

1 An Introduction to Environmental Science



Before you read the chapter, answer each question with information you know. After you complete the chapter, re-answer the questions using information you learned.

BIGQUESTION How Do Scientists Uncover, Research, and Solve Environmental Problems?

	What I Know	What I Learned
<p>1.1 How does environmental science help us understand the natural world?</p>	<p><i>Sample answer: Environmental science explains relationships between the environment and living things.</i></p>	<p><i>Sample answer: By understanding the interaction of living and nonliving things, humans can reduce their ecological footprint.</i></p>
<p>1.2 What does it mean to “do science”?</p>	<p><i>Sample answer: To “do science” means to conduct an experiment in a lab or out in the field.</i></p>	<p><i>Sample answer: Science is a process that involves observation, experimentation, and an analysis of quantitative data.</i></p>
<p>1.3 What happens to a scientific study after data have been gathered and the results are analyzed?</p>	<p><i>Sample answer: After data are gathered and analyzed, others review the findings to make sure they are valid and support a scientific idea.</i></p>	<p><i>Sample answer: A scientific study must undergo peer review, replication, and self-correction before its findings are widely accepted by the scientific community.</i></p>

1.1 Our Island, Earth

Key Concepts

-  Environmental scientists study how the natural world works, and how humans and the environment affect each other.
-  In the last several hundred years, both human population and resource consumption have increased dramatically.



SKILL BUILDER Vocabulary Preview

Define each vocabulary term in your own words. Then, write yourself a quick note on how you will remember each. One term has been done for you.

Term	Definition	How I Remember
Environment	All the living and nonliving things with which organisms interact	Accept all reasonable responses for How I Remember. A few samples are provided.
Environmental science	The study of how the natural world works, how our environment affects us, and how we affect our environment	I know that science refers to the study of why and how things happen, so environmental science must refer to the study of things around us.
Environmentalism	A social movement dedicated to protecting the natural world, including people, from undesirable changes brought about by human actions	
Natural resource	A material or energy source provided by nature that people need to survive	I think of all the resources in my school library and then think of what that means in a natural environment.
Renewable natural resource	A resource that is naturally replenished over a short period	The prefix re- means "again," so renewable must mean "able to make new again."

Term	Definition	How I Remember
Nonrenewable natural resource	<i>A natural resource that forms much more slowly than it is used</i>	
Sustainable	<i>Having the rate of use be equal to the rate of replenishment for resources now and into the foreseeable future</i>	<i>I know the word sustain means "to keep going for a long time," so sustainable must mean "able to keep going for a long time."</i>
Fossil fuel	<i>A nonrenewable energy resource such as oil, coal, and natural gas</i>	
Ecological footprint	<i>The environmental effects of an individual or population based on the amount of land and water needed for raw materials and for disposing of or recycling waste</i>	

Our Environment

1. List three examples of nonliving things in the environment.

Sample answer: oceans, buildings, mountains

2. Give two reasons why environmental science is important.

Sample answer: Environmental science reminds us that we are part of the natural world and that our interactions with that world matter, and it is the first step toward solving environmental problems.

3. Name four of the disciplines that contribute to the study of our interactions with the environment.

Sample answer: Ecology, biology, economics, political science

4. What is the difference between environmental science and environmentalism?

Sample answer: Environmental science is what we know about the workings of the environment; environmentalism is a social movement dedicated to protecting the natural world from the negative effects of human actions.

Population Up, Resources Down

For Questions 5–10, write True if the statement is true. If the statement is false, replace the underlined word to make the statement true. Write your changes on the line.

- varied _____ 5. Nature makes natural resources at similar speeds.
- True _____ 6. Fruit is an example of a renewable resource.
- low _____ 7. For most of human history, population has been high and relatively stable.
- nonrenewable _____ 8. The Industrial Revolution marked a shift from a rural society to an urban society powered by renewable resources.
- True _____ 9. Our ecological footprint is affected by the number of people on Earth and how much we consume.
- True _____ 10. The tragedy of the commons refers to the overuse of unregulated resources.

11. In what way is living on Earth similar to living on an island?

In both situations, the natural resources that people need to survive are limited.

12. Why are sunlight and oil on opposite sides of the renewability continuum?

Sunlight is on the renewable natural resources end of the continuum because it is completely renewable and is essentially always available to us. Oil is on the other end of the continuum because it is a nonrenewable resource that exists in limited quantities that may one day be gone.

13. What could cause a renewable natural resource to become a nonrenewable resource?

If a renewable natural resource is not used at a sustainable rate, it could become a nonrenewable resource.

14. How can a nonliving thing have an ecological footprint?

Sample answer: Even an object, whether natural or synthetic, uses up natural resources when it is formed or manufactured and when it is disposed of or recycled.

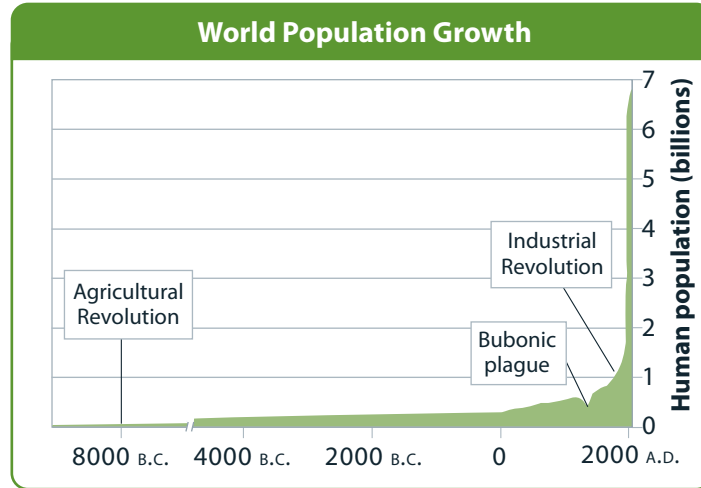
15. What is one way the tragedy of the commons could be avoided?

Sample answer: People who share a common resource can organize, cooperate, and enforce responsible use of the resource.



SKILL BUILDER Think Visually

Use the graph below to answer Questions 16 and 17.



16. Which event shown on the graph signaled the biggest change in human population growth? **Industrial Revolution**

17. Explain how understanding environmental science can help people solve problems related to human population growth.

Sample answer: Because environmental science describes complex interactions between people and the environment, it can help us understand the effects increased human population will have on resources in the environment.

EXTENSION Choose two different organisms or objects. Think about the relationship they have with other organisms or objects in their environment. Compare their ecological footprints by listing the ways they affect the environment. **Answers will vary.**

1.1 SELF-CHECK

Answer the questions to test your knowledge of lesson concepts. You can check your work using the answers on the bottom of the page.



18. Why is it important to remember that people are part of the environment, too?

19. Why is natural gas considered a nonrenewable resource? _____

18. Sample answer: Because people interact with, rely on, and affect the health of the environment 19. Be- cause it forms much more slowly than humans use it

1.2 The Nature of Science

Key Concepts

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



SKILL BUILDER Vocabulary Preview

Define each vocabulary term in your own words. Then, write yourself a quick note on how you will remember each. One term has been done for you.

Term	Definition	How I Remember
Hypothesis	<i>A testable idea that attempts to explain a phenomenon or answer a scientific question</i>	<i>Accept all reasonable responses for How I Remember. A few samples are provided.</i>
Prediction	<i>A specific statement about what will happen if a hypothesis is true</i>	<i>I think about how a weather reporter makes a prediction about tomorrow's weather.</i>
Independent variable	<i>The variable a scientist manipulates in an experiment</i>	
Dependent variable	A variable that depends on the conditions set up in an experiment	I think of how I am dependent on something. For example, what I wear depends on the weather.
Controlled study	<i>A study in which all variables are controlled except for the one variable being investigated</i>	
Data	<i>Information gathered from a study</i>	<i>I think of all the data I collected when I did a survey on wearing school uniforms.</i>



SKILL BUILDER Reading Strategy

Fill in the chart to preview the lesson. Then, on the lines below the chart, write one sentence to explain what you think this lesson will be about.

What is the title of this lesson?	<i>The Nature of Science</i>
Which vocabulary words are new to you?	<i>Sample answer: Independent variable, dependent variable</i>
Which key concept can help you understand the definition of science?	<i>Science is both an organized and methodical way of studying the natural world and the knowledge gained from such studies.</i>
What do the photos show?	<i>Sample answer: Most of the photos show scientists working in different environments.</i>
What do the diagrams show?	<i>Sample answer: The diagrams organize information about the process of science.</i>

Sample answer: I think this lesson will help me understand what science is and how scientific studies are conducted.

What Science Is and Is Not

1. What are the two components of science?

Science is both a systematic process for learning about the natural world and a summary of what scientists already have learned.

2. What does the natural world include?

Sample answer: Every part of our physical environment, and the forces and energies that operate on and within our environment

3. What is the goal of science?

To discover how the rules of the natural world operate and what effect they have

4. How do scientists examine the workings of the natural world?

By collecting evidence

5. Explain the following statement: “Nothing in science can be absolutely proven no matter how much evidence is collected.”

Sample answer: Even ideas that are generally accepted in science continue to be rigorously tested, with the understanding that any idea in science can change or be refuted if enough evidence is collected to do so.

The Process of Science

For Questions 6–9, circle the letter of the correct answer.

6. Which of the following statements best describes the process of science?

- A. It is mysterious.
- B. It is predictable.
- C. It proceeds in a linear fashion.
- D. It produces knowledge over time.

7. Which of the following plays an especially important role in the early stages of an investigation?

- A. making observations
- B. gathering data
- C. interpreting data
- D. making predictions

8. Which of the following is NOT involved in testing ideas?

- A. making predictions
- B. making observations
- C. making policy decisions
- D. conducting experiments

9. What must scientists do if a large number of tests refute their hypothesis?

- A. repeat each test
- B. publish a report
- C. reject the test results
- D. reject the hypothesis

10. What is the relationship between hypotheses and predictions?

Hypotheses generate predictions.

11. What do scientists use models for?

Sample answer: To generate predictions when they cannot observe a phenomenon directly

12. Name two methods scientists use to test predictions.

Experiments, observational studies

13. What is the difference between an independent variable and a dependent variable?

An independent variable is manipulated by the scientist to see the effect of what is being studied; a dependent variable is kept constant and depends on the conditions set up in the experiment.

14. Briefly define *correlation*.

A meaningful and predictable relationship among variables

15. Why is it important to control all variables except one when studying cause-and-effect relationships?

To be more confident that any differences observed were caused by the factor being investigated

16. Why are quantitative data particularly helpful to scientists?

Because numbers are precise and easy to compare

1.2



SELF-CHECK

Answer the questions to test your knowledge of lesson concepts. You can check your work using the answers on the bottom of the page.

17. Give an example of a rule of the natural world that a scientist can assume is always true.



18. What activities make up the process of science? _____

19. What is controlled in a controlled study? _____

17. Sample answer: The boiling point of water is always 100°C at sea level. 18. Making observations, asking questions, developing hypotheses, making and testing predictions, analyzing and interpreting data 19. All variables except the one being studied

1.3 The Community of Science

Key Concepts

-  The scientific community, through peer review and replication, helps to verify the accuracy of results and contributes to the establishment of scientific theories.
-  Environmental ethics explores how environmental science interacts with, and is guided by, a society's morals and principles.



SKILL BUILDER Vocabulary Preview

Define each vocabulary term in your own words. Then, write yourself a quick note on how you will remember each. One term has been done for you.

Term	Definition	How I Remember
Peer review	<i>A formal review of an unpublished report by other scientists who specialize in the topic</i>	<i>Accept all reasonable responses for How I Remember. A sample is provided.</i>
Theory	A broad explanation that applies to a wide range of situations and observations and that is supported by several lines of evidence and broadly accepted by the scientific community	I remember reading about the Big Bang theory in a science magazine.
Ethics	<i>A branch of philosophy that involves the study of good and bad, and of right and wrong; a set of moral principles or values held by a person or society</i>	<i>I think of the discussion we had in my government class on ethics in government.</i>
Environmental ethics	<i>The application of ethical standards to relationships between humans and their environment</i>	

Community Analysis and Feedback

1. How does peer review benefit the scientific community?

It guards against faulty science contaminating the literature on which all scientists rely.

2. What happens to a scientific article that is rejected by a panel of other scientists?

Scientific journals will refuse to publish it.

3. Why is the replication of results important?

A hypothesis must be tested repeatedly and those tests must produce the same results before the scientific community will accept the hypothesis.

4. Explain the following statement: “Science is self-correcting.”

It means that science is a process that refines and improves itself over time.

5. Give an example of a self-correction in science.

Sample answer: In the sixteenth century, when Copernicus demonstrated that Earth is not at the center of the universe, scientists abandoned their strongly held scientific belief and accepted Copernicus’s findings.

6. What is the difference between a hypothesis and a theory?

A hypothesis explains a fairly narrow set of phenomena; a theory is a broader explanation that applies to a wider range of situations and observations.

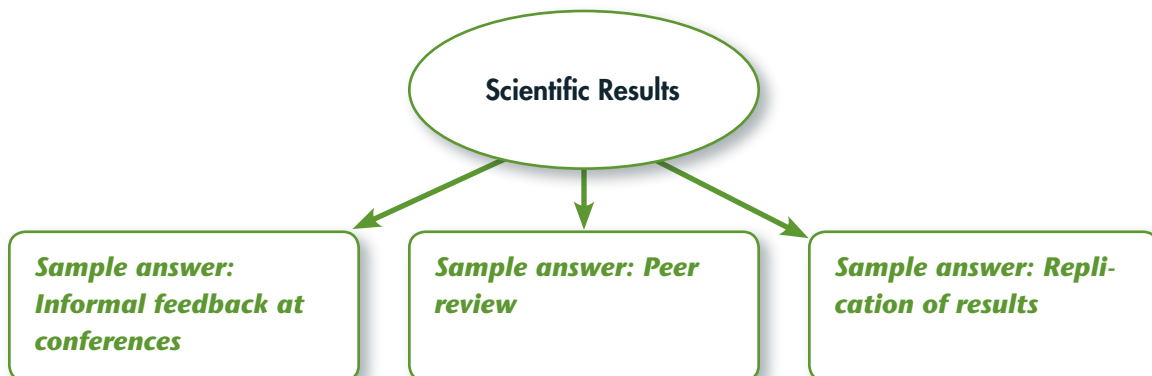
7. How does popular use of the word *theory* differ from use of the word *theory* in science?

Popular use of theory suggests something is just an idea without much substance. In science, theory means the opposite: It refers to an idea that effectively explains a phenomenon, makes accurate predictions in a wide range of situations, and has undergone extensive and rigorous testing.

8. Give one reason why an idea is not a theory.

Sample answer: Because an idea has not gone through extensive and rigorous testing

9.  **Think Visually** Fill in the diagram by writing three ways the scientific community reviews scientific results.



Benefits and Outcomes

10. Give an example of how ethics could impact a government's policy on science.

Sample answer: Policy makers might increase government funding for medical research because they want to reduce people's pain and suffering.

11. Briefly explain the relationship between culture and worldview.

Culture—the knowledge, beliefs, values, and learned ways of life shared by a group of people—influences how people perceive the world and their worldview.

12. What role do a society's beliefs play in an objective process like science?

A society's beliefs influence how it interprets and then acts on scientific findings.

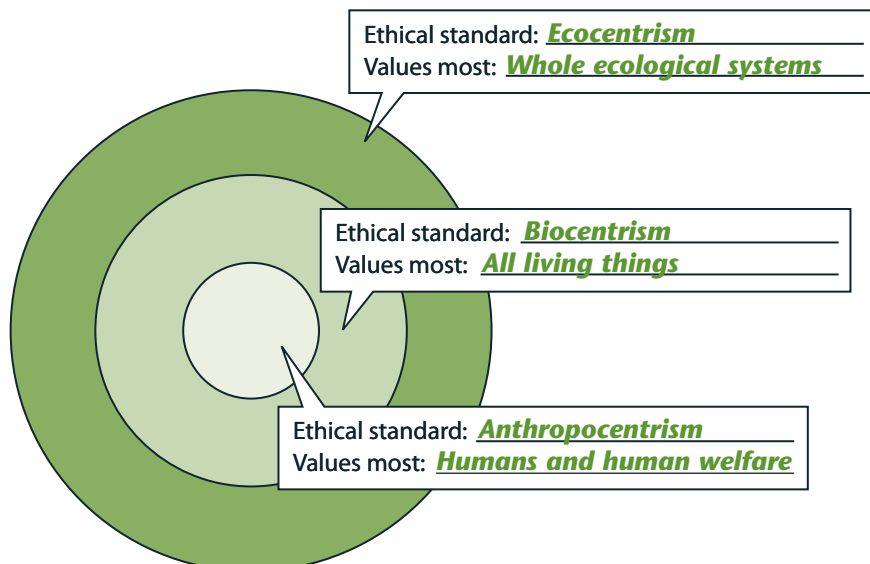
13. What led to the application of ethical standards to relationships between people and their environment?

People's awareness of the environmental changes brought about by industrialization

14. What does the environmental justice movement promote?

Fair treatment of all people with respect to environmental policies and practices, regardless of income, race, or ethnicity

15. **Think Visually** *Anthropocentrism, biocentrism, and ecocentrism* are ethical standards in environmental ethics. Think about what they mean. Then, label each of the circles below with the name of the ethical standard it represents and a description of what that standard places the highest value on.





SKILL BUILDER Organize Information

16. Write each term from the word bank in the correct column of the table below.

build knowledge develop technologies inform policy
 peer review replication satisfy curiosity self-correction

Analysis and Feedback of Scientific Knowledge	Benefits and Outcomes of Scientific Knowledge
<i>Peer review</i>	<i>Develop technologies</i>
<i>Replication</i>	<i>Inform policy</i>
<i>Self-correction</i>	<i>Satisfy curiosity</i>
	<i>Build knowledge</i>

EXTENSION Use the Internet to research a group or organization that works for environmental justice. On a separate sheet of paper, write a short report on the group's recent environmental initiatives. *Answers will vary.*

1.3



SELF-CHECK

Answer the questions to test your knowledge of lesson concepts. You can check your work using the answers on the bottom of the page.

17. How do peer review of scientific articles and replication of test results contribute to the development of scientific theories? _____

18. Give an example of how ethical standards have been applied to a worldwide environmental issue. _____

19. Give an example of an ethical question related to people and their interactions with the environment. _____

20. Name three ethical standards that are applied to environmental issues.

17. Sample answer: Both peer review and replication are forms of testing, and an idea must be rigorously tested before it is accepted as a theory. 18. Sample answer: In 1987, 93 nations signed the Montreal Protocol, agreeing to control the use and production of ozone-depleting substances. 19. Sample answer: Does the present generation have an obligation to conserve resources for future generations? 20. Anthropocentrism, biocentrism, ecocentrism.

Chapter Vocabulary Review

Match each term with its definition.

- | | |
|---------------------------------------|--|
| <u> j </u> 1. natural resource | a. information gathered from a study |
| <u> d </u> 2. ethics | b. all living and nonliving things with which organisms interact |
| <u> f </u> 3. independent variable | c. a testable idea that attempts to explain a phenomenon |
| <u> i </u> 4. peer review | d. the study of right and wrong |
| <u> b </u> 5. environment | e. used at a rate equal to the rate of replenishment into the foreseeable future |
| <u> k </u> 6. dependent variable | f. a factor scientists manipulate in an experiment |
| <u> e </u> 7. sustainable | g. the environmental effects of an individual or group in terms of resources used and waste produced |
| <u> a </u> 8. data | h. a social movement dedicated to protecting the natural world |
| <u> l </u> 9. theory | i. formal examination of a research report by the scientific community |
| <u> h </u> 10. environmentalism | j. a material or energy source provided by nature that people need to survive |
| <u> c </u> 11. hypothesis | k. a factor determined by the conditions set up in an experiment |
| <u> g </u> 12. ecological footprint | l. a broad explanation for a wide range of situations and observations |

Use each vocabulary term in a sentence.

13. controlled study **Sample answer: In my controlled study, I have to keep all the variables constant except for the one I'm testing.**
14. environmental ethics **Sample answer: Governments apply environmental ethics when they make policies and develop best practices concerning environmental issues.**

EXTENSION Use ten or more vocabulary words to create a poster that explains the study of environmental science. Add images to your poster that illustrate some aspect of the environment. **Answers will vary.**



Ecological Footprints



“Overshooting” Ecological Resources

About 1.8 hectares of functioning ecosystem are available per person in the world. However, the average person has an ecological footprint of about 2.2 hectares. In this activity, you will calculate the percentage by which people in the world and people in various nations are using more than the resources available per person.

► To find the percentage by which people in the world are “overshooting” available resources, use the steps shown below.

Step 1 Find the difference between the number of hectares required per person and the number of hectares available per person.	$2.2 - 1.8 = 0.4$ hectare
Step 2 Write a ratio that compares the difference found in Step 1 to the number of hectares available per person.	$\frac{0.4}{1.8} \approx 0.2222$
Step 3 Write the ratio as a percentage, rounding to the nearest tenth.	$0.2222 = 22.2\%$

1. For each nation listed in the table below, calculate the difference between the ecological footprint, or the number of hectares required per person, and the number of hectares available per person. Write your answers in the third column.

Nation	Ecological Footprint (hectares per person)	Hectares Required Minus Hectares Available (per person)	Percentage Over Hectares Available (per person)
Bangladesh	0.5	-1.3	
Colombia	1.3	-0.5	
Mexico	2.6	0.8	44.4
Sweden	6.1	4.3	238.9
Thailand	1.4	-0.4	
United States	9.6	7.8	433.3

Data from *Living Planet Report 2006*. WWF International, Zoological Society of London, and Global Footprint Network.

2. Which nations have an ecological footprint greater than the resources available per person? **Mexico, Sweden, United States**

3. By what percentage are these nations “overshooting” available resources? Round your answers to the nearest tenth and add them to the fourth column in the table.



Fixing a HOLE in the SKY

Depletion of Ozone

Ozone is both harmful and beneficial. Ozone near Earth's surface is a damaging pollutant. But in the stratosphere, ozone protects Earth from harmful UV radiation. Depletion of ozone in the stratosphere concerns scientists because it allows too much UV radiation to reach Earth.

Overexposure to UV radiation may harm the body's immune system and cause skin cancer and cataracts. Scientists also believe excess UV radiation reaching Earth's surface disrupts the reproductive cycle of phytoplankton. These single-celled organisms are found in the top 2 meters of ocean water and are the bottom level of the food chain for many other marine organisms. Scientists also believe excessive ultraviolet radiation

disrupts the reproductive rates of young fish, shrimp, crabs, frogs, and salamanders.

The Montreal Protocol was signed in 1987, with the goal of phasing out the production and use of substances that deplete the stratospheric ozone layer. Since then, the world's scientific community has met several times to accelerate and adjust its provisions. Targeted substances include CFCs, halons, carbon tetrachloride, methyl bromide, and methyl chloroform. Phaseout schedules differ among nations and for different substances. The ultimate goal, however, is the worldwide elimination of ozone-depleting substances by the middle of the twenty-first century.

Tracking the Ozone Hole

The U.S. Environmental Protection Agency collects data daily on ozone levels near Earth's surface. These data are carefully monitored and studied to determine where and how ozone levels near Earth's surface are changing. But how do scientists collect data high up in Earth's stratosphere—10 to 40 kilometers above Earth?

The United States began monitoring ozone levels in 1920 using ground-based instruments at various places around the globe. The instruments measured the amount of UV radiation reaching Earth's surface. As valuable as these data were, they did not tell scientists if a change in ozone levels in one place meant a global reduction

in ozone in the stratosphere. In recent years, NASA and the National Oceanic and Atmospheric Administration (NOAA) have worked together to monitor and understand changes in global ozone levels through images and other data collected by satellites orbiting far above Earth.

Data from satellites provide evidence that stratospheric ozone is definitely being depleted, but scientists are not yet sure how much of the depletion is due to human activity and how much is the result of Earth's natural cycles. Tracking the ozone hole remains an important scientific activity, one that will yield vital scientific knowledge as scientists continue to collect data from afar.

Use the information in **Depletion of Ozone** to answer the questions below.

1. Why are scientists concerned about the depletion of ozone levels in the stratosphere?

Sample answer: Ozone depletion increases the amount of UV radiation reaching Earth, which can harm people and disrupt the reproductive cycle of phytoplankton and other organisms.

2. How were ozone levels monitored in 1920?

Ground-based instruments monitored UV radiation at various places around the globe.

3. How is information on ozone levels in the stratosphere tracked today?

Scientists use images and other data collected by satellites orbiting far above Earth.

4. The data collected over the years clearly confirm a depletion of ozone in the stratosphere. What do scientists still need to learn about the ozone hole?

Sample answer: Scientists need more data to prove how much of the depletion is due to human activity and how much is due to natural changes.

5. **BIGQUESTION** How does the information in Depletion of Ozone affect your answer to the Big Question: “How do scientists uncover, research, and solve environmental problems?”

Sample answer: Scientists use information gathered over time and from many sources to uncover, study, and solve environmental problems.

21st Century Skills

Use the Internet to find out more about the ozone hole and how scientists track its status. Work with a partner to research the ozone hole over Antarctica. Create a poster that explains what you learned about the ozone hole. Your poster should include images of the hole when it was first identified and at regular intervals since.

*The 21st Century Skills used in this activity include **Information Literacy, Initiative and Self-Direction, and Information, Communication, and Technology (ICT) Literacy.***



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