr>
<tr>
<td>245 million years ago</td>
</tr>
<tr>
<td>200 million years ago</td>
</tr>
<tr>
<td>65 million years ago</td>
</tr>
<tr>
<td>3.5 million years ago</td>
</tr>
<tr>
<td>100,000 years ago</td>
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<tr>
<td>10,000 years ago</td>
</tr>
<tr>
<td>4,500 years ago</td>
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<td>650 years ago</td>
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<tr>
<td>270 years ago</td>
</tr>
<tr>
<td>230 years ago</td>
</tr>
</tbody>
</table>
Lesson 3  REVIEW

On a sheet of paper, write the word or words from the Word Bank that complete each sentence correctly.

1. About 11,000 years ago, during the _____, people started planting crops and raising animals.
2. Many goods and services today are a result of the _____.
3. A(n) _____ is the place where an organism lives.

On a sheet of paper, write the letter of the correct answer.

4. Farming supports over 500 times as many people as _____.
   A hunting and gathering  C searching and moving
   B industry                  D raising cows

5. Which of the following did not happen as a result of the Industrial Revolution?
   A The world’s population decreased.
   B The world’s population increased.
   C More goods and services became available.
   D Pollution increased.

6. During the Agricultural Revolution, _____ provided power.
   A animals    C machines
   B computers  D plants

Critical Thinking
On a sheet of paper write the answers to the following questions. Use complete sentences.

7. How did hunter-gatherers survive when they ran out of food in one location?

8. Compare the Agricultural Revolution and the Industrial Revolution.

9. Describe one way that farmers affect the environment.

10. What are some ways the Industrial Revolution affected the environment?
Understanding Earth’s History

Earth was created approximately 4.6 billion years ago. However, life did not appear until over one billion years later. Even after the first basic signs of life, it took over three billion more years for the first pre-humans to appear. This lab will help you visualize periods of time during Earth’s long history.

Procedure

1. Place the pennies in one large pile. These pennies represent Earth’s history.

2. Mark the index cards A, B, C, and D.

3. Divide the pennies into two piles. Put 110 pennies in Pile A and 350 pennies in Pile B. Pile A represents the time period from Earth’s creation to the appearance of life. Pile B represents the time period from the appearance of life to the present time.

4. Take 65 pennies from Pile B and place them in Pile C. This third pile shows how long organisms with more than one cell have existed.

5. Take one penny from Pile C and place it in Pile D. This represents the last 10 million years of Earth’s history. The time period since *Homo sapiens* appeared would be one-hundredth of this penny.
Cleanup/Disposal
Return the pennies to your teacher. Wash your hands with soap and warm water.

Analysis
1. How would you represent recorded human history using these pennies?
2. How would you represent the point when dinosaurs became extinct?

Conclusions
1. How many years does each penny represent?
2. What type of life has been present through most of Earth’s history?

Explore Further
Create your own timeline by using a meter stick and a piece of tape. Measure out the amount of time for each event from left to right.

<table>
<thead>
<tr>
<th>Table 1.3.1 Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6 billion years ago</td>
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<tr>
<td>3.7 billion years ago</td>
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<td>230 years ago</td>
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</tbody>
</table>
For most of human history, people have believed the earth had unlimited natural resources. There were huge forests and oceans, as well as fertile soils where crops could grow. There was also an amazing diversity, or variety, of wildlife. Today, however, people are using many resources faster than they can be replaced. As a result, pollution and overuse are harming many of the world’s ecosystems. An ecosystem is made up of all the living and nonliving things in an area. When part of an ecosystem is harmed, the entire system is affected.

Protecting ecosystems is only one goal of environmental science. One of the most important goals of environmental science is to create a more sustainable society. A society is a group of people who share a common culture. A sustainable society works to meet the needs of the current generation while preserving resources for future generations. The natural systems that support life on Earth are also protected. However, there are a number of environmental challenges that prevent societies from becoming sustainable.

Major Environmental Challenges
Some environmental challenges are global and affect the whole world, such as rising temperatures. Others are regional, such as an oil spill that affects the ocean near several countries. Environmental challenges can also be local. Examples would include chemicals polluting a local lake or trash littering a nearby park.

Technology and Society
As technology advances, so does people’s ability to deal with environmental challenges. For example, wireless technology makes it possible to monitor pollution levels around the world.
Global, regional, and local environmental problems can be put into several categories, or groups.

**A Growing Population.** More than 6.4 billion people live on Earth. Each year, that population increases by about 85 million people. That is like adding another New York City each month or another India every nine years. Experts estimate that by 2050, the population could grow to more than 9 billion. Both China and India already have populations of over a billion. This worldwide population increase has put pressure on the environment. You will learn more about population issues and how population affects the environment in Chapters 6 and 11.

**Using Too Many Resources.** Population growth is directly connected to overconsumption. When people use natural resources, they consume them. Overconsumption means using more resources than can be replaced.

Natural resources include everything people get from the environment that helps them survive. They include things such as water, air, wood, food, coal, oil, gas, minerals, and metals. Overconsumption will be discussed in more detail in Chapter 6.

**Pollution and Climate Change.** The use of resources produces waste. You have probably seen examples of this waste where you live. It can be waste in the air from burning trash. It can be chemicals spilled along the coast, or overflowing dumps. Sometimes people cannot see the waste, but its harmful effects show it is there. Poisonous chemicals in the water or air can cause health problems for humans and animals. Too much heat in the water can kill fish.

All of these are examples of pollution. Since the Industrial Revolution, the amount of pollution has increased along with the human population. Global temperatures are also rising, in a trend called global warming. Global warming is an increase in Earth's average surface temperature. This is partly caused by increased amounts of carbon dioxide escaping into the air. You will learn more about pollution in Chapters 8, 9, and 10.
Loss of Biodiversity. **Biodiversity** is the variety of life on Earth. It includes all the living things on the planet, from trees to tigers. Loss of biodiversity is another serious problem. Many species have already become **extinct** in the past 200 years. When a species becomes extinct, it no longer exists.

Today, many species and ecosystems are in danger of becoming extinct. You will learn more about loss of biodiversity in Chapters 4 and 12.

**Unequal Division of Resources.** Earth's natural resources are not spread out evenly. Some countries have many natural resources and others have only a few. Some countries have much higher populations per square kilometer than other countries. All this adds up to some countries having more wealth per person than others.

People living in wealthier countries often use a greater share of Earth's natural resources. On average, people from the United States use more resources than people from any other country. These resources make life easier for people living in the United States. However, this unequal resource use can create hardships in other parts of the world. More than half of the people in the world do not have what they need to survive. They do not have enough food or clean drinking water. They also lack health care, jobs, and education. People in less wealthy countries often overuse local resources because they have no other choice. This puts more pressure on the environment.

**The Role of Values**

Scientific research can help people understand more about environmental problems and possible solutions. Research can help people understand the possible results of different decisions. However, scientists usually do not tell people what to do. They leave those decisions to society. Decisions about the environment often involve **values**. A value is what is important to a person. Values are shaped by people's view of the world.
Values play an important role in creating a sustainable global society. They help people decide what to do. How will a solution affect people's lives? Will it hurt some people more than others? Is the solution fair? How will it affect people in the short-term? How will it affect future generations? People making environmental decisions need to think about what is most important.

In this textbook, you will find out more about these major environmental challenges. You will learn what problems scientists have discovered and what creative solutions they have found. You will also see how you can help create a more sustainable world. Learning more about these issues and getting involved in your community are both important. In these ways, you can help protect the environment.

**Science in Your Life**

**Consumer Choices: Reducing Global Warming**

The amount of carbon dioxide released into the air increases each year. This trend began during the Industrial Revolution. Carbon dioxide is one possible cause of global warming, an increase in global temperatures. Many scientists are working to reduce the amount of carbon dioxide being released. You can also make choices at home that can help reduce global warming.

Carbon dioxide is released when fuels such as oil, coal, and gasoline are burned. The electricity that you use probably comes from a power plant that burns these fuels. You can lower the amount of carbon dioxide that goes into the air by using less electricity.

Appliances that use less energy can reduce your electricity use. Most products have labels that list their energy use. A flat-screen computer monitor uses less than half the electricity of a cathode ray tube monitor. Front-loading washing machines use less energy than those that load from the top. It also helps to keep size in mind. An oversized air conditioner or refrigerator wastes energy and money. By choosing an energy-efficient product, you can make a difference every day.

1. How does reducing the use of electricity help reduce global warming?
2. What are two ways you can reduce your use of electricity?
On a sheet of paper, write the word from the Word Bank that completes each sentence correctly.

1. Using more resources than the environment can support is called _____.
2. A species that is _____ has no more living members.
3. People use their _____ to make decisions.

On a sheet of paper, write the letter of the answer that completes each sentence correctly.

4. The population of Earth grows by about _____ each year.
   A 8 million  B 18 million  C 80 million  D 8 billion
5. Pollution problems in your neighborhood are _____ problems.
   A national  B local  C regional  D global
6. _____ is any human-caused change in the environment that harms living things.
   A Energy  B Pollution  C Diversity  D Farming

Critical Thinking
On a sheet of paper, write the answers to the following questions. Use complete sentences.

7. Describe how overconsumption harms the environment.
8. Explain how the division of resources can influence how different societies affect the environment.
9. What role do values have in finding solutions to environmental problems?
10. Explain why it is important for people to work for a sustainable society.
How Science Works

Objectives
After reading this lesson, you should be able to
• understand why scientists use the scientific method
• define each step of the scientific method

Coral bleaching
A process in which a coral dies and turns white

Algae
Tiny organisms that make their own food

Scientific method
A series of steps used to test possible answers to scientific questions

Bias
A personal belief that can affect an experiment's results

In the late 1980s, scientists and underwater divers noticed that many coral reefs were dying. When corals are under stress, they turn white. This is known as coral bleaching. It happens because of the algae that live in the coral. Algae are tiny organisms that make their own food. They give corals their bright colors and also provide them with food. When corals are stressed, they expel the algae, almost like spitting them out. Without their food source, the corals start to die. All that is left are the white skeletons that once housed tiny, living corals.

When scientists first noticed the problem, they started asking questions. What was causing the increased stress? Why did it happen in only some places? How could they stop it?

The Scientific Method
Like all scientists, environmental scientists follow a process to answer questions and find solutions. This process is called the scientific method. Scientists may skip steps or not follow steps in order, but they all use this process.

Scientists use the scientific method for many reasons. The steps help make sure that people's biases do not affect the results of their research. Scientists anywhere in the world should have the same results if they repeat the experiment. Science depends on facts that can be tested and retested by other scientists.

The scientific method requires that scientists use many skills. These skills include predicting, observing, organizing, classifying, modeling, measuring, inferring, analyzing, and communicating. The steps of the scientific method are:

1. Observation
2. Question
3. Hypothesis
4. Experiment
5. Analysis
6. Communication
Figure 1.5.1 shows the steps in the scientific method. You will learn about each step below.

*Figure 1.5.1 The scientific method is a constant cycle scientists use to find answers to many questions.*

**Observation.** You perform this step without even being aware of it. Look at your classmates and all the objects in the room. The first step is simply looking at the world around you, watching life. While scientists are watching, or observing, they may see something they do not understand. If it interests them, they move to the next step of the scientific method.

In the example above, people observed that coral reefs were turning white. This led many scientists to start asking questions about why.

**Question.** When scientists see something they do not understand, they ask a question. Environmental scientists ask questions about how living things interact with their environment. They work to find answers to questions like, “Why are frogs and toads around the world disappearing?” or “Why are so many children in cities having trouble breathing?” Once environmental scientists have questions, they can begin looking for answers.
**Hypothesis.** A **hypothesis** is an educated guess. After asking a question, scientists try to guess the right answer. Scientists make their guesses based on what they already know. They also read what has been published about the topic or collect other information. Scientists then use experiments to see if they are right.

Here is an example. A scientist's hypothesis might be that corals die if ocean temperatures rise more than 1.5°C. This statement could be tested in a lab using corals from around the world.

**Experiment.** An experiment is used to test whether a hypothesis is correct. Environmental scientists perform many different kinds of experiments. The kind they perform depends on the question they are trying to answer. Scientists might conduct a survey, an experiment, or a **field study** to gather information. A field study is conducted in a natural environment.

Scientists design experiments to test possible answers to the question. There are two groups in a scientific experiment: a **control group** and an **experimental group.** In the control group, nothing is changed. The experimental group is similar to the control group, except for one part that is changed. That part is called the **variable.** Scientists control the variables in their experiments to get information they can use.

For example, an environmental scientist might want to test the hypothesis above. It states that corals will die if ocean temperatures rise more than 1.5°C. To test this hypothesis, the scientist would put corals of the same species into two groups of tanks. Both groups of tanks would be the same size and have the same amount of seawater in them. Then the scientist would raise the temperature of the water in one group of tanks 1.5°C. The water in the other group of tanks would stay the same temperature. The scientist would then record what happened to the corals.
Scientists usually perform their experiments many times. They need to be sure that they get a similar answer every time. They also need to keep track of all the data, or information, they collect. Scientists use different tools to keep track of information, such as computers and calculators. They also use special equipment that is designed for their experiments. Math is also important in experiments. Scientists use math to gather data, analyze data, and communicate results.

**Analysis.** Analysis is the process of making sense of the results. Scientists look at the information and ask questions: Does the information collected support the hypothesis? Were there any unexpected results? If the results do not agree with the hypothesis, scientists may ask a different question. Sometimes the results answer the question but do not agree with the hypothesis. A hypothesis is an educated guess and can be wrong. The answers scientists find often lead to more questions. Say that scientists discovered that raising the water temperature 1.5°C caused corals to die. Then the scientists might ask what caused the ocean to become warmer.

**Communication.** After scientists have tested their hypothesis and checked their results, they share their results. Other scientists may be interested in the same questions. Scientists use the Internet to share their data. The Internet, a worldwide network of computers, helps scientists communicate.

Scientists also communicate their methods and results in scientific journals. Scientists publish their results in journals that are reviewed and read by other scientists. These journals help scientists keep up on advances in science. By publishing the results of their research, scientists contribute to what is known about a subject.
Sharing data not only allows others to know what one scientist did. It also allows scientists to review the data and check for mistakes. It also allows other scientists to suggest new questions or interpret the data in a different way. Environmental scientists share their data to help other scientists working on similar problems. When more scientists study a question, it increases the chances that it can be answered.

**Science at Work**

**Field Research Technician**

Field research technicians run experiments and gather data. They often set up experiments and make observations outside the laboratory. Field research technicians usually work with a professor or a chief researcher throughout the experiment.

Field research technicians must master many skills. Before setting up an experiment, the technician must often research past experiments and techniques. The technician writes up the experimental procedure and sets up the experiment. Often a field investigation takes several weeks, or even months, to run. During that time, the technician runs the experiment and collects data. Then the technician helps to analyze the data and write up the results.

It is common for a field research technician to have a bachelor's degree or be working toward one. However, many field research technicians have only an associate's degree.
On a sheet of paper, write the word or words from the Word Bank that complete each sentence correctly.

1. The ______ in an experiment has no variable changed.
2. Forming and testing a ______ is an important part of the scientific method.
3. Information collected from experiments and research is called ______.

On a sheet of paper, write the letter of the correct answer.

4. Which of the following is not a step in the scientific method?
   - A observation
   - B experiment
   - C copying
   - D analysis

5. A scientist who is ______ experimental data checks to see if it supports the hypothesis.
   - A communicating
   - B questioning
   - C creating
   - D analyzing

6. Scientists publish their results in scientific journals and on the Internet to ______ their results.
   - A question
   - B analyze
   - C communicate
   - D check

**Critical Thinking**

On a sheet of paper, answer the following questions. Use complete sentences.

7. Describe how a scientist develops a hypothesis to test.

8. How does the control group help scientists test a hypothesis?

9. What should a scientist do when an experiment does not support a hypothesis?

10. Describe one method that a scientist could use to keep track of experimental data.
Using the Scientific Method

Scientists answer questions and solve problems in an orderly way. They use a series of steps called the scientific method. How can you use the scientific method to answer questions? You will find out in this lab.

Plants need several things to grow well. Among them are light, space, and air. Also, plants require liquid, but the amount and type of liquid used can vary. How important are these variables for plant growth?

Procedure

1. In a small group, discuss the question in the second paragraph above. Then write a hypothesis that you can test with an experiment. Choose one variable to test: amount of light or water, or the type of liquid used.

2. Write a procedure for your experiment, including any Safety Alerts. Use materials from the Materials list. The experiment should take eight days to complete.

3. Be sure your experiment changes, or tests, only one variable at a time. Include a control group in which you do not change any variables.

4. Draw a data table to record your data for eight days.

5. Have your entire procedure approved by your teacher. Then carry out your experiment.
**Cleanup/Disposal**
Before leaving the lab, clean up your materials and wash your hands.

**Analysis**
1. What variable did you change in this experiment?
2. What changes did you see among the bean seeds after Day 4? What changes did you see after Day 8?

**Conclusions**
1. Was your hypothesis supported by the results of your investigation? Explain.
2. What problems did you have in performing the experiment? What part of the procedure would you change to be more successful?

**Explore Further**
In your group, discuss the variables of plant growth that you did not test. Pick one of these variables to investigate in the future. Write a procedure to carry out your investigation.
Science is important to human society. It provides information that helps people make better decisions. It helps people understand what effect decisions can have today, as well as in the future.

**Theories and Principles**

Scientific information is based on centuries of work. It is through sharing information that human knowledge grows. As new evidence is discovered, scientific ideas and theories may change. A theory is a well-tested hypothesis that explains many scientific observations. One example is the theory of gravity. With so much evidence, there is almost no chance that this theory could be proved wrong.

Scientists often add to the understanding of a theory. This may refine the theory, but not prove it wrong. Theories are believed to be some of the greatest achievements in science. They show how far humans have come in understanding how the world works.

After years of research, some theories can become principles of science. A principle is a statement of a basic law or truth. Principles about the laws of motion have been tested and retested. Scientists will tell you, though, that even principles may be questioned. Everything can change as humans learn more about the universe.

**Science Myth**

*Myth:* Theories are scientific ideas that are often proven wrong.

*Fact:* For an idea to become a theory, it must be tested and proven repeatedly. Scientific theories are supported by evidence and accepted by other scientists.
What Makes a Good Scientist?

Good science depends on good scientists. A good scientist may be described as curious, honest, patient, and creative.

Many people become scientists because they are curious about the world. They start by asking questions. They are also **skeptical**, meaning they do not just accept all that they read or hear. If something does not seem to make sense, they will question it. Being skeptical also means that scientists constantly question their own beliefs, research methods, and results. This questioning leads to more knowledge and understanding.

**Ethics** also are an important part of science. Ethics are a set of **moral** principles that help a person decide what is right. They are guidelines for how a scientist should act. Scientists must be honest about what they learn and what it means. Sometimes this is difficult. People who pay them or work with them might be expecting different results. For example, the results of an experiment might show that a scientist's hypothesis was wrong. The scientist might want to change his or her results to appear correct. A scientist must remember that honesty is critical to good science.

Patience is another characteristic of a successful scientist. Good science takes time. Most of the changes in people's understanding of the world happen in bits and pieces. Major changes in thinking have happened, but discovery is usually a slow process. Each new finding adds another piece of the puzzle of how the world works.

Scientists also try to be **objective** when making observations or collecting data from experiments. That means that they focus on facts and scientific measurements. They try not to include personal feelings or opinions, which are **subjective**. Although no one can be completely objective, scientists try not to be biased. They need to make sure their observations are accurate. Subjective observations are important in art, music, and literature, but not in science.
Environmental scientists often work on issues, or problems, that affect people and society. They might focus on issues such as:

- How to create new energy sources that do not pollute
- How to provide clean water to the billions of people who need it
- How to provide enough food for Earth’s 6.4 billion people without harming the environment
- How to protect wild tigers or reintroduce wolves into Yellowstone National Park

Environmental scientists do not make decisions for society. Instead, they provide information to the members of governments, communities, and businesses who make decisions. This information can help people understand the possible consequences, or effects, of different actions. It can influence people’s decisions about how they interact with the environment. In this way, environmental scientists can make a difference.

Figure 1.6.1 Environmental scientists work to find solutions to problems that affect society.
Environmental Justice

Environmental problems also create many social problems around the world. Environmental justice means dealing with environmental problems in a way that treats everyone equally.

Knowing the consequences of decisions helps to answer many questions:

- How will the solution affect people's daily lives?
- Will it hurt some people more than others?
- Is the solution ethical?
- How will it affect people in the short-term?
- How will it affect people in the future?

In a world that practices environmental justice, all of these questions would be equally important. Every environmental decision would try to balance the positive and negative effects for all groups. These groups include people from different countries and people who make different amounts of money. They also include people of different races and people with different backgrounds. The whole world benefits when everyone is treated equally.

Technology and Society

The catalytic converter was invented in 1976. It reduces the amount of pollution that is released by an automobile's exhaust system. The converter changes engine exhaust into harmless materials. This helps reduce the amount of dangerous pollution in the air.
Lesson 6  REVIEW

On a sheet of paper, write the word from the Word Bank that completes each sentence correctly.

1. A ____ is a well-tested explanation that helps explain a variety of scientific observations.

2. A person’s feelings or opinions help them make _____ judgments.

3. “Energy cannot be created or destroyed” is a ____ because it is a basic law of science.

On a sheet of paper, write the letter of the correct answer.

4. Which of the following characteristics does not help a scientist perform good science?
   A disorganized  C curious
   B honest  D skeptical

5. A scientific theory _____ be disproved.
   A cannot  C might
   B should not  D will always

6. _____ are moral principles that guide people’s actions.
   A Objectives  C Ethics
   B Relationships  D Theories

Critical Thinking
On a sheet of paper, answer the following questions. Use complete sentences.

7. Which two characteristics of a good scientist do you think are most important? Explain your answer.

8. How are scientific principles and theories different?

9. Explain why it is important for scientists to be as objective as possible when doing research.

10. Give an example of how science works to improve society.
A Cleaner America

The U.S. Environmental Protection Agency (EPA) started in 1970. Its job is to protect human health and the environment. Before 1970, the U.S. government had few laws against releasing harmful chemicals into the environment. As a result, the EPA had to clean up a lot of pollution.

The EPA’s headquarters are in Washington, D.C. Approximately 18,000 EPA employees work throughout the United States. Some workers research ways to reduce air and water pollution. Other workers run educational programs for communities and businesses. EPA workers also measure pollution coming from businesses and make sure they follow environmental laws.

The EPA runs several types of waste programs. These programs make sure that dangerous chemicals are disposed of properly. Chemicals such as paint thinner and gasoline can pollute water and soil. That means these chemicals must be disposed of differently than other wastes.

The EPA also gives money and direction to help repair areas damaged by pollution. Through this effort, polluted land becomes a place where people can live and work again.

1. What is the mission of the Environmental Protection Agency?

2. Describe two services that the EPA provides.

3. How might the environment be different if the EPA had not been established?
Environmental science draws on many different sciences to help solve the world’s environmental challenges.

The environment has two parts: the natural environment and the built environment.

Living things have basic needs, including energy, oxygen, nutrients, and water. In addition, living things also need shelter, space to raise their young, and a place to live.

Almost all energy comes from the sun.

Scientists estimate that the earliest life forms appeared about 3.5 billion years ago. Humans emerged about 100,000 years ago.

Human societies first survived as hunters and gatherers. Later societies learned to farm and use machines to produce goods and services.

Since the 1800s, the world population has grown from 1 billion people to more than 6 billion.

In a sustainable society, natural resources are used in ways that ensure that there will be enough for current and future generations.

Environmental problems include population growth, overconsumption, pollution, climate change, biodiversity loss, and unequal distribution of resources.

Scientists use the scientific method to understand the universe.

A theory is an idea explaining many events that has been tested and retested. A principle is a basic law of science.

### Vocabulary

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Chapter 1 REVIEW

Vocabulary Review
On a sheet of paper, write the word or words from the Word Bank that best complete each sentence.

1. The ____ includes buildings where people live, work, and play.

2. Environmental science is called a(n) ____ because scientists apply scientific knowledge to solve environmental problems.

3. Soil, water, and plants are all examples of Earth's ____.

4. Two organisms that can breed together and produce offspring belong to the same ____.

5. It changes forms, but ____ is never created or destroyed.

6. Most living things on Earth need water, energy, ____, and oxygen to survive.

7. Environmental science studies the interaction between ____ and their environment.

8. Heat waves and light waves are types of ____.

9. When farmers use ____ on their crops, they can harm more than just the pests.

10. The scientific name for humans is ____.

11. The first humans were ____ who lived off the land and moved from place to place to find food.

12. During the ____ people started raising crops and animals.

13. During the ____, machines were used to provide goods and services to society.

14. A(n) ____ is one that uses resources in a way that meets the needs of current and future generations and other living things.

Continued on next page
15. When people use more resources than the environment can support, it is called _____.

16. The _____ is a series of steps that scientists follow to test possible answers to scientific questions.

17. An educated guess in science is called a(n) _____.

18. A(n) _____ has been well-tested and makes sense of a great variety of scientific observations.

**Concept Review**

On a sheet of paper, write the letter of the answer that completes each sentence correctly.

19. The human population has grown from 1 billion in the 1800s to more than _____ billion today.
   - A 2
   - B 6
   - C 9
   - D 12

20. A road is part of the _____.
   - A applied environment
   - B natural environment
   - C organic environment
   - D built environment

21. _____ are basic laws or truths that have been tested and retested over time.
   - A Variables
   - B Principles
   - C Values
   - D Hypotheses

22. The Industrial Revolution increased the amount of _____ released into the air.
   - A carbon dioxide
   - B ozone
   - C oxygen
   - D water vapor
Critical Thinking
On a sheet of paper, write the answers to the following questions. Use complete sentences.

23. List each step of the scientific method along with a short description of what happens during the step. Then explain why scientists use the scientific method.

24. Describe how people's lives changed as a result of the Industrial Revolution.

25. Describe five major environmental problems.

Test-Taking Tip
When studying for a test, work with a partner to write your own test questions. Then answer each other's questions. Check your answers.