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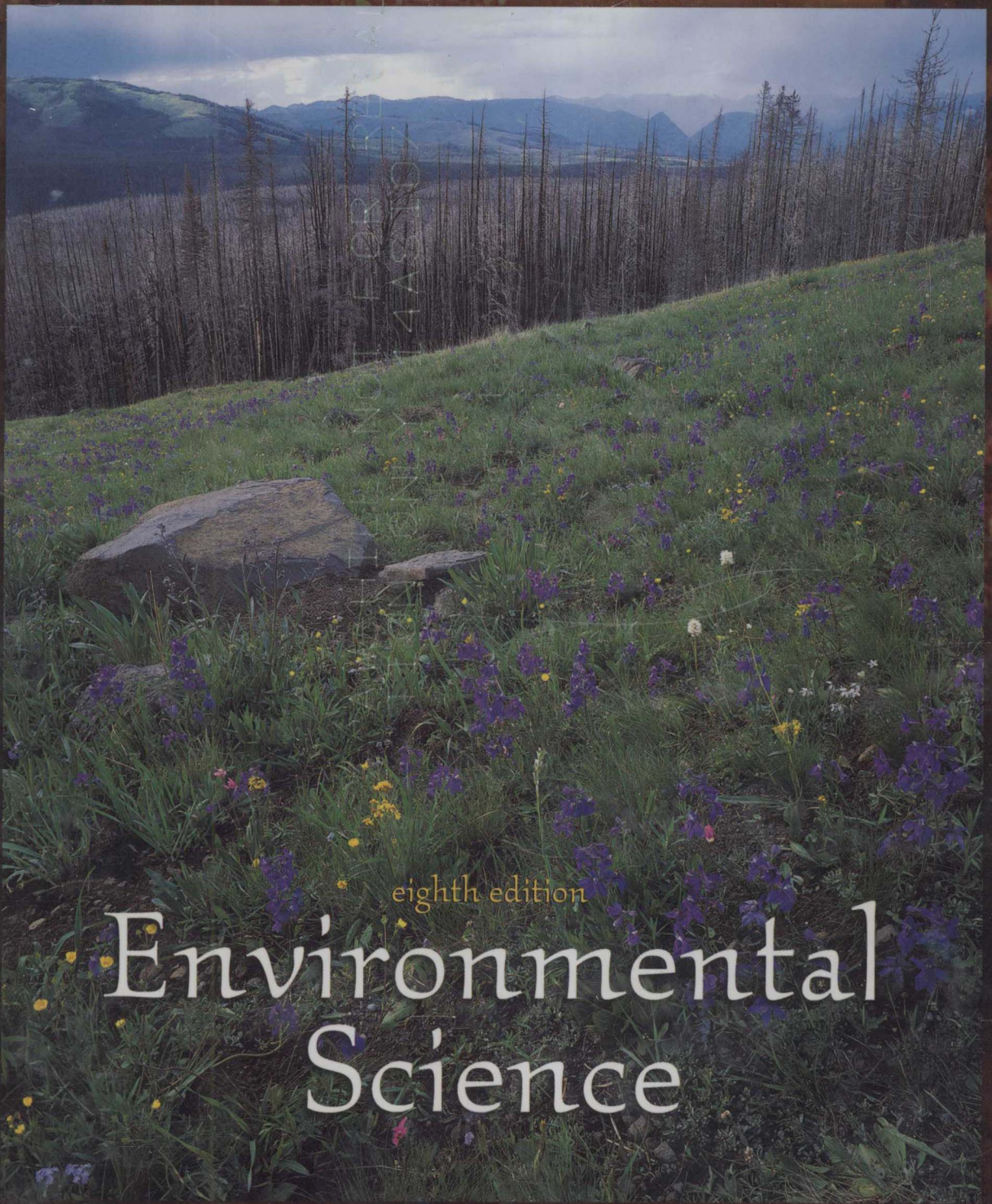

eighth edition

Environmental Science

A Study of Interrelationships

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A Study of Interrelationships

Delta College

Bradley F.Smith

Western Washington University

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To Judy, my wife and friend,
for sharing life's adventures.
Eldon Enger

To my wife, Daria, for her love, support,
patience and understanding.
Brad Smith

Preface

Environmental science is an interdisciplinary field. Because environmental disharmonies occur as a result of the interaction between humans and the natural world, we must include both when seeking solutions to environmental problems. It is important to have a historical perspective, appreciate economic and political realities, recognize the role of different social experiences and ethical backgrounds, and integrate these with the science that describes the natural world and how we affect it. *Environmental Science: A Study of Interrelationships* incorporates all of these sources of information when discussing any environmental issue. Furthermore, the authors have endeavored to present a balanced view of issues, diligently avoiding personal biases and fashionable philosophies.

Environmental Science: A Study of Interrelationships is intended as a text for a one-semester, introductory course for students with a wide variety of career goals. They will find it interesting and informative. The central theme is interrelatedness. No text of this nature can cover all issues in depth. What we have done is to identify major issues and give appropriate examples that illustrate the complex interactions that are characteristic of all environmental problems. There are many facts—presented in charts, graphs, and figures—that help to illustrate the scope of environmental issues. However, this is not the core of the text, since the facts will change.

Organization and Content

This book is divided into five parts and twenty chapters. It is organized to provide an even, logical flow of concepts and to provide clear illustrations of the major environmental issues of today.

Part 1 establishes the theme of the book—in chapter 1—by looking at the kinds of environmental issues typical of different regions of North America. In each region, the specific issues selected involve scientific, social, political, and economic components typical of environmental problems. Chapter 2 focuses on the philosophical base needed to examine environmental issues by discussing various ethical and moral stands that shape how people approach environmental issues. Chapter 3 introduces economic issues and the concept of risk analysis. Both of these topics will be brought up at several points later in the text.

Part 2 provides an understanding of the ecological principles that are basic to organism interactions and the flow of matter and energy in ecosystems. The nature of food chains and how they affect the flow of matter and energy are discussed. Other topics included are the efficiency of energy flow through ecosystems, the intricacies of organism-to-organism interaction, and the creative role of natural selection in shaping ecological relationships. Principles of population structure and organization are also developed in this section, with particular attention to the implications of these principles to growth and impact of human populations.

Part 3 focuses on energy. A major emphasis is on the historically important, nonrenewable fossil fuels that have stimulated economic success of the developed economies of the world. Renewable sources of energy are discussed, but with the recognition that they currently are a small part of the world energy picture. Weapons production and nuclear power plants use enormous amounts of energy that can be released from the nucleus of the atom. Both of these uses have caused fear among the public related to the dangers of radiation and the adequacy of waste disposal. These issues are discussed in this section.

Part 4 emphasizes the impact of human activity on natural ecosystems. As human populations grow, and technology changes, the magnitude of human actions becomes more apparent. The natural ecosystems on land and water are modified to meet human needs. The heavy use of pesticides in agriculture is discussed in this section.

Part 5 deals with the major types of pollution. Pollution affects the health and welfare of humans and other organisms. Air pollution, solid waste, and hazardous and toxic substances are discussed in this section. The cost of pollution cannot always be measured in financial terms but may be reflected in the mental and physical health of the populace. Ultimately, governments must address environmental concerns and develop policy to address the concerns. Increasingly, the concerns are international in scope and require negotiations between governments with very different economic conditions and concerns.

New to this Edition

1. The text has been edited throughout and rewritten where needed to include the most recent data and ways of thinking about environmental issues.
2. Many new illustrations were developed and many others were modified to improve their ability to convey information.
3. Several chapters have been substantially revised:
   - Chapter 3, Risk and Cost: Elements of Decision Making, has been moved near the front of the text. Since economics and risk are integral parts of many kinds of environmental discussions, several reviewers have

suggested that this discussion should appear early in the text. This chapter includes expanded coverage of market-based instruments for addressing environmental issues and additional material on the concept of sustainability.

- Chapter 4, Interrelated Scientific Principles, has been substantially rewritten. The section on the scientific method was rewritten, the concepts of entropy and pH were expanded, and a new table was added that describes the various subunits of matter.
- Chapter 5, Interactions: Environment and Organisms, was rewritten to include significantly more material on the concepts of evolution and natural selection and how evolution relates to what is seen in ecosystems. The material on nutrient cycles was extensively rewritten and several boxed readings have been incorporated into the text to provide a better flow of ideas.
- Chapter 12, Human Impact on Resources and Ecosystems, was substantially reorganized with more meaningful headings. The material on minerals has been reduced and the topic of speciation has been moved to chapter 5.
- Chapter 13, Land-Use Planning, was completely rewritten with expanded sections on land-use planning principles, the causes and problems associated with urban sprawl, and redevelopment of inner cities.
- Chapter 17, Air Quality Issues, was substantially rewritten with expanded coverage of climate change and its effects, as well as steps that can be taken to reduce human impact on the global climate.

4. Many new topics or boxed readings have also been added, or have replaced previous readings:
   - Chapter 1 has new material on the harp seal hunting, and a new Environmental Close-Up on forest management.
   - Chapter 2 has expanded coverage of the topic of environmental justice and a new Environmental Close-up on illegal trade in rare species.
   - Chapter 3 has a new Global Perspective—Wombats and the Australian Stock Exchange and much new information on market approaches to managing environmental problems.
   - Chapter 4 has new material on subunits of matter, and an expanded discussion of pH and of latent heat and sensible heat.
   - Chapter 5 has a new section on evolution and natural selection that includes discussion of evolutionary patterns and coevolution, and includes several new examples. A new section on keystone species was added.
   - Chapter 8 has new material on total fertility rate and on the importance of breastfeeding in population control. Additional material was also added on India as a major force in human population growth.
   - Chapter 9 has expanded coverage of OPEC, energy development in China, and a new Environmental Close-Up on hybrid vehicles.
   - Chapter 10 has new material on the forces that cause rising fuel prices, the potential for energy conservation, and expanded wind energy and biomass conversion technologies. The status of the Three Gorges Dam in China has also been updated.
   - Chapter 12 contains a new Issues and Analysis case study dealing with the use of fire as a forest management tool, and a new figure on the impact of technology on natural systems.
   - Chapter 13 has major new sections on land-use planning principles, the cause and consequences of urban sprawl, and a new figure related to flooding.
   - Chapter 15 has added material on the efforts of the World Wildlife Fund to ban DDT use worldwide. The topics of precision agriculture and the controversy surrounding the use of genetically modified crops are also introduced.
   - Chapter 17 has increased coverage of climate change and its impacts, and a new section that deals with strategies for addressing climate change.
   - Chapter 19 has a new Environmental Close-Up on computers a hazardous waste problem. There is also expanded coverage of pollution prevention and international awareness of hazardous wastes as a problem.
   - Chapter 20 has a new section on the cyanide poisoning incident on the Danube River. In addition, there is expanded coverage of current environmental policy and environmental security.

Useful Ancillaries

1. An **Instructor's Manual** accompanies the text and includes chapter outlines, objectives, key terms, a range of test and discussion questions, suggestions for demonstrations, and suggestions for audiovisual materials and other teaching aids.
2. A set of one hundred **transparencies** is also available to users of the text. The transparencies duplicate text figures that clarify essential ecological, political, economic, social, and historical concepts.
3. **Computerized Testing Software** allows for easy test generation using the questions found in the printed test bank.
4. The **Environmental Science Visual Resource Library (VRL)** is a dual platform CD-ROM that allows the user to search with key words or terms and access hundreds of images to illustrate classroom lectures, with just the click

of a mouse. It contains images from four McGraw-Hill textbooks and over 400 additional photographs.

5. Visit our comprehensive **online learning center** at http://www.mhhe.com/environmentalscience/ and discover a variety of valuable resources for both instructor and student. Examples include chapter-by-chapter Internet links (updated regularly) that correspond to each chapter, laboratory exercises, case studies, classroom activities, concept mapping exercises, current global environmental events in the news, practice quizzing, career information, and more.
6. Available on CD-Rom, or accessed via the Online Learning Center, the Environmental Science **Essential Study Partner** is a complete, interactive study tool offering animations and learning activities to help students understand complex environmental science concepts. This valuable resource also includes self-quizzing to help students review each topic and provides hyperlinks to tutorial sections for further review.
7. **BioCourse.com** is an electronic meeting place for students and instructors. Its breadth and depth goes beyond our Online Learning Centers to offer six major areas of up-to-date and relevant information: Faculty Club, Student Center, News Briefing Room, BioLabs, Lifelong Learning Warehouse, and R & D Center.

Related Titles

Field and Laboratory Exercises in Environmental Science

ISBN = 0-07-0290913-7

This lab manual provides hands-on experiences that are relevant, easy to understand, and applicable to students' lives. The experiments are designed to be concise, unique, inexpensive, and easily tailored to any course.

Online *Taking Sides: Clashing Views on Controversial Environmental Issues*

ISBN = 0-07-243097-4 • www.dushkin.com/online

This debate-style reader is designed to introduce one to controversies in environmental policy and science, and reflects a variety of viewpoints staged as "pro" and "con" debates. Issues are organized around four core areas: general philosophical and political issues, the environment and technology, disposing of wastes, and the environment and the future.

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This volume brings together primary source selections of enduring intellectual value—classic articles, book excerpts, and research studies that have shaped environmental studies and our contemporary understanding of it.

You Can Make a Difference: Be Environmentally Responsible

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This book is organized around the three parts of the biosphere: land, water, and air.

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Ghulam Aasef
Kaskaskia College

Thomas J. Algeo
University of Cincinnati

John Vincent Aliff
Georgia Perimeter College

Julius Alker
Central Florida Community College

Margaret M. Avard
Southeastern Oklahoma State University

Robert M. Barry
Palm Beach Community College

R. P. Benard
American International College

William B. N. Berry
University of California, Berkeley

Patricia J. Beyer
Bloomsburg University

Deborah Bird
Pima Community College

Andrew David Bixler
Chaffey College

Del Blackburn
Clark College

Dorothy Boorse
Gordon College

Richard A. Boutwell
Missouri Western State College

Steven G. Brumbaugh
Tacoma Community College

David Byres
Florida Community College, Jacksonville

Catherine W. Carter
Georgia Perimeter College

David A. Charlet
Community College Southern Nevada

Terence H. Cooper
University of Minnesota

William C. Culver
Saint Petersburg Junior College

William T. Davin
Berry College

James N. DeVries
Lancaster Bible College

Darren Divine
University of Nevada, Las Vegas

Patricia Dooris
Saint Leo College

Vernon P. Dorweiler
Michigan Technological University

Terese Dudek
Kishwaukee College

Tom Dudley
Angelina College

Andrew Evans, Jr.
James Madison University

Sharon Flanagan
Nunez Community College

Stephen Fleckenstein
Sullivan County Community College

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Bakersfield College

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John Gault
Missouri Valley College

J. Phil Gibson
Agnes Scott College

Nancy L. Goodyear
Bainbridge College

Andrew P. Goyke
Northland College

Thomas F. Grittinger
University of Wisconsin, Sheboygan

Carl W. Grobe
Westfield State College

Elizabeth A. Guthrie
University of Tennessee, Chattanooga

Dallas Hanks
Utah Valley State College

Steve Hardin
Ozarks Technical Community College

Keith R. Hench
Kirkwood Community College

Stephen R. Herr
Oral Roberts University

Graham C. Hickman
Texas A & M University, Corpus Christi

Sue Holt
Cabrillo College

Alan R. Holyoak
Manchester College

Huey-Min Hwang
Jackson State University

Al Iglar
East Tennessee State University

Joseph Jay Jacquot
Grand Valley State University

Wendel J. Johnson
University of Wisconsin, Marinette

Gina Johnston
California State University, Chico

Eric N. Jones
Mary Baldwin College

Martin G. Kelly
State University of New York, Buffalo

Suzanne Kempke
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John F. Logue
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Oregon Coast Community College

Jean B. McManus
North Greenville College

Michael T. Mengak
Ferrum College

Mark Mitch
New England College

David A. Munn
The Ohio State University, Agricultural Technical Institute

Thomas E. Murray
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Herman S. Muskatt
Utica College of Syracuse University

Muthena Naseri
Moorpark College

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Connecticut College

Chuks Ogbonnaya
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Chris E. Petersen
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Jon K. Piper
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Arapahoe Community College

William G. Raschi
Bucknell University

Joyce O. Rasdall
Western Kentucky University

C. Lee Rockett
Bowling Green State University

Steven J. Ropski
Gannon University

Eleanor Saboski
University of New England

Robert Sanford
University of Southern Maine

Bradley A. Sarchet
Colby—Sawyer College

Christine L. Schadler
University of New Hampshire

Fred Schindler
Indian Hills Community College

Bruce A. Schulte
Providence College

Alan M. Schwartz
Saint Lawrence University

Harold F. Sears
University of South Carolina, Union

Janet Anne Sherman
Pennsylvania College of Technology

Leslie A. Sherman
Providence College

Gary Silverman
Bowling Green State University

Stephanie Smith
Northeast Mississippi Community College

Rolf Sohn
Brevard Community College

John R. Spear
Colorado School of Mines

Douglas J. Spieles
Southwest State University

Joseph D. Stogner
Ferrum College

Max R. Terman
Tabor College

Jamey Thompson
Maysville Community College

Darwin R. Thorpe
Compton Community College

Olli H. Tuovinen
Ohio State University

Daniel A. Underwood
Peninsula College

Dale A. Utt, Jr.
Oklahoma Baptist University

W. M. von Zharen
Texas A & M University, Galveston

Marjorie Welch
Southwestern Community College

Arlene A. Westhoven
Ferris State University

Thomas M. Wolf
Washburn University

Richard J. Wright
Valencia Community College

Len Yannielli
Naugatuck Valley Community Technical College

Metin Yersel
Lyndon State College

John M. Zamora
Middle Tennessee State University

Astatkie Zikarge
Texas Southern University

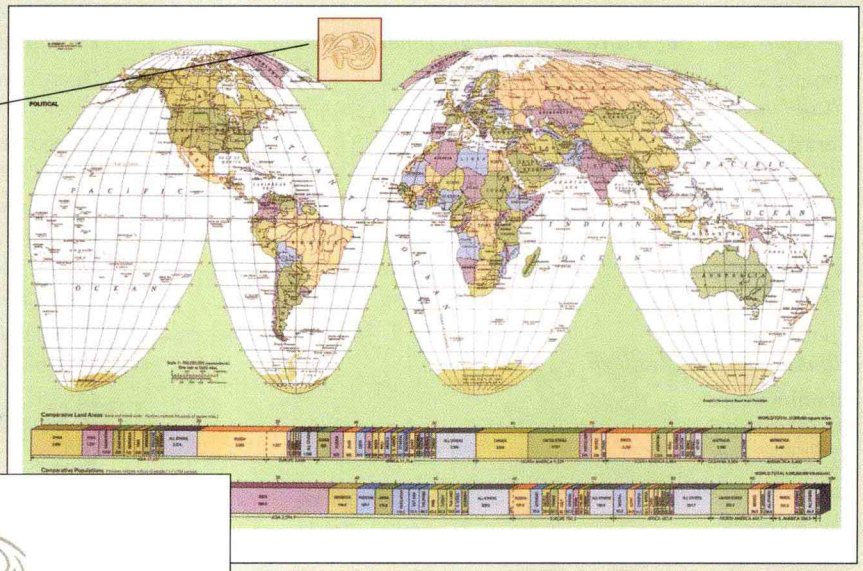
GUIDED TOUR

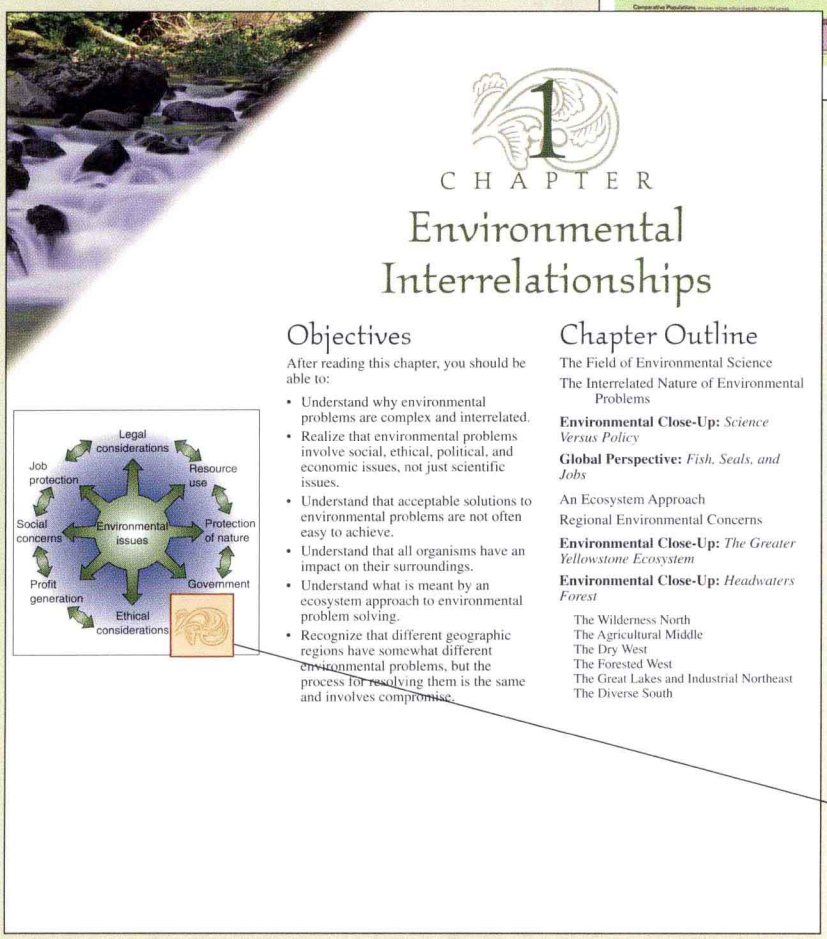
The features of this book are Unique

The organization and principle features of this book were planned with the students' wholistic learning and comprehension in mind:

WORLD MAP

A **world map** with political boundaries can be found immediately following the preface. This will help the reader to more fully understand and appreciate global environmental issues.





CHAPTER 1

Environmental Interrelationships

Objectives

After reading this chapter, you should be able to:

- Understand why environmental problems are complex and interrelated.
- Realize that environmental problems involve social, ethical, political, and economic issues, not just scientific issues.
- Understand that acceptable solutions to environmental problems are not often easy to achieve.
- Understand that all organisms have an impact on their surroundings.
- Understand what is meant by an ecosystem approach to environmental problem solving.
- Recognize that different geographic regions have somewhat different environmental problems, but the process for resolving them is the same and involves compromise.

Chapter Outline

The Field of Environmental Science

The Interrelated Nature of Environmental Problems

Environmental Close-Up: *Science Versus Policy*

Global Perspective: *Fish, Seals, and Jobs*

An Ecosystem Approach

Regional Environmental Concerns

Environmental Close-Up: *The Greater Yellowstone Ecosystem*

Environmental Close-Up: *Headwaters Forest*

The Wilderness North
The Agricultural Middle
The Dry West
The Forested West
The Great Lakes and Industrial Northeast
The Diverse South

INTRODUCTION

The five parts of the text each present an **introduction** that places the upcoming chapters in context for the reader by recalling previously discussed material and by describing the organization of the chapters to come.

LEARNING OBJECTIVES, OUTLINE, CONCEPTUAL DIAGRAM

Each chapter begins with a set of **learning objectives,** an **outline,** and a **conceptual diagram,** all of which give the student a broad overview of the interrelated forces that are involved in the material to be discussed. Students are encouraged to refer to these resources while reading and reviewing the chapter.

TABLES, CHARTS, GRAPHS, MAPS, DRAWINGS, OR PHOTOGRAPHS

To dramatize and clarify text material, each chapter includes a number of **tables, charts, graphs, maps, drawings,** or **photographs.** Every illustration has been carefully chosen to provide a pictorial image or an organized format for showing detailed information, which helps the reader comprehend the chapter material.

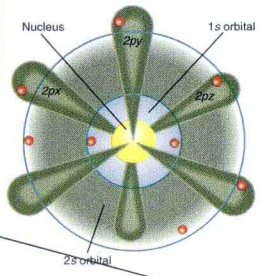


figure 4.2 **Diagrammatic Oxygen Atom** Most oxygen atoms are composed of a nucleus containing eight positively charged protons and eight neutrons without charges. Eight negatively charged electrons spin around the nucleus.

Table 4.1 Relationships Between the Kinds of Subunits Found in Matter

Category of Matter	Subunits	Characteristics
Subatomic Particles	protons	Positively charged
		Located in nucleus of the atom
	neutrons	Have no charge
		Located in nucleus of the atom
	electrons	Negatively charged
		Located outside the nucleus of the atom
Elements	atoms	Atoms of an element are composed of specific arrangements of protons, neutrons, and electrons.
		Atoms of different elements differ in the number of protons, neutrons, and electrons present
Compounds	molecules	Molecules of compounds are composed of two or more atoms chemically bonded together
		Molecules of different compounds contain different atoms or different proportions of atoms.
Mixtures	molecules	Molecules of mixtures are not chemically bonded to each other.
		The number of each kind of molecule present is variable.

many plants such as tobacco, poison ivy, and rhubarb leaves naturally contain toxic materials, while the use of chemical fertilizers has contributed to the health of major portions of the world since their use accounts for about one-third of the food grown in the world. However, it is appropriate to question if the use of agricultural chemicals is always necessary or if trace amounts of specific agricultural chemicals in food are dangerous. It is often easy to jump to conclusions or confuse fact with hypothesis, particularly when we generalize.

The Structure of Matter

stant motion. Although different kinds of matter have different properties, they are similar in one fundamental way. They are all made up of one or more kinds of smaller subunits called atoms.

Atomic Structure

Atoms are the fundamental subunits of matter. They in turn are made up of protons, neutrons, and electrons. There are 92 kinds of atoms found in nature. Each kind forms a specific type of matter known as an **element.** Gold (Au), oxygen (O), and mercury (Hg) are examples of elements. All atoms are composed of a central region known as a **nucleus,** which is composed of two kinds of relatively heavy particles: positively charged particles called **protons** and uncharged particles called **neutrons.** Surrounding the nucleus are clouds of relatively lightweight, fast-moving, negatively charged particles called **electrons.** As mentioned earlier, each kind of element is composed of a specific kind of atom. The atoms of different kinds of elements differ from one another in the number of protons, neutrons, and electrons present. For example, a typical atom of mercury contains 80 protons and 80 electrons; figure 4.2.) (Appendix 3 contains a periodic table of the elements.) All atoms of an element always have the same number of protons and electrons, but the number of neutrons may vary from one atom to the next. Atoms of the same element that differ from one another in the number of neutrons they contain are called **isotopes.**

Molecules and Mixtures

Atoms can be attached to one another into stable units called **molecules.** When two or more different kinds of atoms are attached to one another, the kind of matter formed is called a **compound.** While only 92 kinds of atoms are commonly found, there are millions of ways atoms can be combined to form compounds. Water (H_2O), sugar ($C_6H_{12}O_6$), salt (NaCl), and methane gas (CH_4) are examples of compounds.

Many other kinds of matter are **mixtures,** variable combinations of atoms or molecules. Honey is a mixture of several sugars and water; concrete is a mixture of cement, sand, gravel, and reinforcing rods; and air is a mixture of several gases of which the most common are nitrogen and oxygen. Table 4.1 summarizes the

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ENVIRONMENTAL CLOSE-UP

Exposure to Toxins

We are all exposed to materials that are potentially harmful. The question is, at what levels is such exposure harmful or toxic? One measure of toxicity is $\mathbf{LD_{50}}$, the dosage of a substance that will kill (lethal dose) 50 percent of a test population. Toxicity is measured in units of poisonous substance per kilogram of body weight. For example, the deadly chemical that causes botulism, a form of food poisoning, has an LD_{50} in adult human males of 0.0014 milligrams per kilogram. This means that if each of 100 human adult males weighing 100 kilograms consumed a dose of only 0.14 milligrams—about the equivalent of a few grains of table salt—approximately 50 of them will die.

Lethal doses are not the only danger from toxic substances. During the past decade, concern has been growing over minimum harmful dosages, or threshold dosages, of poisons, as well as their sublethal effects.

The length of exposure further complicates the determination of toxicity values. Acute exposure refers to a single exposure lasting from a few seconds to a few days. Chronic exposure refers to continuous or repeated exposure for several days, months, or even years. Acute exposure usually is the result of a sudden accident, such as the tragedy at Bhopal, India, mentioned at the beginning of the chapter. Acute exposures often make disaster headlines in the press, but chronic exposure to sublethal quantities of toxic materials presents a much greater hazard to public health. For example, millions of urban residents are continually exposed to low levels of a wide variety of pollutants. Many deaths attributed to heart failure or such diseases as emphysema may actually be brought on by a lifetime of exposure to sublethal amounts of pollutants in the air.

other fish-eating carnivores failed to reproduce. Once these substances are identified as toxic, their use is regulated. Countries contemplating regulation of hazardous and toxic materials and wastes must consider not only how toxic each one is but also how flammable, corrosive, and explosive it is, and whether it will produce mutations or cause cancer.

Setting Exposure Limits

Even after a material is identified as hazardous or toxic, there are problems in determining appropriate exposure limits. Nearly all substances are toxic in sufficiently high doses. The question is, When does a chemical cross over from safe to toxic? There is no easy way to establish acceptable levels. For any new compounds that are to be brought on the market, extensive toxicology studies must be done to establish their ability to do harm. Usually these are tests on animals. (See Environmental Close-Up:

of exposure at which none of the test animals is affected (**threshold level**) and then set the human exposure level lower to allow for a safety margin. This safety margin is important because it is known that threshold levels vary significantly among species, as well as among members of the same species. Even when concentrations are set, they may vary considerably from country to country. For example, in the Netherlands, 50 milligrams of cyanide per kilogram of waste is considered hazardous; in neighboring Belgium, the toxicity standard is fixed at 250 milligrams per kilogram.

Acute and Chronic Toxicity

Regulatory agencies must look at both the effects of one massive dose of a substance (**acute toxicity**) and the effects of exposure to small doses over long periods (**chronic toxicity**). Acute toxicity is readily apparent because organisms respond to the toxin shortly after being exposed. Chronic toxicity is much more

an acute exposure may make an organism ill but not kill it, while chronic exposure to a toxic material may cause death. A good example of this effect is alcohol toxicity. Consuming extremely high amounts of alcohol can result in death (acute toxicity and death). Consuming moderate amounts may result in illness (acute toxicity and full recovery). Consuming moderate amounts over a number of years may result in liver damage and death (chronic toxicity and death).

Another example of chronic toxicity involves lead. Lead has been used in paints, in gasoline, and in pottery glazes for many years, but researchers discovered that it has harmful effects. The chronic effects on the nervous system are most noticeable in children, particularly when children eat paint chips.

Synergism

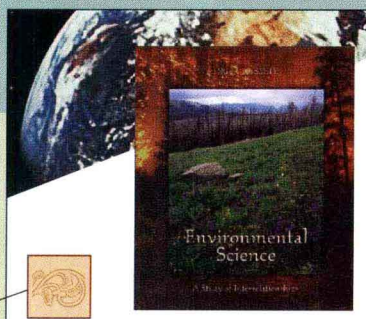
Another problem in regulating hazardous materials is assessing the effects of mixtures of chemicals. Most toxico-

BOX READINGS

Each chapter also includes **boxed readings.** These provide an in-depth consideration of a specific situation that is relevant to the content, an alternative viewpoint, or a wider worldview of the issues discussed in the chapter.

WEB INTEGRATION

Chapters conclude with an **"Issues and Analysis"** case study, a **summary,** a list of **key terms, review questions,** and **critical thinking questions,** and a list of **articles** and **animations** available on the accompanying website. The case studies, articles, and animations have been specifically selected to allow the reader to apply the chapter concepts to actual situations. All material in light blue reflects a direct connection to much more information available via the **online learning center.**



Interactive Exploration

Check out the website at
http://www.mhhe.com/environmentalscience
and click on the cover of this textbook for interactive versions of the following:

KNOW THE BASICS

activated-sludge sewage treatment *359*
aquiclude *341*
aquifer *341*
aquitard *341*
artesian well *342*
biochemical oxygen demand (BOD) *349*
confined aquifer *341*
domestic water *344*
eutrophication *350*
evapotranspiration *341*
fecal coliform bacteria *351*
groundwater *341*
groundwater mining *361*
hydrologic cycle *341*
industrial water use *346*
in-stream water use *347*
irrigation *345*
limiting factor *350*
nonpoint source *350*
point source *350*
porosity *342*
potable waters *340*
primary sewage treatment *358*
runoff *341*
salinization *361*
secondary sewage treatment *358*
sewage sludge *359*
storm-water runoff *356*
tertiary sewage treatment *360*
thermal pollution *353*
trickling filter system *358*
unconfined aquifer *341*
vadose zone *341*
water diversion *357*
water table *341*

On-line Flashcards
Electronic Glossary

IN THE REAL WORLD

Supposedly, the importance of wetlands is understood, but the ion continue. Check out the history ds protection. Stronger Wetland d and The Prairie Wetlands of

drinking water comes from? Is your e water? A detailed explanation of essee's water supply is provided in lls, Not from the River.
cting groundwater from contamina- rotecting Groundwater Resources

ning of groundwater, and politically es when water is a scarce resource. ecment on Water Allotments in Drought Focuses on Long-standing Water Disputes in the Middle East to learn more about conflicts that result from the lack of water. Although water is not scarce in the Great Lakes region, see why Low Water Levels in the Great Lakes are causing concerns in this area.

Restoration projects, protection, and funding for cleanup activities are just a few examples. Check out Everglades Restoration: Greatest Restoration Yet, or Just More of the Same? for an example of a restoration project.

A variety of ways to clean up and improve water quality can be found in the following stories: International Accord to Clean Up the Rhine River, and Food Web Control of Primary Production in Lakes.

Another way to improve water quality is to support local conservation measures. Look over American Heritage River System Created for details on how this program aims to help coordinate efforts to improve water quality.

PUT IT IN MOTION

What is the link between fertilizer runoff and the green soupy lake in an adjacent area? Now is your chance to study it in more detail. Check out the Deoxygenation of Lakes animation for a better understanding of the process.

Normal rainfall is neutral. . . right? What causes acid rain? When is the effect of acid rain most apparent? Study the Acid Rain animation for answers to these questions and to see how acid rain affects aquatic ecosystems such as lakes.

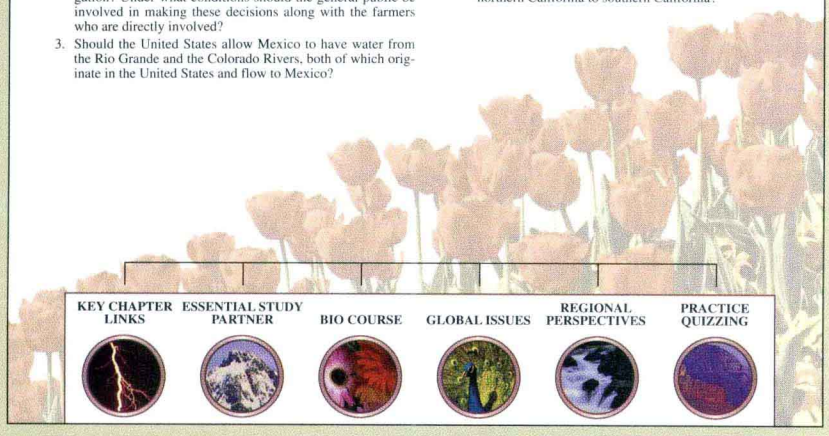
TEST PREPARATION

Review Questions

1. Describe the hydrologic cycle.
2. Distinguish between withdrawal and consumption of water.
3. What are the similarities between domestic and industrial water use? How are they different from in-stream use?
4. How is land use related to water quality and quantity? Can you provide local examples?
5. What is biochemical oxygen demand? How is it related to water quality?
6. How can the addition of nutrients such as nitrates and phosphates result in a reduction of the amount of dissolved oxygen in the water?
7. Differentiate between point and nonpoint sources of water pollution.
8. How are most industrial wastes disposed of? How has this changed over the past 25 years?
9. What is thermal pollution? How can it be controlled?
10. Describe primary, secondary, and tertiary sewage treatment.
11. What are the types of wastes associated with agriculture?
12. Why is storm-water management more of a problem in an urban area than in a rural area?
13. Define groundwater mining.
14. How does irrigation increase salinity?

Critical Thinking Questions

1. Leakage from freshwater distribution systems accounts for significant losses. Is water so valuable that governments should require systems that minimize leakage in order to preserve the resource? Under what conditions would you change your evaluation?
2. Do non-farmers have an interest in how water is used for irrigation? Under what conditions should the general public be involved in making these decisions along with the farmers who are directly involved?
3. Should the United States allow Mexico to have water from the Rio Grande and the Colorado Rivers, both of which originate in the United States and flow to Mexico?
4. Do you believe that large scale hydroelectric power plants should be promoted as a renewable alternative to power plants that burn fossil fuels? What criteria do you use for this decision?
5. After reading the Issues and Analysis concerning the California Water Plan, do you believe water should be diverted from northern California to southern California?



APPENDICES

The text concludes with several **appendices** that deal with critical thinking. the metric system, the periodic table of the elements, some thoughts on what you can do to make the world a better place in which to live, and how to write to public officials. In addition, there is a complete **glossary** and **index.**

Appendix 1

CRITICAL THINKING

We live in an age of information. Computers, e-mail, the Internet, CD-ROMs, instant news, and fax machines bring us information more quickly than ever before. A simple search of the Internet will provide huge amounts of information. Some of the information has been subjected to scrutiny and is quite valid, some is well-informed opinion, some is naive misinformation, and some is even designed to mislead. How do we critically evaluate the information we get?

Critical thinking involves a set of skills that help us to evaluate information, arguments, and opinions in a systematic and thoughtful way. Critical thinking also can help us better understand our own opinions as well as the points of view of others. It can help us evaluate the quality of evidence, recognize bias, characterize the assumptions behind arguments, identify the implications of decisions, and avoid jumping to conclusions.

Characteristics of Critical Thinking

Critical thinking involves skills that al- a meaning- or useless izing that ey compo-

context. All ain assump-

tions. It is important to recognize what those assumptions are. Critical thinking involves looking closely at an argument or opinion by identifying the historical, social, political, economic, and scientific context in which the argument is being made. It is also important to understand the kinds of bias contained in the argument and the level of knowledge the presenter has.

Consider alternative views. A critical thinker must be able to understand and evaluate different points of view. Often these points of view may be quite varied. It is important to keep an open mind and to look at all the information objectively and try to see the value in alternative points of view. Often people miss obvious solutions to problems because they focus on a certain avenue of thinking and unconsciously dismiss valid alternative solutions.

Expect and accept mistakes. Good critical thinking is exploratory and speculative, tempered by honesty and a recognition that we may be wrong. It takes courage to develop an argument, engage in debate with others, and admit that your thinking contains errors or illogical components. By the same token, be willing to point out what you perceive to be shortcomings in the arguments of others. It is always best to do this with good grace and good humor.

Have clear goals. When analyzing an argument or information, keep your goals clearly in mind. It is often easy to get sidetracked. A clear goal will allow you to quickly sort information into that which is pertinent and that which may be interesting but not germane to the particular issue you are exploring.

Evaluate the validity of evidence. Information comes in many forms and has differing degrees of validity. When evaluating information, it is important to understand that not all the information from a source may be of equal quality. Often content about a topic is a mix of solid information interspersed with less certain speculations or assumptions. Apply a strong critical attitude to each separate piece of information. Often what appears to be a minor, insignificant error or misunderstanding can cause an entire argument to unravel.

Critical thinking requires practice. As with most skills, you become better if you practice. At the end of each chapter in the text, there are a series of questions that allow you to practice critical thinking skills. Some of these questions are straightforward and simply ask you to recall information from the chapter. Others ask you to apply the information from the chapter to other similar contexts. Still others ask you to develop arguments that require you to superimpose the knowledge you have gained from the chapter on quite different social, economic, or political contexts from your own.

Practice, Practice, Practice.

Glossary

A

abiotic factors Nonliving factors that influence the life and activities of an organism.

abyssal ecosystem The collection of organisms and the conditions that exist in the deep portions of the ocean.

acid Any substance that, when dissolved in water, releases hydrogen ions.

acid deposition The accumulation of potential acid-forming particles on a surface.

acid mine drainage A kind of pollution, associated with coal mines, in which bacteria convert the sulfur in coal into compounds that form sulfuric acid.

acid rain (acid precipitation) The deposition of wet acidic solutions or dry acidic particles from air.

activated sludge sewage treatment Method of treating sewage in which some of the sludge is returned to aeration tanks, where it is mixed with incoming wastewater to encourage degradation of the wastes in the sewage.

activation energy The initial energy input required to start a reaction.

active solar system A system that traps sunlight energy as heat energy and uses mechanical means to move it to another location.

acute toxicity A serious effect, such as a burn, illness, or death, that occurs shortly after exposure to a hazardous substance.

age distribution The comparative percentages of different age groups within a population.

agricultural products Any output from farming: milk, grain, meat, etc.

agricultural runoff Surface water that carries soil particles, nutrients, such as phosphate, nitrates, and other agricultural chemicals, as it runs off agricultural land to lakes and streams.

air stripping The process of pumping air through water to remove volatile materials dissolved in the water.

alpha radiation A type of radiation consisting of a particle with two neutrons and two protons.

aquiclude An impervious confining layer of an aquifier.

aquifer A porous layer of earth material that becomes saturated with water.

aquitard A partially permeable layer in an aquifer.

artesian well The result of a pressurized aquifer being penetrated by a pipe or conduit, within which water rises without being pumped.

atom The basic subunit of elements, composed of protons, neutrons, and electrons.

auxin A plant hormone that stimulates growth.

B

base Any substance that, when dissolved in water, removes hydrogen ions from solution; forms a salt when combined with an acid.

benthic Describes organisms that live on the bottom of marine and freshwater ecosystems.

benthic ecosystems A type of marine or freshwater ecosystem consisting of organisms that live on the bottom.

beta radiation A type of radiation consisting of electrons released from the nuclei of many fissionable atoms.

bioaccumulation The buildup of a material in the body of an organism.

biocentric Life-centered, a theory of moral responsibility that states that all forms of life have an inherent right to exist.

biochemical oxygen demand (BOD) The amount of oxygen required by microbes to degrade organic molecules in aquatic ecosystems.

biocide A kind of chemical that kills many different types of living things.

biodegradable Able to be broken down by natural biological processes.

biodiversity A measure of the variety of kinds of organisms present in an ecosystem.

biomagnification The increases in the amount of a material in the bodies of organisms at successively higher trophic levels.

biotic factors Living portions of the environment.

biotic potential The inherent reproductive capacity.

birthrate The number of individuals born per thousand individuals in the population per year.

black lung disease A respiratory condition resulting from the accumulation of large amounts of fine coal dust particles in miners' lungs.

boiling-water reactor (BWR) A type of light water reactor in which steam is formed directly in the reactor, which is used to generate electricity.

boreal forest A broad band of mixed coniferous and deciduous trees that stretches across northern North America (and also Europe and Asia); its northernmost edge is integrated with the arctic tundra.

brownfields Buildings and land that have been abandoned because they are contaminated and the cost of cleaning up the site is high.

brownfields development The concept that abandoned contaminated sites can be cleaned up sufficiently to allow some specified uses without totally removing all of the contaminants

C

carbamate A class of soft pesticides that work by interfering with normal nerve impulses.

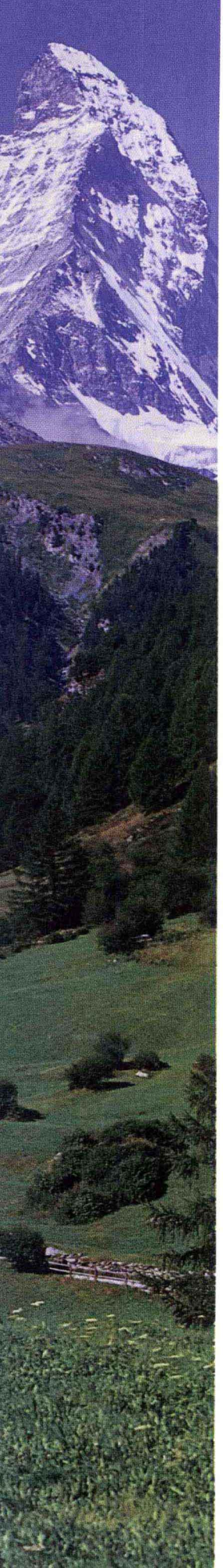
carbon absorption The use of carbon particles to treat chemicals by having the chemicals attach to the carbon particles.

carbon cycle The cyclic flow of carbon from the atmosphere to living organisms and back to the atmospheric reservoir.

carbon dioxide (CO_2) A normal component of the Earth's atmosphere that in elevated concentrations may interfere with the Earth's heat budget.

carbon monoxide (CO) A primary air pollutant produced when organic materials, such as gasoline, coal, wood, and trash, are incompletely burned.

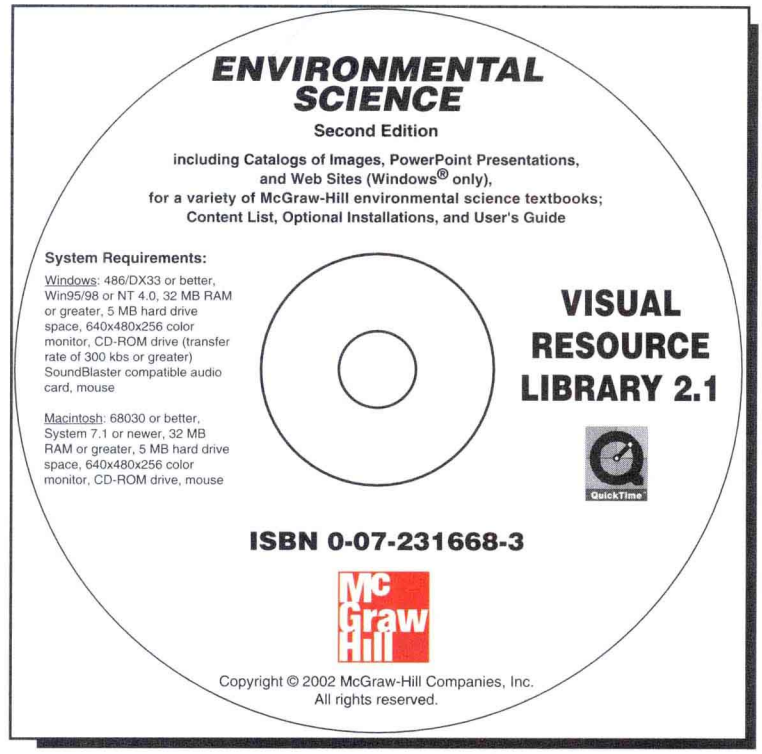
carcinogen A substance that causes cancer.



Visual Resource Library CD-ROM

A VRL is an electronic library of educational presentation resources that instructors can use to enhance their lectures. View, sort, search, and print catalog images, play chapter-specific slideshows using PowerPoint, or create customized presentations when you:

- Find and sort thumbnail image records by name, type, location, and user-defined keywords
- Search using keywords or terms
- View images at the same time with the Small Gallery View
- Select and view images at full size
- Display all the important file information for easy file identification
- Drag and place or copy and paste into virtually any graphics, desktop publishing, presentation, or multimedia application



The Environmental Science Visual Resource Library CD-ROM

This helpful CD-ROM contains illustrations from this book, plus four other texts in environmental science and ecology. Hundreds of exclusive photographs are also included. You'll be able to create interesting multimedia presentations with the use of these images, and students will have the ability to easily access the same images in their texts to later review the content covered in class

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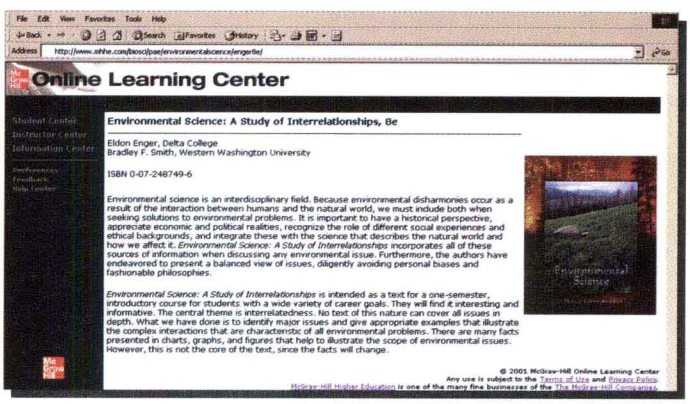
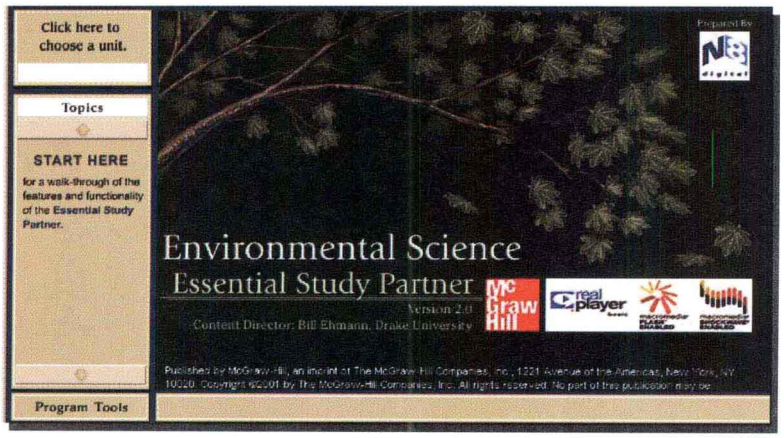


Environmental Science
Essential Study Partner 2.0



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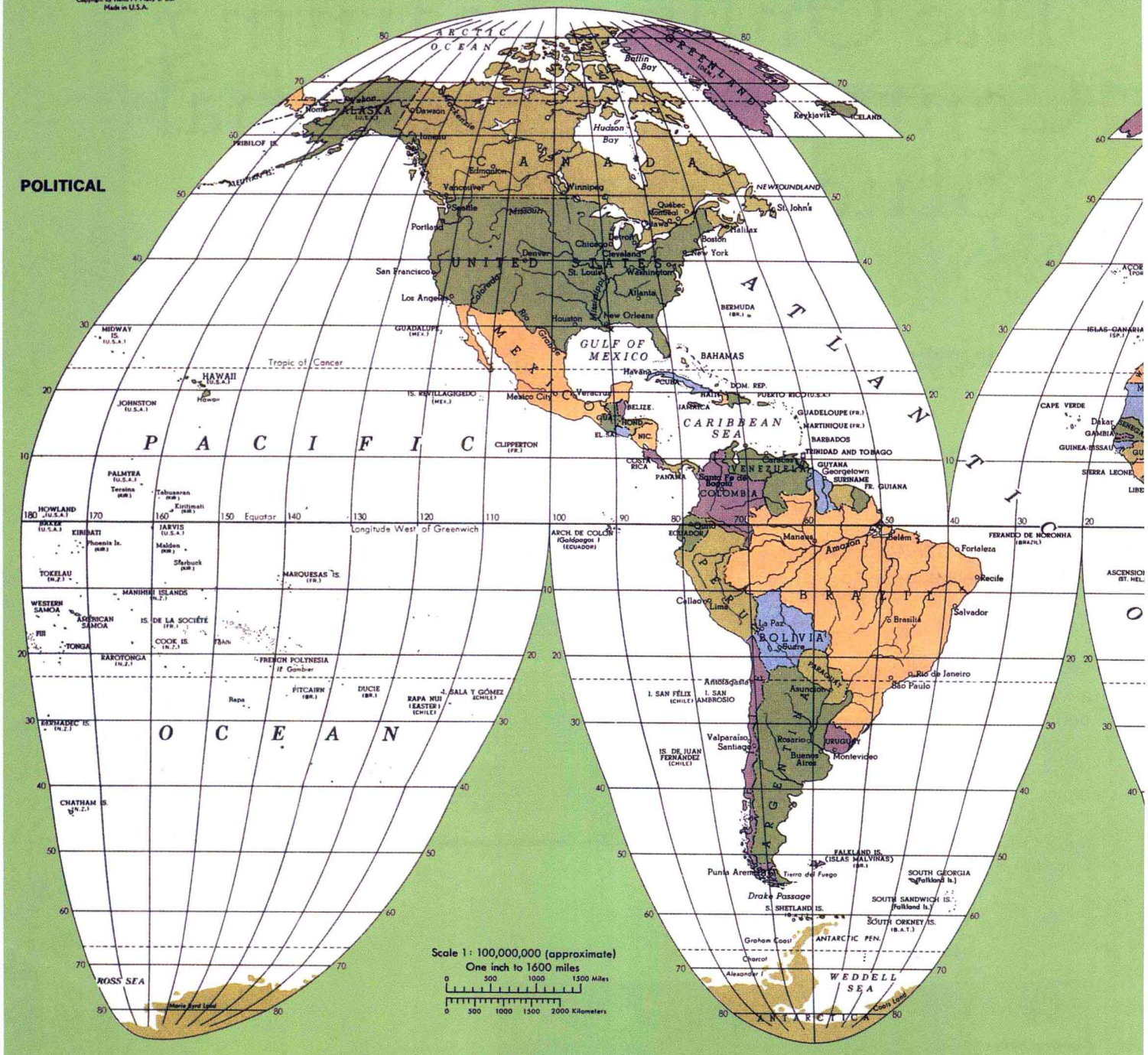
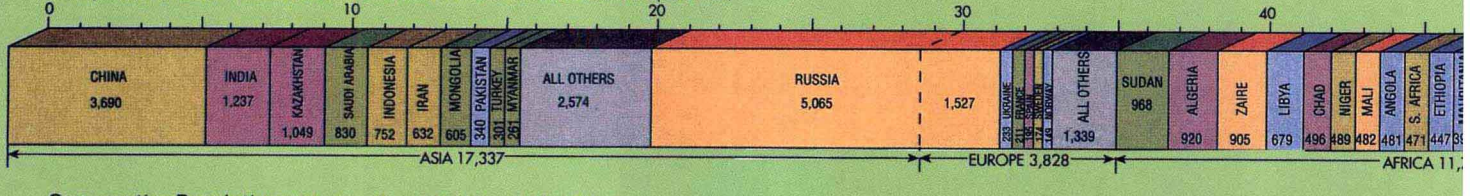
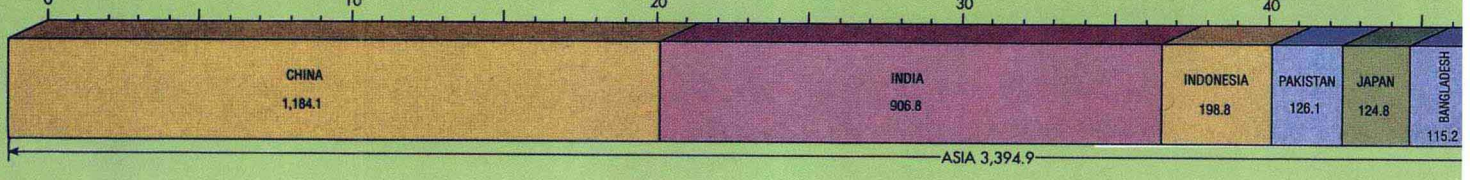
POLITICAL

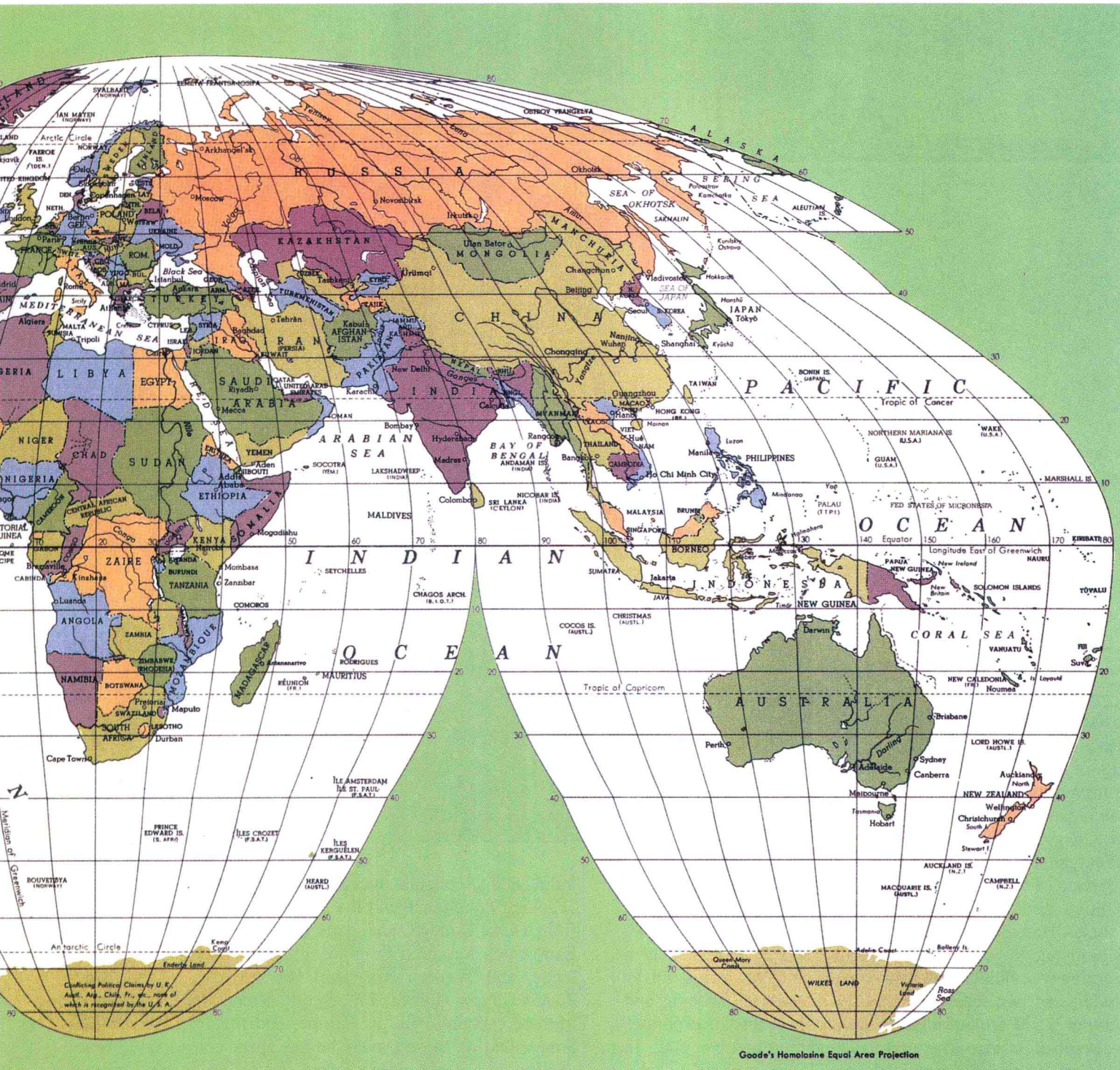


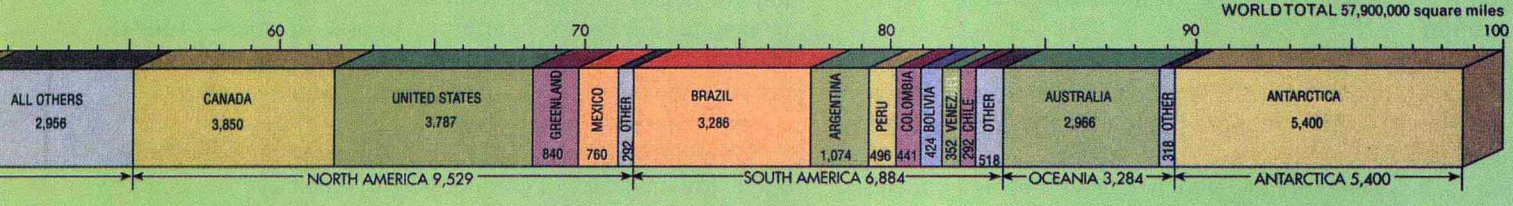
Comparative Land Areas (land and inland water. Numbers indicate thousands of square miles.)

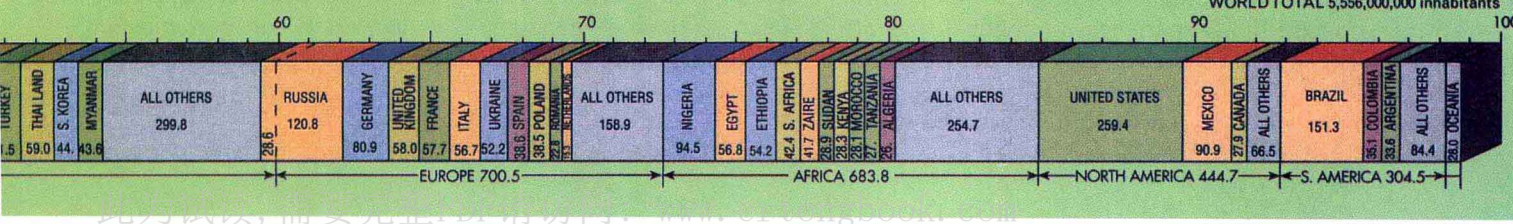


Comparative Populations (Numbers indicate millions of people.) 1/1/94 estimate




RUSSIA
CHINA
INDIA
INDONESIA
AUSTRALIA
PACIFIC OCEAN
INDIAN OCEAN
ATLANTIC OCEAN
ARCTIC OCEAN
ANTARCTIC OCEAN
KAZAKHSTAN
MONGOLIA
SAUDI ARABIA
IRAN
IRAQ
TURKEY
LIBYA
EGYPT
SUDAN
ETHIOPIA
NIGERIA
ZAIRE
KENYA
TANZANIA
ANGOLA
NAMIBIA
BOTSWANA
ZIMBABWE
MOZAMBIQUE
MADAGASCAR
JAPAN
PHILIPPINES
NEW GUINEA
NEW ZEALAND
ALASKA
Tropic of Cancer
Tropic of Capricorn
Equator
Longitude East of Greenwich
Antarctic Circle
Arctic Circle
Meridian of Greenwich
Goode's Homolosine Equal Area Projection


WORLD TOTAL 57,900,000 square miles
ALL OTHERS 2,956
CANADA 3,850
UNITED STATES 3,787
GREENLAND 840
MEXICO 760
OTHER 292
BRAZIL 3,286
ARGENTINA 1,074
PERU 496
COLOMBIA 441
BOLIVIA 424
VENEZ. 362
CHILE 292
OTHER 518
AUSTRALIA 2,966
OTHER 318
ANTARCTICA 5,400
NORTH AMERICA 9,529
SOUTH AMERICA 6,884
OCEANIA 3,284
ANTARCTICA 5,400


WORLD TOTAL 5,556,000,000 inhabitants
TURKEY
THAI LAND 59.0
S. KOREA 44.
MYANMAR 43.6
ALL OTHERS 299.8
RUSSIA 120.8
GERMANY 80.9
UNITED KINGDOM 58.0
FRANCE 57.7
ITALY 56.7
UKRAINE 52.2
SPAIN 38.6
POLAND 38.5
ROMANIA
ALL OTHERS 158.9
NIGERIA 94.5
EGYPT 56.8
ETHIOPIA 54.2
S. AFRICA 42.4
ZAIRE 41.7
SUDAN 28.9
KENYA 28.3
MOROCCO 28.1
TANZANIA 27.
ALGERIA 26.
ALL OTHERS 254.7
UNITED STATES 259.4
MEXICO 90.9
CANADA 27.9
ALL OTHERS 66.5
BRAZIL 151.3
COLOMBIA 35.1
ARGENTINA 33.6
ALL OTHERS 84.4
OCEANIA 28.0
EUROPE 700.5
AFRICA 683.8
NORTH AMERICA 444.7
S. AMERICA 304.5