b e ontents

LABORATORY INVESTIGATIONS

ace

You are about to embark on an exciting journey. AP Environmental Science is a unique course because it is an applied science that focuses on problem solving. There is very little pure theory. You have already learned some basic principles of biology, chemistry, physics and mathematics. *Lab Investigations in AP Environmental Science* will help you apply that knowledge by examining the natural environment and considering how human activity is changing it. In addition, you will search for viable resolutions to environmental problems. Along the way you will also learn some political science, sociology, and economics.

You should treat the word *science* as a verb—an action word. You will learn much more by being actively involved than just by reading. Environmental Science holds many opportunities to learn by doing. This is a program tailor-made for curious students who enjoy taking an active role in their education.

USING THE BOOK

The main approach of this book is to examine how the biosphere works and changes naturally and then investigate how humans are affecting it. A major emphasis will be on sustainability of ecosystems and resources and on human responsibility.

Investigation 1 is a series of twelve field studies and long-term projects. One or more of these can be done at any time of the school year, time permitting, and in any order. Most are designed to require a minimum amount of equipment, and many can be done indoors with little problem.

The rationale for the order of the remaining investigations is that to understand human effect on the environment, one must appreciate how the Earth works as if humans were not here. The early labs deal with physical earth systems, plate tectonics, heat absorption and climate, protected natural areas, and the tides. The next few relate to resources, soils and water. Biological systems are studied next, with labs on productivity, food chains and trophic levels, predation, and biodiversity.

Once there is a comprehension of how the natural world works, you will probe various aspects of human population growth and their effects on the Earth. After looking at the impact of the size of human populations, you will turn to investigate how humans meet their energy needs and the effects of those methods.

Lastly you will look into the effects that over six billion people in a growing industrial society have on the biosphere. Many of our environmental predicaments are due to rapid human population growth and unsustainable allocation and use of resources. For example, transportation systems, water use, growth of cities and suburbs, agriculture, energy production and consumption, and waste production and disposal all are carried out in unsustainable ways.

AP Environmental Science is a college-level course, and the experiments and projects should be conducted at that level. Consequently, the format for writing up your results must, in many cases, be more sophisticated than the ways to which you may be accustomed. All your lab experiments and reports should contain the following parts:

Abstract

This is a synopsis of the investigation. It should be written in concise English and be not more than 200 words. Assume that the reader has some background knowledge in the area of your investigation. The beginning sentences should indicate the subject of the investigation and what your goals are. The middle part of the abstract should tell about your observations and measurements and what you concluded. You could include pertinent data that stands out as a result of the experiment.

Introduction

Here you will state the objectives of the investigation, why you are performing this experiment, and why it is important. In many cases it is also where you predict your results. It is important to state your objectives clearly, because they will again be addressed in your conclusions at the end of the experiment. At that point your objectives will have to be analyzed to find out whether you were successful.

Materials

This is simply a list of equipment, chemicals, and instruments you used to complete this study. It should be comprehensive enough to let someone else easily gather materials to repeat your procedures.

Procedure

The objective here is to give others enough directions to perform your experiment themselves. Normally procedures are written in the first person, because they tell what you did. You can organize them as a list, but be sure of the order of steps. Do not outline too much, but include sufficient detail to allow the experiment to be repeated.

Data Tables

The data table is a graphical organizer to record the data you gather in the investigation. It is important to read through the whole experiment to determine what information needs to be documented. A good table of data will make doing the calculations more organized. Keep in mind what data will be used in the actual calculations and graphs; structure the table so that the initial measurements come before the needed values.

Calculations

In doing this part be sure to organize your work. Show numbers and calculations in order on the paper. Show the equation used, then how you substituted the values into it, and finally the result. Always use proper units. If the units cancel out correctly, then you can be confident you set the problem up properly. Underline your final answers.

Graphs

Not all investigations will have graphs, but when they do be sure to use proper form. The independent variable is always on the *x*-axis (horizontal) and the dependent variable is plotted on the *y*-axis (vertical). When setting up the scales, mark off the axes in proportional units, even if the data are not uniformly spaced. Label each axis and give the units of measure. Plot the points as accurately as you can and connect the points with a smooth continuous line of best fit. If more than one line is to be plotted, label each one. Do not use a legend on the side. Give the graph a title.

Results

This is the heart of the investigation. It is here that you discuss and analyze the results. Outline whether your data were as you expected and whether there were any sources of error. Based on your outcomes, suggest ways to improve the investigation.

Conclusion

You can use the questions at the end of the investigations for guidance. The conclusion is where you give overall perspective to your experiment. You should summarize your findings and discuss any implications that lead from them. In the conclusion you may opt to discuss extensions to the lab and suggestions for further areas of study.

AP Environmental Science is a stimulating and vibrant course. As you will see, there are no simplistic answers to environmental problems. You are about to set out on a year of exploration that will make you more aware of your natural and human-made surroundings. It will also improve your skills as a critical thinker and help you look at all sides of a problem to search for the best solution. But don't sit back and be passive. Be an active learner and participate—get involved! And enjoy the year.

William Molnar

Further Research *and* Reading

As you worked through this program, you found that there are a great variety of sources to learn about the environment and its workings. Your textbook and this lab manual are great places to start, but you should not limit yourself to just two sources of knowledge.

THE INTERNET

Each topic you study can be probed more deeply on the Internet. When you use the Internet as a source, be aware of where the information comes from; it is not always reliable. Most Web sites from college and university researchers are likely to be useful and of high quality. Also dependable are the sites from government agencies such as the EPA, United States Geologic Survey (USGS), National Oceanographic and Atmospheric Administration (NOAA), U.S. Department of Energy (DOE), NASA, U.S. Forest Service (USFS), U.S. Fish Game and Wildlife (USFGW), and others.

Some Web sites are mainly environmental in scope. One of the better ones is EurekAlert (www.eurekalert.org), maintained by the American Association for the Advancement of Science (AAAS). It is a general purpose science news Web site, but there are a lot of environmental topics that you can search.

The Environmental News Network (www.enn.com) is an excellent site that has four or more environmental news stories everyday. There are additional links for more in-depth reading. You can also sign up for an e-mail newsletter.

The EnviroLink Network (www.envirolink.org) Web site has about thirty subtopics that allow you to find information on topics from agriculture to wildlife. It also has four or five news articles from a variety of sources.

Environment and Energy Publishing LLC (www.eenews.net) has a Web site that is broken down into three sections. One, Environment and Energy Daily, deals with congressional legislation on energy-related issues. Another, Greenwire, tracks the politics, policies, and the press on energy issues. Lastly, Land Letter deals with natural resource policy.

JOURNALS AND PERIODICALS

Scientific journals are another excellent resource. Many have free access to their articles. Some require that you register as a user at no charge.

The premier science journal in the United States is *Science* (www.sciencemag.org). It is a weekly periodical that has news stories and frontier research articles that can be read by interested readers. An interesting section on the Web page is the Essays on Science and Society. These give perspective on the interaction of science, scientists, and society. Many are environmentally related.

Scientific American (www.sciam.com) is a monthly journal that has longer articles, some environmental in scope. There also are news and technology sections that are applicable.

The *New Scientist* (www.newscientist.com) is a British weekly that often has environmental topics highlighted. The articles also have suggested related stories to deepen your understanding of a topic.

The weekly *Science News* (www.sciencenews.org) does not post all its articles on its Web page, but it documents the references and sources so you can probe the topic.

Many newspapers have a weekly science section. An outstanding one is in the *New York Times*, where every Tuesday a whole section, (Science Times, www.nytimes.com/pages/science/index.html), is devoted to science. In recent years topics that have appeared there prior to the APES exam sometimes were the theme for a few free-response questions on the APES exam.

BOOKS

A major source of information and discovery is paperback books. These are inexpensive, often written for popular consumption, and not overly technical. Some large bookselling franchises, such as Barnes and Noble and Borders, have extensive science sections where you can find a variety of environmentally focused books. Many students who tried these books have said how surprised they were at how interesting a science book can be! No matter which ones you select, they will in some way be addressed during the year in this course. Some students find it stimulating to keep a diary of their comments, questions, and insights as they read. Below are some suggestions.

FURTHER READINGS IN ENVIRONMENTAL SCIENCE

Title	Author	
A Civil Action	Jonathan Harr	1996
A Fierce Green Fire	Philip Shabecoff	1993
A Fine Piece of Water	Tom Anderson	2002
Against the Tide—Battle for America's Beaches	Cornelia Dean	1999
A Green History of the World	Clive Pointing	1992
Atmosphere, Climate and Change	Thomas Graedel and Paul Crutzen	1997
Becoming Human	Ian Tattersal	1998
Biogeochemistry of a Forest Ecosystem	Gene Likens	1977
Cadillac Desert	Marc Reisner	1986
Changes in the Land	William Cronon	1984
Climate Change: The IPCC Scientific Assessment	J. T. Houghton et al.	1990
Deep Ecology	Bill Devall	1985
Degrees of Disaster: Prince William Sound	Jeff Wheelwright	1994
Desert Solitaire	Edward Abbey	1968

Title	Author	
Digging Dinosaurs	John Horner	1988
Earth in the Balance	Al Gore	1992
Earth Under Siege	Richard P. Turco	1997
Ecology and the Politics of Scarcity	William Ophuls	1992
Ecology, Economics, Ethics: The Broken Circle	Bonnann and Kellert	1991
Eco-warriors	Rick Scarce	1990
Encounters with the Archdruid	John McPhee	1990
Endurance: Shackelton's Legendary Antarctic Expedition	Caroline Alexander	1998
Energy: From Nature to Man	Wiliam C. Reynolds	1974
Extinction: Bad Genes or Bad Luck	David Raup	1992
Field Guide to Nature Observation and Tracking	Tom Brown	1983
Four Corners	Kenneth Brown	1995
Green Delusions	Martin Lewis	1992
Guns, Germs and Steel	Jared Diamond	1999
How Many People Can the Earth Support?	Joel E. Cohen	1995
Into the Wild	Jon Krakauer	1997
Into Thin Air: Personal Account of the Mt. Everest Disaster	Jon Krakauer	1998
Isaac's Storm	Eric Larson	1999
Ishmael	Daniel Quinn	1995
Last Refuge: Environmental Showdown in the American West	Jim Robbins	1994
Last Oasis—Facing Water Scarcity	Sandra Postel	1992
Life in the Balance: Humanity and the Biodiversity Crisis	Niles Eldridge	2000
Of Wolves and Men	Barry Lopez	1979
On Human Nature	E. O. Wilson	1978
Our Common Future	World Commission on Environment and Development	1987
Our Ecological Footprint	Wackernagel and Rees	1996
Pilgrim at Tinker Creek	Annie Dillard	1974
Prisoner's Dilemma	William Poundstone	1993
Replenish the Earth	Lewis Regebstein	1991
Rivers of Life	Sandra Postel and Brian Richter	2003
Sand County Almanac	Aldo Leopold	1949
Silent Spring	Rachel Carson	1962
Sociobiology	E. O. Wilson	1975
Surely You're Joking, Mr. Feynmann?	Richard Feynman	1985
Tales of the Shaman's Apprentice	Mark Plotkins	1994
The Burning Season	Andrew Revkin	1990
The Cold and the Dark: The World After Nuclear War	Carl Sagan, Paul Ehrlich, et al.	1984
The Coming Plague	Laurie Garrett	1994
The Control of Nature	John McPhee	1990
The Cowboy Way	David McCumber	1999
The Dinosaur Heresies	Robert Bakker	1986
The Diversity of Life	E. O. Wilson	1999

Title	Author	Date
The End of Nature	Bill McKibben	1990
The Limits to Growth, 2nd Edition	Donella Meadows	1992
The Monkey Wrench Gang	Edward Abbey	1975
The Naturalist	E. O. Wilson	1994
The Night of the Grizzlies	Jack Olsen	1969/96
The Perfect Storm	Sebastian Junger	1997
The Population Bomb	Paul Ehrlich	1997
The Population Explosion	Paul and Anne Ehrlich	1990
The Sand Dollar and the Slide Rule	Delta Willis	1996
The Sixth Extinction	Richard Leakey	1996
The Solace of Open Spaces	Gretel Ehrlich	1985
The Song of the Dodo	David Quammen	1997
The Stork and the Plow	Paul Ehrlich	1997
The Warning: The Accident at Three Mile Island	Mike Gray and Ira Rosen	1982
Three Scientists and Their Gods	Robert Wright	1988
Tracking the Vanishing Frogs	Kathryn Phillips	1994
Walden Pond	Henry Thoreau	1854
Waterheads 3—10 Cases of Environmental Ethics	Lisa Nelson and Catherine Dillingham	2002
Why People Believe Weird Things	Michael Shermer	1998
Wolves of Isle Royale	Rolk Peterson	1995

Also, always consider reading:

- Any geology or natural history title by John McPhee
- All books by Stephen J. Gould, Edward O. Wilson, Carl Sagan, and Edward Abbey

The goal of all these resources is to inspire you to be an interested, life-long learner on environmental issues. Most of the severe problems that face humans today in one way or another relate to the environment—problems involving over-population, energy production and fuels, potable drinking water supplies, natural resource depletion, global climate change, farms and food production, solid waste disposal, and toxic wastes. Even the economy and jobs are indirectly related to environmental issues. To be an effective citizen in this complex and modern world, it is important to understand environmental concerns and their ramifications.