

# Environmental Science for a Changing World Coursebook



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# Table of Contents

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|                                                                                             |             |
|---------------------------------------------------------------------------------------------|-------------|
| <b>Introduction .....</b>                                                                   | <b>xiii</b> |
| <b>Lesson 1: A Matter of Perspective .....</b>                                              | <b>1</b>    |
| Activity A: Earth Time Line Analogy                                                         |             |
| Activity B: Outdoor Observations                                                            |             |
| Activity C: Understanding Maps                                                              |             |
| <b>Lesson 2: What Is Environmental Science? .....</b>                                       | <b>9</b>    |
| Textbook reading: Chapter 1, “An Introduction to Environmental Science,”<br>lesson 1        |             |
| 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                                                |             |
| <b>Lesson 3: The Tools of Environmental Science .....</b>                                   | <b>17</b>   |
| Textbook reading: Chapter 1, “An Introduction to Environmental Science,”<br>lessons 2 and 3 |             |
| Activity: Can You Repeat That?                                                              |             |
| <b>Lesson 4: Exploring an Ecosystem Field Activity .....</b>                                | <b>23</b>   |
| Field Activity: Exploring an Ecosystem                                                      |             |
| <b>Lesson 5: Economics and Environmental Policy .....</b>                                   | <b>29</b>   |
| Textbook reading: Chapter 2, “Economics and Environmental Policy”                           |             |

**Activity choices:**

Activity A: Ecosystem Services Value Survey

Activity B: Cost/Benefit Analysis

Activity C: U.S. Forest Service and National Park Service

Activity D: Protecting Land Assets

**Lesson 6: Earth's Systems and Water Cycle ..... 35**

Textbook reading: Chapter 3, "Earth's Environmental Systems," lessons 1, 2, and 3

**Activity choices:**

Activity A: Tectonic Plates

Activity B: Aquifers

Activity C: Documentary Video

**Lesson 7: Biogeochemical Cycles ..... 41**

Textbook reading: Chapter 3, "Earth's Environmental Systems," lesson 4

Activity: Journey of a Carbon Atom

**Lesson 8: Population Ecology ..... 47**

Textbook reading: Chapter 4, "Population Ecology"

Activity A: Identifying Biotic and Abiotic Factors

Activity B: Choice Project (choose one)

Option 1: Graphing Survivorship Curves

Option 2: Modeling Population Growth

**Lesson 9: Evolution and Species Interactions ..... 55**

Textbook reading: Chapter 5, "Evolution and Community Ecology," lessons 1 and 2

Activity A: Artificial Selection

Activity B: Choice Project (choose one)

Option 1: Evolution and Community Ecology Crossword Puzzle

Option 2: Observing Competition at the Bird Feeder

Option 3: "The Loves and Lies of Fireflies"

|                                                                                    |    |
|------------------------------------------------------------------------------------|----|
| <b>Lesson 10: Communities and Ecology</b> .....                                    | 61 |
| Textbook reading: Chapter 5, “Evolution and Community Ecology,”<br>lessons 3 and 4 |    |
| Activity A: “Animal Tales from Icy Wonderlands”                                    |    |
| Activity B: Choice Project (choose one)                                            |    |
| Option 1: Food Web Poster                                                          |    |
| Option 2: Presentation on Invasive Species                                         |    |
| <b>Lesson 11: Exploration Labs</b> .....                                           | 67 |
| Lab options:                                                                       |    |
| Lab A: Dissecting Owl Pellets                                                      |    |
| Lab B: Studying Plant Succession                                                   |    |
| Lab C: Introduction to Biomimicry                                                  |    |
| <b>Lesson 12: Biomes</b> .....                                                     | 81 |
| Textbook reading: Chapter 6, “Biomes and Aquatic Ecosystems,”<br>lessons 1 and 2   |    |
| Activity choices:                                                                  |    |
| Activity A: Biome Playlist                                                         |    |
| Activity B: African Elephant Research                                              |    |
| Activity C: Create a Climatograph                                                  |    |
| <b>Lesson 13: Aquatic Ecosystems</b> .....                                         | 87 |
| Textbook reading: Chapter 6, “Biomes and Aquatic Ecosystems,” lesson 3             |    |
| Activity A: Vocabulary Crossword Puzzle                                            |    |
| Activity B: Choice Project (choose two)                                            |    |
| Option 1: Coral Reef Poster                                                        |    |
| Option 2: Mangrove Forest Presentation                                             |    |
| Option 3: Hydrothermal Vent Project                                                |    |
| Option 4: Plankton/Nekton/Benthos Poster                                           |    |
| Option 5: Oxbow Lake Formation Project                                             |    |

|                                                                          |     |
|--------------------------------------------------------------------------|-----|
| <b>Lesson 14: Biodiversity</b> .....                                     | 93  |
| Textbook reading: Chapter 7, “Biodiversity and Conservation”             |     |
| Activity choices:                                                        |     |
| Activity A: Living Planet Index                                          |     |
| Activity B Choice Project (choose one)                                   |     |
| Option 1: International Biodiversity Legislation                         |     |
| Option 2: IUCN Red List of Threatened Species                            |     |
| Activity C: Biodiversity Interview                                       |     |
| <b>Lesson 15: Soundscape Ecology</b> .....                               | 99  |
| Lab: Soundscape Exploration                                              |     |
| <b>Lesson 16: Human Population</b> .....                                 | 107 |
| Textbook reading: Chapter 8, “Human Population”                          |     |
| Activity A: Data Analysis Practice                                       |     |
| Activity B: Choice Project (choose one)                                  |     |
| Option 1: Bubonic Plague Poster                                          |     |
| Option 2: Age Structure Diagram                                          |     |
| <b>Lesson 17: The Environment and Health</b> .....                       | 113 |
| Textbook reading: Chapter 9, “Environmental Health,” lessons 1, 2, and 3 |     |
| Activity A: Chemical Hazards                                             |     |
| 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                                            |     |

|                                                                        |     |
|------------------------------------------------------------------------|-----|
| <b>Lesson 18: First Semester Wrap-Up: Movie Week!</b> .....            | 121 |
| Activity A: <i>A Fierce Green Fire: The Battle for a Living Planet</i> |     |
| Activity B: Documentary Choice (choose one)                            |     |
| Option 1: <i>Green Gold</i>                                            |     |
| Option 2: <i>DamNation</i>                                             |     |
| <b>Lesson 19: Natural Disasters</b> .....                              | 125 |
| Textbook reading: Chapter 9, “Environmental Health,” lesson 4          |     |
| Lab: Construct an Earthquake-Proof Building                            |     |
| Activity choices:                                                      |     |
| Activity A: Interviews on Experiencing Natural Disasters               |     |
| Activity B: Connecting Climate Change and Avalanches                   |     |
| Activity C: Natural Disaster Report                                    |     |
| Activity D: Emergency Warning Systems                                  |     |
| Activity E: Tsunami Prediction Technology                              |     |
| Activity F: Earthquake Mapping                                         |     |
| Activity G: Literary Exploration of Disaster Recovery                  |     |
| <b>Lesson 20: Urbanization</b> .....                                   | 133 |
| Textbook reading: Chapter 10, “Urbanization”                           |     |
| Activity A: Group Discussion on Urban Growth                           |     |
| Activity B: Choice Project (choose one)                                |     |
| Option 1: Identify Sprawl in Your Area                                 |     |
| Option 2: Renovate an Inner-City Area                                  |     |
| Option 3: Light Pollution                                              |     |
| <b>Lesson 21: Exploring Our Impact</b> .....                           | 139 |
| Project choices:                                                       |     |
| Project Choice A: Carbon Footprint Project                             |     |
| Project Choice B: Creating a Land-Use Model                            |     |

**Lesson 22: Our Precious Resources** ..... 149

Textbook reading: Chapter 11, “Forestry and Resource Management”

Activity choices:

Activity A: The Effects of Logging on Salmon Habitat

Activity B: Timber Harvesting

Activity C: The Legacy of Dr. Wangari Muta Maathai

**Lesson 23: Soil** ..... 153

Textbook reading: Chapter 12, “Soil and Agriculture,” lessons 1 and 2

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

**Lesson 24: Agriculture** ..... 165

Textbook reading: Chapter 12, “Soil and Agriculture,” lessons 3 and 4

Activity choices:

Activity A: Permaculture

Activity B: Cactus Moth Invasion

Activity C: Honeybees and Colony Collapse Disorder

Activity D: Monarch Butterflies

Activity E: Plant a Pollinator Garden

**Lesson 25: Mining and Mineral Resources** ..... 171

Textbook reading: Chapter 13, “Mineral Resources and Mining”

Activity choices:

Activity A: Hardrock Mining and Reclamation Act

Activity B: Centralia Mine Fire

- Activity C: Mining Methods
- Activity D: Toxic Spill at Ajka Alumina Plant
- Activity E: Virunga Documentary Project
- Activity F: Chilean Mine Rescue
- Activity G: Mineral Pigments in Art
- Activity H: Mineral Sources of Products You Use

## **Lesson 26/27: Water** ..... 177

Textbook reading: Chapter 14, “Water Resources”

Activity A: Exploring the Local Watershed

Activity B: Choice Project (choose one)

- Option 1: Aquifer Research
- Option 2: Water Sources
- Option 3: Large Dams
- Option 4: The Green Lagoons
- Option 5: Wastewater Treatment
- Option 6: Clean Water Legislation
- Option 7: Pharmaceuticals in the Environment
- Option 8: Xeriscaping
- Option 9: Cultural Eutrophication Lab

## **Lesson 28: The Atmosphere** ..... 189

Textbook reading: Chapter 15, “The Atmosphere”

Activity A: The Antarctic Ozone Hole

Activity B: Choice Project (choose one)

- Option 1: Clean Air Act
- Option 2: The Effects of Acid Precipitation
- Option 3: Ozone Hole Real Time Data

## **Lesson 29/30: Climate Change** ..... 195

Textbook reading: Chapter 16, “Global Climate Change”

Activity A: Observing the Greenhouse Effect



- Activity B: Choice Project (choose one)
  - Option 1: Modeling Global Air Movement
  - Option 2: Modeling Ice Shelves on a Warming Earth
- Activity C: Ecosystem Exploration/Phenology Follow-Up

**Lesson 31/32: Nonrenewable Energy** ..... 219

- Textbook reading: Chapter 17, “Nonrenewable Energy”
- Activity A: Fossil Fuel Media Watch
- Activity B: Nuclear Fission
- Activity C: Speak Out
- Activity D: Choice Project (choose one)
  - Option 1: Mountaintop Removal Coal Mining
  - Option 2: Arctic Oil Exploration
  - Option 3: Seismic Oil Exploration
  - Option 4: Oil in the Gulf of Mexico
  - Option 5: Oil Spills
  - Option 6: Virunga Documentary Project
  - Option 7: Nuclear Energy
  - Option 8: The Future of Nuclear Waste
  - Option 9: Fossil Fuel Sources

**Lesson 33: Renewable Energy** ..... 227

- Textbook reading: Chapter 18, “Renewable Energy Alternatives”
- Activity choices:
  - Activity A: Large Dams
  - Activity B: Renewable Energy Crossword Puzzle
  - Activity C: Create a Sun Chart
  - Activity D: Tidal Energy
  - Activity E: Wind Farm Visit

|                                                               |     |
|---------------------------------------------------------------|-----|
| <b>Lesson 34: Your Household Energy Consumption</b> .....     | 233 |
| Lab: Household Energy Consumption                             |     |
| <b>Lesson 35: Waste Management: Full Circle or Not?</b> ..... | 243 |
| Textbook reading: Chapter 19, “Waste Management”              |     |
| Activity A: A Mockumentary                                    |     |
| Activity B: Choice Project (choose one)                       |     |
| Option 1: Trash Assessment                                    |     |
| Option 2: The Environmental Cost of Bottled Water             |     |
| Activity C: Choice Project (choose two)                       |     |
| Option 1: Hazardous Waste Survey                              |     |
| Option 2: Hazardous Wastes in Businesses                      |     |
| Option 3: E-Waste and eCycling                                |     |
| Option 4: Field Trip                                          |     |
| Option 5: Municipal Composting Programs                       |     |
| Option 6: Recycling Process                                   |     |
| Option 7: Waste Management around the Globe                   |     |
| <b>Lesson 36: Rising to the Challenge</b> .....               | 253 |
| Activity A: The Round River                                   |     |
| Activity B: Choice Project (choose one)                       |     |
| Option 1: Create a Children’s Book                            |     |
| Option 2: Free Choice or Original Idea                        |     |
| <b>For Further Inspiration</b> .....                          | 257 |
| Resource List                                                 |     |
| Getting Involved: Citizen Science Opportunities               |     |

**Appendix ..... 261****Materials List**

Materials List (sorted by lesson)

Alphabetical List of Materials

**Academic Expectations****Original Work Guidelines****Finding Reputable Sources****Citing Your Sources****Elements of Good Writing****The Writing Process****Works Cited**



# Introduction

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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 course-book 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)

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.

### ASSIGNMENT CHECKLIST

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



(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.
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?

## 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?

## 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.

## 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?
  - b. What is the name of the lake formed by this dam?
  - c. What direction does the Nile River flow? What sea does it empty into?
  - d. There are two rivers that combine to form the Nile. Name them and state what countries they flow through.
  - 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?
2. Glen Canyon Dam
  - a. What country and state is this dam in?
  - b. What is the name of the lake formed by this dam?
  - c. What national monument is directly adjacent to the lake?
  - d. What national park is downstream from the dam?
  - e. What states/countries does the Colorado River flow through upstream of the dam? Below the dam?
  - 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.)

## 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.

## Learning Objectives

- Relate the “Tragedy of the Commons” concept to our study of the environment.
- Identify examples of the interdisciplinary nature of environmental science.

### 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

- 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?
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.
3. Describe the difference between a renewable and a nonrenewable resource.
4. Read the paragraph that describes sustainability on page 7 of your textbook. Then close your book and define *sustainability* in your own words.



### 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](http://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!

## Critical Thinking Questions

1. How do you affect the environment in your daily life? Describe three to five ways.
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.
  - b. Choose one of these problems/levels, and describe a positive environmental action or trend that you are aware of.
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.
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.

## 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 *biología* 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.”

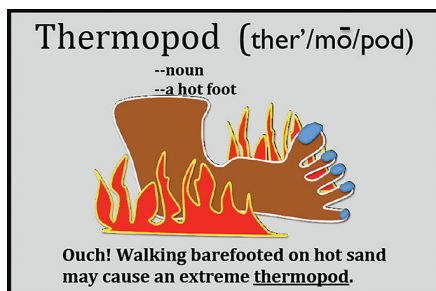
Rather than avoiding scientific terminology, let’s embrace it and have some fun with it! Let’s create some new words.

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      |                  |
|---------------|------------------|
| <b>thermo</b> | heat             |
| <b>geo</b>    | earth            |
| <b>pachy</b>  | thick            |
| <b>tele</b>   | far, distant     |
| <b>ortho</b>  | straight         |
| <b>crypto</b> | hidden           |
| <b>phono</b>  | sound, voice     |
| <b>micro</b>  | small            |
| <b>cyano</b>  | blue/bluish      |
| <b>stereo</b> | solid            |
| <b>tachy</b>  | fast, swift      |
| <b>bio</b>    | life             |
| <b>eco</b>    | house, household |
| <b>chrono</b> | time             |
| <b>hydro</b>  | water            |
| <b>pedi</b>   | foot             |

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

| Prefixes        |       | Suffixes |                                                  |
|-----------------|-------|----------|--------------------------------------------------|
| hemo            | blood | logy     | study of                                         |
| anthro/anthropo | human | sophy    | science of                                       |
| aero            | air   | sol      | (short for <i>solution</i> ) 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?

### 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.

## 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.

## 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.

## 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



## 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.

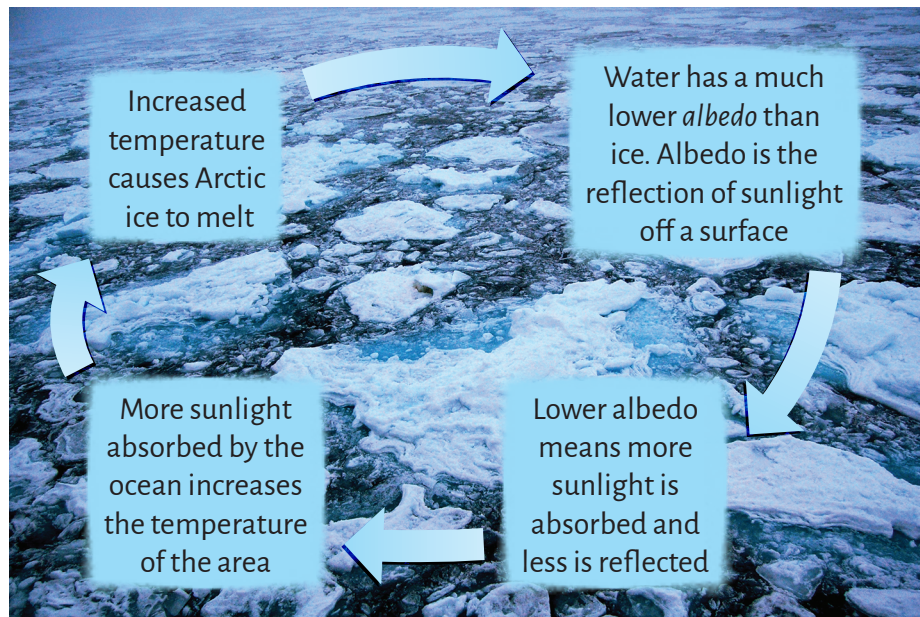
**Positive feedback (common):** praise or a good response.

**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.
2. Name four organic compounds that are the building blocks of life.
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.
4. Describe the two principle ways in which water is returned to the atmosphere in the water cycle.

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

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.

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

### 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, your 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.
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.
  - 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.
  - 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.



3. Describe some factors that can increase the risk of a negative response to an environmental health hazard.
4. Describe how *biomagnification* works.
5. What are VOCs? What are POPs? Give two examples of each.

## 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.
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](http://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.

## 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.

### **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.

## **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.

### 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](http://www2.epa.gov/toxics-release-inventory-tri-program)

Here’s another great website for current information:

Environmental Health News

[www.environmentalhealthnews.org](http://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

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

3. Define soil leaching.
4. Describe three farming practices that can help reduce soil erosion.
5. Describe one soil conservation policy, either U.S. or international.
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](http://www.nrcs.usda.gov), and typing “salinization” in the search bar.

## 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.

## 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.

## 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.

## 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.

#### 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.

### 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](http://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 of 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.

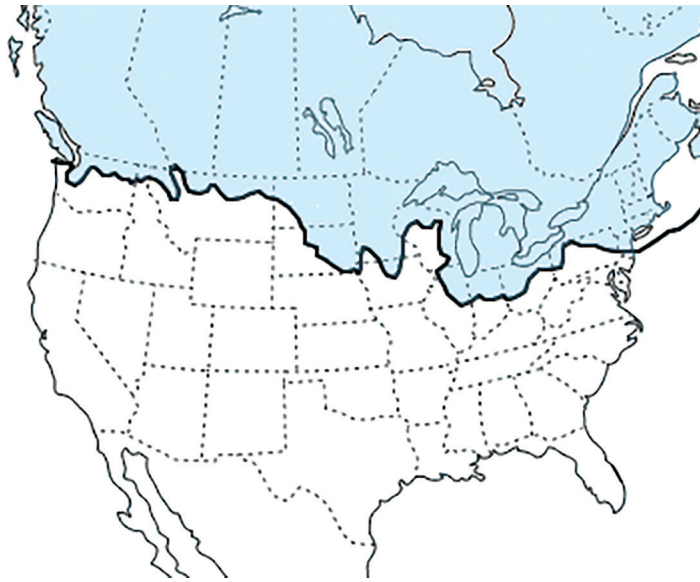
### Option 3: The Effects of Earthworms

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:

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### 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.

### 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.

### 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?

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### 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?

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

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

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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 foot-path, dirt road, etc.
- another intermediate plot of your choice (describe it)

#### Before You Begin

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

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Which plot do you think will absorb water faster?

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Describe your third location (intermediate plot).

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#### 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?

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2. Which plot absorbed water faster?

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

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

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### 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.

## 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

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## 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](http://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](http://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](http://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](http://www.audubon.org/conservation/science/christmas-bird-count)

“Citizen Science” (*National Wildlife Federation*)

[www.nwf.org/Educational-Resources/Wildlife-Guide/Understanding-Conservation/Citizen-Science](http://www.nwf.org/Educational-Resources/Wildlife-Guide/Understanding-Conservation/Citizen-Science)

“Citizen Science” (*Scientific American*)

[www.scientificamerican.com/citizen-science](http://www.scientificamerican.com/citizen-science)

“Citizen Science” (*NASA Science*)

[science.nasa.gov/citizenscience](http://science.nasa.gov/citizenscience)

*Zooniverse* (a “master list” of citizen science projects)

[www.zooniverse.org](http://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

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|                                              |            |
|----------------------------------------------|------------|
| <b>Materials List .....</b>                  | <b>262</b> |
| Materials List (sorted by lesson)            |            |
| Alphabetical List of Materials               |            |
| <b>Academic Expectations .....</b>           | <b>267</b> |
| <b>Original Work Guidelines.....</b>         | <b>268</b> |
| Plagiarism                                   |            |
| <b>Finding Reputable Sources .....</b>       | <b>268</b> |
| <b>Citing Your Sources .....</b>             | <b>269</b> |
| In-text citations                            |            |
| Citing print, online, and film sources       |            |
| Citing images                                |            |
| <b>Elements of Good Writing.....</b>         | <b>272</b> |
| Varied sentences                             |            |
| Strong paragraphs                            |            |
| <b>The Writing Process .....</b>             | <b>275</b> |
| Prewriting activities                        |            |
| Writing the rough draft                      |            |
| Revising                                     |            |
| Editing                                      |            |
| Proofreading                                 |            |
| Publishing, submitting, or sharing your work |            |
| Five-paragraph essay                         |            |
| Comparative essay                            |            |
| Multimedia presentations                     |            |
| <b>Works Cited .....</b>                     | <b>280</b> |

## 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<br>felt pens or colored pencils of several colors<br>pen or pencil<br>4–8 stakes<br>string, about 50 meters<br>tape measure or meter stick<br>field guides to local insects and plants<br>camera<br>hand lens or magnifying glass |
| 8      | Activity B, Option 2: Modeling Population Growth               |      | handful of dry beans<br>calculator                                                                                                                                                                                                                         |
| 9      | Activity B, Option 2: Observing Competition at the Bird Feeder |      | bird feeder<br>commercial birdseed<br>field guide to local birds                                                                                                                                                                                           |
| 11     | Lab A: Dissecting Owl Pellets                                  |      | owl pellet<br>baking pan<br>disposable gloves<br>tweezers or forceps<br>needle<br>white paper<br>camera<br>small animal identification field guide that includes skull illustrations (or online equivalent)                                                |

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

| Lesson | Assignment                                                 | Req. | Materials Needed                                                                                                                                                                                                                                                                                                                                                                        |
|--------|------------------------------------------------------------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 23     | Activity C, Option 4:<br>Preventing Soil Erosion Quick Lab |      | 4 trays<br>4 large bowls, pots, or buckets to collect the runoff<br>watering can or similar device that will mimic a rainstorm<br>plain soil<br>sod or soil with a dense mat of undisturbed vegetation on it<br>some type of mulch (hay, wood chips, leaves, etc.)<br>soil with compost mixed in<br>wood blocks, bricks, or other materials to prop up the trays<br>large measuring cup |
|        | Activity C, Option 5: Soil Depth and Compaction Quick Lab  |      | meter stick<br>1 liter measuring cup or bottle<br>stopwatch                                                                                                                                                                                                                                                                                                                             |
| 26/27  | Activity B, Option 9: Cultural Eutrophication LAB          |      | tap water<br>pond, stream, or lake water (or water from a freshwater aquarium)<br>3 quart jars with lids<br>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<br>adjustable goose-neck lamp, with a 100W incandescent bulb (or other bulb that produces heat)<br>large ice cubes, at least 24<br>incense stick, preferably about 30 cm long<br>masking tape<br>matches or a lighter<br>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<br>aluminum foil<br>wax paper<br>modeling clay<br>multipurpose white glue, 4 oz<br>Borax powder (20 Mule Team detergent booster), 1 Tbsp<br>stirring stick<br>small plastic cup<br>scissors<br>clear packing tape<br>measuring cups and spoons<br>colored markers<br>large sheet of construction paper or poster board<br>1 $\frac{1}{4}$ cups water<br>2 small plastic tubs (like a butter tub)<br>camera |
|        | Activity C: Ecosystem Exploration/Phenology Follow-Up         | ✓    | notebook for field notes<br>felt pens or colored pencils of several colors<br>pen or pencil<br>field guides to local insects and plants<br>camera<br>hand lens or magnifying glass<br>4–8 stakes (if needed)<br>string, about 50 meters (if needed)<br>tape measure or meter stick (if needed)                                                                                                                                                                 |
| 34     | Lab: Household Energy Consumption                             | ✓    | watt meter (optional)<br>flashlight<br>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<br>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                                                     | gloves, disposable                                                |
| aquarium (10–20 gallons) with cover, or clear plastic storage bin | glue, multipurpose white                                          |
| aquarium or large glass container                                 | graph paper                                                       |
| baking pan                                                        | hand lens or magnifying glass                                     |
| beans, dry                                                        | incense stick                                                     |
| bird feeder                                                       | jars, quart size with lid (3)                                     |
| birdseed                                                          | lamp, adjustable goose-neck, with a 100W incandescent bulb        |
| blindfold (scarf, bandana, etc.)                                  | liquid fertilizer                                                 |
| Borax powder (20 Mule Team detergent booster)                     | markers, colored                                                  |
| bottle, small with a neck                                         | matches or a lighter                                              |
| bottled water (2–3)                                               | measuring cup or bottle, 1 liter                                  |
| buckets, large bowls, pots, etc. (4)                              | measuring cups and spoons                                         |
| *building materials (see instructions, lesson 19)                 | meter stick                                                       |
| calculator                                                        | mulch (hay, wood chips, leaves, etc.)                             |
| *camera                                                           | needle                                                            |
| clay, modeling                                                    | *notebooks                                                        |
| construction paper or poster board                                | owl pellet                                                        |
| *electric bill                                                    | *pan, large shallow                                               |
| field guide to local birds                                        | *pencils, colored                                                 |
| field guide to small animal identification (or online equivalent) | pens, felt                                                        |
| *field guides to local insects and plants                         | plastic bags or containers (4)                                    |
| *flashlight                                                       | plastic cup, small                                                |
| food coloring                                                     | plastic tubs, small (2)                                           |
| *gelatin                                                          | pond, stream, or lake water (or water from a freshwater aquarium) |
| glasses, small (2)                                                | ruler                                                             |

|                                                              |                                         |
|--------------------------------------------------------------|-----------------------------------------|
| scale, household                                             | tape, masking                           |
| scissors                                                     | *tape measure or meter stick            |
| shovel, flat, square spade                                   | *thermometer                            |
| soil                                                         | thermometer, outdoor (2)                |
| soil or sod with a dense mat of undisturbed vegetation on it | *timer or stopwatch                     |
| soil with compost mixed in                                   | trays (4)                               |
| *stakes (4–8)                                                | tweezers or forceps                     |
| stirring stick                                               | watering can                            |
| stopwatch                                                    | watt meter (optional)                   |
| *string                                                      | wax paper                               |
| tape, clear packing                                          | 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.