Environmental Science for a Changing World

Teacher Edition

Oak Meadow

Oak Meadow, Inc.
Post Office Box 615
Putney, Vermont 05346
oakmeadow.com

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Teacher Edition Introduction

For as long as humans have existed on Earth, we have interacted with and had an impact on the environment. In this course, students will learn that environmental science is an interdisciplinary science. Just as our impact on the planet extends into every area of life, this course combines ideas and principles from many subject areas. In a nutshell, environmental science is about how everything is connected to everything else. This will be a common theme throughout the course, and you will see that the topics of the lessons overlap and intertwine.

The textbook for this course is *Environmental Science: Your World, Your Turn* by Jay Withgott (Pearson, 2011). In addition, students will read passages from Aldo Leopold's classic of environmental literature, *A Sand County Almanac.* This course also makes good use of technology and the vast resources found online. If you don't have internet service at home, your student is encouraged to do the online activities at a local library. If no internet access is available, you can help your student identify alternative resources and adapt assignments as needed. Lastly, it is highly recommended that students keep a globe or a world map handy at all times.

There are many hands-on activities and labs in this course, most of which use household items. You will find a full materials list (sorted according to lesson and alphabetically) in the appendix. This will help you and your student plan ahead so that all the necessary materials are on hand when needed.

There is an assignment checklist at the beginning of each lesson in both the student coursebook and your teacher edition. Encourage your student to use the checklist to check off assignments that have been completed and keep track of what still needs to be done. This can help your student develop time management skills and keep their work organized.

In this teacher edition, you will find the full text for all assignments, activities, and labs. Teacher edition answers are shown in **orange**. If more information is needed about any assignment, you can refer to the textbook. You are also encouraged to familiarize yourself with the lesson structure and appendix resources and to read the coursebook introduction. This can help you better support your student's learning.

The questions in the coursebook are designed to be answered using information from the textbook readings. No additional research is needed unless otherwise stated. In fact, though students can be tempted to look up answers online, this is strongly discouraged, as it often takes the material out of context and does not contribute to a solid understanding of the material.

Students may choose to find online videos to help explain some of the topics. There are many great videos available, and several are included in these lessons. Watching these is encouraged if it helps a student to visualize a concept.

If you are homeschooling independently, this teacher edition can serve as your support as you guide and evaluate your student's work. When a student gets a factual answer wrong, you can share the correct answer and address any underlying misconceptions. The focus should always be on the learning process rather than on a sense of judgment. Several incorrect answers related to a particular topic point to an area the student will benefit from revisiting.

For obvious reasons, it is best not to share this teacher edition with your student. Each student is expected to produce original work, and any incidence of plagiarism should be taken very seriously. If you notice a student's answers matching those of the teacher edition (or a resource book or website) word for word, a discussion about plagiarism and the importance of doing original work is necessary. While students in high school are expected to be well aware of academic honesty, some confusion may exist, so any discussion about it should be approached as a learning opportunity. Make sure your student is familiar with when and how to properly attribute sources.

We encourage you and your student to explore the topics introduced this year through dynamic exchanges of ideas, relevant field trips, viewing and discussing films and videos related to course topics, and in other active, experiential ways. We hope this course leads your student to become a dedicated steward of our planet Earth.

Coursebook Introduction

Welcome to Oak Meadow *Environmental Science for a Changing World*! For as long as humans have existed on Earth, we have interacted with the environment around us, and have impacted our environment in ways different from any other species on the planet.

Like any animal, our concerns, at first, were obtaining the obvious necessities: food, shelter, and warmth. As we have evolved, and culture, the arts, leisure time, and creature comforts have become increasing priorities, our impact on the planet has increased. Add to that our exponential population growth, and suddenly we are face to face with the limits of the Earth's ability to provide us with our basic needs, while maintaining the incredible diversity of other life-forms that we share our planet with. In fact, our existence is causing a mass extinction of other life-forms, which is unfortunate because we depend on those life-forms for our basic needs. This quandary has triggered the origin of the relatively new sciences of environmental science, ecology, conservation biology, and sustainability.

In this course you will learn that environmental science is an interdisciplinary science. It combines ideas and principles from many subject areas. This is what keeps the field of environmental science interesting—there are many possible career options in the field. One needn't be fluent in all the disciplines that make up environmental science. You might be interested in environmental law, environmental policy, environmental ethics, ecology, sustainable development, environmental chemistry, or one of many more possibilities. It is, however, essential to understand how the subjects relate to one another. In a nutshell, environmental science is about how everything is connected to everything else. This will be a common theme throughout the course, and you will see that the topics of the lessons overlap and intertwine. To do this course right, you will be flipping back and forth often in your coursebook as well as your textbook.

It is assumed that, whether or not you are enrolled in Oak Meadow School, you will have a parent, teacher, or tutor who will be supporting your learning and evaluating your work. If you become especially interested in any particular topics in the course, don't hesitate to let your teacher know. Your teacher will be happy to share available information, or better yet, to provide direction to help you unearth information for yourself. It is ultimately through you that this course comes alive. So now is the time to sharpen your senses and expand your mind as you embark on this exciting and challenging journey.

Course Materials

This coursebook contains complete instructions for the wide variety of assignments and activities you will be doing throughout this course. You will see that sometimes there are only a few activity choices, and sometimes there are so many it may be hard to choose between them. And this only scratches the surface of the possibilities! Activities and research are a fundamental part of this course. The projects and assignments will exercise your imagination, curiosity, creativity, analytical mind, and critical thinking faculties.

The textbook you will be using is *Environmental Science: Your World, Your Turn* by Jay Withgott (Pearson, 2011). This textbook presents an unbiased approach with comprehensive content.

Also included in your course materials is *A Sand County Almanac: With Essays on Conservation from Round River* by Aldo Leopold. This is classic environmental literature. Aldo Leopold was one of the first great conservationists. He was a visionary and an eloquent writer, using delightful description and metaphor to describe the natural world and human impact on it. Leopold was way ahead of his time in foreseeing where humans were headed. You only have two assignments from *A Sand County Almanac*, but you are encouraged to read the entire book.

This course makes good use of technology and the vast resources found online. You'll have plenty of opportunities to do online research and activities. If you don't have internet service at home, you are encouraged to do the online activities at your local library. If you are unable to use the internet, please talk to your teacher about alternative assignments.

In addition, it is highly recommended that you keep a globe or a world map handy at all times.

How to Read Your Textbook

A science textbook is not a novel, and it takes a different kind of reading. Here are some tips:

- First, look through the key concepts, section headings, and main ideas. Then fill in your reading with the content. Later in the course, you will find that you are already familiar with some of the content (remember, it is all connected!), so you will be able to skim sections.
- Reading a chapter straight through is not always the best approach. Skip around, go back and forth between sections, reading some parts two or three times. Skim some parts, and read other parts in depth, as needed.
- Pay special attention to the images and diagrams. There is a reason that "a picture is worth a thousand words." They might be especially helpful for you if you are a visual learner. It will also be increasingly important for you to be able to read and interpret graphs and charts, so you will be given some practice with this in this course.
- As you go through the reading in this course, keep a list of any vocabulary terms that are new to you. The highlighted terms in the text may be a good start, but there will be others as well.

Writing these down is one good way to help learn them. You will be expected to understand the terminology. Equally important is pronunciation. Look up any pronunciation you are uncertain of, and practice speaking the terms aloud.

- Become very familiar with the skills handbook and appendices (SH-1 to SH-32) at the back of the textbook. There's a lot of very helpful stuff here—even a world map! This should be your first place to look if you are having trouble with a math skill, a graphing skill, the scientific process, or understanding diagrams.

How the Course Is Set Up

In this course, there are 36 lessons divided equally into 2 semesters. The questions in the lessons are divided into comprehension and critical thinking questions. This has nothing to do with the length of the answers expected, but in the thought process that goes into the questions. Try to be concise, yet answer each question completely using full sentences. This could be one or a few sentences. If you are expected to write more, it will be specified in the assignment. Sometimes, if you are simply naming something, full sentences are not required. You will be able to discern when to write a full sentence based on the way the question is worded. When in doubt, write in full sentences.

You will find concepts and topics that repeat themselves during the course. Each time we loop around to a topic that we've already covered, it is in order to introduce a different perspective, or to deepen your understanding of the topic/issue. An example of a topic that's mentioned frequently is fresh water. There are political and cultural issues to study; there are watershed and ecology issues—it is a vast topic that needs a lot of attention.

There is often a choice of activities to complete. Read through the projects (and all the choices) before you start. Your favorite choice might be at the end. Please be sure to read the instructions very carefully so you know what is required. You will see more project options later in the course when we are learning more about human impact on the environment across the world. If you see an activity that you want to do, but cannot do it at this time because it is the wrong season, or you are traveling, etc., discuss this with your teacher. As you go through the course, make a note of any projects that interest you that you weren't able to get to because there were too many choices. In lesson 36, you will be given the option to go back and revisit a project from anywhere in the course.

Some of the project options are creative activities. Occasionally you will be required to combine science and some art form. Even if you don't think you are very creative, please don't be intimidated by these. You will not be marked down for "bad" artwork or poetry. Practice expressing yourself while at the same time demonstrating your scientific awareness. Art and science have an exciting connection. Many people have been attracted to science through art, and to art through science.

Read all background information to the questions carefully. Then read it again. The information that accompanies the questions is often necessary for you to start from an informed perspective, and will

allow you to think more deeply about the issue. Note that sometimes the question is much longer than the answer will be. Don't feel intimidated by the length of this background information.

In each lesson, you will find sections to guide your studies and deepen your understanding of the material:

An **introduction** provides a brief overview of the lesson and is designed to spark engagement. Often it refers to the quote that starts off most of the lessons.

Learning Objectives outline the main goals of the lesson and give you an idea of what to expect.

An **Assignment Checklist** is included at the beginning of each lesson so you can see at a glance what is required, and check off assignments as you complete each one. Assignments are fully explained in the lesson.

Think About It provides you with an opportunity to explore topics in more depth by discussing them with family or friends. The issues brought up in a course like this are not meant to be studied in a vacuum. Discussing your thoughts and opinions will invite perspective and help you consider alternate viewpoints, clarify your views, and practice logical argumentation.

What Does It Mean? clarifies terms you will be learning that often have confusing meanings—a scientific meaning and a common usage. It is important to differentiate between them in order to communicate scientific concepts.

Comprehension Questions are designed to help you solidify key concepts and knowledge.

Critical Thinking Questions encourage you to think deeper about the material and make important connections by applying your knowledge and your best scientific reasoning skills.

Activities provide a wide range of research options and hands-on ways to explore the topics you are studying. These activities are set up as discovery and exploration exercises, and they may or may not follow the typical "scientific method." There are many ways to "do" science.

Why Does This Matter? is included at the end of each lesson to put it in perspective and summarize the lesson. This should answer the question about what the point is of learning the material in the lesson!

Share Your Work is found at the end of most lessons. This section provides reminders and information for students who are enrolled in Oak Meadow School and submitting work to their Oak Meadow teacher.

The **appendix** contains important material that you will be expected to read and incorporate into your work throughout the year. Take some time to familiarize yourself with the information in the appendix. You will find Oak Meadow's academic expectations, original work guidelines, information about how to avoid accidental plagiarism, and details on citing sources and images. You will also find a comprehensive works cited page that lists the dozens of excellent resources mentioned in this course and a full materials list.

Finally, you'll find a **For Further Inspiration** section at the end of lesson 36 (just before the appendix). Refer to this section for additional interesting reading, videos, and citizen science opportunities. There are an immense number of excellent resources about the environment, as well as ways to get involved in making a difference!

Academic Expectations for Enrolled Students

If you are enrolled in Oak Meadow School, you'll find a reminder at the end of every other lesson that instructs you to submit your work to your Oak Meadow teacher. Continue working on your next lesson while you are waiting for your teacher to send lesson comments. After you have submitted the first 18 lessons, you will receive a first-semester evaluation and grade. At the end of 36 lessons, you will receive a final evaluation and grade.

Please follow the assignments in order and, whenever possible, place your responses to the assignments in the Google Drive course doc provided by your teacher. Your teacher will give you feedback on your work in this shared Google doc, so the more work that can be put there, the better. Some labs and activities have blank spaces or data tables for you to fill in. If possible, scan these pages and attach them to the shared doc so that all your work stays in one place. Details about how to do this can be found on the Google Drive help page.

If you prefer to submit your work through the postal mail, your Student Handbook provides detailed information on how to do so. Whenever you find mention of the Google course doc in your lessons, you can disregard these instructions and submit the work in your preferred manner. If you have questions on how to work around the Google-related instructions, ask your teacher.

You are expected to meet your work with integrity and engagement. Your work should be original and give an authentic sense of your thoughts and opinions, rather than what you think the teacher reviewing your work wants to hear. When you use other sources, you are required to cite them accurately. Plagiarism, whether accidental or intentional, is a serious matter.

The appendix of this coursebook includes complete details on Oak Meadow's academic expectations and original work guidelines. It is your responsibility to make sure you understand these academic expectations and abide by them.

Please remember to stay in touch with your Oak Meadow teacher and share your comments, ideas, questions, and challenges. Your teacher is eager to help you!

The Earth: Our Home, Our Responsibility

The goal of this course is to help you understand the basics of ecology and the environment, as well as environmental policy on a local and global level. It is no longer enough to only learn about the environment right outside your door, although that is extremely important and necessary, so you will be doing plenty of that. But environmental issues have largely become global issues now. Invasive species travel

throughout the world. Air pollution reaches the most remote ecosystems on Earth. Climate change is a worldwide challenge.

This course will challenge you to think in new and different ways. As you are approaching your young adult years, it becomes important that you understand the realities of the world that you are inheriting. We encourage you to expand your thought processes and think deeply about your role in that world, and your responsibilities as a citizen of the Earth.

Lesson

1 A Matter of Perspective

Environmentalist David Brower was once asked, "Why are you conservationists always against things?" He replied, "If you are against something, you are always for something. If you are against a dam, you are for a river."

Yvon Chouinard, "Damned If We Don't" (2012)

ASSIGNMENT CHECKLIST

- ☐ Answer questions, doing research as needed.
- ☐ Activity A: Earth Time Line Analogy
- ☐ Activity B: Outdoor Observations
- ☐ Activity C: Understanding Maps

Take a look at the picture below and ask yourself, "What's wrong with this picture?" Make a note of the first thing that comes to mind and then any others you may think of.

(Image credit: Image created by Reto Stockli with the help of Alan Nelson, under the leadership of Fritz Hasler.)

It's most likely that the first thing that comes to mind is that this picture of the planet Earth is upside down. Looking deeper, you might think that the moon is in the wrong place, or that the moon is the wrong size. Maybe you will find other things wrong with the picture, but let's just concern ourselves with these for now.

Initially, the question "What's wrong with this picture?" tends to put you into a frame of mind where you try to find something that is different than you may think it should be. Already, you have been set up for a specific way to look at the image. You are "looking for trouble" of sorts. Do you notice how easy it is to find something "wrong" if you are looking for it?

Okay, so you notice the picture is "upside down." Why do you think this? Is it because you are used to seeing the Earth presented with the North Pole at the top of the page and the South Pole at the bottom? That certainly is our accustomed way of viewing pictures of the Earth. But is the Earth really upside down?

It's not, of course. Just because we are used to seeing things a certain way doesn't mean that is the way they really are. As any astronaut who has looked back at the Earth from space can tell you, there is really no up or down as the Earth moves around the sun and through the Milky Way galaxy. How you see the Earth depends on the angle or direction from which you are looking. It depends on your *perspective*.

One dictionary definition of *perspective* is "a particular attitude toward or way of regarding something; a point of view." What you perceive about the world around you—how it looks, feels, sounds, tastes, and smells—depends on where you are and how you are. It is affected by what you know, your past experiences, what you've been told, and how you feel physically or emotionally. The ability of your senses to perceive, and of your mind to make "sense" of, the world around you also affects your perspective.

Here's another example: Have you watched the sun rise or taken in a beautiful sunset? These concepts are so embedded into our way of thinking that we rarely stop to consider that the sun neither rises nor sets. Really, the Earth is spinning on its axis, causing what looks like a sunrise or sunset. As the Earth rotates, the horizon moves in relation to the sun. It is *you* that is moving, not the sun!

These may seem like obvious and picky examples, but the point here is that the world looks very different to different people and at different times. Sometimes our perception of a thing is not what it really is; it is simply one way of looking at something, or it is just a part of the whole picture. A forest may look like a scary jungle to a city dweller, a beautiful wilderness to a backpacker, board feet to a forester or logger, money in the bank to a developer, a spiritual masterpiece to a philosopher or poet, or home to a salamander. If you usually love the forest, and find yourself in it on a very cold and snowy winter night without the right clothing, you may start resenting the forest, fearing for your survival. If you are studying the organisms in the soil on the forest floor, the forest looks significantly different from the forest seen by a biologist studying the birds in the treetops.

Environmental science is a field that recognizes that there are many ways to look at the world, and that all of these perspectives are important because of the way they all fit together. Seeing the world in this way and studying environmental science with an open mind helps us find meaning, truth, and even wisdom. This is challenging! We are all conditioned by (and sometimes limited by) our past. Just because something has been assumed to be true for a while does not guarantee that it will always be so. As knowledge changes, so might perspective. As scientists and citizens of the world, the more we learn, the more we find out how much we still have to learn.

Where in the world are you?

As we study the world around us, locally, nationally, or globally, it is easy to think of the world as existing "out there," apart from us. This is a perspective. If we look to experience and the information that our senses give us to define our place in the world, it may look and feel quite different. Whether we are outside taking in our surroundings with all our senses, engaging with members of our community, or absorbing news on the radio or internet, the more we can feel a deep knowledge that we are part of this world—one of Earth's many species—the more connected we may feel. The more connected we feel, the more we may want to do our part in being good stewards of our planet. This is another perspective, and we are going to begin this course by getting outside and starting the experience.

Part of education about the environment involves immersing oneself in the elements in which you live: walking, crawling, climbing, wading, or swimming. Explore the swamp, dirt, mud, sand, rocks, wind, rain, sun, forest, or field—all of these have lessons to teach. All you have to do is close your mouth, empty your mind, and open your senses! In this lesson, you will be asked to do just that.

Learning Objectives

- Explain the concept of perspective as it relates to environmental science.
- Describe the political structure of your home region.
- Apply map-reading skills to start increasing global awareness.
- Engage in careful observation of nature and describe observations in words and sketches.

Questions

1. Take another look at the quote at the beginning of this lesson. How does David Brower's sentiment relate to the concept of perspective? Write one paragraph.

   Answers will vary. Students should note the different perspectives that are evoked in the statement. Rather than seeing an environmentalist as "against" certain actions, one can look at what they are "for," such as intact ecosystems (that humans depend on) or aesthetics. To be fair, the converse is also true. Those who are seen as against the environment could also be viewed as proponents of certain things—perhaps higher economic status or better education.

2. Answer the following questions, doing internet research as needed.

   a. In what town/city and state (or province or region) do you live?

   b. Where in the state/region geographically is your hometown located?

   c. What is the population of your hometown and of the state/region in which you live?

   d. What is the governing body of your town/city? Do you know the names of any of your local elected officials?

e. Who is the governor of your state? Do you know the names of any of your state/regional elected officials?

f. Who are your representatives in the federal government? (If you are in the United States, please name your congressional delegate and your state's senators.)

g. Who is the political leader of your country?

h. What is the population of the country in which you live?

i. What is the current world population?

j. Lastly, why do you think this information is relevant to an environmental science course?

Answers will vary. Be sure that each question is answered. The goal is for students to become aware of their community and country, and the political figures that represent them. This is relevant for the course, because environmental legislation is an important role of government officials. It is also through these government officials that people can get their voice heard about environmental issues.

Activities

Please complete the following three activities.

- Activity A: Earth Time Line Analogy
- Activity B: Outdoor Observations
- Activity C: Understanding Maps

Activity A: Earth Time Line Analogy

In his book *Let the Mountains Talk, Let the Rivers Run: A Call to Those Who Would Save the Earth,* David Brower gives the following analogy to put things in perspective, reducing the 4.5 billion-year history of the Earth to 6 days. There are many similar time lines that have been created by others. Read this passage and then do the following activity.

> *Sunday at midnight, the Earth is created. There is no life until Tuesday noon. Millions upon millions of species come during the week, and millions of species go. By Saturday morning at seven, there's been enough chlorophyll manufactured for the fossil fuels to begin to form. Around four in the afternoon, the great reptiles [dinosaurs] come on stage. They hang around for a long time, as species go, until nine-thirty, a five hour run. The Grand Canyon begins to take shape eighteen minutes before midnight. Nothing like us shows up for another fifteen minutes. No Homo sapiens until thirty seconds ago. Let the party begin! A second and a half back, we throw the habits of hunting and gathering to the winds, and learn how to change the environment to suit our appetites. We get rid of everything we can't eat as fast as we possibly can, and that's the beginning of agriculture.*
>
> *A third of a second before midnight, Buddha; a quarter of a second, Jesus Christ; a fortieth of a second, the Industrial Revolution; an eightieth of a second, we discover oil; a two-hundredth of a second, how to split atoms.*

Cut four pieces of paper in half lengthwise so you have eight long and narrow pieces of paper. Tape them together, end to end, so that you have one sheet of paper that is at least 80 inches or 200 cm long. On this paper draw a time line, using a scale of 12" (30 cm) = 1 day, so that you have a time line that is 72" (180 cm) long and represents 6 days. Fill in each of the events of David Brower's time line analogy.

Write a brief paragraph, discussing what you think of this time line analogy and the exercise. How does it make you feel as a human on this Earth today? Did the task of physically creating this time line have any effect on your experience of the concept?

Students will create the time line and write a paragraph about the experience and the analogy. It is likely that they have seen analogies like this before. The hands-on act of creating a time line that is six feet long will hopefully have an impact. Students might comment on how much change we have effected in the world in the few seconds that humans have existed on Earth.

Activity B: Outdoor Observations

Find a place near your home that is relatively natural. The less it is maintained by humans, the better, but there are still wonders to observe in a small garden or empty city lot. Take with you something to write and draw on.

1. First, walk around the area and get a feel for it. Spend about 20 minutes walking, climbing, scrambling, and observing with all your senses.
2. Find a place to sit quietly for 15 minutes, paying attention to all that is there and all that is going on around you.
3. Write a description of the place and what your senses tell you about it. Your description should be detailed and specific; the little things are important! Draw two sketches of the area or something that you observe there.
4. Think back in time, about 500 years ago. What do you think this "natural" place was like then, if you were sitting in this exact same spot? Consider landforms, plants, animals, humans, and any other characteristics you think apply. Answer from your current understanding of the history of your area.

Extra credit (optional): When you return home, do a little research and see if you can learn more about the history of the area where you explored, and write what you learn.

Extra credit (optional): Create a poem that is inspired by the natural area you explored.

Students will submit their written description and sketches. Written descriptions should be detailed, and all of the senses addressed. For example, they may smell dampness in the air, feel the cool breeze, taste the salt of the ocean, hear the rustle of leaves, etc. This is an exercise in careful observation.

Activity C: Understanding Maps

When asked the question "where are you?" a map might come to mind. In these days where more and more people are relying on GPS in their phones and cars to find their way around, the use of maps is taking a back seat. There is a decreasing awareness of "where we are" and a reduced spatial awareness that results from not remaining practiced at map reading.

Throughout this course, you will be asked to look at maps often. Maps have an important place in science, and there is a growing field of science called Geographic Information Systems (GIS) technology, which involves using computers to store, analyze, manipulate, and display geographic data for numerous applications. If you are interested in computers as well as the environment, becoming a GIS specialist could be an exciting career path.

For this exercise, you will need to consult maps and find the locations of two dams, both of which were constructed in the 1960s. The first is the Aswan High Dam on the Nile River, and the second is the Glen Canyon Dam on the Colorado River. You will have the opportunity later in the course to investigate the environmental, cultural, and economic impacts of these and other large dams. For now, we will practice locating them. Answer the following questions:

1. Aswan High Dam
   a. What country is this dam in?

      This dam is in Egypt.

   b. What is the name of the lake formed by this dam?

      The lake formed by the dam is Lake Nasser.

   c. What direction does the Nile River flow? What sea does it empty into?

      The Nile River flows north and empties into the Mediterranean Sea.

   d. There are two rivers that combine to form the Nile. Name them and state what countries they flow through.

      The Blue Nile and the White Nile combine to form the Nile River. The Blue Nile starts in Ethiopia and flows into Sudan where it joins the White Nile. The White Nile flows through Tanzania, Uganda, South Sudan, and Sudan.

   e. There is a famous historical area called "Valley of the Kings" on the Nile River. Is this upstream or downstream of the Aswan High Dam?

      Valley of the Kings is downstream of the dam.

2. Glen Canyon Dam
   a. What country and state is this dam in?

      This dam is in the United States, in Arizona.

   b. What is the name of the lake formed by this dam?

The lake formed by the dam is Lake Powell.

c. What national monument is directly adjacent to the lake?

Grand Staircase-Escalante National Monument is directly adjacent to the lake. Students might also say Rainbow Bridge National Monument. Both are acceptable.

d. What national park is downstream from the dam?

Grand Canyon National Park is downstream of the dam.

e. What states/countries does the Colorado River flow through upstream of the dam? Below the dam?

Upstream: The Colorado River starts in Colorado, flows through Utah and into Arizona. Downstream: The Colorado River flows through Arizona, then along the Arizona border with Nevada and California, and into Mexico.

f. Where did the Colorado River historically enter the ocean? (The river does not make it to the ocean anymore because all the water has been removed for irrigation along the way.)

It historically entered the ocean in the Gulf of California (Pacific Ocean).

Why Does This Matter?

What was the point of doing all these activities? It's all about raising awareness of the world around you, both in space and time. Where do we come from as humans? Where are we now? Where are we going? Who are my neighbors, locally and globally? As you go through this course, keep your eyes and ears open. Look around you; recognize that you are a very small part of this world, but you are an important part. Thomas Jefferson said,

> *"I know of no safe depository of the ultimate powers of the society but the people themselves; and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them, but to inform their discretion by education."*

As the next generation of stewards of the planet, take this opportunity to broaden your perspective and educate yourself!

SHARE YOUR WORK

When you have completed this lesson, share your work with your teacher. Make sure each assignment is clearly labeled. Please proofread your work and make any corrections before notifying your teacher that it is ready to review.

If you are using a shared Google doc to submit your work, when you have finished adding your responses for this lesson, click on the File tab in the upper left corner, and use the Email Collaborators command to let your teacher know your work for lesson 1 is ready for review. When this is done, please proceed to lesson 2.

If you have any questions about the lesson assignments or how to share your work, let your teacher know. If you would like to modify any of the assignments or activities (now or in the future), please consult with your teacher first.

If you are a student enrolled in Oak Meadow's distance learning school, be sure to look closely at the Google course doc your Oak Meadow teacher shares with you because the assignments or submission schedule may have been modified.

Lesson

2

What *Is* Environmental Science?

What is common to the greatest number gets the least amount of care. Men pay most attention to what is their own; they care less for what is common; or at any rate they care for it only to the extent to which each is individually concerned. Even when there is no other cause for inattention, men are more prone to neglect their duty when they think that another is attending to it.

Aristotle (384–322 BCE), *Politics*

This lesson presents an overview of environmental science and the history of humans in the environment. The social and economic aspects of the study of the environment are also covered. Please do not be intimidated by the "heavy" nature of these topics. Consider this lesson an introduction to the tangled web that constitutes environmental studies. Who is involved? Who is responsible? Whose job is it to fix things? What are the causes? What are the solutions? It can all get rather overwhelming in a hurry. You have all year to unravel some of the knots in the web, and incorporate the concepts into your environmental mindset. For now, we will start building your foundation of environmental understanding, or strengthen the foundation you have already started.

ASSIGNMENT CHECKLIST

- ☐ Complete reading assignments.
- ☐ View and discuss "The Tragedy of the Commons."
- ☐ Answer comprehension questions.
- ☐ Answer critical thinking questions.
- ☐ Activity A: Invent-a-Word!
- ☐ Activity B: Choice Project (choose one)
  - Option 1: Extinction Time Line
  - Option 2: Extinct or Not?
  - Option 3: Renewable and Nonrenewable Sources

Learning Objectives

- Relate the "Tragedy of the Commons" concept to our study of the environment.
- Identify examples of the interdisciplinary nature of environmental science.
- Describe some effects humans have on the environment.
- Practice using scientific terminology.

Reading

Read the letter from the author of the textbook to you, found on page xxxii of *Environmental Science: Your World, Your Turn* by Jay Withgott. (Throughout this course, we will cite specific text references, noted by page numbers in parentheses. Unless otherwise stated, these citations refer to *Environmental Science: Your World, Your Turn*.)

Read Chapter 1, "An Introduction to Environmental Science," lesson 1 (3–11) in your textbook.

Read pages 28–29, "The Lesson of Easter Island," in your textbook.

As you go through the next two lessons, keep the central case study about the ozone hole in mind. It is an environmental success story that you will be referring back to.

In this lesson and throughout the course, we will be exploring terms that have a different meaning in science and in popular usage. These words will be highlighted in text boxes titled "What Does It Mean?" sprinkled through your coursebook.

What Does It Mean?

Discipline (common usage): controlled behavior resulting from following rules.

Discipline (scientific meaning): a branch of knowledge.

Comprehension Questions

1. Differentiate between what an environmental scientist and an environmentalist does. In which person are you more likely to see bias?

   Environmental scientists study the natural world to describe how environmental systems work, and to describe our interactions with the environment. Environmentalists strive to protect the environment through various means: by raising awareness, lobbying politicians, etc. You are more likely to see bias in an environmentalist, as scientists try to be as objective as possible (5–6).

2. Define the word *interdisciplinary*, and describe, using some examples, how it applies to the study of the environment. Think of additional examples to add to the ones listed in the textbook. Are you taking any other courses this year that could be classified as interdisciplinary? Give examples.

   Interdisciplinary: of or relating to more than one branch of knowledge. Students will give some examples from the textbook, and add some additional examples, such as social sciences, law, ethics, physics, etc. (6). Answers will vary in regards to other courses the student is taking, but many courses could be considered interdisciplinary.

Think About It

In the textbook, you will read about "The Tragedy of the Commons." You can see from the quote above by Aristotle that this idea is not new! It is something humans have experienced throughout history. Discuss this concept with your parents, family, or fellow students. Are there any "commons" in your area that you can identify? How are the resources there being managed? What about in your country? On a global scale? Work together to come up with a list.

For more insight into this issue and to stimulate discussion, check out the following YouTube video:

"Tragedy of the Commons"

www.youtube.com/watch?v=MLirNeu-A8I

Consider the role of self-interest in the tragedy of the commons. Think about possible solutions. Is private ownership a solution? Is privatization even possible for some of the resources you listed? This is a huge topic, and something that we will be addressing in different ways and from different perspectives throughout the course.

Enrolled students: you are not required to submit your list with the lesson, but if you want to share it, or a summary of your discussion, with your teacher, please do for extra credit!

This is a very deep topic, and students are encouraged to start thinking about the "big picture" right from the start. Examples of "commons" that students may come up with are public parks, water sources for household or agricultural use, bodies of water for fishing or recreation (including the oceans), and more. The concept of "commons" can also refer to the air we breathe (and pollute), and underground resources such as minerals and fossil fuels. Groundwater and mineral resources are difficult to regulate or own. Federal grazing lands or forests that are leased to private individuals may be considered commons by students, but they are regulated, with limits, so in that sense they differ from the free-for-all definition of commons, and fall into the category of managed public land that is mentioned in the video. The same might be true for city parks that are maintained by the city, using tax dollars.

Hopefully, students will comment that there is definitely self-interest at play in the tragedy of the commons, and people should think about others, and the environment, before they help themselves to common resources. Opinions will vary on privatization or public ownership as solutions. Consider the role of self-interest in the tragedy of the commons. Think about possible solutions. Is private ownership a solution? Is privatization even possible for some of the resources you listed? This is a huge topic, and something that we will be addressing in different ways and from different perspectives throughout the course.

3. Describe the difference between a renewable and a nonrenewable resource.

   Renewable resource: a resource that can be replaced relatively quickly by natural processes. Nonrenewable resource: a resource that forms much too slowly to be replenished, if at all (7).

4. Read the paragraph that describes sustainability on page 7 of your textbook. Then close your book and define *sustainability* in your own words.

   Sustainability: human needs being met in such a way that future generations can survive and enjoy the same standard of living as the current one (7).

Critical Thinking Questions

1. How do you affect the environment in your daily life? Describe three to five ways.

   Answers will vary. Driving cars, eating organic food (or not), buying products made of plastic, using water, recycling, picking up litter, heating your home . . . the list goes on and on! Consider positive effects as well as negative.

2. Now look outside your home and do the following:

   a. Describe an environmental problem that you see at the local level in your community. Describe one you see at a regional level, and one at a global level. You will be describing three environmental problems in all.

      Answers will vary.

   b. Choose one of these problems/levels, and describe a positive environmental action or trend that you are aware of.

      Answers will vary. A positive trend at the global level discussed in the chapter reading is the halting of the ozone destruction due to international cooperation.

3. By one estimate, the ecological footprint left by a citizen of the United States is about four times larger than that of the average person on Earth (33). Why is this the case? Write one paragraph, giving specific examples.

   Students should mention the high rates of consumption by citizens of developed countries (that includes anyone in the United States). This is a result of relative wealth. Land is cleared for housing, fossil fuels are mined for energy and to manufacture products, forests are cleared for construction, and citizens of developed countries tend to have many modern conveniences and gadgets that all require resources to manufacture.

4. Notice that the title of the chapter section you read is "Our Island, Earth." After reading "The Lesson of Easter Island" at the end of the chapter, what analogies can you draw between Easter Island and our planet Earth? Notice how small Easter Island is. Consider the population of Earth (over 7 billion) and human impact on the environment. Are there lessons to be learned? Write at least one paragraph.

Essays will vary, but students should draw analogies between Earth, which is an island in the solar system, and Easter Island, a small island in the ocean. There is nowhere else to go to bring in resources, just as there wasn't a way for the inhabitants of Easter Island to import wood or fresh water. The lesson to be learned is that we need to manage our limited resources and our population better to avoid the fate of Easter Island.

Activities

Please complete the following activities.

- Activity A: Invent-a-Word!
- Activity B: Choice Project (choose one)

  Option 1: Extinction Time Line

  Option 2: Extinct or Not?

  Option 3: Renewable and Nonrenewable Sources

Activity A: Invent-a-Word!

In this lesson, you have already been exposed to some new terminology, and you will be hearing many more new words throughout the course. Scientists have a vocabulary that is full of complicated words; some high school science textbooks have more new words than you might get in a beginning language course! What is equally confusing is that many common words have different meanings in the context of science. While scientists need to learn to use less scientific "jargon" to communicate their ideas with the general public, we need to become more conversant in the language of science.

Many science words consist of a combination of word stems. Roots (word bases), prefixes (added at the beginning), and suffixes (added at the end) are the building blocks of language. Understanding the Latin and Greek origins of word stems can help bridge the gap between some languages. For example, the English word *biology* and the Spanish word *biologia* are both derived from the Greek roots *bio* (life) and *logy* (the study of).

Sometimes, scientists have to invent new words to name new discoveries. The word *astronaut* is derived from *astro* (star) and *naut* (sailor), or "star-sailor." Astronaut was originally created by science fiction writers and then adopted by the NASA space program to name the Mercury 7 crew in 1959. The Russian space program coined the word *cosmonaut* to name their "space-sailors."

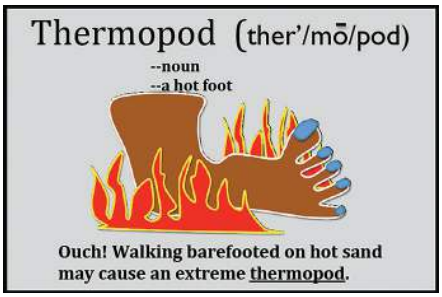
Rather than avoiding scientific terminology, let's embrace it and have some fun with it! Let's create some new words.

Using the process below, invent at least three new words.

1. Choose a prefix and a suffix from the table below, and create a new word. Be sure it is not a word that already exists.

2. Create a definition and a dictionary pronunciation of your word.
3. Identify the part of speech (noun, verb, adjective, etc.).
4. Illustrate the new word.
5. Write a sentence using the new word in context.
6. Repeat for at least two more words.

Here is an example:



(Image credit: Adapted from an activity developed by Louise T. Huffman, MSEd; used by permission.)

Prefixes	
thermo	heat
geo	earth
pachy	thick
tele	far, distant
ortho	straight
crypto	hidden
phono	sound, voice
micro	small
cyano	blue/bluish
stereo	solid
tachy	fast, swift
bio	life
eco	house, household
chrono	time

Suffixes	
pod	foot
scope	device
morph/ morphic	shaped like
phage/ phagous	eater/eating
graph/gram	something that writes/something written
kinesis	movement
mania/maniac	craving/someone who craves
derm	skin
pterous	having wings
phobia	fear of
philia	love of
nomy	system of rules or body of knowledge
genous/genic	producing/making
phone	device for listening

Prefixes	
hydro	water
pedi	foot
hemo	blood
anthro/anthropo	human
aero	air

Suffixes	
meter	device for measuring
lith	stone
logy	study of
sophy	science of
sol	(short for *solution*) particles suspended

Activity B: Choice Project

Choose one of the following projects to complete.

Option 1: Extinction Time Line

Create a time line of the past 200 years. Indicate on the time line when five species of animals became extinct. For each extinct species, describe where it lived, when the last sighting was, and any known reasons for extinction. Include pictures of the species you include.

Option 2: Extinct or Not?

The ivory-billed woodpecker used to live in the forests of Cuba and the southern United States. Though it hadn't been seen for several decades—since the 1950s—there have been reports of sightings in the last 15 years.

The Tasmanian tiger, also known as the thylacine, lived in remote Tasmania. The last known Tasmanian tiger died in the Hobart Zoo in 1936. However, there are many who still believe this animal exists, and there are recent reported sightings.

Choose one of these species believed to be extinct and do some research. Find out why they went extinct, and what evidence there is to support their possible continued existence. Describe what you find about the current status of the species. When doing this kind of research, it's important to report in an unbiased way. Don't let what you *want* to be true affect what you write. You may finish your report with your own thoughts: Given the current data, do you think this animal still exists?

Students will submit a report on one of the extinct species. There is no conclusive evidence that either of these species still exists, though there is a lot of anecdotal evidence and stories. Students should acknowledge this. They may want to believe the species exist, and are given the opportunity to say that at the end of the report.

Option 3: Renewable and Nonrenewable Sources

Choose ten objects that are in the room with you as you are doing your schoolwork. List the objects, and write down the materials they are made of. Make two lists or a chart with two columns: renewable and nonrenewable. Put each item (or part of the item) in its appropriate place on the chart.

Choose two items from the "nonrenewable" list, and hypothesize their origins. Do some research, and find out if your hypothesis was correct.

Results will vary, but two lists or a chart should be created. Students may think that plastics or rubber are renewable, but they are both made from fossil fuels (with the exception of natural rubber, which is rare).

Why Does This Matter?

If we are going to start taking steps to improve our environment, we need to know all the factors involved. We need the experts in the different scientific disciplines involved in environmental science to share their knowledge. Economists and politicians, if they listen to the scientists, will make informed decisions. And you? You need to understand your role, the effects you have on the environment, and the effects humans as a species have had on the environment throughout history, so that you can take positive steps to ensure that your children and their children will have a place on this Earth.

SHARE YOUR WORK

When you are ready, share your work with your teacher, and include any questions you might have. Notify your teacher when your work is ready to be reviewed, and then continue to the next lesson. Feel free to share the list you generated for the Think About It prompt (regarding "The Tragedy of the Commons") or a summary of your discussion for extra credit.

Lesson

6

Earth's Systems and Water Cycle

The sun, moving as it does, sets up processes of change and becoming and decay, and by its agency the finest and sweetest water is every day carried up and is dissolved into vapour and rises to the upper region, where it is condensed again by the cold and so returns to the earth. This, as we have said before, is the regular course of nature.

Aristotle, *Meteorology* (350 BCE)

Isn't this a wonderfully poetic way to describe the water cycle? Though Aristotle incorrectly refers to the "movement" of the sun, it should be noted that even way back in 350 BCE, the water cycle, driven by energy from the sun, was recognized as a necessity for life on Earth. The idea of systems and cycles was already in place. In this lesson, we will explore the elements and compounds that make up life on Earth, the amazing properties of water that support life, and the interacting systems through which they all move. This is a very basic introduction for the purpose of creating a foundation for this course; every one of these topics is an entire field of study. We invite you to pursue any of the interesting topics introduced in this lesson in more detail.

ASSIGNMENT CHECKLIST

- ☐ Read Chapter 3, "Earth's Environmental Systems," lessons 1, 2, and 3.
- ☐ Answer comprehension questions.
- ☐ Answer critical thinking questions.
- ☐ Choose one or more activities to complete:
  - Activity A: Tectonic Plates
  - Activity B: Aquifers
  - Activity C: Documentary Video

Learning Objectives

- Identify the basic materials that form living organisms.
- Describe the unique properties of water and the water cycle.
- Identify negative and positive feedback loops.
- Describe Earth's "spheres" and how they interact.
- Explain the significance of Earth's freshwater crisis.

Reading

Read Chapter 3, "Earth's Environmental Systems," lessons 1, 2, and 3 (64–82), in your textbook. You may save the case study on page 63 for the next lesson.

What Does It Mean?

Organic (common usage): produced without the use of chemical fertilizers or pesticides.

Organic (scientific meaning): containing carbon atoms.

Negative feedback (common usage): criticism.

Negative feedback (scientific): when the output of a change in one direction in a system causes the system to move in the other direction, enhancing stability.

Positive feedback (common): praise or a good response.

Positive feedback (scientific): a self-reinforcing cycle; when change in one direction causes further change in the same direction.

Comprehension Questions

1. Define *bioremediation*, and give an example of it.

   Bioremediation: using organisms to consume or neutralize chemical pollutants in order to clean up a polluted site. Examples include using bacteria to consume oil or gasoline spills, using microorganisms to break down pesticide residue in soil, or using plants to absorb toxic metals into their roots (64).

2. Name four organic compounds that are the building blocks of life.

   Proteins, nucleic acids, carbohydrates, and lipids are the building blocks of life (67–69).

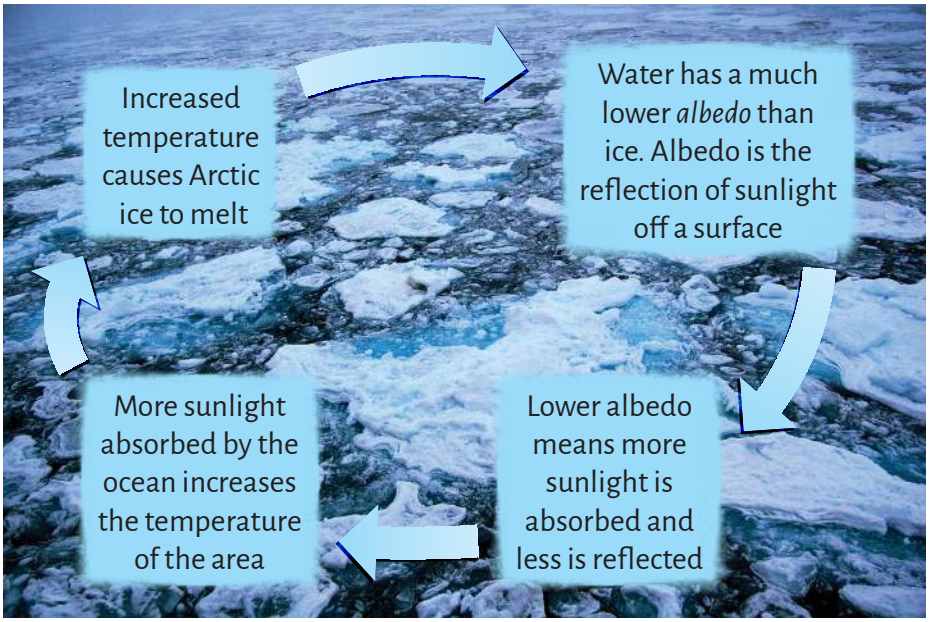
3. The concept of feedback loops is important in science. Any system, whether it is in your body or involving the whole planet, is loaded with feedback loops. Explain why, in natural systems, negative feedback loops are common and positive feedback loops are relatively rare.

   Negative feedback loops are more common in nature because they enhance stability. In order for a natural system to sustain itself, it must be stable. Positive feedback systems are rare for this same reason—they do not contribute to stability. Many positive feedback systems are brought about by human activity (73–74).

4. Describe the two principle ways in which water is returned to the atmosphere in the water cycle.

   Water is returned to the atmosphere by evaporation (from water or land), and by transpiration. Transpiration is the release of water vapor by plants through their leaves (81).

Arctic Feedback Loop



(Background image credit: Pink floyd88 a)

Critical Thinking Questions

1. For each of the four properties of water, explain how it is essential for a fish living in a pond.

   a. Cohesion between water molecules allows the transport of nutrients and waste in the fish.

   b. Resistance to temperature change keeps the temperature of the fish's environment stable.

   c. The fact that ice is less dense than water causes ice to float on top of the lake, insulating and protecting the water below, enhancing survival of the fish. (Students may be interested in the additional fact that because water is most dense at 4°C, many temperate lakes "turn over" in the spring and fall when the surface water warms or cools to that temperature. This is an important means of distributing oxygen and nutrients throughout the lake.)

   d. Water is a universal solvent; it dissolves chemicals necessary for life (including oxygen, nutrients, etc.). (70)

2. Consider the Arctic Feedback Loop pictured above. This is a well-known feedback loop that you will be exploring when you learn about climate change. Is this a negative or positive feedback loop? Explain.

   This is a positive feedback loop. A change in one direction stimulates further change in the same direction. The result is more Arctic ice melting.

3. Using an example of a plant such as a pine tree, explain how the Earth's "spheres" interact and overlap.

   The pine tree absorbs nutrients from, and anchors its roots in, the lithosphere (or geosphere). Organic matter returns to the lithosphere when the tree drops its needles or dies. The pine tree absorbs water from the hydrosphere, and returns it to the hydrosphere (and atmosphere) through transpiration. The tree exchanges gases with the atmosphere, absorbing carbon dioxide and releasing oxygen. Substances circulate throughout the Earth's spheres.

4. Use your knowledge of the water cycle to answer the following question.

   > Consider this hypothetical scenario: There is a very large and polluted lake about 200 km upwind from your town. The water that evaporates from that lake falls back to Earth over your town.

   Will the rain that falls contain the same pollutants that are in the lake? Explain.

   No, the pollutants from the lake will not return to Earth in rainfall. Only water vapor evaporates, so the water is distilled (81). (It may pick up pollutants from other sources in the atmosphere, however!)

5. Using figures from the textbook about the amount of water on Earth that is available to humans, explain why water conservation and controlling water pollution are important. Give examples of ways that you can conserve water. Write one to three paragraphs.

   Students' essays will vary, but should mention the fact that fresh water makes up only 2.5 percent of the water on Earth, and of that, 79 percent is ice, resulting in 0.5 percent of the water on Earth being available for human use (80). Essays should use these figures to explain why water conservation and pollution control is important. Students will also describe ways they can conserve water.

Note: If you choose Activity C below (watch and write about a documentary on water) in addition to another activity (A or B), you may skip Critical Thinking Question #5.

Activities

Choose at least one of the following activities to complete.

- Activity A: Tectonic Plates
- Activity B: Aquifers
- Activity C: Documentary Video

Students will choose one of the three activity options. For A and B, if a presentation or poster is chosen, it should include some visual elements, not just bullet points. For C, students will choose one of the documentaries on the water crisis to watch and report on, addressing the talking points mentioned in the assignment.

Activity A: Tectonic Plates

Explore tectonic plates. Use the map on page 77 to determine what tectonic plate you live on. Do some research and prepare a report that addresses the following questions. Write at least one page. You may create a poster, or a PowerPoint or Google presentation as an alternative to a written report if you like.

- Describe the plate and the types of boundaries that border it.
- How do these boundaries demonstrate plate movement?
- What direction is your tectonic plate moving?
- Briefly describe how the movement of tectonic plates is measured.

Alternatively, if you are interested in technology, you can focus the bulk of your report on the techniques for measuring plate movement.

Activity B: Aquifers

Research a major aquifer. People throughout the world depend on aquifers to provide water for domestic and agricultural use. Many aquifers are in danger because the water is removed faster than it is replenished. Some of the the largest aquifers in the world include the Ogallala Aquifer in the United States, the Guarani Aquifer in South America, and the Great Artesian Basin in Australia.

Choose one of these aquifers and research it, addressing some of the following questions. In your research, you may come across the terms *confined* and *unconfined aquifer.* Distinguish between them, and state which type of aquifer you're researching. Write at least one page. You may create a poster, or a PowerPoint or Google presentation as an alternative to a written report if you like.

- How large is the aquifer? Describe the area it covers.
- What human uses is the aquifer subjected to?
- What conflicts are there regarding its use?
- Is the aquifer in danger of depletion?
- What measures are being taken to conserve the water in the aquifer?

Activity C: Documentary Video

Watch either of the following film documentaries about the water situation in our world today. They were made a few years apart, but both bring up many of the same issues, and even have some of the same scientists in them. The content of these films is not happy news, but given the importance of water, it is urgent news.

Watch the video with your family or fellow students. Pause the video as needed for discussion. Keep a pen and paper with you and jot down notes that you feel are important, such as the vital issues being raised, the location, the people involved, etc. Are there workable solutions in progress? What can you

do? Write a one- to two-page summary of the documentary, and the main points that "hit home" with you the most. Conclude with your feelings about the film and its message.

Film options:

Blue Gold: World Water Wars

This 2008 documentary explores the Earth's dwindling freshwater supplies, and the political and environmental implications of water shortage. As you will learn in the documentary, the water crisis is upon us; it is not something we need to think about for the future. You may have never thought of "ownership" of water and water rights, but big corporations own and distribute much of the world's water in the same way that oil is handled. According to one prediction, we are 50 years away from a collapse in the planet's water systems. The film also explores solutions, with a focus on serious conservation as the one viable solution. It makes a strong case for community action.

Last Call at the Oasis

This 2012 documentary examines many of the same issues that are brought up in *Blue Gold*. After all, it is the same planet Earth, and the same water shortages. Like *Blue Gold*, it addresses global water shortages, but the film centers more on the United States, with a big focus on water contamination and drought. It weaves together local stories and explanations of the worldwide water crisis. There is a certain degree of optimism in this otherwise "gloom and doom" true story; could this be misplaced optimism?

Why Does This Matter?

In case you are wondering how understanding plate tectonics and the structure of DNA are related to environmental science, recall that environmental science is an interdisciplinary field. Other disciplines mentioned here include chemistry, hydrology, seismology, geology, and more. In order to proceed further with a study of environmental science, it is important to understand these basics. For example, many chemical pollutants in the environment are fat soluble, meaning that they settle into the fat of the animal that ingests them. Knowing the role of lipids in the body, as you learned in this lesson, helps us understand the effects of these pollutants. Everything is connected!

The availability and purity of water defines whether life can even exist—that seems obvious. The films speak for themselves. Understanding the systems that make up Earth are important in understanding human impact, including climate change. If you think about it, you could come up with many more examples of why this information is important and relevant!

SHARE YOUR WORK

When you complete this lesson, please submit your work to your teacher. When you receive comments on your work, it is important to incorporate your teacher's suggestions into future lessons. If you have questions about any of the feedback, you teacher will be happy to discuss things with you.

Lesson

17

The Environment and Health

ASSIGNMENT CHECKLIST

- ☐ Read Chapter 9, "Environmental Health," lessons 1, 2, and 3, plus pages 284–285.
- ☐ Answer comprehension questions.
- ☐ Answer critical thinking questions.
- ☐ Activity A: Chemical Hazards (choose one)
  - Option 1: Radon and Carbon Monoxide Assessment
  - Option 2: Sources of Potential Hazards
- ☐ Activity B: Choice Project (choose one)
  - Option 1: Biomagnification Cartoon
  - Option 2: Disease Detective
  - Option 3: Diseases in the News
- ☐ Activity C: Phenology Project

MATERIALS

Activity C: Phenology Project

notebook for field notes
felt pens or colored pencils of several colors
pen or pencil
field guides to local insects and plants
camera
hand lens or magnifying glass

If you need to mark the site again, you will need the following materials:

4–8 stakes
string, about 50 meters
tape measure or meter stick

These sprays, dusts and aerosols are now applied almost universally to farms, gardens, forests and homes—non-selective chemicals that have the power to kill every insect, the "good" and the "bad" . . . Can anyone believe it is possible to lay down such a barrage of poisons on the surface of the earth without making it unfit for all life? They should not be called "insecticides" but "biocides."

Rachel Carson, *Silent Spring*, 1962

Rachel Carson was arguably the most influential person in history when it came to raising public awareness of the chemicals that we were starting to use indiscriminately on our environment. Though she did not live to see the result of her work, her legacy includes the kick-starting of the environmental movement, which resulted in the banning of DDT in the United States, the formation of the Environmental Protection Agency, and the passage of other environmental legislation. Carson spoke out at a time when women were not recognized as knowledgeable enough to make a difference in the world. She was driven by a passion that transcended all stereotypes as well as her own battle with cancer.

However, if Rachel Carson had lived another 30 years, she would have been horrified at the number of chemicals that have since been developed and used in manufacturing and agriculture. This lesson is just a basic introduction to some of the major categories of the hazards that affect our environment and our health, many of which are of human origin.

Learning Objectives

- Compare epidemiology and toxicology.
- List examples of local environmental health hazards.
- Identify how chemicals in the environment could affect public health as well as ecosystem health.
- Understand the challenges of emerging diseases.

Reading

Read Chapter 9, "Environmental Health," lessons 1, 2, and 3 (255–276), in your textbook. You may skim the section titled "Types of Chemical Hazards" (268–269). Also read pages 284–285.

Comprehension Questions

1. For each of the types of environmental health hazards listed on pages 256–257, describe three examples that you are exposed to on a regular basis.

   Biological hazards: cold or flu viruses, bacterial infections, insect or tick bites, allergies from pet dander, etc.

   Social hazards: cigarette smoke, vehicle exhaust, other chemicals in the air (air pollution), chemicals in the diet.

   Chemical hazards: cleaning substances, motor oil, poison ivy, insecticides.

   Physical hazards: fire, earthquake, drought, sunlight, storms, etc.

2. For each of the following scenarios, state whether the work is the job of an epidemiologist or a toxicologist.

a. Scientists and public health workers study the spread of the Ebola virus in African communities.

epidemiologist

b. A certain pesticide appears to be causing liver damage and other ill effects in farmworkers, and work is being done to determine the dose of the pesticide that causes the damage.

toxicologist

c. There is an increase in cancer in a certain location in town, and studies show a correlation between a nearby hazardous waste dump site and the incidences of cancer.

epidemiologist

The epidemiologist would figure out the connection, and the toxicologist would then determine how the toxins cause cancer (258).

3. Describe some factors that can increase the risk of a negative response to an environmental health hazard.

People with health issues or a compromised immune system might be more sensitive to environmental hazards. Fetuses or very young children are still developing and can be affected more. Genetics also may play a part (261).

4. Describe how *biomagnification* works.

Some substances are stored in the body, accumulating in the fatty tissue. With each step up the food chain, the substances will then accumulate as the predators eat many prey. The higher level predators, therefore, accumulate the highest concentrations of the toxins (275).

5. What are VOCs? What are POPs? Give two examples of each.

VOCs are volatile organic compounds, carbon-containing compounds that are released into the air: plastics, perfumes, pesticides, etc. (272).

POPs are persistent organic pollutants, chemicals that do not break down in the environment, and biomagnify in the food web. Examples are dioxins, PCBs, and chlordane (276).

Critical Thinking Questions

1. POPs have been found in remote regions of Antarctica since the 1960s. In fact, they have been found everywhere on Earth. Explain the mechanism by which you think these pollutants have traveled.

The main way the POPs travel around the world is through the air. Students should be able to figure this out.

2. It has long been thought that frogs are the "canary in the coal mine" of freshwater ecosystems, when it comes to pollutants. It was thought that since amphibians absorb water through their

skin, they are especially susceptible to pollutants. Therefore it was assumed that if the frogs were okay, the ecosystem was not in danger. Recent research has found this not to be true. Frogs tend to be rather resilient, and other less adaptable aquatic species may be better indicators of threats from pollution. However, it also depends on the type of pollutant.

This information comes from a *Nature* news article:

> "Amphibians Rarely Give Earliest Warning of Pollution"
>
> www.nature.com/articles/news.2009.1048

Mainstream media articles that attempt to summarize scientific studies range from wildly inaccurate to quite good, depending on the journalist's understanding of the science. Notice that this news article has good sources that link you right to the original scientific studies.

Knowing this, comment on the value of skepticism in scientific research. Why do we encourage questioning and continued scientific study, and why should our conclusions be based on peer reviewed studies? (Review lesson 3 for a discussion of the peer review process.) How easy is it for a cause/effect relationship to appear so obvious, when in nature there are so many intertwined parts that complicate a situation? Write one or two paragraphs discussing these issues.

The purpose of this question is to help students become aware of research that is being done to identify the effects of toxins in the environment, as well as understand what sources of information to trust. Scientists are constantly testing one another's theories and coming up with new knowledge. Peer reviewed studies are essential, as peer review makes sure the claims are based on sound science. Interactions in nature are extremely complex, just as they are in the human body, so all information that is presented should be treated with a degree of skepticism, and the sources checked. It is through continuous questioning that new knowledge emerges.

Activities

Complete the following activities.

- Activity A: Chemical Hazards (choose one)

  Option 1: Radon and Carbon Monoxide Assessment

  Option 2: Sources of Potential Hazards

- Activity B: Choice Project (choose one)

  Option 1: Biomagnification Cartoon

  Option 2: Disease Detective

  Option 3: Diseases in the News

- Activity C: Phenology Project

Activity A: Chemical Hazards

Choose one of the following options.

Option 1: Radon and Carbon Monoxide Assessment

Do a radon and carbon monoxide assessment of your home. If you live in the United States, do you live in an area of the country where the radon risk is high? (See figure 17 in your textbook.) If you live outside the U.S., find out whether radon is a problem in your area. Then do an assessment of your home. Do you have a radon detector? Do you have venting to keep radon out of your home? How about carbon monoxide? What sources of carbon monoxide are in your home? Do you have carbon monoxide detectors in your home? Report on your findings for both of these hazardous substances.

Students will learn about the carbon monoxide detectors in their home, the risk of radon gas, and any radon mitigation infrastructure that is in their home. The sources of carbon monoxide will be listed. Note that it is not produced by clean burning and well-functioning units. It is a product of "incomplete combustion," common in old and poorly maintained appliances.

Option 2: Sources of Potential Hazards

Take a walk around your neighborhood. Record potential sources of chemical or biological hazards. Write your list, and include suggestions of ways that the risks from each of these hazards might be reduced.

Students will walk through their neighborhood and list biological and chemical hazards. Examples are insecticides, lawn sprays, paint, pet droppings, leaked oil or gas, etc.

Activity B: Choice Project

Choose one of the following options.

Option 1: Biomagnification Cartoon

Create a cartoon, intended to be used as an educational tool, that illustrates the process of biomagnification.

Option 2: Disease Detective

Write a detective story about a disease that was caused by environmental factors. Make sure that your detective uses epidemiological techniques to solve the case.

Option 3: Diseases in the News

Produce a news story about an emerging disease, such as H1N1, hantavirus, West Nile virus, or Ebola. You will need to do some research to become informed, but this is not a research report; rather, it is more of a public service announcement. It can take the form of a written news article, or an audio or video report.

Activity C: Phenology Project

In lesson 4, you completed a thorough exploration of your local ecosystem. It is time now to revisit your site and document the changes that have occurred with the change of seasons. You may do this anytime within the next two weeks, and submit your results with lesson 18.

Students will revisit their ecosystem exploration activity from lesson 4, and create a new site map based on what their site looks like now. Students will follow all the steps of the procedure and analysis questions, taking photos and comparing with the previous ones. The process is streamlined this time, with a focus on how the organisms have changed with the seasons. This will be due with lesson 18.

Materials

- notebook for field notes
- felt pens or colored pencils of several colors
- pen or pencil
- field guides to local insects and plants
- camera
- hand lens or magnifying glass

If you need to mark the site again, you will need the following materials:

- 4–8 stakes
- string, about 50 meters
- tape measure or meter stick

Procedure

1. Go back to your 10m × 10m site, and either find your stakes, or use your detailed notes and mark the site again.
2. Record the date and the weather in your notebook.
3. Examine your site again. Prepare a new site map, using the same symbols that you used in lesson 4. The site map will have some of the same features on it as before, along with some different ones. Include a key for your site map, as before.
4. Record any additional notes about the organisms present. Do the trees have leaves? Are there any new plants, or fewer of any particular plants? Depending on the season, your site map and notes might be more or less detailed than the first time.
5. As before, take additional notes about the physical characteristics of your study area, including but not limited to the following:

    a. **Sunlight exposure:** How much of the area is exposed to sunlight?

   b. **Precipitation:** When was the last recorded rain or snow in this area? How much was received?

   c. **Water drainage:** Is the area well drained? Does the soil absorb any rainfall or irrigation, does it flow down the slope, or is there any standing water?

   d. **Vegetative cover:** How much of the area is covered by vegetation, and how much of the soil is exposed?

   e. **Maintenance:** Is the area maintained? If so, do you know how often the area is watered, fertilized, mowed, or treated with pesticides?

6. Now go back to your 2m × 2m smaller site, and remark it if necessary. Do a close inspection, as before, using your hand lens as necessary. Record the types of insects, plants, or other features that you see when looking close up. You are not required to record the soil type if you were able to do that in lesson 4, as that has likely not changed much. Is the ground frozen? If there is snow on the ground, record how much snow, including a description.
7. Take photos of your site, including close-ups of insects or plants that you can use to help you with identification later. Now you have two sets of photos from two different seasons. You will collect more when you revisit the site in lesson 29/30.

Analysis

1. Use your field guides to identify as many plants or animals as you can. Are there any new ones that you didn't see last season? Are there fewer organisms now?
2. Write a description of your 10m × 10m site. Compare the way it looks now with your previous photos of the site. Describe any differences that you notice.
3. Repeat #2, using your 2m × 2m site.
4. Write a prediction of what your site might look like in another three months when you come back here.

Extension

Here are two more optional activities to explore. These are not required, but will earn extra credit.

1. Read the "book that changed the world" *Silent Spring* by Rachel Carson (1962). How many people can write an international bestseller about chlorinated hydrocarbons? Carson had the power to communicate complex science as well as draw in readers and help them understand what is really important. More than 50 years after its publication, this book is still celebrated.
2. Alternatively, read the book *Living Downstream: An Ecologist Looks at Cancer and the Environment* by Sandra Steingraber (1997, updated 2010). Or you can choose to watch the video documentary of the same name.

If you choose to read one of these books, take your time reading it, and write a one- or two-page book report when you are done. It is not something that needs to be submitted with this lesson. You can turn it in whenever you complete it.

Additional Resources

Check out the toxics release inventory here:

"Toxics Release Inventory (TRI) Program"

www2.epa.gov/toxics-release-inventory-tri-program

Here's another great website for current information:

Environmental Health News

www.environmentalhealthnews.org

Why Does This Matter?

As population increases, our impact on the environment increases. Humans are spreading to new places, coming into contact with emerging diseases, and carrying them around. Many of these diseases thrive because of our dense human population. Population increase and environmental health hazards go hand in hand, so it is important that we keep up with our understanding of the connections between them. Infectious diseases as well as toxins in the environment seem to have no trouble traveling everywhere in the world these days. We are the ones causing this spread. The first step to finding solutions? Education!

SHARE YOUR WORK

Please submit all parts of Activity C: Phenology Project to your teacher when you share your work. You can either scan your handwritten notes, or type them into a shared doc. Include your answers to the procedure and analysis questions, a photo or scan of your site map(s), and any photos that you have taken of your site.

Lesson

23 Soil

ASSIGNMENT CHECKLIST

- ☐ Read Chapter 12, "Soil and Agriculture," lessons 1 and 2.
- ☐ Answer comprehension questions.
- ☐ Answer critical thinking questions.
- ☐ Activity A: Desertification Feedback Loops
- ☐ Activity B: Soil Inspiration
- ☐ Activity C: Choice Project (choose one)
  - Option 1: Dig a Soil Pit!
  - Option 2: Forensic Geology
  - Option 3: The Effects of Earthworms
  - Option 4: Preventing Soil Erosion Quick Lab
  - Option 5: Soil Depth and Compaction Quick Lab
  - Option 6: Managing Public Grazing Lands

MATERIALS

Activity C, Option 1: Dig a Soil Pit!

flat, square spade shovel
meter stick
camera

Activity C, Option 2: Forensic Geology

tweezers
hand lens or magnifying glass
4 plastic bags or containers

Activity C, Option 4: Preventing Soil Erosion Quick Lab

4 trays
4 large bowls, pots, or buckets to collect the runoff
watering can or similar device that will mimic a rainstorm
plain soil
sod or soil with a dense mat of undisturbed vegetation on it
some type of mulch (hay, wood chips, leaves, etc.)
soil with compost mixed in
wood blocks, bricks, or other materials to prop up the trays
large measuring cup

Activity C, Option 5: Soil Depth and Compaction Quick Lab

meter stick
1 liter measuring cup or bottle
stopwatch

We know more about the movement of celestial bodies than about the soil underfoot.

Leonardo Da Vinci, circa 1500s

The nation that destroys its soil, destroys itself.

Franklin Delano Roosevelt (1882–1945)

Essentially, all life depends upon the soil . . . There can be no life without soil and no soil without life; they have evolved together.

Charles E. Kellogg, *USDA Yearbook of Agriculture* (1938)

The soil is the great connector of our lives, the source and destination of all.

Wendell Berry, *The Unsettling of America* (1977)

As you can see from the quotes above and the wide date range of them, soil is, to say the least, very important! So important, in fact, that we will spend two lessons exploring soil, agriculture, and human impact. We'll discuss soil structure, soil horizons, erosion of soil, conservation of soil, policies about soil, and other things we've done to, for, and with soil. When you complete this lesson, you should be able to clearly distinguish between what we call dirt and living, breathing, life-giving soil. So let's dig in!

Learning Objectives

- Explain how soil forms.
- Describe causes and prevention of soil erosion, pollution, and desertification.
- Analyze and apply knowledge of soils through research or labs.

Reading

Read Chapter 12, "Soil and Agriculture," lessons 1 and 2 (351–364), in your textbook.

Comprehension Questions

1. Explain how living organisms help to maintain soil fertility.

   Soil organisms, such as bacteria, fungi, earthworms, and insects, decompose organic matter and incorporate the nutrients into the soil. Insects, earthworms, and burrowing mammals help aerate the soil. Living things such as plants and animals provide the

organic matter that is decomposed to add nutrients (353–354). Organic matter in the soil helps retain moisture as well.

2. Describe the three processes that contribute to the formation of soil.

   Physical and chemical weathering break down rocks into smaller particles. Deposition follows erosion, when eroded material is deposited in a new area. Decomposition of organic matter adds an important component to soil (354).

3. Define soil leaching.

   Leaching occurs when rainwater filters through the soil and dissolves minerals, carrying them to the lower horizons, often out of the reach of plant roots (355).

4. Describe three farming practices that can help reduce soil erosion.

   Answers will include three of the following: intercropping, crop rotation, cover crops, shelterbelts, no-till farming, terracing, and contour plowing. Descriptions are on page 359.

5. Describe one soil conservation policy, either U.S. or international.

   The Conservation Reserve Program is a U.S. program that pays farmers to stop cultivating damaged farmland and instead develop conservation reserves planted with grass and trees to help recover the soil. The United Nations, through the Food and Agriculture Organization, has a similar program known as FARM (Farmer-centered Agricultural Resource Management Program), which operates in developing countries by educating local farmers about resource management practices (362–363).

6. Salinization is a huge soil problem in dry areas. In the United States, it has become severe in the southwest. Describe what causes salinization, what can be done to prevent it, and what can be done once it has occurred. Do you live in an area where salinization is a problem? You can learn more about it by going to the Natural Resources Conservation Service website, www.nrcs.usda.gov, and typing "salinization" in the search bar.

   Salinization is the buildup of salts in the upper layers of the soil, as a result of evaporation pulling up salts from the lower horizons through capillary action, and also from salt that is in irrigation water. There is not enough rain or water to leach the salts through the soil. It can be prevented by using minimal water, planting crops that don't require much water, and making sure irrigation water has low salt content. It is difficult to reverse, but salt-tolerant plants could be grown (363–364).

Critical Thinking Questions

1. In lesson 12, you learned that in the rain forest biome, there is very nutrient-poor soil; all the nutrients are in the vegetation. Given that tropical rain forests receive over 2 meters of rainfall per year, explain why this rapid uptake of nutrients by the vegetation is important for the rain forest. Use the term *leaching* in your answer.

   With so much rainfall, any nutrients in the soil would be rapidly leached out of the reach of plant roots. Since the plants take up the nutrients as soon as they become available, this leaching is prevented. (That is, until the rain forest is cleared!)

Activities

Complete the following activities.

- Activity A: Desertification Feedback Loops
- Activity B: Soil Inspiration
- Activity C: Choice Project (choose one)

  Option 1: Dig a Soil Pit!

  Option 2: Forensic Geology

  Option 3: The Effects of Earthworms

  Option 4: Preventing Soil Erosion Quick Lab

  Option 5: Soil Depth and Compaction Quick Lab

  Option 6: Managing Public Grazing Lands

Activity A: Desertification Feedback Loops

In your reading, you learned of several causes of desertification. Review them, and choose two causes other than overgrazing. Using the flowchart in figure 8 as an example (360), create a flowchart for each of the causes that you chose, showing the positive feedback cycle that is created with each. If you need to review feedback cycles, refer to lesson 6.

Answers will vary depending on which causes of desertification the student chooses. Besides overgrazing, causes are erosion, soil compaction, forest removal, drought, salt buildup, climate change, depletion of water sources, and more. This should demonstrate students' understanding of positive feedback loops. Example: salt buildup>unhealthy plants>smaller and fewer plants>more bare soil>erosion>fewer nutrients in soil>unhealthy plants, etc.

Activity B: Soil Inspiration

Read the following description a few times and think of some images that it evokes in your mind. You might even want to close your eyes and have someone else read it to you.

> Soil has long been recognized as the source of life. It is what makes the land area of Earth inhabitable, not just by us, but by every living thing that derives nutrients from it and anchors itself in it. Fertile soils are rich, crumbly, and dark. The resource is precious to us, yet we have nearly destroyed it. However, the good news is that soil is renewable, even though recovery is very slow.

Once you have some pictures in your mind, create a poem, song, drawing, painting, or collage that expresses the importance, wonder, and necessity of soil.

Answers will vary, but reward any creative effort.

Activity C: Choice Project

Choose one of the following projects to complete. In lesson 24, you are given more project options, but you may also come back to this lesson and choose another one of these projects if you find more than one that interests you.

Option 1: Dig a Soil Pit!

Not everyone lives in a place where they can dig a big hole in the ground, but some of you do, and might have fun with this project. Find a natural place where you can dig a deep pit to explore soil layers. Don't choose a spot right next to your home, as often there has been fill dirt put in near homes, and you won't see any layering.

Students will submit a labeled sketch of their soil profile, photos of the horizons and the soil pit, and a summary of the activity.

Materials

- flat, square spade shovel (you need the sides of the pit to be straight and smooth)
- meter stick
- camera

Procedure

1. With your spade, dig a pit that is at least $\frac{1}{3}$ of a meter (1 foot) wide on each side, and as deep as you can go (at least $\frac{1}{3}$ meter, or 1 foot). Carefully remove the soil from your pit, setting it aside so you can replace it later. Be sure to keep any sod or organic material that was on top separate to put it back into place when you are done. It is important that at least one side of the pit is straight (vertical) and smooth, so you can see any layering.
2. Observe your pit and make note of the layers. Using your meter stick, measure the depth of each soil layer that you can find. You may use the soil horizon diagram in your textbook (355) to help you identify them. It is okay if you only find the O, A, B, and C horizons, and you may not be able to easily identify all of them. Some soils are very deep and you might not even find the bottom of the B layer! Sketch your soil profile, including the proper scale based on your measurements.
3. Take photos. Not only will they add to your final report, but you might be able to identify the layers better if you can hold the camera down in the pit.
4. When you are done, fill in your pit, trying to replace the layers where they originated from.
5. Submit your sketch, any photos, and any comments on the activity. Include color descriptions of the soil horizons.

Option 2: Forensic Geology

Practice soil forensics! Using soil for forensic analysis is part of a growing field called forensic geology. This activity has two parts.

First, students will explore forensic geology using the website and case studies provided, and write a paragraph. Then, students will carry out the "investigation" with a partner, and describe the experience. Using the hand lens and tweezers and referring to the description of soils in the textbook, students should obtain a better understanding of soil structure.

Part I: What Is Forensic Geology?

First, read about forensic geology and some interesting case studies in this article:

"Collecting Crime Evidence from Earth"

www.geotimes.org/jan05/feature_forensicevidence.html

Write a paragraph in which you summarize the topic and comment on the details involved and the skills needed to pursue such work.

Part II: Solve a Mystery Using Forensic Geology

Now, you will work with a partner and one of you will solve a mystery.

Materials

- tweezers
- hand lens or magnifying glass
- 4 plastic bags or containers (to separate the soil samples)

Procedure

Here is the scenario: There are three suspects in the case (you can make up the crime—maybe poaching on public lands or an illegal logging operation, or even a murder!). Since it had recently rained, soil had collected between the tread of each suspect's boots. Which soil matches the soil at the scene of the crime? Your job will be to connect that soil to a location in your yard or a natural area you choose to use as your crime scene.

1. One of you will be the investigator and will provide the puzzle, and the other will be the forensic geologist and try to solve the crime. First, you both should review the characteristics of soil in this week's reading (356–357).
2. The investigator needs to gather soil from three locations. (Use plastic bags or containers to keep the soil samples separate.) The locations should have slightly different soil, but not radically different. For example, there might be a tiny bit of mulch in one soil that isn't in another, or

they could be slightly different colors (but not enough to be obvious). It could be just a matter different particle sizes. One of the samples will also represent the crime scene soil as well, so that sample will be larger. The majority of that sample will represent what was found at the crime scene (label that "Crime Scene"), and the smaller part will join the other two samples to represent the soil from the boots of the three suspects. Label these soil samples "Suspect 1," "Suspect 2," and "Suspect 3."

3. Now the investigator will present all the samples to the forensics expert. The scientist will use the tweezers, hand lens, and whatever other tools are needed, and thoroughly investigate all the soils, comparing them to the crime scene soil. Use information from the text as well as the website to help you with the analysis.
4. The scientist should prepare a report that guesses which suspect is the most likely criminal in the case.
5. Was the scientist correct? Describe the experience, and how difficult it was. If you want to switch roles and do this again, you can both try out being the forensic scientist.

Option 3: The Effects of Earthworms

In this activity, you will research destructive earthworms. In this lesson reading, you learned how good earthworms are for the soil, right? You've probably been learning about that since kindergarten. Do you know how many earthworm species are native to the northern United States?

Before reading further, take a guess and write it down here:

Glaciated Areas of North America

(Image credit: University of Minnesota Duluth, National Resources Research Institute)

What did you guess? 10? 20? 3? Well, the answer is 0. That's right: 0. There are no native earthworm species that have been found in any of the area that was glaciated during the last ice age, which is what the map above depicts. It is assumed they were all extirpated when the ice came through. If you live in the northern United States or Canada, any worms you see are nonnative, and they arrived with the Europeans.

Worms aerate the soil and decompose and mix in nutrients. We know that, so aren't they a good addition? Well, in agricultural land and in your garden, yes, they are good. But earthworms have spread into the northern hardwood forests, where they are extremely destructive to the soil.

Your job is to research earthworms and northern hardwood forests, and prepare a written report or an illustrated presentation or poster about the topic. Include in your report the effects that earthworms have on the forest soil and the ecosystem in general.

Students will research and prepare a report or illustrated presentation about the effects of earthworms on northern hardwood forests, both the forest soil and the effects on the ecosystem as a whole.

Option 4: Preventing Soil Erosion Quick Lab

In this lab, you will experiment with different types of soils to determine which erodes more easily. Your four types of soils will be plain soil, soil covered with living plants, soil covered with mulch, and soil with compost mixed in.

Materials

- 4 trays
- 4 large bowls, pots, or buckets to collect the runoff (or use one and clean it after each use)
- watering can or similar device that will mimic a rainstorm
- plain soil (the amount will vary with the size of the trays used—see procedure step 2)
- sod or soil with a dense mat of undisturbed vegetation on it
- some type of mulch (hay, wood chips, leaves, etc.)
- soil with compost mixed in
- wood blocks, bricks, or other materials to prop up the trays
- large measuring cup

Note: Try to have all soil samples equally dry or moist, so the starting soil moisture is constant.

Students will complete the activity, following all instructions, including the hypothesis and analysis questions. Results will vary depending on soil composition.

Before You Begin

Hypothesize which type of soil will erode the most and which will erode the least. Which will have the most and least water runoff?

Procedure

1. Prop up one end of each tray to create a surface that resembles a hill. Place a bowl or other gathering vessel at the lower end of each tray to catch the runoff.
2. Place some soil at the upper end of trays 1, 2, and 3. Tray 1 will be "soil only." The soil should be at least 5 cm (2 inches) thick.
3. Tray 2 will be "soil with vegetation." On top of the base layer of soil, put your sod or layer of living vegetation.
4. Tray 3 will be "soil with mulch." On top of your base layer of soil, layer some mulch.
5. Tray 4 will be "soil and compost mixture." There is no base layer of soil on tray 4, since the compost is mixed in. Put your soil and compost mixture at the upper end of tray 4.
6. Check that the thickness of material on all the trays is similar. You might need to add to tray 1 and 4 so they are similar to trays 2 and 3.
7. Put 2 liters of water in the watering can. Sprinkle the water on the soil on tray 1. Let the runoff water and eroded soil settle in the collecting vessel. Then gently try to pour off the water, separating it from the soil. Measure how much water came through, and also measure how much eroded soil there is. (These will be estimates, as there will still be water in the eroded soil.) Enter these values in the data table below.

8. Repeat for each tray.

Runoff Data Table

Tray	Volume of water runoff	Volume of soil eroded
Tray 1 (plain soil)		
Tray 2 (soil with vegetation)		
Tray 3 (soil with mulch)		
Tray 4 (soil and compost mixture)		

Analysis

1. Which tray had the most soil erosion? Which had the least? Was your hypothesis correct?

   The tray with the living plants likely had the least erosion.

2. Which tray had the most water runoff? The least? Was your hypothesis correct?

   The tray with the living plants likely had the least runoff.

3. Explain your results. What does this lab demonstrate about soil erosion and runoff? Give details!

   Students will summarize their results in more depth. This lab demonstrates that a cover crop, or intact vegetation of any kind, can prevent soil erosion. Mulch also can help prevent erosion, although how effective it is depends on the soil structure, the degree of slope, and the type of mulch. Organic matter in the soil helps absorb moisture and might help to prevent erosion.

   Submit your data table to your teacher along with your hypothesis and analysis.

Option 5: Soil Depth and Compaction Quick Lab

In this lab, you will explore the effect of soil compaction on water absorption by seeing how deep you can push a meter stick into different soils, and timing how long water takes to absorb.

Materials

- meter stick
- 1 liter measuring cup or bottle
- stopwatch

You will also need three locations:

- a plot of undisturbed soil, such as in a forest, park, or meadow
- a plot of disturbed soil that has been compacted and is bare of vegetation, such as in a worn footpath, dirt road, etc.
- another intermediate plot of your choice (describe it)

Students will complete the activity, following all instructions, including the hypothesis and analysis questions.

Before You Begin

Hypothesize which plot will allow the meter stick to go deeper.

Which plot do you think will absorb water faster?

Describe your third location (intermediate plot).

Procedure

1. In your undisturbed plot, press the meter stick down into the soil as far as it will go. Record how deep the stick went into the soil in the data table below. Also record how soft the soil was and how easy it was to push the meter stick into the soil.
2. Repeat this two more times in different spots of the undisturbed plot, so you have three depths.
3. Pour 1 liter of water onto the undisturbed soil. Use the stopwatch to record how long it takes for the soil to fully absorb the water.
4. Repeat steps 1–3 in both of your other plots, recording the data.

5. Calculate the average of each set of three trials, and record that in the data table.

Soil Compaction Data Table

Plot	Depth of meter stick, trial 1	Depth, trial 2	Depth, trial 3	Average depth	Time to absorb water	Additional observations
Undisturbed						
Disturbed						
Intermediate						

Analysis

1. How did the soil depth and hardness in each plot differ?

   Disturbed soils will be more compact, especially at the surface. Undisturbed soils will have a more even density.

2. Which plot absorbed water faster?

   The undisturbed soil should absorb water faster.

3. How might grazing cattle affect an undisturbed plot of land?

   Grazing cattle will decrease the depth and increase the compaction of soil.

4. How might clear-cutting affect an undisturbed plot of land?

   Clear-cutting will remove root systems that hold the soil in place, compact the soil with heavy machinery, and leave the surface bare and prone to erosion.

Option 6: Managing Public Grazing Lands

Imagine you are a land manager with the federal agency in your country that oversees a good portion of public grazing lands. In the United States, that is the Bureau of Land Management (BLM). You have just been put in charge of 200,000 hectares (500,000 acres) of public lands that have been degraded by decades of overgrazing and poor management. The soil is eroding, and invasive plants such as cheatgrass (which has taken over the American West) have replaced the native grasses and greatly reduced biodiversity. Ranchers want to continue grazing, but they realize the land is in poor condition, and they are concerned. Environmentalists want to end grazing on the land entirely.

Your job is to assess the land's condition and come up with a plan to restore its soil and vegetation. Where would you start? Would you allow grazing, and if so, under what limitations? Use information you have learned in this week's reading as well as any additional research you need to describe your plan of assessment and action.

Answers will vary. This is one of the more challenging projects in this lesson. Students should use information from the textbook, additional resources, and accumulated knowledge from the course so far. This should be a thorough assessment and plan; there are many variables at work here, and different interests. Perhaps letting all the land lie fallow, and then reintroducing rotational grazing on a limited basis will be suggested. It should be noted that it is unrealistic to try to remove invasive species over such a large area, and other measures to try to restore biodiversity should be implemented.

Why Does This Matter?

Soil, as you learned, gives us life. Soil can control our health and well-being. With proper care and nurturing, soil has the potential to sustain us indefinitely. We have ravaged our soils; therefore, the more we can learn about them, the more hope we have to bring them back into balance. Soil science is an interdisciplinary science that includes chemistry, physics, biology, ecology, and more. It is fascinating stuff!

SHARE YOUR WORK

When you have completed this lesson, share your work with your teacher. Feel free to contact your teacher at any time if you have any questions about any of the assignments.

For Further Inspiration

Resource List

In addition to the books and videos that are part of the course, here is a small sampling of the huge number of excellent books and documentaries about the environment and topics covered in this course. We hope you will peruse this list and read a few. If there are others that you know about, please let your teacher know for possible inclusion in future editions of this list!

Books

Let the Mountains Talk, Let the Rivers Run: A Call to Those Who Would Save the Earth by David Brower

The Sixth Extinction: An Unnatural History by Elizabeth Kolbert

Silent Spring by Rachel Carson

Your Water Footprint: The Shocking Facts about How Much Water We Use to Make Everyday Products by Stephen Leahy

The Diversity of Life by Edward O. Wilson

Letters to a Young Scientist by Edward O. Wilson

The Sense of Wonder by Rachel Carson

Letters to My Grandchildren by David Suzuki

Walden; Or, Life in the Woods by Henry David Thoreau

Cadillac Desert: The American West and Its Disappearing Water by Marc Reisner

Earth in the Balance: Ecology and the Human Spirit by Al Gore

Dead Pool: Lake Powell, Global Warming, and the Future of Water in the West by James Lawrence Powell

Deadbeat Dams: Why We Should Abolish the U.S. Bureau of Reclamation and Tear Down Glen Canyon Dam by Daniel P. Beard

Dam Nation: How Water Shaped the West and Will Determine Its Future by Stephen Grace

Collapse: How Societies Choose to Fail or Succeed by Jared Diamond

Blessed Unrest: How the Largest Social Movement in History Is Restoring Grace, Justice, and Beauty to the World by Paul Hawken

Big Coal: The Dirty Secret behind America's Energy Future by Jeff Goodell

Eaarth: Making a Life on a Tough New Planet by Bill McKibben

The Sacred Balance: Rediscovering Our Place in Nature by David Suzuki, Amanda McConnell, and Adrienne Mason

How to Live a Low-Carbon Life by Chris Goodall

The End of the Line: How Overfishing Is Changing the World and What We Eat by Charles Clover

Salmon without Rivers: A History of the Pacific Salmon Crisis by Jim Lichatowich

The End of Plenty: The Race to Feed a Crowded World by Joel K. Bourne Jr.

Documentary Films

A Sense of Wonder: Rachel Carson's Love of the Natural World and Her Fight to Defend It

Chasing Ice

Getting Involved: Citizen Science Opportunities

At some point, you might want to take advantage of one of the hundreds of citizen science opportunities there are.

If you enjoy spending your time outside observing nature, there are many options for you to help out. Here's one where you get outside and record pollinators that come to your plants:

The Great Sunflower Project

www.greatsunflower.org/node/1000010

Here's an unusual one: categorize roadkill! Do you realize how much valuable information (about animal movements and populations) can be obtained from roadkill, something that is usually ignored? Unlike live animals, roadkill doesn't run away from you when you approach! You can help science when you are out for a bike ride or a walk.

"RoadkillGarneau" (Epicollect5)

five.epicollect.net/project/roadkillgarneau

Cornell Lab of Ornithology (some of the most well-developed citizen science bird-watching projects, adaptable for all ages):

"Citizen Science" (Cornell Lab of Ornithology)

www.birds.cornell.edu/citizenscience

You can record when and where you see an aurora, help create a map of marine debris, help map carbon-producing power plants, count frogs, watch birds, measure snow and ice depth—the list goes on and on. There are many citizen science projects, both outdoors collecting data, and indoors analyzing it, described on the following websites:

"Audobon Christmas Bird Count" (*Audubon*)

www.audubon.org/conservation/science/christmas-bird-count

"Citizen Science" (*National Wildlife Federation*)

www.nwf.org/Educational-Resources/Wildlife-Guide/Understanding-Conservation/Citizen-Science

"Citizen Science" (*Scientific American*)

www.scientificamerican.com/citizen-science

"Citizen Science" (NASA Science)

science.nasa.gov/citizenscience

Zooniverse (a "master list" of citizen science projects)

www.zooniverse.org

The best part is that citizen science activities like these let you be an *active contributor* to the world of science.

Appendix

Materials List

Below you will find all the materials required for the activities in this course. Most of the items should be commonly available, and you may even have them around the house already. The first list is sorted by lesson and activity, and the second list shows the same materials, sorted alphabetically. Both lists show the same information; they are simply arranged differently so that you can plan your activities in the way that works best for you.

Before you purchase or gather your materials, please read through the entire lab so you have a better idea of what you need (and why). Please note that many of the activities are optional so you may not need all the materials listed. Required activities are noted with a checkmark in the list below.

Materials List (sorted by lesson)

Lesson	Assignment	Req.	Materials Needed
3	Activity: Can You Repeat That?	✔	camera
4	Field Activity: Exploring an Ecosystem	✔	notebook for field notes felt pens or colored pencils of several colors pen or pencil 4–8 stakes string, about 50 meters tape measure or meter stick field guides to local insects and plants camera hand lens or magnifying glass
8	Activity B, Option 2: Modeling Population Growth		handful of dry beans calculator
9	Activity B, Option 2: Observing Competition at the Bird Feeder		bird feeder commercial birdseed field guide to local birds
11	Lab A: Dissecting Owl Pellets		owl pellet baking pan disposable gloves tweezers or forceps needle white paper camera small animal identification field guide that includes skull illustrations (or online equivalent)

Lesson	Assignment	Req.	Materials Needed
11	Lab B: Studying Plant Succession		notebook camera field guides (optional)
	Lab C: Introduction to Biomimicry		blindfold (scarf, bandana, etc.)
13	Activity B, Option 3: Hydrothermal Vent Project		large glass container or aquarium string small bottle with a neck food coloring hot and cold water
15	Lab Activity: Soundscape Exploration	✔	notebooks pens or pencils timer or stopwatch
17	Activity C: Phenology Project	✔	notebook for field notes felt pens or colored pencils of several colors pen or pencil field guides to local insects and plants camera hand lens or magnifying glass 4–8 stakes (if needed) string, about 50 meters (if needed) tape measure or meter stick (if needed)
19	Exploration Lab: Construct an Earthquake-Proof Building	✔	building materials (see instructions) large shallow pan gelatin
21	Project Choice B: Creating a Land-Use Model		colored pencils graph paper ruler
23	Activity C, Option 1: Dig a Soil Pit!		flat, square spade shovel meter stick camera
	Activity C, Option 2: Forensic Geology		tweezers hand lens or magnifying glass 4 plastic bags or containers

Lesson	Assignment	Req.	Materials Needed
23	Activity C, Option 4: Preventing Soil Erosion Quick Lab		4 trays 4 large bowls, pots, or buckets to collect the runoff watering can or similar device that will mimic a rainstorm plain soil sod or soil with a dense mat of undisturbed vegetation on it some type of mulch (hay, wood chips, leaves, etc.) soil with compost mixed in wood blocks, bricks, or other materials to prop up the trays large measuring cup
	Activity C, Option 5: Soil Depth and Compaction Quick Lab		meter stick 1 liter measuring cup or bottle stopwatch
26/27	Activity B, Option 9: Cultural Eutrophication LAb		tap water pond, stream, or lake water (or water from a freshwater aquarium) 3 quart jars with lids liquid fertilizer
29/30	Activity A: Observing the Greenhouse Effect	✔	thermometer
	Activity B, Option 1: Modeling Global Air Movement		aquarium (10–20 gallons) with cover, or clear plastic storage bin adjustable goose-neck lamp, with a 100W incandescent bulb (or other bulb that produces heat) large ice cubes, at least 24 incense stick, preferably about 30 cm long masking tape matches or a lighter 2 outdoor thermometers

Lesson	Assignment	Req.	Materials Needed
29/30	Activity B, Option 2: Modeling Ice Shelves on a Warming Earth		outline map of Antarctica and its major ice shelves aluminum foil wax paper modeling clay multipurpose white glue, 4 oz Borax powder (20 Mule Team detergent booster), 1 Tbsp stirring stick small plastic cup scissors clear packing tape measuring cups and spoons colored markers large sheet of construction paper or poster board $1\frac{1}{4}$ cups water 2 small plastic tubs (like a butter tub) camera
	Activity C: Ecosystem Exploration/Phenology Follow-Up	✔	notebook for field notes felt pens or colored pencils of several colors pen or pencil field guides to local insects and plants camera hand lens or magnifying glass 4–8 stakes (if needed) string, about 50 meters (if needed) tape measure or meter stick (if needed)
34	Lab: Household Energy Consumption	✔	watt meter (optional) flashlight recent electric bill
35	Activity B, Option 1: Trash Assessment		household scale
	Activity B, Option 2: The Environmental Cost of Bottled Water		2–3 bottles of store-bought water 2 small glasses that are identical

Alphabetical List of Materials

You will not necessarily need all the items on this list; some are optional items and some lessons provide a choice of activity. The materials for required assignments are marked with an asterisk.

aluminum foil

aquarium (10–20 gallons) with cover, or clear plastic storage bin

aquarium or large glass container

baking pan

beans, dry

bird feeder

birdseed

blindfold (scarf, bandana, etc.)

Borax powder (20 Mule Team detergent booster)

bottle, small with a neck

bottled water (2–3)

buckets, large bowls, pots, etc. (4)

*building materials (see instructions, lesson 19)

calculator

*camera

clay, modeling

construction paper or poster board

*electric bill

field guide to local birds

field guide to small animal identification (or online equivalent)

*field guides to local insects and plants

*flashlight

food coloring

*gelatin

glasses, small (2)

gloves, disposable

glue, multipurpose white

graph paper

hand lens or magnifying glass

incense stick

jars, quart size with lid (3)

lamp, adjustable goose-neck, with a 100W incandescent bulb

liquid fertilizer

markers, colored

matches or a lighter

measuring cup or bottle, 1 liter

measuring cups and spoons

meter stick

mulch (hay, wood chips, leaves, etc.)

needle

*notebooks

owl pellet

*pan, large shallow

*pencils, colored

pens, felt

plastic bags or containers (4)

plastic cup, small

plastic tubs, small (2)

pond, stream, or lake water (or water from a freshwater aquarium)

ruler

scale, household

scissors

shovel, flat, square spade

soil

soil or sod with a dense mat of undisturbed vegetation on it

soil with compost mixed in

*stakes (4–8)

stirring stick

stopwatch

*string

tape, clear packing

tape, masking

*tape measure or meter stick

*thermometer

thermometer, outdoor (2)

*timer or stopwatch

trays (4)

tweezers or forceps

watering can

watt meter (optional)

wax paper

wood blocks, bricks, or other materials

Academic Expectations

Whether you are enrolled in school or doing this course independently and having your work assessed by a parent, tutor, or school district representative, the following information applies to all completed work.

- **Assignment instructions**

Be sure to read all assignments carefully and in full. Often a student misses a part of the assignment, or glances too quickly at it and misunderstands it, so take your time and make sure you know just what is expected for each assignment. Reading and responding to instructions is an important skill. By taking the time to review all the assignments before beginning the lesson's reading, you can read with purpose and take relevant notes.

- **Delivering your best work**

After you have finished your assignments, take the time to proofread for spelling errors and grammar mistakes. Essays and other longer assignments will require revising and editing as well as proofreading. Reviewing your work before submitting it helps ensure that you are turning in work that is an accurate representation of your knowledge and skills.

- **Formatting and labeling**

If you are typing your work, please format your typed documents with a standard font (such as Ariel), and use a font size, paragraph spacing, and margin setting that will make it easy for your teacher to read your work and provide comments. If you handwrite your work, please do so legibly. Neatness counts! Make sure that your work is well organized and labeled with your name, course, lesson number, and assignment number.