LESSON 1 Our Island, Earth

Guiding Question: How does environmental science help us understand the natural world?

Knowledge and Skills

- Explain the focus of environmental science.
- Describe the recent trends in human population and resource consumption.

Reading Strategy and Vocabulary

Reading Strategy Create a KWL chart for each of the vocabulary terms in this lesson. Before you read, fill in what you know and what you want to learn. After reading, fill in what you learned.

Vocabulary environment, environmental science, environmentalism, natural resource, renewable natural resource, nonrenewable natural resource, sustainable, fossil fuel, ecological footprint

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1.1 LESSON PLAN PREVIEW

Real World Students list specific ways they influence the environment.

Differentiated Instruction Less proficient readers use different strategies to break the reading into manageable parts.

1.1 RESOURCES

Modeling Activity, *Finite Resources* • Graph It, *An Introduction to Graphing* • Map It Online • Lesson 1.1 Worksheets • Lesson 1.1 Assessment • Chapter 1 Overview Presentation

GUIDING QUESTION

FOCUS Have students write for two minutes about the term *environmental science*. Then, have them review what they have written. Call on volunteers to share what they wrote with the class. Use students' responses to launch a class discussion on how environmental science can promote understanding of the natural world.

VIEWED FROM SPACE, our home planet resembles a small blue marble suspended against a vast inky-black backdrop. Earth may seem vast here on its surface, but an astronaut's perspective reveals that Earth and its natural systems are limited. It has become clear that as our population and technological powers increase, so does our ability to change our planet and possibly damage the very systems that keep us alive.

Our Environment

Environmental scientists study how the natural world works, and how humans and the environment affect each other.

From space, Earth looks simple—blue oceans, green and brown land masses, white clouds—but this is not a complete picture of the environment. The **environment** includes all the living and nonliving things with which organisms interact. It includes the continents, oceans, clouds, and icecaps visible in the photo of Earth from space, but it also includes the animals, plants, forests, and farms that you cannot see from such a great distance. The environment includes remote areas rarely visited by people, but it also includes all of the buildings, urban centers, and houses that people have built, as well as the complex webs of social relationships that shape our daily lives.

Humans and the Environment Unfortunately, *environment* is often used to mean the nonhuman or "natural" world. But humans are part of nature. Like all other species on Earth, we interact with our environment and rely on a healthy, functioning planet for everything we need—including air, water, food, and shelter. Without a healthy environment, we cannot survive. Studying environmental science reminds us that we are part of the natural world and how we interact with it matters a great deal.

Understanding Human Influences Many people today enjoy longer life spans, better health, and greater material wealth than ever before. We can fly around the world with ease and cure previously incurable diseases with a pill. However, these improvements have often harmed the natural systems that sustain us, destroying habitats and polluting the water and atmosphere. The discovery that synthetic chemicals were harming Earth's ozone layer served as a wake-up call, illustrating how human influences can ultimately threaten long-term health and survival.

Environmental science is the study of how the natural world works, how our environment affects us, and how we affect our environment. Understanding interactions between humans and the environment is the first step toward solving environmental problems. The size and scope of these problems can seem overwhelming. However, with these problems also come countless opportunities for devising creative solutions. In the case of ozone depletion, a very real and effective solution has been found to a seemingly impossible problem. Scientists now predict that within fifty years, ozone depletion will be reversed and the ozone hole will be gone.

Environmental scientists study issues that are important to our world and its future. Right now, global conditions are changing quickly, but so is our knowledge and understanding of the natural world. With such large challenges and opportunities, this particular moment in history is a very exciting time to be studying environmental science.

✓ Reading Checkpoint *Why do people need the natural world?*

ANSWERS

Reading Checkpoint People rely on the natural world for everything they need to survive.

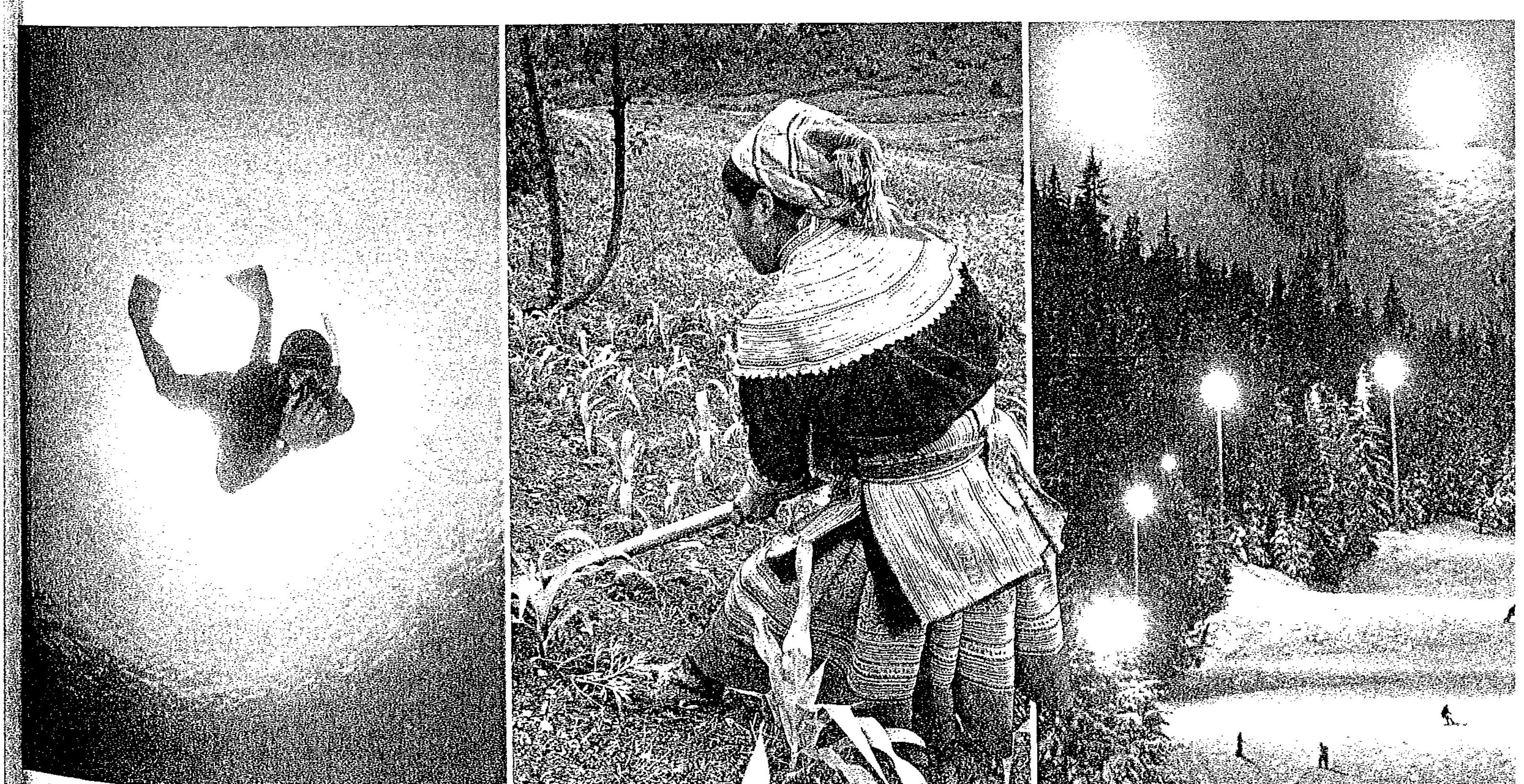

FIGURE 1 Humans in the Environment For better or worse, people—just like every other species—affect the environment. Unlike other species, however, our actions have the ability to do great harm, or great good, on a global scale.

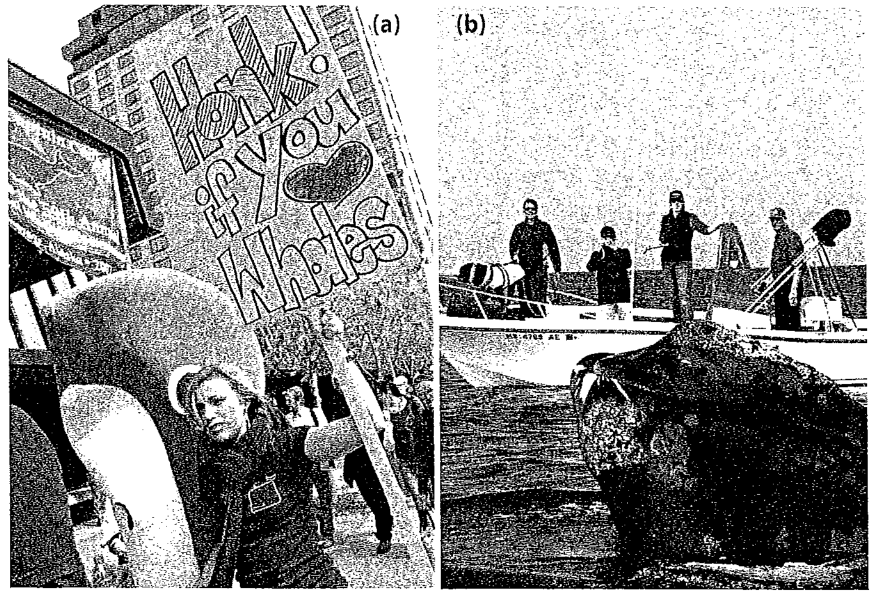

FIGURE 2 Environmentalism or Environmental Science? Can you tell which is which? **(a)** Environmentalists protest commercial whaling in Anchorage, Alaska, in 2007. **(b)** Environmental scientists from the New England Aquarium, in Boston, Massachusetts, collect data on right whales that will help them understand how the whales live in the wild.

Environmental Science vs. Environmentalism Many environmental scientists are motivated by a desire to develop solutions to environmental problems. Studying our interactions with our environment is a complex endeavor that requires expertise from many disciplines, including ecology, earth science, chemistry, biology, economics, political science, and others. Environmental science is thus an *interdisciplinary* field, one that borrows techniques from numerous disciplines and brings research results from these disciplines together.

Although many environmental scientists are interested in solving problems, it would be incorrect to confuse environmental science with environmentalism, or environmental activism. They are *not* the same, as shown in **Figure 2.** Environmental science is the pursuit of knowledge about the workings of the environment and our interactions with it. **Environmentalism** is a social movement dedicated to protecting the natural world—and, by extension, people—from undesirable changes brought about by human actions. Although environmental scientists may study many of the same issues environmentalists care about, they try to maintain an objective approach in their work, avoiding bias whenever possible. *Bias* is a preference or viewpoint that is personal, not scientific. Attempting to remain free from bias, open to whatever conclusions the data demand, is a hallmark of the effective scientist.

Population Up, Resources Down

In the last several hundred years, both human population and resource consumption have increased dramatically.

Inhabitants of an island must cope with limited materials, whether food, water, or other supplies. On our island Earth, human beings, like all living things, ultimately face environmental constraints. Specifically, there are limits to many of our **natural resources,** materials, and energy sources found in nature, that humans need to survive.

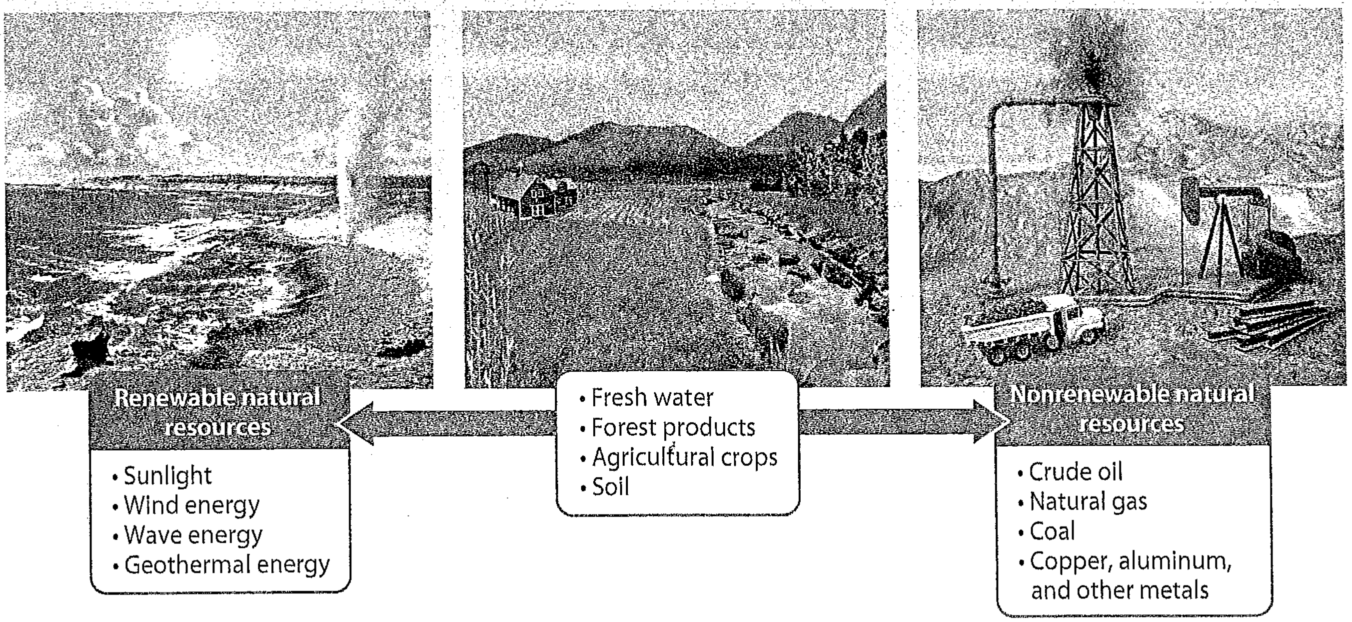

FIGURE 3 Natural Resources Natural resources lie along a continuum from always available and completely renewable to nonrenewable. Completely renewable resources, such as sunlight and wind energy, will always be there for us. Nonrenewable resources, such as oil and coal, exist in limited amounts that could one day be gone. Resources such as timber, soil, and fresh water can be renewed naturally if we are careful not to use them faster than nature can replace them.

Renewable or Nonrenewable? Nature "makes" natural resources in different ways and at varied speeds. Some natural resources, such as fruits and grains, are naturally replenished, or renewed, over short periods. These resources are **renewable natural resources.** In contrast, resources such as coal and oil are **nonrenewable natural resources** because they are naturally formed much more slowly than we use them. Once nonrenewable resources are completely depleted, or used up, they are gone forever.

▶ ***A Renewability Continuum*** As shown in **Figure 3,** the renewability of natural resources can be visualized as a continuum. Some renewable resources, such as sunlight, wind, and wave energy, are essentially available at all times. Nonrenewable resources, such as coal and oil, are at the other end of the continuum—for example, it takes millions of years of intense heat and pressure to form oil, but only a few hours to burn through a tank of gasoline.

▶ ***Sustainability*** In between these two extremes are natural resources such as fresh water, timber, and soil. These resources can renew themselves, but it takes some time—not millions of years like nonrenewable resources, but still months, years, or decades. These types of renewable resources may become nonrenewable if they are not used at a sustainable rate. Resource use is considered **sustainable** if it can continue at the same rate into the foreseeable future.

If nonrenewable resources and the "in between" resources like timber and water are used unsustainably, then we can run out of them. For example, lakes and reservoirs can dry up if the freshwater supplies are drained faster than rainfall and snowmelt can refill them. In recent years, consumption of natural resources has increased to unsustainable levels, driven by the growth of the largest human population in history.

Reading Checkpoint *How do we use resources sustainably?*

ANSWERS

Reading Checkpoint We use resources sustainably by using them at a rate that can continue for the foreseeable future.

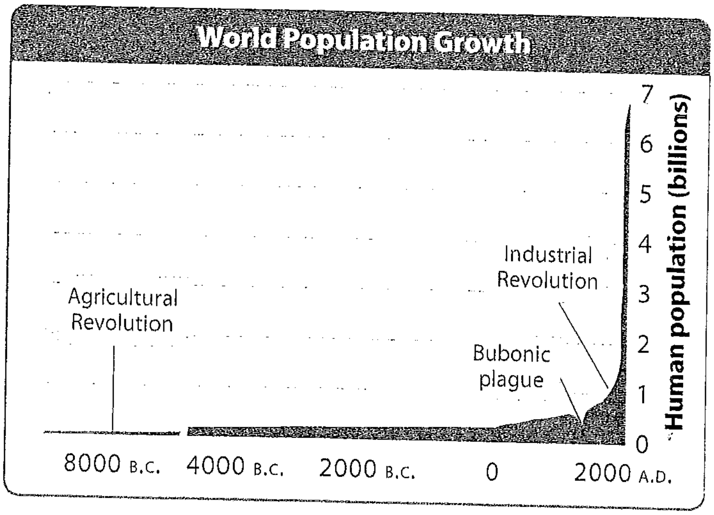

FIGURE 4 Human Population Growth For almost all of human history, our population was low and relatively stable. It increased significantly due to two events: the Agricultural Revolution and the Industrial Revolution. The only significant drop in population occurred when 25 million people died of bubonic plague in the 1300s.

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• Graph It An Introduction to Graphing

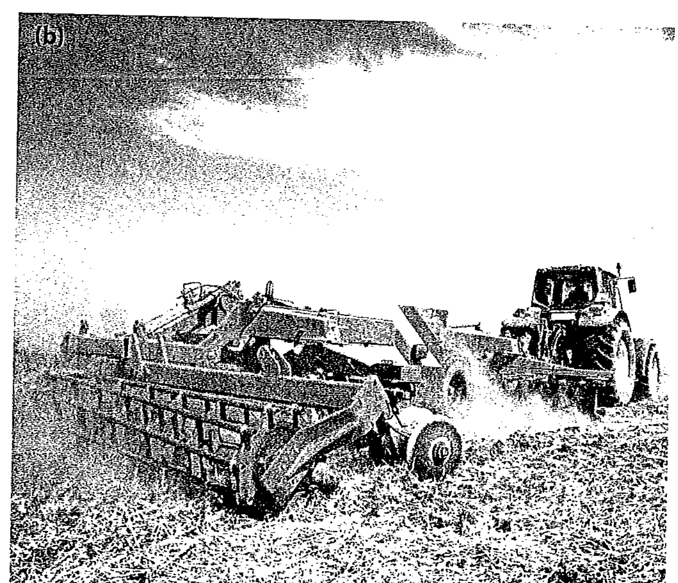
Human Population Growth For nearly all of human history, only a few million people lived on Earth at any one time. Although past populations cannot be calculated precisely, **Figure 4** gives you some idea of just how recently and suddenly our population has grown to about 6.8 *billion* people. We add about 78 million people to the planet each year—that's more than 200,000 people each day. Today, the rate of population growth is slowing, but our absolute numbers continue to increase and shape our interactions with one another and with our environment.

▶ ***The Agricultural Revolution*** The remarkable increases in population size can be attributed to two events in recent human history. The first was the transition from a hunter-gatherer lifestyle to an agricultural way of life. This change began around 10,000 years ago and is known as the *Agricultural Revolution.* As people began to grow crops, raise domestic animals, and live in villages, they found it easier to meet their nutritional needs. As a result, they began to live longer and to produce more children who survived to adulthood.

▶ ***The Industrial Revolution*** About 300 years ago in the early 1700s, the second event, known as the Industrial Revolution began. The *Industrial Revolution* describes the shift from rural life, with animal-powered agriculture, and handmade manufacturing, to an urban society powered by nonrenewable energy sources. These nonrenewable energy resources, such as oil, coal, and natural gas, are known as **fossil fuels.** The Industrial Revolution introduced many improvements. Medical technology advanced, sanitation improved, and agricultural production increased with the use of fossil-fuel-powered equipment and chemical fertilizers. Humans lived longer, had healthier lives, and over time, enjoyed new technologies like telephones, automobiles, and computers.

FIGURE 5 Less Time, More Power Technologies developed during the Industrial Revolution have made many tasks easier, but many of them require the use of nonrenewable resources. For example, **(a)** horses used to power plows, like this one from 1903, but **(b)** today gasoline powers plows.

(a)



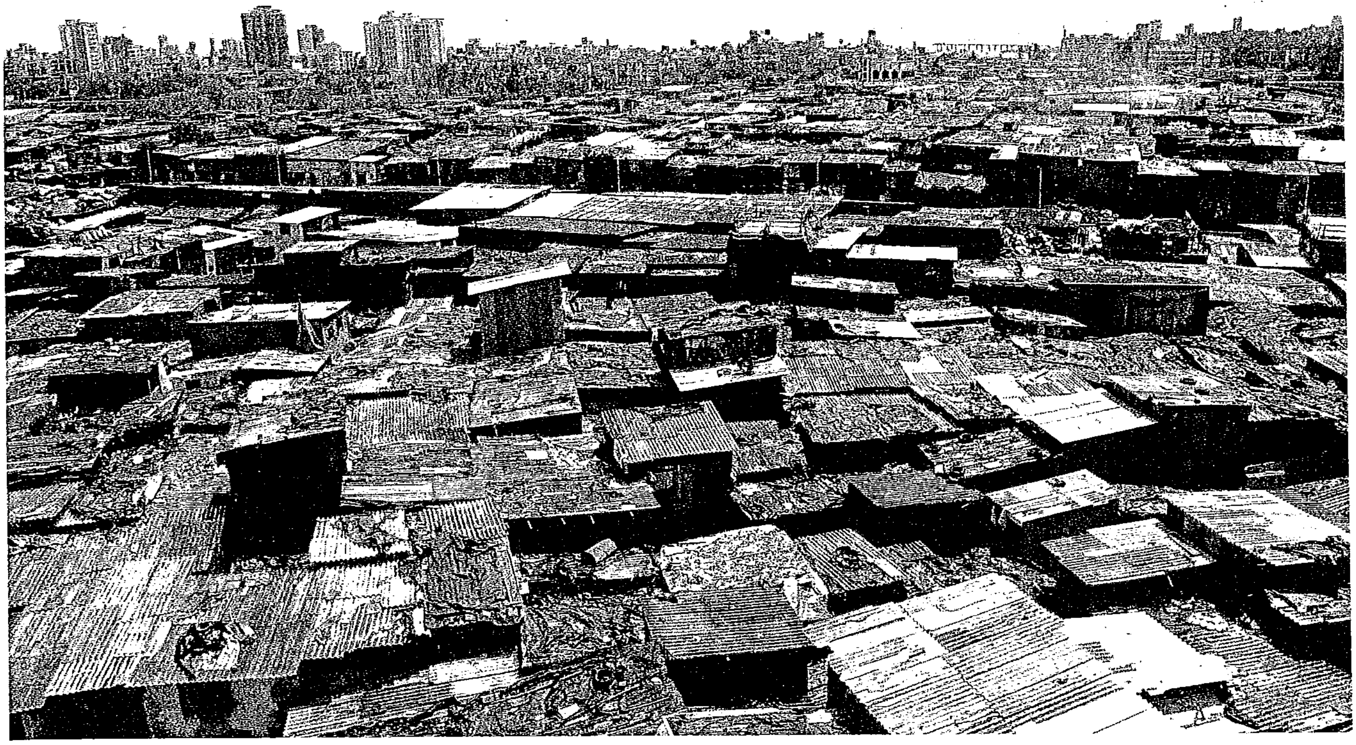


FIGURE 6 **Too Many People, Too Little Space** For residents of Mumbai, India, there simply aren't enough resources to go around. Many people live in extreme poverty within slums. This slum, Dharavi, is the largest in Mumbai. It is estimated to have a population of around 1 million people—the densest population of any city on Earth.

The Problem With Population Growth At the outset of the Industrial Revolution in England, population growth was regarded as a good thing. For parents, high birthrates meant more children to support them in old age. For society, it meant a greater pool of labor for factory work. British economist Thomas Malthus had a different opinion, however. Malthus claimed that unless population growth was controlled, the number of people would outgrow the available food supply until starvation, war, or disease arose and reduced the population. Malthus expressed his ideas in *An Essay on the Principle of Population*, published in 1798.

More recently, biologists Paul and Anne Ehrlich of Stanford University have warned that population growth will have disastrous effects on human welfare. In his book *The Population Bomb*, published in 1968, Paul Ehrlich predicted that the rapidly increasing human population would unleash famine and conflict that would consume civilization by the end of the twentieth century. Luckily for us, Ehrlich's forecasts have not materialized on the scale he predicted. Some, such as economist Julian Simon, think this dire prediction unlikely and maintain that technology can stretch our resources. However, concerned scientists warn that a global population crisis is still possible.

Ecological Footprints Population growth unquestionably leads to many environmental problems. However, it is not just the number of people on Earth, but how much we consume, that is to blame. Resource consumption can be quantified using the concept of the "ecological footprint," developed in the 1990s by environmental scientists Mathis Wackernagel and William Rees. An **ecological footprint** expresses the environmental effects of an individual or population in terms of the total amount of land and water required: (1) to provide the raw materials the individual or population consumes and (2) to dispose of or recycle the waste the individual or population produces. The ecological footprint concept is most commonly applied to humans, but every organism and natural or synthetic object has a footprint.

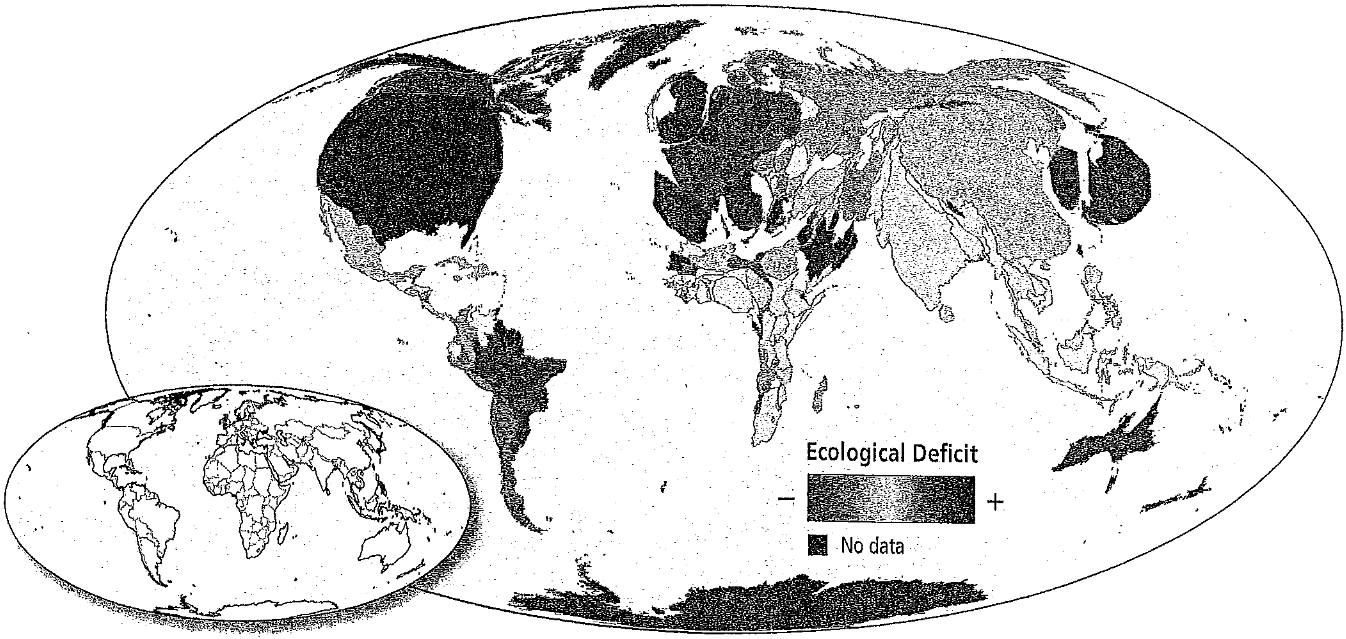
ANSWERS

What Do You Think? Students' opinions will vary but should be well supported.

Your world, your turn

WHAT DO YOU THINK?

What do you think accounts for the variation in sizes of ecological footprints among societies? Do you think that nations with larger footprints should have to reduce their effects on the environment, to leave more resources available for nations with smaller footprints?



Map adapted from 2003 World Consumption Cartogram, © Jerrard Pierce 2007.

FIGURE 7 Relative Footprints In this map, nation sizes have been altered to indicate their relative ecological footprints. Nations in red have positive ecological deficits, meaning that they have ecological footprints greater than the global average. These nations appear bloated on the map. In contrast, nations in shades of green have negative deficits and appear shrunken because their ecological footprints are below average.

ANSWERS

Map It For answers to the Map It activity, see page A–1 at the back of the book.

There is no universal way to calculate an ecological footprint. When looking at the footprint for a potato, for example, one group of researchers may include only the resources needed to grow the potato, while another group of researchers might include the resources needed to cook the potato as well. When comparing footprints, however, it does not matter what approach is used to calculate footprint values as long as it is used consistently. In this way, ecological footprints can be enormously useful as a tool to compare resource use across individuals or populations.

For example, by one set of calculations, the average American has an ecological footprint about 3.5 times that of the global average. Residents of other nations, such as Canada, Chile, and Australia, however, are consuming resources at a rate less than the global average. **Figure 7** shows one research group's summary of how footprints compare across the globe.

Map it

Comparing Ecological Footprints

The map in **Figure 7** uses data from the Global Footprint Network and *CIA World Factbook* to compare resource consumption in the world's nations. Each nation's shape has been stretched in proportion to its relative ecological footprint size. Color also serves to indicate how a nation compares to the world average.

1. **Interpret Maps** Describe how color is used in the map. What does green indicate? What does red indicate?
2. **Interpret Maps** Use the Internet or an atlas to identify five of the nations shown in the darkest shades of red.
3. **Infer** Use the Internet or other reference material to look up the ten nations with the largest gross national product (GNP), a measure of a nation's wealth. How does the wealth of a nation relate to its relative ecological footprint?

The Tragedy of the Commons What will happen if we use resources globally at an unsustainable rate? Increased resource use can cause what Garrett Hardin of the University of California at Santa Barbara called a *tragedy of the commons*. According to Hardin, unless resources are regulated, we will eventually be left with nothing.

▶ ***The Original "Commons"*** Hardin bases his argument on a scenario described in an 1833 English pamphlet describing public pastures, or "commons," that were open to unregulated community grazing. Hardin argues that the commons model, in which a resource is left unregulated, motivates individuals to increase their resource consumption. If the common is open to public use, why would anyone turn it down? But as more and more people acted in their own self-interest, in this case by adding animals to graze upon the pasture, a problem arose: The animals ate the grass faster than it could regrow. Eventually, no grass was left and all of the animals suffered. Hardin argues that when resources are unregulated, everyone takes what he or she can until the resource is depleted. No *one* takes responsibility, so *every*one eventually loses. As shown in **Figure 8**, tragedies of the commons still occur today.

▶ ***Learning From the Past*** How can the tragedy of the commons be avoided? The most obvious solution, perhaps, is for people sharing a common resource to voluntarily organize, cooperate, and enforce responsible use. Some have argued that this type of management is often impractical, and that private ownership of natural resources is the better option. With resource privatization, a regulating body, such as a government, gives each person a share of the resource that he or she controls instead of leaving resources open to everyone. While this strategy has potential with discrete resources such as minerals, fish, or farmland, privatization does not work as well with continuous, global resources such as the oceans or the ozone layer.

It is important for individuals and governments to consider every kind of solution for the diverse problems facing us today. One way or another, environmental scientists warn, we must address the rate at which resources are consumed—and soon.

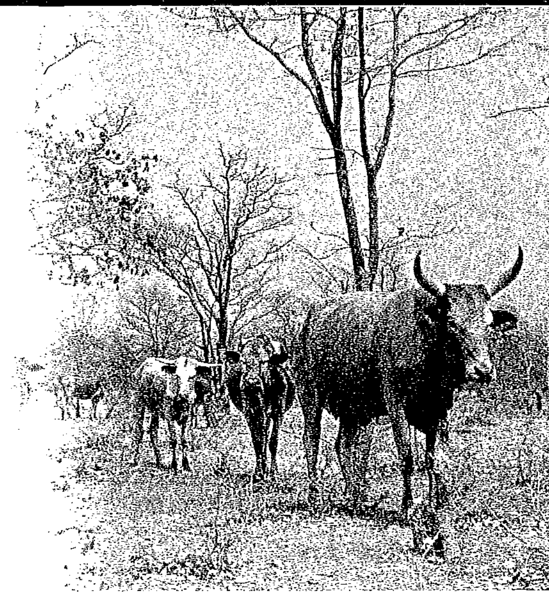


FIGURE 8 **A Modern-Day Tragedy of the Commons** Many parts of southern Africa are experiencing a tragedy of the commons today. Vast forested regions have been cleared to enable farming and ranching. Improper techniques coupled with overuse, however, are causing the land to dry up, making it unsuitable for the very crops and animals it was intended for.

ANSWERS

Lesson 1 Assessment For answers to the Lesson 1 Assessment, see page A-1 at the back of the book.

LESSON 1 Assessment

1. **Apply Concepts** Ecology is the study of how organisms interact with their environments. How is environmental science different from ecology? In what way is ecology part of environmental science? Explain.
2. **Form an Opinion** Do you think it is possible to have the benefits of the Agricultural and Industrial revolutions without the environmental costs? Explain why or why not.
3. **THINK IT *THROUGH*** Suppose you make your living fishing for lobster. You and everyone else are free to set out as many traps as you like. As more and more traps are set up, however, fewer and fewer lobsters are caught. Soon, lobster catches are too small to support your families. A meeting is coming up where you and your fellow lobster fishers will present possible solutions to this problem. What will you propose to combat this tragedy of the commons and restore the fishery?

LESSON 2

The Nature of Science

Guiding Question: What does it mean to "do science"?

Knowledge and Skills

- Explain what science is.
- Describe the process of science.

Reading Strategy and Vocabulary

Reading Strategy Before you read, write *process of science* on a piece of paper and draw a circle around it. As you read, make a cluster diagram using this circled phrase as your main idea.

Vocabulary hypothesis, prediction, independent variable, dependent variable, controlled study, data

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1.2 LESSON PLAN PREVIEW

Inquiry Students develop scientific questions and discuss ways to investigate them.

Differentiated Instruction Struggling students study the parts of a diagram to understand the process of science.

1.2 RESOURCES

Scientific Method Lab, *Green vs. Conventional Cleaners* • Lesson 1.2 Worksheets • Lesson 1.2 Assessment • Chapter 1 Overview Presentation

THE END OF THE WORLD AS WE KNOW IT? It seems like predictions of environmental catastrophe come out every day. Constantly, scientists are on television, the radio, in the newspapers, or on the Internet explaining their latest data—of a warming Earth, rising seas, and declining resources. On the other hand, there are reports that these environmental concerns are exaggerated and the science is flawed. How do we sort fact from fiction? Studying environmental science will outfit you with the tools that can help you to evaluate information on environmental change and to think critically and creatively about possible actions to take in response.

What Science Is and Is Not

Science is both an organized and methodical way of studying the natural world and the knowledge gained from such studies.

What is science? Modern scientists describe it as a systematic process for learning about the world and testing our understanding of it. The term *science* also refers to the accumulated body of knowledge that arises as a result of this process. Therefore, science is both a process of learning about the natural world and a summary of what we have already learned. Many scientists are motivated by the potential for developing useful applications of scientific knowledge and a desire to understand how the world works. Science is essential if we hope to develop solutions to the problems—environmental and otherwise—that we face.

Science and the Natural World Whether storm chasers waiting for tornadoes, or bird watchers waiting for a rare species, scientists work exclusively within the natural world. This includes every part of our physical environment, from the smallest atom to the largest galaxy. The natural world also includes the forces and energies that operate on and within our environment, such as gravity and solar radiation.

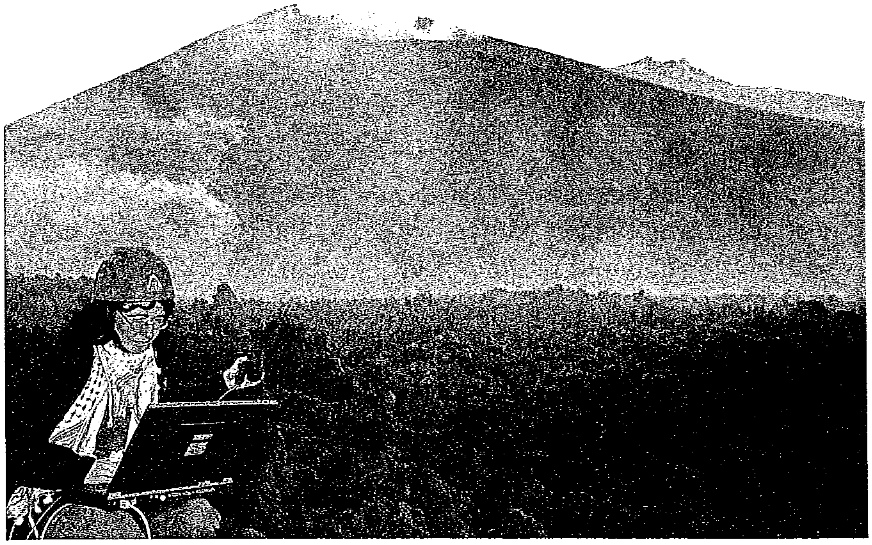
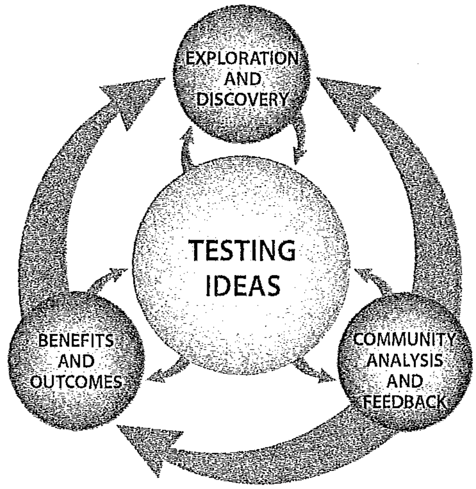


FIGURE 9 Gathering Evidence
A scientist takes and records readings as Mount Etna, a volcano in Sicily, Italy, erupts nearby.

Science assumes that the natural world functions in accordance with rules that do not change unpredictably from time to time or from place to place. The boiling point of pure water at sea level, for example, is 100°C. As long as you're at sea level, water will boil at 100°C today, tomorrow, and 1000 years from now, because boiling point is determined by rules of molecular attraction and bonding that do not change. The goal of science is to discover how the rules of the natural world operate and what effect they have. Science does *not* deal with the supernatural, which includes anything not governed by the rules of the natural world.

Science and Evidence Scientists examine the workings of the natural world by collecting evidence. They rely on their senses and test results for evidence. Then they use their reasoning abilities to figure out what that evidence suggests about the underlying processes at work. Ideas that cannot be tested against evidence gathered and analyzed in this way cannot be evaluated by science. For example, science cannot determine which flower is prettier, a rose or a tulip, even though roses and tulips are part of the natural world. The answer to this question is an opinion rooted in personal preference and not in scientific evidence. However, science can examine what percent of people prefer roses to tulips and under what conditions they might change their minds. Science can also help us learn about the chemical processes these flowers use to perform photosynthesis.

Science, Skepticism, and Change Nothing in science can be absolutely proven no matter how much evidence is collected. Instead, ideas can only be repeatedly supported by rigorous scientific testing.



Adapted from *Understanding Science*, www.understandingscience.org, UC Berkeley, Museum of Paleontology

FIGURE 10 The Process of Science Science involves many different people doing many different activities at different points in time. Testing ideas is at the heart of science, but it relies on constant interactions among scientists, society, and the larger scientific community. These interactions make science an ongoing, unpredictable, and dynamic process.

Note that Chapter 1 was done in collaboration with the University of California Berkeley, Museum of Paleontology. The Central Case covered in Chapter 1 is developed in more detail at its website **www.understandingscience.org.**

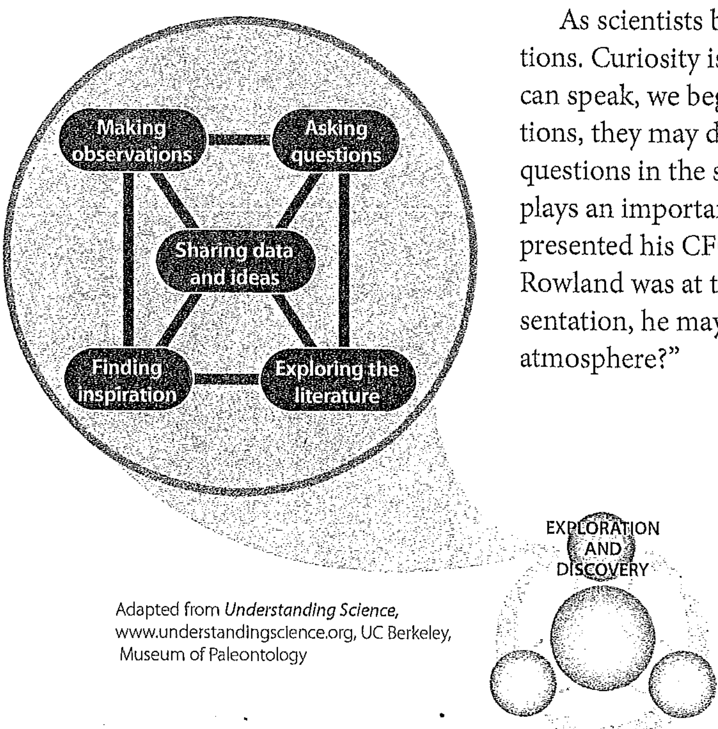
The Process of Science

The process of science involves making observations, asking questions, developing hypotheses, making and testing predictions, and analyzing and interpreting results—often many times and in many changing orders.

In their quest for understanding, scientists engage in many different activities: They ask questions, make observations, seek evidence, share ideas, and analyze data. These activities are all part of the dynamic process of science. There is nothing mysterious about the process of science; it uses the same reasoning abilities and logical steps that any of us might naturally follow, using common sense, to resolve a question. As practiced by individual researchers or research teams, the process of science typically consists of the components shown in **Figure 10.** Notice that the parts of the process do not proceed in a linear fashion. Real science usually involves many activities that loop back on themselves, building up knowledge as they proceed. In fact, science is at its heart a creative endeavor. Scientists take many different paths through the process depending on the questions they are investigating and the resources available to them.

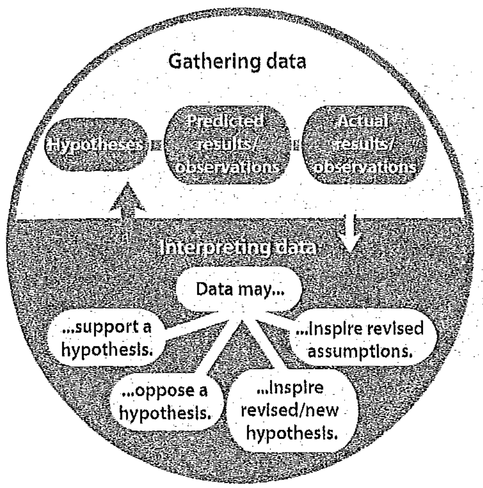
Exploration and Discovery Scientific investigations begin in many different ways, but the early stages of an investigation often involve the observation of some phenomenon that the scientist wishes to explain. Observations also function throughout the process as scientists gather evidence about their ideas. Observations can be made simply with the eye, or they can require sensitive instruments. Observations can happen unexpectedly, or they can be carefully planned after reading about other ideas and studies. Alternatively, by exploring the scientific literature, a scientist can stumble upon an interesting idea or phenomenon to test. Inspiration for scientific investigations can come from almost anywhere.

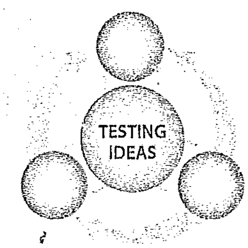
As scientists begin an investigation, they usually ask many questions. Curiosity is a fundamental human characteristic. As soon as we can speak, we begin asking questions. As scientists explore these questions, they may discuss them with their colleagues and read about similar questions in the scientific literature. Sharing ideas, like questioning, often plays an important role in the beginning of an investigation. Lovelock presented his CFC research at a scientific meeting in 1972. Sherwood Rowland was at the same meeting, and when he heard Lovelock's presentation, he may have asked: "What are the effects of CFCs in our atmosphere?"



Adapted from *Understanding Science*, www.understandingscience.org, UC Berkeley, Museum of Paleontology

FIGURE 11 Exploration and Discovery Observing, questioning, sharing ideas, and exploring the literature are all ways in which scientists can be inspired to investigate a phenomenon or problem.





Adapted from *Understanding Science*, www.understandingscience.org, UC Berkeley, Museum of Paleontology

FIGURE 12 Testing Ideas Gathering and interpreting data are at the center of scientific investigations. Generally, data either support or contradict a hypothesis, but occasionally data suggest that a test is not working as expected or inspire a new potential explanation.

ANSWERS

Figure 13 Chlorine atoms are released when CFCs are exposed to solar radiation.

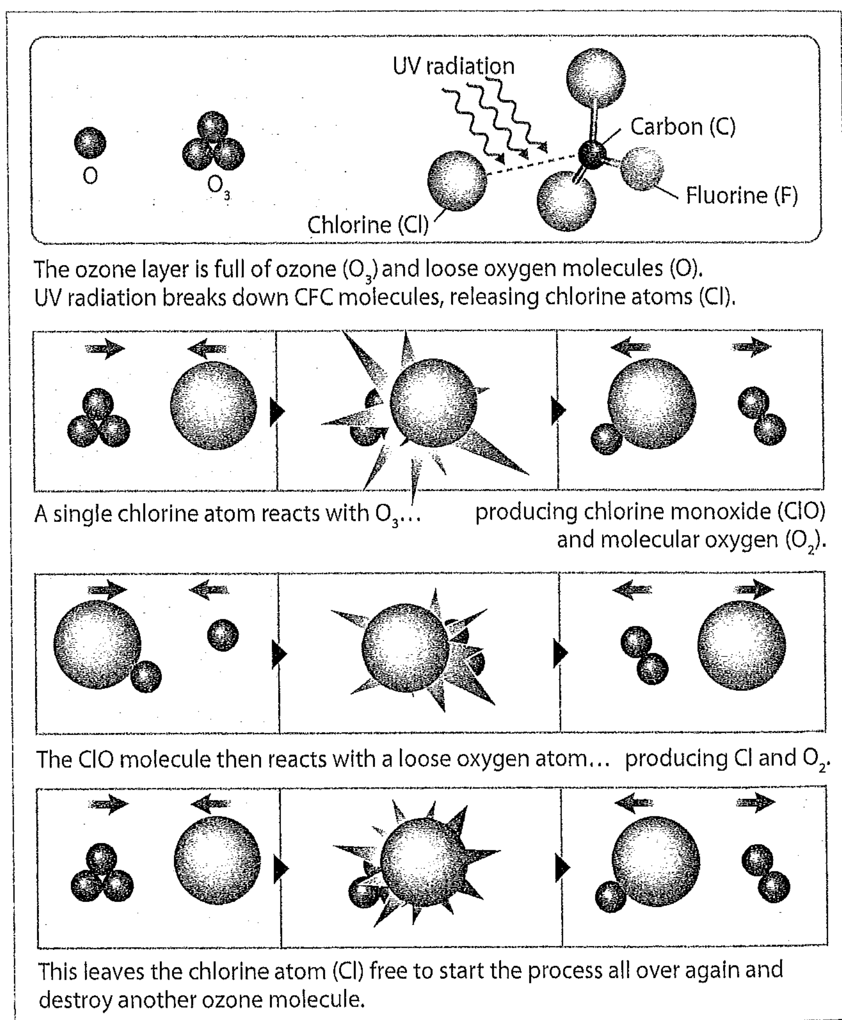
Testing Scientific Ideas As **Figure 12** shows, scientists attempt to answer their questions by devising explanations that they can test. A **hypothesis** is a testable idea that attempts to explain a phenomenon or answer a scientific question. Scientists often explore many hypotheses at the same time. Rowland, together with Mario Molina, developed the hypothesis that CFCs break down in the upper atmosphere and react with ozone, destroying it in the process.

Molina and Rowland came to this hypothesis after a review of the scientific literature on CFCs revealed no known process that affects CFCs in the lower atmosphere. Because nothing destroyed them, CFCs would eventually diffuse to the upper atmosphere. Both Molina and Rowland had backgrounds in chemistry and knew that solar radiation is far more intense in the upper atmosphere than in the lower atmosphere. Intense solar radiation, they reasoned, would break apart CFC molecules. What else was in the upper atmosphere for CFCs to react with? Ozone.

Molina and Rowland hypothesized that chlorine released from CFCs would react with the oxygen in ozone, as shown in **Figure 13.** These reactions are similar to the destructive reactions between nitrogen compounds and ozone that Paul Crutzen had studied more than five years before. Molina and Rowland calculated that one chlorine atom could destroy about 100,000 ozone molecules.

Connect to the Central Case

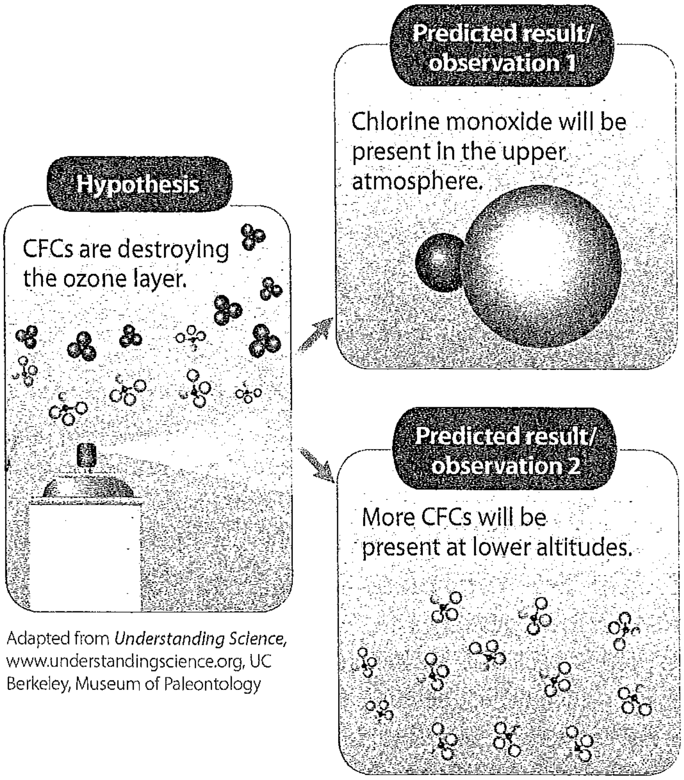
FIGURE 13 Chlorine and Ozone: A Bad Combination When a chlorine atom collides with ozone in the upper atmosphere, a chain reaction starts that results in the destruction of many—even tens of thousands—ozone molecules. **Interpret Diagrams** Where do the chlorine atoms in the upper atmosphere come from?



Adapted from *Understanding Science*, www.understandingscience.org, UC Berkeley, Museum of Paleontology

Connect to the Central Case

FIGURE 14 Molina-Rowland Hypothesis and Predictions Molina and Rowland's hypothesis that CFCs break down only in the upper atmosphere where they react with, and destroy, the ozone layer generated two key predictions: (1) Chlorine monoxide (ClO), a byproduct of CFC-ozone reactions, will be present in the upper atmosphere; and (2) more CFCs will be present at lower altitudes than higher altitudes.



Adapted from *Understanding Science*, www.understandingscience.org, UC Berkeley, Museum of Paleontology

▶ ***Predictions*** Scientists use hypotheses to generate **predictions,** which are specific statements about what we would expect to observe if the hypotheses are true. Sometimes figuring out what predictions a hypothesis generates is straightforward, but sometimes it is more difficult. The Earth's atmosphere is an immensely complex system. In fact, it is so complex that Molina and Rowland's fellow scientists, including Paul Crutzen, had to use mathematical models to generate predictions about what should be happening in the atmosphere if Rowland and Molina's ideas were correct.

▶ ***Modeling*** Scientists often use models to generate predictions when they cannot observe a phenomenon directly. Geologists, for example, cannot easily perform experiments to test the effects of tectonic plate motion! Instead, they build computer or mathematical models that represent the system they are studying. Later in this book, you will use a mathematical equation to calculate population sizes—a simple mathematical model that helps predict population size under a given set of conditions. While you will be able to solve the population equation easily, the mathematical models that tested Rowland and Molina's ideas were far more complicated and required a computer to solve.

The atmospheric models generated two predictions based on the Molina-Rowland hypothesis: (1) chlorine monoxide (ClO) should be present in the upper atmosphere, and (2) more CFCs will be present at lower altitudes. These predictions are shown in **Figure 14.**

Reading Checkpoint *What did Molina and Rowland hypothesize about the ozone layer?*

ANSWERS

Reading Checkpoint They hypothesized that CFCs break down in the upper atmosphere and react with ozone, destroying it in the process.

FIGURE 15 Caught on Camera Remote, motion-activated cameras help scientists gather data on hard-to-find rainforest animals.

Gathering Data Scientists test predictions by gathering evidence. If the evidence matches their predictions, the hypothesis is supported, and if the evidence doesn't match the predictions, the hypothesis is contradicted. There are many different ways to test predictions, including experiments and observational studies. Depending on the scientific question being investigated, one type of test might be more useful than others.

▶ ***Experiments*** An *experiment* is an activity designed to test the validity of a prediction or a hypothesis. It involves manipulating *variables,* or conditions that can change. Consider the hypothesis that fertilizers stimulate algal growth. This hypothesis generates the prediction that adding agricultural fertilizers to a pond will cause the quantity of algae in the pond to increase. A scientist could test this prediction by selecting two similar ponds and adding fertilizer to one while leaving the other in its natural state. In this example, fertilizer input is an **independent variable,** a variable the scientist manipulates, whereas the quantity of algae that results is the **dependent variable,** one that depends on the conditions set up in the experiment.

Of course, some hypotheses cannot easily be tested with experiments. In these cases, the appropriate experiment might take too long or might be too expensive, dangerous, or ethically questionable. For example, a doctor studying the effects of solar radiation on humans would not knowingly place human subjects in potentially harmful conditions. And in other cases, experiments are simply impossible. Earth only has one atmosphere and CFCs were already present in it when Molina and Rowland began investigating a possible link to ozone destruction. A simple experiment could not answer their question. Experiments are just one way that scientists carry out their research.

Reading Checkpoint *What is the difference between an independent and dependent variable?*

ANSWERS

Reading Checkpoint An independent variable is manipulated by the scientist; a dependent variable changes depending on the conditions set up in the experiment.

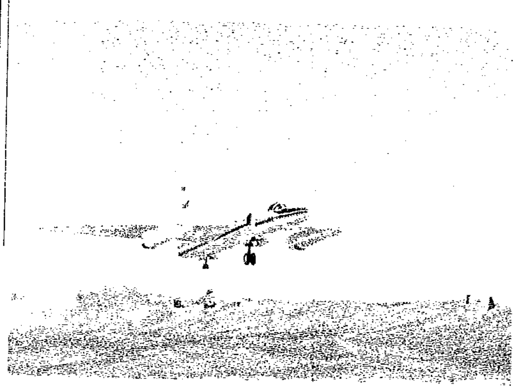


FIGURE 16 Up in the Air James Anderson and his team collected data using weather balloons and a NASA ER-2 stratospheric research aircraft like this one.

▶ *Observational Studies* Observational studies provide another key source of scientific evidence. In an observational study, scientists look for evidence in the natural world that would help confirm or contradict the predictions generated by their hypotheses. Observational studies often rely on *correlation*, a meaningful and predictable relationship among variables. In the mid-1970s, scientists searched for evidence about whether or not CFCs were destroying the ozone layer using observational studies. They used planes and high-altitude balloons to collect data about CFC and chlorine monoxide concentrations at different altitudes. They were looking for the predicted correlations between altitude and the levels of these chemicals. If Molina and Rowland were right, the evidence should show high CFC levels at low altitudes and chlorine monoxide at high altitudes.

▶ *Controlled Variables and Repetition* Scientists studying cause-and-effect relationships are careful to manage the variables in their tests; that is, they try to keep all variables constant except the one whose effect they are testing in a study. *Controlled variables* are variables kept constant in a study. **Controlled studies,** in which all variables are controlled except one, allow scientists to be more confident that any differences observed were caused by the factor they are investigating.

Controlled variables are important in both experimental and observational tests. For example, in the pond experiment described earlier, the scientist would try to pick two ponds that are as similar as possible—same geographic region, same temperature, and so on—in order to be confident that any difference in algal growth was caused by the fertilizer and not one of the other variables. In the tests of the Molina-Rowland hypothesis, the scientists tried to make their observations of CFC levels at different altitudes in exactly the same way—same instruments, same technique, and so on—to be confident that the different levels detected were related to altitude and were not a result of the measurement technique.

Whenever possible, it is best to repeat the same test many times. For example, our wetlands scientist could perform the same experiment on, say, ten pairs of ponds, adding fertilizer to one of each pair. Repetition is also important in observational tests. To test the Molina-Rowland hypothesis, James Anderson and the other scientists studying chlorine monoxide levels in the atmosphere repeated the same measurements on three different days in order to be more confident in their results.

✓ Reading Checkpoint *What does it mean for variables to show correlation?*

ANSWERS

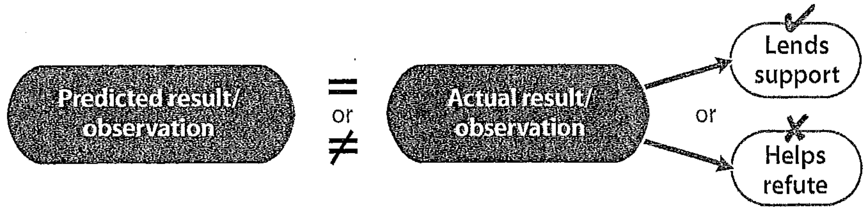
Reading Checkpoint It means there is a meaningful and predictable relationship between the variables.

Go Outside

1. Students should notice that decimals make metric measurements easier to record and convert.
2. Answers will vary. Students may mention liter bottles.

Figure 19 There is a high CFC concentration at low altitudes and a sudden drop-off at higher altitudes.

FIGURE 17 Underwater Science Divers surveying a reef off of Kanton Island in the Pacific Ocean carefully measure and document fragile table coral.



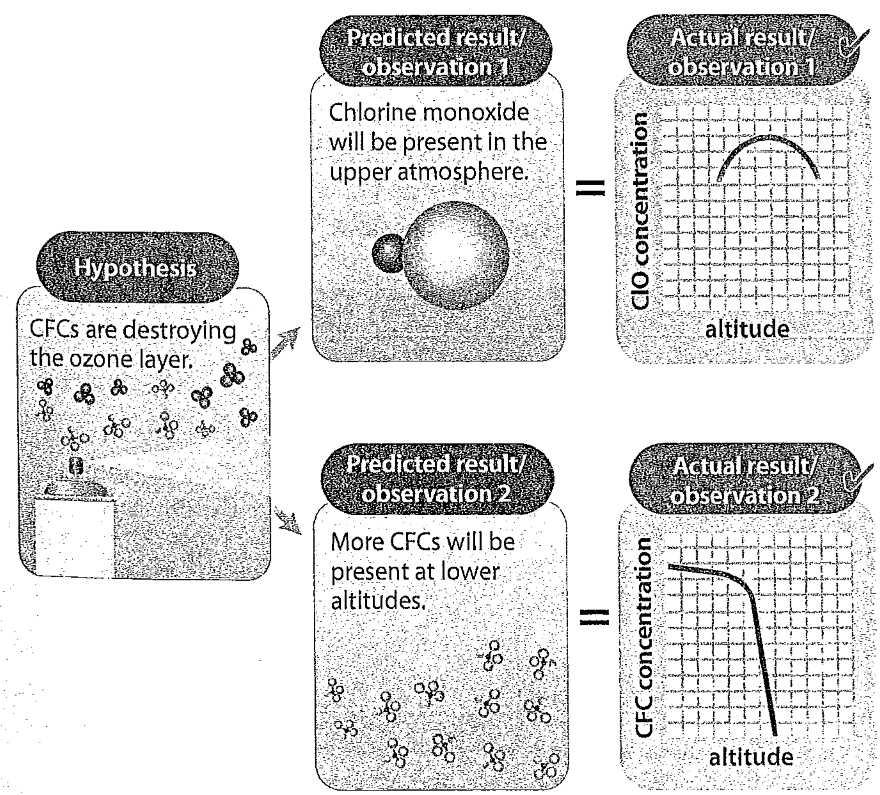
Adapted from *Understanding Science*, www.understandingscience.org, UC Berkeley, Museum of Paleontology

FIGURE 18 What Can Data Do for You? Most data gathered and analyzed in the course of a scientific investigation will either lend support to a hypothesis or will help to refute it. Data cannot prove or disprove any hypothesis.

▶ ***Interpreting Data*** Scientists collect and record **data,** or information, from their studies. They particularly value *quantitative* data (information expressed using numbers) because numbers provide precision and are easy to compare. The scientists testing the first CFC model prediction quantified the concentration of chlorine monoxide in the upper atmosphere. For the second prediction, that CFCs should remain intact in the lower atmosphere but break apart in the upper atmosphere, scientists quantified the concentration of CFCs at different altitudes.

Generally, data in the form of results and observations either lend support to or help to refute a hypothesis, as shown in **Figure 18.** If many tests refute a hypothesis, the scientist will ultimately have to reject that hypothesis. It is important to remember, though, that science is always tentative: We can never completely *prove* or *disprove* an idea. Science is always willing to revise its ideas if warranted by new evidence.

In 1975, two research groups measured CFC concentrations at various altitudes. Their data matched the predictions of the mathematical models, and therefore supported the hypothesis that CFCs destroy the ozone layer. And in 1976, James Anderson's team detected chlorine monoxide concentrations in the upper atmosphere consistent with the predictions of atmospheric models, providing further support.



Adapted from *Understanding Science*, www.understandingscience.org, UC Berkeley, Museum of Paleontology

Go Outside

Measure for Measure

⚠

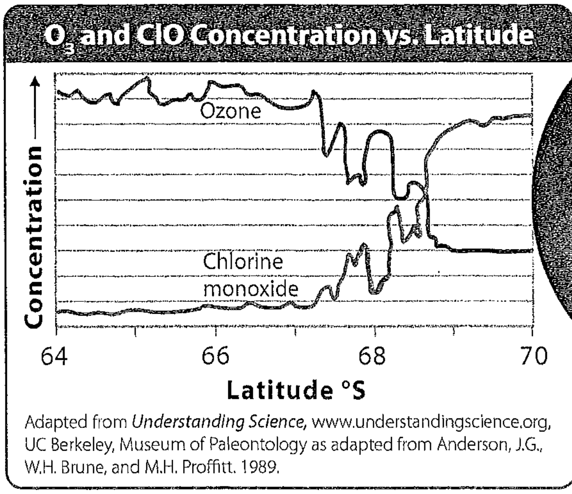
1. Use string, scissors, and a marker to capture the diameter of three trees in your neighborhood.
2. Use both a yard stick and a meter stick to record the diameter of each tree. Place the data in a comparison table, using both inches and centimeters. Be as precise as you can in taking the measurements.
3. Calculate the average diameter of the three trees, in inches and centimeters.
4. Convert your average into yards and meters.

Analyze and Conclude

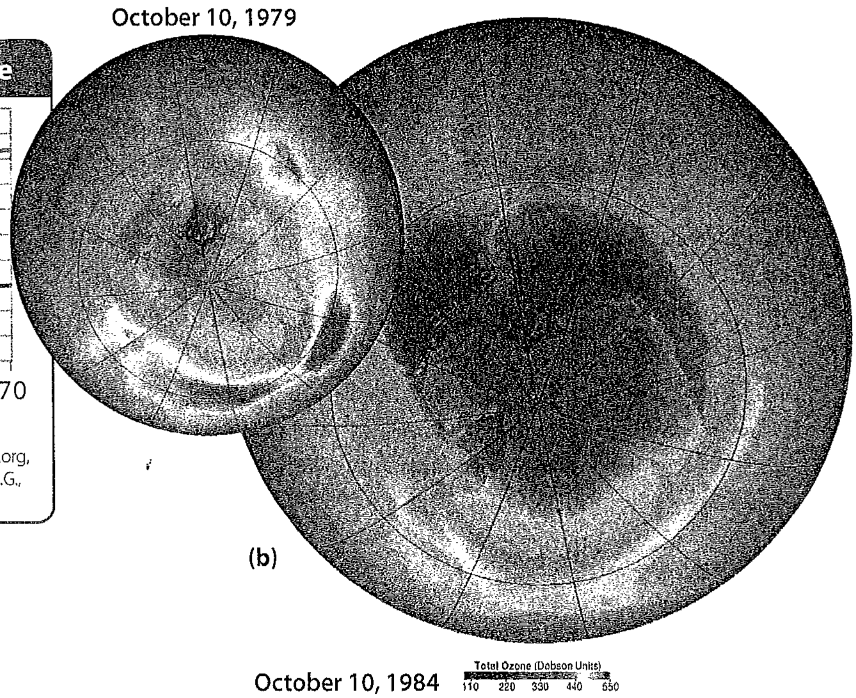
1. **Compare and Contrast** Which type of measure was easiest to work with and why?
2. **Communicate** What everyday objects use metric units?

Connect to the Central Case

FIGURE 19 Gathering Support Both of the predictions generated by the Molina-Rowland CFC hypothesis were supported by data gathered by researchers in the mid-1970s. **Interpret Graphs** Describe how CFC concentration changes with altitude according to the graph.



(a)



(b)

Connect to the Central Case

FIGURE 20 An Ozone Decline in Space and Time (a) James Anderson found that within the "ozone hole," ozone levels are low and ClO levels are high—just as predicted by the Molina-Rowland hypothesis. **(b)** NASA satellite data confirm Joseph Farman's ozone findings—increasingly low levels of ozone (purple and blue) over Antarctica beginning around 1979. **Interpret Graphs** According to the graph, at what latitudes are ozone concentrations the lowest?

ANSWERS

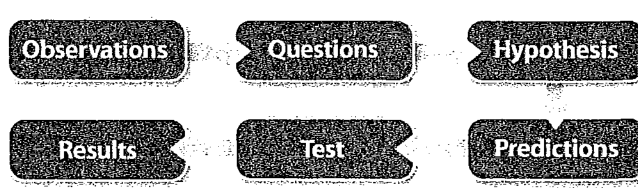
Figure 20 69°S and 70°S

Lesson 2 Assessment For answers to the Lesson 2 Assessment, see page A-1 at the back of the book.

Then, in 1982, a scientist named Joseph Farman detected a 40 percent drop in ozone concentration over the Antarctic. He had been collecting ozone readings since 1957 and had never encountered such a dramatic shift. The following year, he detected another steep decline. Reanalyzing data he had collected since 1977, Farman realized that ozone concentration had been steadily declining. Together with NASA scientists, Farman had discovered the "ozone hole," a region of depleted ozone the size of the United States in the atmosphere above Antarctica. The extent of ozone damage was greater than scientists had predicted. Further study showed that clouds of ice particles over Antarctica sped up ozone destruction. The evidence all pointed to one fact—CFCs were indeed destroying the ozone layer.

LESSON 2 Assessment

1. **Compare and Contrast** What makes science different from other subjects you study in school, such as writing, history, or language?
2. **Explain** Some people think that *science* can be defined as "a collection of facts." Explain why that is an inaccurate definition, and, in your own words, write your own definition of science.
3. (Explore the **BIG**QUESTION) Why is the process of science better represented by the diagram shown in **Figure 10** than by a diagram like the one seen here?



The Community of Science

LESSON 3

Guiding Question: What happens to a scientific study after data have been gathered and the results are analyzed?

Knowledge and Skills

- Describe the major roles of the scientific community in the process of science.
- Explain the study of environmental ethics.

Reading Strategy and Vocabulary

Reading Strategy As you read, make a T-chart that identifies and explains the main concepts of this lesson.

Vocabulary peer review, theory, ethics, environmental ethics

SCIENTIFIC WORK takes place within the context of a community of peers. Molina and Rowland built upon the observations of James Lovelock and others. Other scientists, including James Anderson, tested the predictions of Molina and Rowland. With each discovery, the scientists talked with peers and published their work, making their data accessible to the entire scientific community.

MyEnvironmentalScience.com

1.3 LESSON PLAN PREVIEW

Differentiated Instruction ELLs explore the scientific and popular uses of *theory*.

Real World Students describe examples of how science and society affect each other.

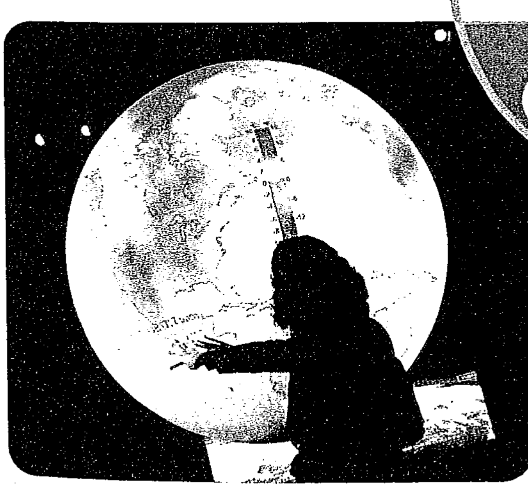
1.3 RESOURCES

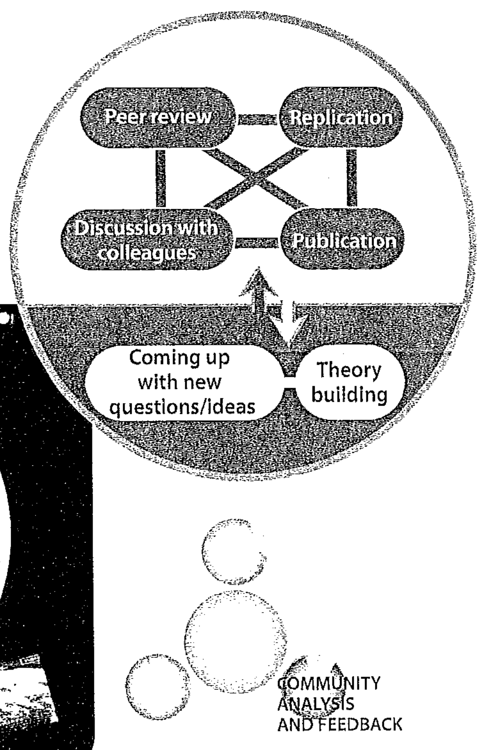
In Your Neighborhood Activity, *Local Research Studies* • Bellringer Video, *Eco-Friendly Food Labels* • Lesson 1.3 Worksheets and Assessment

Community Analysis and Feedback

The scientific community, through peer review and replication, helps to verify the accuracy of results and contributes to the establishment of scientific theories.

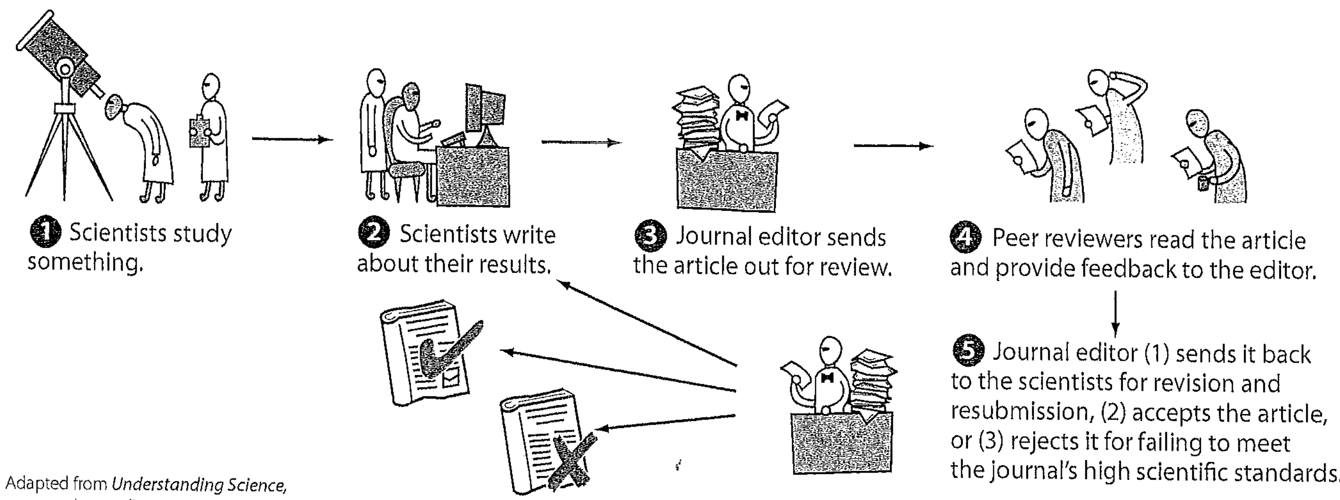
When a researcher's work on a particular test or idea is done, he or she writes up the findings. Frequently, scientists will present their work at professional conferences, where they interact with colleagues and receive informal comments on their research. Such feedback from colleagues can help improve the quality of a scientist's work before it is submitted to a journal for publication.





Adapted from *Understanding Science*, www.understandingscience.org, UC Berkeley, Museum of Paleontology

FIGURE 21 Community Analysis and Feedback Science does not end in the lab or field. Interactions within the scientific community help ensure accuracy and build consensus.



Adapted from *Understanding Science*, www.understandingscience.org, UC Berkeley, Museum of Paleontology

FIGURE 22 Peer Review Results published in peer-reviewed journals are the most respected in science because they have passed through a rigorous evaluation process involving feedback from multiple sources.

Peer Review Once a manuscript is submitted for publication, several other scientists specializing in the topic of the paper examine it. This procedure, known as **peer review**, is a more formal way for the researcher to get comments and criticism from the scientific community. If the reviewers feel the article should be published, the journal may publish it as is or ask the scientists to address comments and turn in a final paper. If, however, the peer reviewers are not satisfied with the work, the journal will not publish the article. Peer review is a valuable guard against faulty science contaminating the literature on which all scientists rely. The peer review process is summarized in **Figure 22.**

Replication Sound science is based on replication rather than a one-time occurrence. Even when a hypothesis appears to explain observed phenomena, scientists are always willing to consider other scientific explanations. After test results are published, other scientists may attempt to reproduce the results by performing their own experiments and data analysis. Generally, a hypothesis must be repeatedly tested and results replicated in various ways before scientists are willing to accept it.

ANSWERS

Quick Lab

1. Answers will vary.
2. Sample answer: So other scientists can replicate the procedures and results

Quick Lab

Can You Repeat That?

1. Together with a partner, arrange ten objects, such as pencils or blocks, into an unusual shape or structure.
2. Write directions that another team can use to replicate your shape or structure without seeing it.
3. Exchange directions with another team. Replicate that team's shape or structure by following their directions. You may not ask questions of the team or look at their original design.
4. Compare each replicated shape or structure to the original.

Analyze and Conclude

1. **Evaluate and Revise** Identify the places where you could have written clearer instructions. Revise your instructions and swap them with another team. Did the instructions work better the second time?
2. **Infer** Why is it important that procedures be included in published scientific papers?

Self-Correction in Science As the scientific community accumulates data in any given area of research, interpretations may change. Most of the time, the changes are minor, small adjustments rather than complete revisions. However, science may go through revolutions in which one strongly held scientific view is abandoned for another.

For example, before the sixteenth century, scientists thought that Earth was at the center of the universe. Their data on the movements of planets fit that concept quite well, yet the idea was eventually shown to be false by Nicolaus Copernicus. Such revolutions in scientific thought demonstrate the strength and vitality of science, showing it to be a process that refines and improves itself through time. Science is self-correcting, and understanding how science works is vital to assessing how scientific ideas and interpretations change through time as new information accrues.

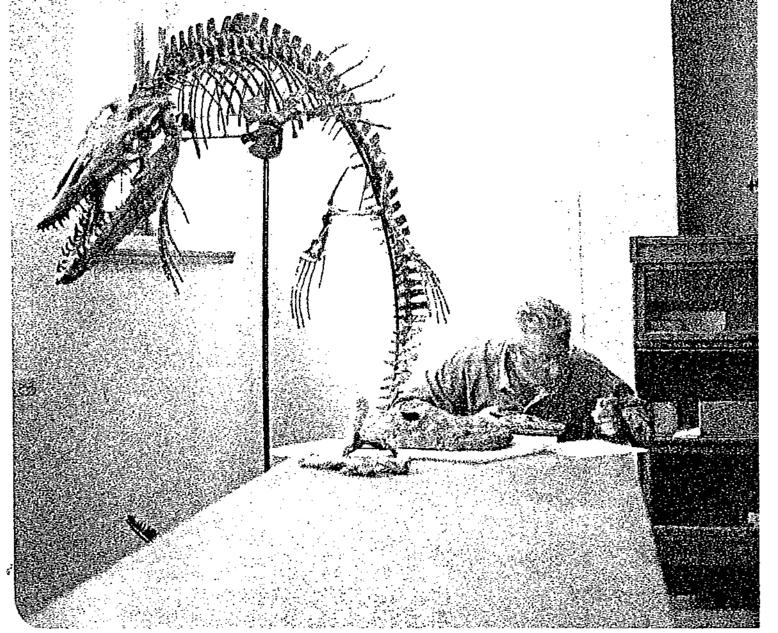


FIGURE 23 The Evolution of a Theory Paleontologist Neil Shubin sketches a 375-million-year-old fossil of *Tiktaalik roseae*. It is a fish, but has many characteristics of a land animal. Near Dr. Shubin is a fossil of an ancient whale. Notice its legs, evidence that whales evolved from terrestrial ancestors. Scientists have been adding to and refining Darwin's theory of natural selection for more than 150 years, making it among the strongest theories in science.

Scientific Theory-Building Hypotheses are explanations for a fairly narrow set of phenomena, while **theories** are broader explanations that apply to a wider range of situations and observations. For example, Molina, Rowland, and others formed specific hypotheses about the ozone-depleting chain of chemical reactions in the upper atmosphere. These specific hypotheses were based on broader chemical and physical theories that deal with how *all* atoms and molecules interact with one another. It is not always clear when an explanation should be called a hypothesis and when it should be called a theory. Some scientists view Molina and Rowland's set of ideas about ozone depletion as a *theory*, and others view it as a *hypothesis*. Regardless of what we choose to call it, their explanation has been supported by many different lines of evidence and is broadly accepted by the scientific community.

Note that scientific use of the word *theory* differs from popular usage of the word. In everyday language when we say something is "just a theory," we are suggesting it is an idea without much substance. Scientists, however, mean just the opposite when they use the term. To be accepted as a *scientific theory*, an idea must effectively explain a phenomenon, make accurate predictions in a wide range of situations, and have undergone extensive, rigorous testing. Scientists are extremely confident in accepted theories. Darwin's theory of evolution by natural selection, for example, has been supported and elaborated upon by many thousands of studies over 150 years of intensive research. Other prominent scientific theories include atomic theory, cell theory, the big bang theory, plate tectonics, and the theory of general relativity.

✓ Reading Checkpoint *Why isn't anything in science "just" a theory?*

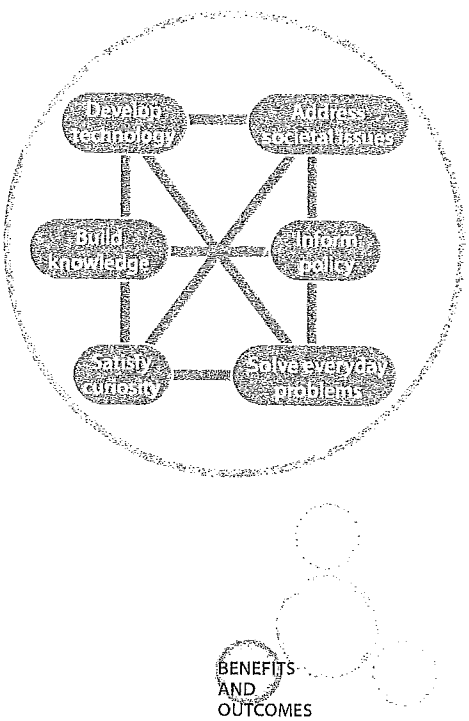
BIG QUESTION

How do scientists uncover, research, and solve environmental problems?

Empathize Bring students' attention to the Big Question. Point out that one way scientists seek to solve environmental problems, like a polluted river, is by sharing their results with the public. Have students explain how scientists must feel when their results are dismissed as "just a hypothesis," or "just a theory." Then, have students develop a short presentation that scientists could use to help the public understand the scientific definitions of *hypothesis* and *theory*.

ANSWERS

Reading Checkpoint Theories in science have undergone extensive testing; they are the best-supported explanations available, not guesses.



Adapted from *Understanding Science,* www.understandingscience.org, UC Berkeley, Museum of Paleontology

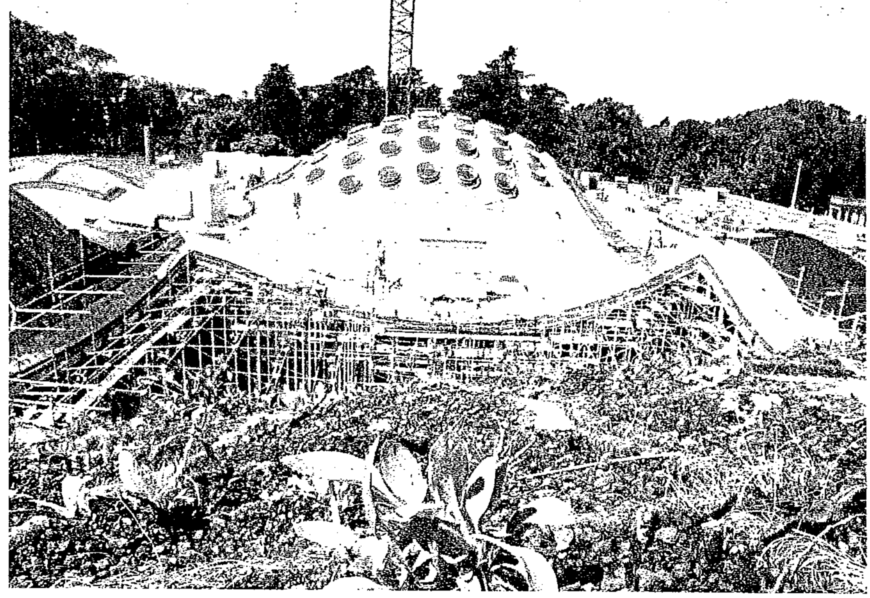


FIGURE 24 Benefits and Outcomes Science does not occur in isolation. Society, especially its ethical standards and worldview, influences science, just as science influences society. Science and society work together to build knowledge, satisfy curiosity, address issues, inform policy, solve problems, and develop technology. One scientific benefit and outcome is this green roof atop the California Academy of Sciences building in San Francisco. Green roofs like this one reduce energy demands and provide wildlife habitat.

Benefits and Outcomes

Environmental ethics explores how environmental science interacts with, and is guided by, a society's morals and principles.

Environmental scientists ask questions, test hypotheses, conduct experiments, gather and analyze data, and draw conclusions about environmental processes. Beyond the simple satisfaction of generating results, their work has helped contribute to our overall knowledge of the environment and has led to the development of new technologies. But the work does not end with the science. To address environmental problems, we need more than an understanding of the science—we also need to understand how people value their environment. To value something is to think it is important. Economics, covered in the next chapter, deals with how things are valued in terms of money. Ethics deals with how things are morally valued. Scientific knowledge can affect our social, ethical, and economic decision making.

Ethics Ethics is a branch of philosophy that involves the study of behavior: good and bad, right and wrong. The term *ethics* can also refer to the set of moral principles or values held by a person or a society. Ethical standards are grounded in values—for instance, promoting human welfare, maximizing individual freedom, or minimizing pain and suffering. We all use our own set of ethical standards as tools for making decisions, consciously or unconsciously, in our everyday lives. Governments and decision makers also employ ethics when deciding on public policy.

Culture and Worldview People of different cultures may differ in their ethical standards. *Culture* is the ensemble of knowledge, beliefs, values, and learned ways of life shared by a group of people. Culture, together with personal experience, influences each person's perception of the world and his or her place within it, something described as the person's *worldview.* Worldview and culture can influence what a scientist chooses to study or where to look for inspiration. Worldview reflects a person's or group's beliefs about the meaning, operation, and essence of the world.

You may be wondering why we are discussing beliefs in a book about science—especially because we have said that scientists do not *believe* in a scientific idea, they accept or reject it based on evidence. Although scientists strive to be objective, worldview influences how society interprets and acts on the results science produces. People with different worldviews can study the same situation and review identical data yet draw dramatically different conclusions.

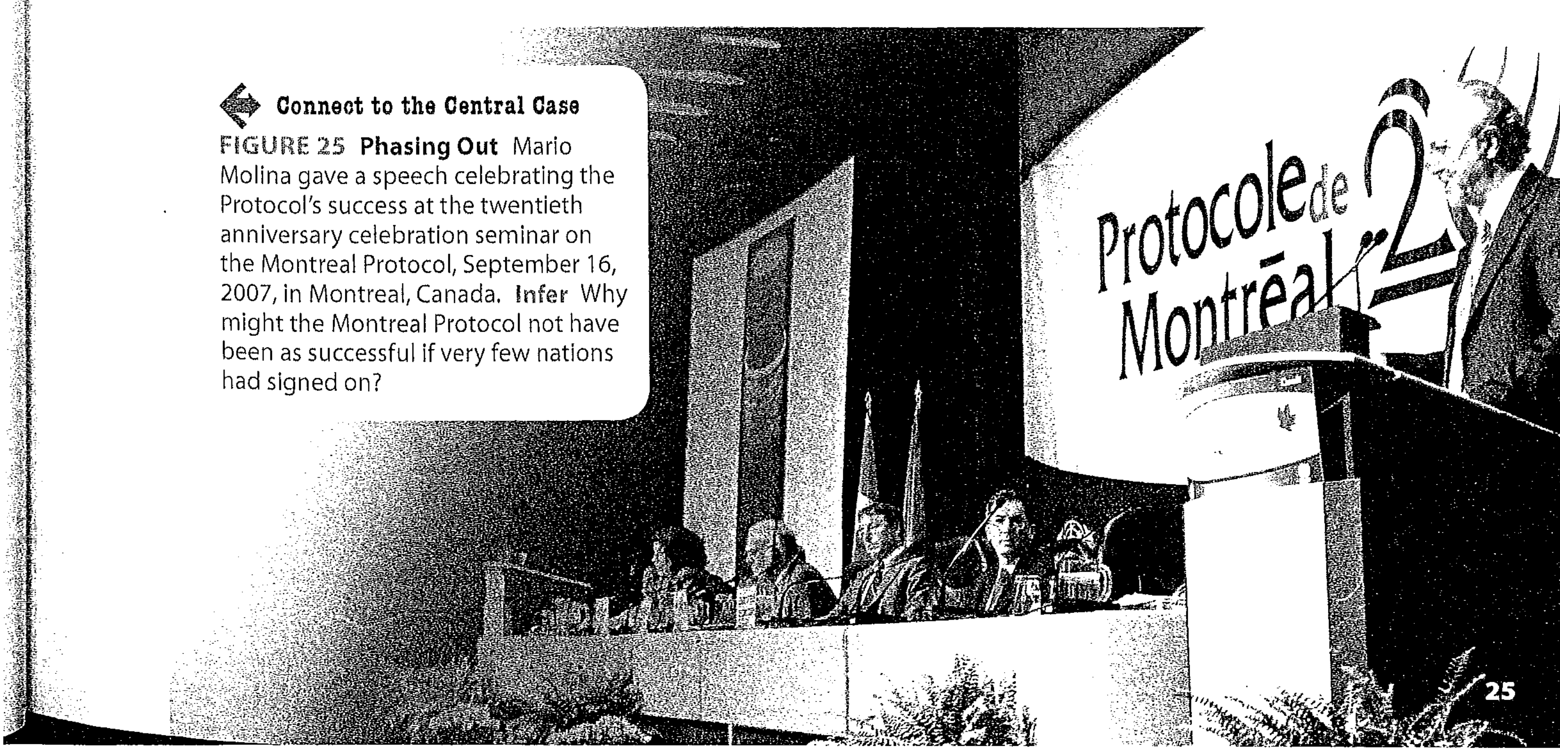
For example, scientific investigations led to the conclusion that CFCs were destroying the ozone layer. A discovery such as this is neither good nor bad, it is just fact. What is done with the information, however, is influenced by worldview, and may be seen differently by different people. On May 11, 1977, the United States government announced that it was phasing out CFCs. In 1987, nations began to sign on to the Montreal Protocol, an agreement to control the production and use of ozone-depleting substances. Within a few years, nations that had adopted the treaty agreed to a complete ban of CFCs and other chemicals. Environmentalists viewed these developments as a triumph, but many people who worked in industries that relied on CFCs were angered.

FOCUS Watch the ABC News video **Eco-Friendly Food Labels**, which describes how food labels in Britain give information about the environmental impact of producing and transporting the food. Have students explain how the food labels could benefit the environment by helping consumers make wise choices.

Ethics and the Environment Did we, as humans, have a responsibility to ban CFCs and protect the ozone layer? The application of ethical standards to relationships between humans and their environment is known as **environmental ethics.** This relatively new branch of ethics arose once people became aware of environmental changes brought about by industrialization. Human interactions with the environment frequently give rise to ethical questions that can be difficult to resolve. For example, does the present generation have an obligation to conserve resources for future generations? What if protecting those resources means people today will suffer because they have fewer resources available to them? Answers to questions like these depend partly on what ethical standards a person chooses to use. Three important ethical standards in environmental ethics are *anthropocentrism, biocentrism,* and *ecocentrism.*

ANSWERS

Figure 25 If only a few nations had signed the Montreal Protocol and banned CFCs, CFCs released by nations that didn't sign the treaty could continue to destroy the ozone layer—a resource shared by everyone. This would lessen the overall success of the treaty.



Connect to the Central Case

FIGURE 25 Phasing Out Mario Molina gave a speech celebrating the Protocol's success at the twentieth anniversary celebration seminar on the Montreal Protocol, September 16, 2007, in Montreal, Canada. **Infer** Why might the Montreal Protocol not have been as successful if very few nations had signed on?

ANSWERS

Find Out More Answers will vary, but should show students researched factories, waste dumps, and polluting facilities in their city or town.

Reading Checkpoint It means that one values groups of organisms and whole ecosystems over individuals.

Figure 27 1997

Lesson 3 Assessment

1. Sample answer: I would recommend peer-reviewed articles because I know that they have been read and evaluated by scientists.
2. Sample answer: Individuals and governments interpret and react to science based on their ethical standards and their worldview.
3. Answers will vary.

your world • your turn • FIND OUT MORE

Where are the factories, waste dumps, and polluting facilities located in your city or town? Prepare a short oral presentation of your findings.

▶ *Anthropocentrism* *Anthropocentrism* describes a human-centered view of our relationship with the environment. An anthropocentrist places the highest value on humans and human welfare. In evaluating a decision, someone with this worldview would likely consider the impacts on human health and economies more important than the impacts on other aspects of the environment.

▶ *Biocentrism* In contrast to anthropocentrism, *biocentrism* gives value to all living things. In this perspective, nonhuman life has ethical standing, so a biocentrist evaluates actions in terms of their overall effect on living things, both human and nonhuman. Some biocentrists advocate equal consideration of all living things, whereas others advocate that some types of organisms should receive more consideration than others.

▶ *Ecocentrism* *Ecocentrism* judges actions in terms of their benefit or harm to the integrity of whole ecological systems, which consist of both living and nonliving elements and the relationships among them. An ecocentrist would value the well-being of species, communities, or ecosystems over the welfare of a given individual. Implicit in this view is that the preservation of larger systems generally protects their components.

Environmental Justice In recent years, people of all persuasions have increasingly realized the connection between environmental quality and human quality of life. Unfortunately, disadvantaged people tend to be exposed to a greater share of pollution, hazards, and environmental degradation than are affluent people. In addition, just as wealthy people often impose their pollution on poorer people, wealthy nations often do the same to poorer nations. The *environmental justice movement* promotes the fair and equitable treatment of all people with respect to environmental policy and practice, regardless of their income, race, or ethnicity. As we explore environmental issues from a scientific standpoint, we will also encounter the social aspects of these issues, and the concept of environmental justice will arise again and again.

✓ Reading Checkpoint *What does it mean to have an ecocentric worldview?*

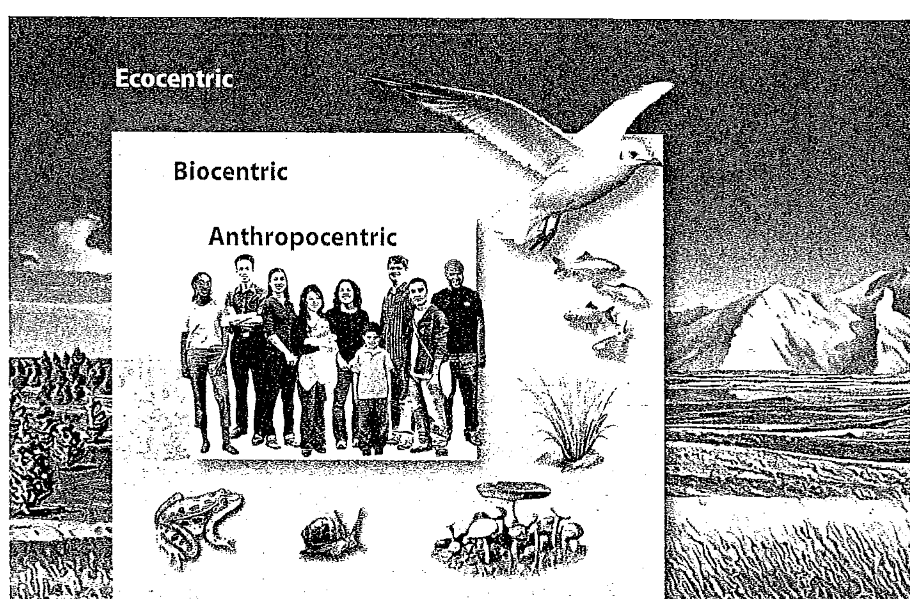
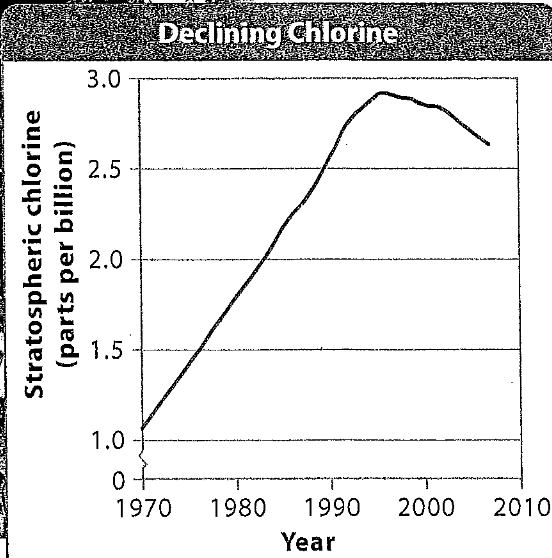


FIGURE 26 Ethical Views Individuals vary in how much value they give living things and the environment. People with an anthropocentric worldview tend to measure the costs and benefits of actions primarily according to their effect on humans. Biocentric individuals consider the costs and benefits to all living things. Ecocentrists tend to think that whole ecological systems, involving living and nonliving parts, should be protected over individuals.



Data from CSIRO Atmospheric Research and Cape Grim Baseline Air Pollution Station, Australian Antarctic Division and Australian Bureau of Meteorology as appears in *Understanding Science*, www.understandingscience.org, UC Berkeley, Museum of Paleontology

Toward the Future Finding effective ways of living peacefully, healthfully, and sustainably on our diverse and complex planet will require a thorough scientific understanding of both natural and social systems. Environmental science helps us understand our intricate relationship with the environment and informs our attempts to solve and prevent environmental problems. The work involving CFCs, for example, is a success story for environmental science. Since the ban of CFCs, chlorine levels in the atmosphere have fallen dramatically, as shown in **Figure 27.** Scientists predict that the ozone hole should be fully repaired sometime this century.

It is important to keep in mind that identifying a problem is the first step in devising a solution to it. Many of the trends detailed in this book may cause us worry, but others give us reason to hope. One often-heard criticism of environmental science courses and textbooks is that too often they emphasize the negative. In this book, we attempt to balance the discussion of environmental problems with a corresponding focus on solutions. Solving environmental problems can move us toward health, longevity, peace, and prosperity. Science in general, and environmental science in particular, can aid us in our efforts to develop balanced and workable solutions to the many environmental dilemmas we face today and to create a better world for ourselves and our children.

Connect to the Central Case

FIGURE 27 A Positive Decline Since the late 1990s, scientists have measured a steady decline in the chlorine concentration in the stratosphere. The trend suggests that efforts to prevent ozone-destroying chemicals from entering the atmosphere have been successful. The Live Earth concerts of 2007 proved to be another successful environmental effort. They raised money for international environmental programs and global awareness of environmental issues such as climate change. **Interpret Graphs** In what year was chlorine concentration highest?

LESSON 3 Assessment

1. **Apply Concepts** Your doctor recommends that someone in your family start taking a new drug to lower cholesterol. Where would you recommend looking for information: articles published in peer-reviewed journals or materials published by the drug company? Explain.
2. **Explain** Explain how although science itself is objective, it can be affected by subjective influences such as worldview and culture.
3. **THINK IT *THROUGH*** Suppose you are the head of a major funding agency that gives money to researchers investigating environmental science issues. Describe how you would decide what types of projects to fund.