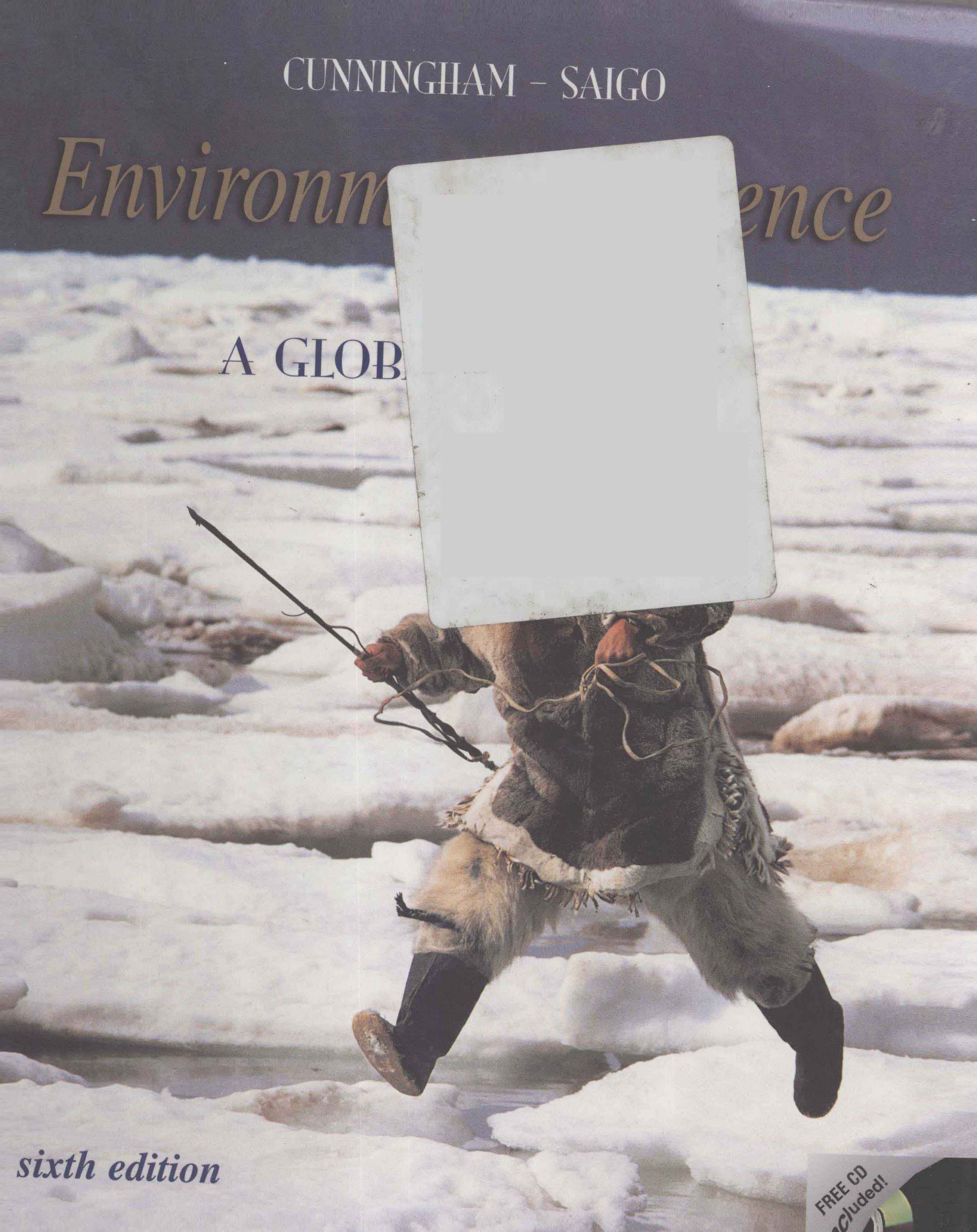
CUNNINGHAM – SAIGO

Environm ence

A GLOB



sixth edition

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SIXTH EDITION

Environmental Science

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In the cover photo, Kavavow Kiguktak, an Inuit hunter from the village of Grise Fiord on Ellesmere Island high in the Canadian arctic, jumps across ice floes as he hunts seals on the Arctic Ocean. He depends on experience, courage, and traditional knowledge to find his way through this dangerous, constantly shifting environment. As remote and exotic as Kav's life may seem to most of us, he also is interconnected to the modern world. In 1999, the government of Canada transferred two million square kilometers of land back to the Inuit people. Commercial air routes and modern telecommunications now connect the widely dispersed residents of the vast new territory of Nunavut.

But links to the outside world also bring problems to these northern people. Alcoholism, AIDS, and suicide are the main killers of Inuit people between 15 and 35 years old. Air pollutants from cities and industries in Europe, Russia, China, and North America drift northward into the Arctic. During the winter, the industrial smog in remote areas of Nunavut can be higher than in London or New York. Furthermore, as contaminants accumulate and are concentrated in arctic food webs, they reach toxic levels in the fish, seals, and sea birds eaten by the Inuit.

This photo provides a good metaphor for our global environmental situation. Like Kav, we face dangerous, rapidly changing environmental conditions. It will take courage, knowledge, and effort to find our way out of our current environmental dilemmas. I hope you'll find information and inspiration in this book to help in your journey toward a better, safe, more equitable world.

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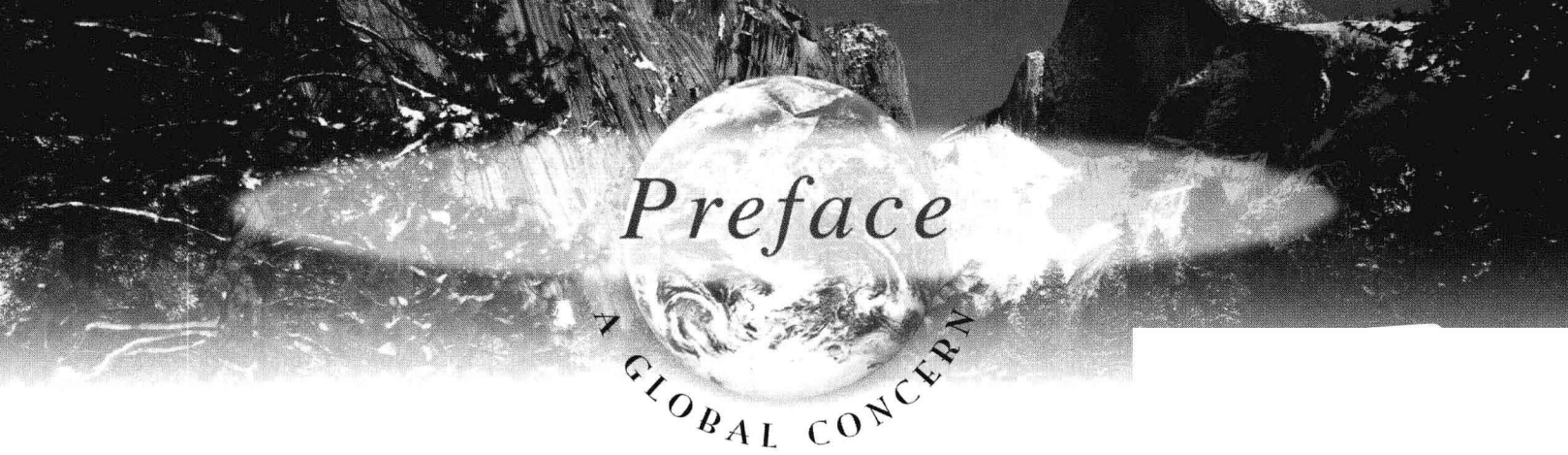

Preface

A GLOBAL CONCERN

危机

The Chinese ideogram for "crisis" combines the character *wei,* meaning danger, with the character *ji,* denoting opportunity. This is a good description of our global environment situation. We are dangerously close to pushing biological communities and biophysical processes beyond the point from which they can recover. At the same time, our greatly increased understanding of the natural world and how it works gives us an opportunity to repair the damage we have caused and to find new, more efficient, and more environmentally friendly ways of providing the goods and services we need. British ecologist Norman Myers points out that the current generation of students has the advantage of being the first in history to have the information, resources, and motivation to do something to solve our environmental crisis. Unfortunately, he adds, if solutions to some of our most pressing problems aren't found quickly, this generation also may be the last to have a chance to do so.

I hope that you will find this book a valuable source of information about our global environment, as well as an inspiration for solutions to the dilemmas we face. Everyone has a role to play in this endeavor. Whether as students, educators, researchers, activists, or consumers, each of us can find ways to contribute in solving our common problems.

WHO MAKES UP THE AUDIENCE FOR THIS TEXT?

This book is intended for use in a one- or two-semester course in environmental science, human ecology, or environmental studies at the college or advanced placement high school level. Because most students who will use this book are freshman or sophomore non-science majors, I have tried to make the text readable and accessible without technical jargon or a presumption of prior science background. At the same time, enough data and depth are presented to make this book suitable for many upper-division classes and a valuable resource for students who will keep it in their personal libraries after their formal studies are completed.

WHY DID I WRITE THIS BOOK?

I have taught aspects of environmental science in a variety of settings for about 40 years. Although the earliest of these classes focused primarily on natural history and conservation, I found my interests and concerns changing in the 1970s. Two broad areas of environmental science that seemed important to me weren't covered in the existing textbooks. One of these is global concerns. We live in an highly interconnected world; the coal burned in China, or the nuclear waste dumped in the ocean by Russia, or the pesticides used on farm crops in Central America affect all of us. The other area is environmental justice and the human dimensions of environmental issues. Although my original interests in the environment were primarily wilderness and wildlife issues, the Civil Rights Movement of the 1960s opened my eyes to the conditions in inner cities and the role of economics, health, policy, and law in environmental concerns. Ecology remains the heart of environmental science, but students also need to know something about the roles of human institutions and social sciences to be educated environmental citizens. It's gratifying to see that since the first edition of this book was published in 1990, concerns about environmental ethics and social justice are appearing in other textbooks as well.

WHY THIS COVER PHOTO?

I'm especially pleased with the cover photograph of this edition of *Environmental Science.* It shows Kavavow Kiguktak, an Inuk hunter jumping across ice floes as he looks for seals off the coast of Ellesmere Island in Canada's high arctic. In spite of the extremely harsh conditions they face, the Inuit people have used traditional knowledge and a strong ethic of cooperation and sharing to live in harmony with their environment for thousands of years. Cultural traditions inform Kav about how many seals he can take from the common pool resource, the respect he must show his prey, and how he shares his catch with other members of his community. He depends on experience and courage to find his way across the constantly shifting ice floes.

In several ways, this image also serves as a good metaphor for our current environmental issues. As he jumps from one ice block to the next in the ever-shifting ice pack, Kav is constantly looking ahead, evaluating risks and opportunities, and making reasoned judgments. He faces great danger—a fall into the frigid ocean could be fatal—but the ice also provides an opportunity to move far out from the shore as he hunts. Simply standing still just isn't an option in this situation; Kav must keep moving to stay afloat. In much the same way, it takes courage, foresight, and nimble footwork for us to find a way out of the complex, constantly changing environmental problems we now face. We can't simply remain where we are, but must use every skill at our disposal to find a safe path to the future.

Although he lives in a remote and exotic part of the world, Kav is affected by events occurring far away. As a resident of the new territory of Nunavut, he is participating in a bold new experiment in self-rule and self-determination. New job opportunities are opening up for First Nations people as they take control of their ancestral territory. During the brief arctic summer, Kav, for instance, is a seasonal ranger at the remote Ellesmere National Park. In the summer of 1998, I made a two-week backpacking trip to this harsh, but beautiful landscape (see figure 15.9). One of the main attractions of hiking there is the opportunity to see arctic animals such as the white wolves, musk ox, Perry caribou, narwhal, polar bears, and arctic hares, all of which have had so little contact with humans that they are generally unafraid of us. Unfortunately, there seems to be a widespread decline in many of these arctic species. The cause isn't known for certain, but one suspicion is that global climate change coupled with pollution carried by wind currents from industrial centers far to the south may be playing a role. While a disappointment to visitors, this decline could be devastating for residents like Kav who try to maintain traditional ways of life.

WHAT'S NEW IN THIS EDITION?

The most difficult thing about writing a broad, introductory text like this is incorporating all the interesting and important material, keeping it current, and still resisting the temptation to let it grow to encyclopedic size. By careful pruning, I've managed to add significant new features to each edition of this book while still maintaining a reasonable length. I have had the good fortune in working on this revision to have more than one hundred reviews from colleagues at colleges and universities across North America. They've offered many useful criticisms and suggestions for improving the book. If you are one of those reviewers, you have my most sincere thanks.

Two New Chapters

- A new introductory chapter presents suggestions to students about why environmental science is interesting and useful, how to study, how to prepare for tests, critical thinking, and concept maps. These topics are presented in the beginning of the book so students can begin to use them immediately. This is the kind of information that most of us cover in the first lecture of a class. No other book goes into the *fundamentals of critical thinking theory and application* found here.
- The other new chapter, "Environmental Policy, Planning and Law," begins with a discussion of the policy cycle of agenda setting, problem definition, implementation, and evaluation by which public policy is established. The environmental law section defines statutory, case, and administrative law, a level of sophistication never before presented in an environmental science textbook. Also included are current concepts such as alternative dispute resolution, wicked problems, resilience in ecosystems and institutions, the precautionary principle, arbitration and mediation, and collaborative approaches to community-based planning. If our students are going to be educated environmental citizens, they need to know how these processes work.

New Case Studies

Every chapter in this book begins with a case study designed to introduce the main topic and pique student interest. Three-quarters of these case studies are new to this edition and most are based on *very recent news stories* to emphasize the currency of environmental issues. All of them have been expanded from previous versions to be more substantive and meaningful. Overall, the total number of boxed readings have been reduced in this edition so that the remaining ones can be more substantial.

More Environmental Ethics

Because critical thinking has been moved from chapter 2, "Environmental Ethics and Philosophy," to the new introductory chapter, space is now available to present environmental ethics in greater detail. Notice that this discussion takes a pluralist approach. There is no prescribed "earthmanship ethics" that divide the world into bipolar camps. A variety of worldviews and ethical perspectives are presented and students are invited to think for themselves. Similarly, the discussion of science isn't limited to positivist, reductionist approaches, but recognizes the validity of descriptive and interpretive sciences.

New Information on Ecological Economics

Chapter 8, "Ecological Economics," has been revised to include a major new section on green business, eco-efficient economy, the Natural Step movement, and "design for the environment." These topics are both very current and are also positive examples of what we can do to improve environmental quality.

Other Significant Changes (A complete list of changes to this edition can be found on the accompanying website.)

- Data in tables, graphs, figures, and the text copy have been thoroughly updated.
- Chapter 9, "Environmental Health and Toxicology," has a new treatment of infectious diseases that emphasizes emergent diseases and how drug resistance is selected for different microorganisms.
- Major revisions and corrections have been incorporated in chapter 16, "Environmental Geology," including new information on earthquakes and flooding, and a new opening case study, "Earthquake in Turkey."
- Chapter 17, "Air, Climate, and Weather," has a helpful new illustration on how tornadoes form, and a new diagram and discussion on El Niño/Southern Oscillations.
- Chapters 19, "Water Use and Management," and 20, "Water Pollution," have been updated with new data and current information.
- Chapter 21, "Conventional Energy," opens with a new case study about the potential for a vast new oil supply under and around the Caspian Sea and how that affects regional politics, including the war in Chechnya.
- An important section has been added to chapter 22, "Sustainable Energy," on the current topics of fuel cells and hybrid gas/electric automobiles.
- Much new and/or corrected material appears in chapter 23, "Solid, Toxic, and Hazardous Waste," such as international toxic shipping, and in chapter 25, "What Then Shall We Do?." Chapter 25 now focuses much more succinctly than in the past on ways we can work individually and cooperatively to build a better world.

HOW IMPORTANT IS SUSTAINABILITY AND ENVIRONMENTAL CITIZENSHIP?

Ultimately the aims of this book are to foster attitudes of stewardship and environmental citizenship, and to encourage the goals of economic, ecological, and social sustainability. In the preamble to the United Nations Earth Charter, the authors declare, "In an increasingly interdependent world, it is imperative that we, the citizens of Earth, declare our responsibility to one another, the greater community of life, and future generations." Among the principles proposed by the Earth Charter are:

1. Respect Earth and all life, recognize the interdependence and intrinsic value of all beings.
2. Care for the community of life in all its diversity as a responsibility shared by everyone.
3. Strive to build free, just, participatory, and sustainable communities.
4. Secure peace and Earth's abundance and beauty for present and future generations.

I hope the readers of this book will come to share those goals and to understand the reasons they are so important.

—William P. Cunningham

RELATED TITLES OF INTEREST

1. *Field and Laboratory Activities Manual* (0-07-290913-7) by Enger and Smith.
2. *Annual Editions: Environment 99/00* (0-07-228498-6) Editor: John L. Allen.
3. *Taking Sides: Clashing Views on Controversial Environmental Issues* (0-07-303184-4) Editor: Theodore D. Goldfarb.
4. *Sources: Notable Selections in Environmental Studies* (0-07-303186-0) Editor: Theodore D. Goldfarb.
5. *The Dushkin Student Atlas of Environmental Issues* (0-697-36520-4) Editor: John Allen. University of Connecticut.
6. *Life Science Living Lexicon* (CD = 0-697-37993-0; Print = 0-697-12133-X) by William Marchuk.
7. *You Can Make a Difference: Be Environmentally Responsible* (0-07-292416-0) by Judy Getis.
8. *Environmental Ethics: Divergence and Convergence* (0-07-006180-7) by Botzler and Armstrong.
9. *Environmental Problem-Solving: A Case Study Approach* (0-07-027686-2) by Isobel W. Heathcote.
10. *Eyewitness World Atlas CD-ROM* (0-07-233220-4), published by Dorling-Kindersley.

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workshop that provided some extremely valuable insights for this edition. In addition, Amanda has written an excellent class activities and assessment guide that will be a great help for instructors teaching with this book. Jim has created a set of web-page lecture notes that make an outstanding template for environmental science courses. And Darby has written a thoughtful student study guide that will be exceptionally helpful in assisting students to study in an effective and efficient way. I remain grateful to Karen Warren of Macalester College from whom I learned most of what I know about critical thinking and environmental philosophy. Caroline Getty, a hiking companion in Ellesmere National Park, led me to the photography of Cherry and Brian Alexander that appears on the book cover.

I'm also indebted to all the students and teachers who have sent helpful suggestions, corrections, and recommendations for improving this book. Unfortunately, space didn't permit inclusion of all the excellent ideas that were provided. All have been saved, however, and will be helpful in future editions. I hope that those who read this edition will offer their advice and insights as well. Little of the vast range of material in this book represents my own personal research. All of us owe a great debt to the many scholars whose work forms the basis of our understanding of environmental science. We stand on the shoulders of giants. If errors persist in spite of my best efforts to root them out, I accept responsibility and ask for your indulgence.

I want to express my appreciation to the entire McGraw-Hill book team for their wonderful work in putting together this edition. Kathy Loewenberg oversaw the developmental stages and has made many creative contributions to this book. Mary Lee Harms was production project manager and kept everything running smoothly. Cathy Conroy did an excellent job of copyediting and spotting errors and inconsistencies. Connie Mueller found superb photographs. The folks at Precision Graphics did an excellent job of composition and page layout. Michelle Watnick and Marge Kemp have supported this project with their enthusiasm and creative ideas.

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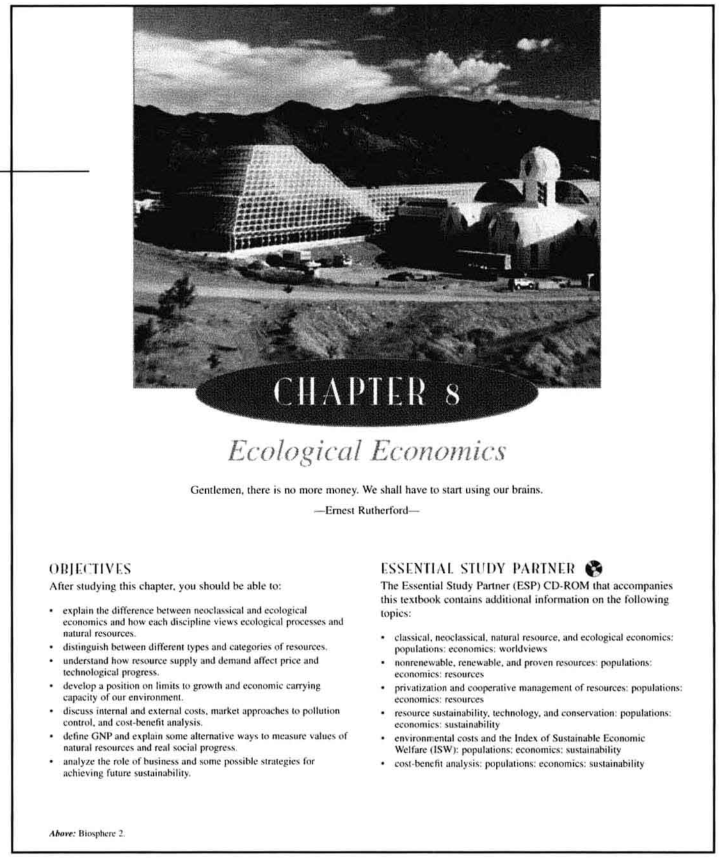
LEARNING AIDS

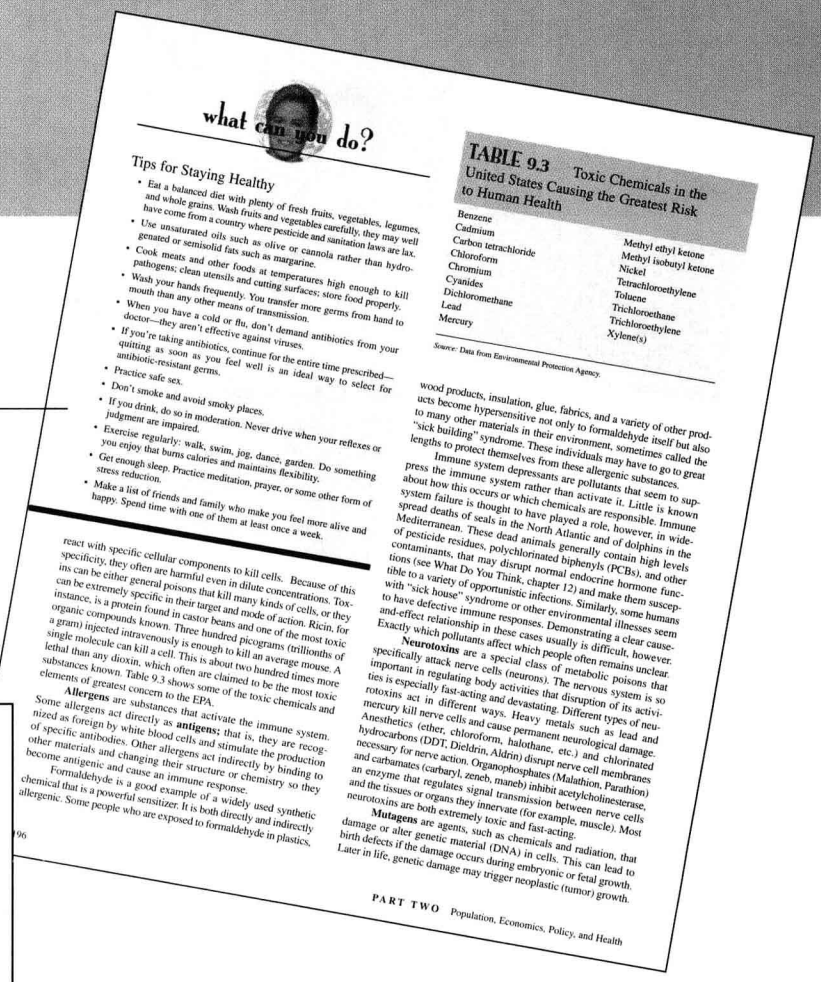
This book is designed to be useful as a self-education tool for students. To facilitate studying and encourage higher-level thinking, each chapter begins with a set of **Objectives** based on major concepts that students should master, and a listing of **ESP CD-ROM Topics** that are chapter-related. A short **Opening Story,** taken from recent news events, follows, setting the subject in context and illuminating the importance of the material to be discussed. **Key Terms,** indicated by boldface type, are defined in context where they are first used and are also listed in the **Glossary** for quick reference.



Case Studies, "In Depth" Boxes, and **"What Do You Think?" Essays,** many with **"Ethical Considerations"** attached, give students real-life examples to evaluate and a chance to practice critical thinking skills and formulate reasoned opinions. These boxes are carefully planned to build upon chapter content and are long enough to present important, real information.

The **"What Can You Do?" Listings** help students to learn that small, individual steps can make a real difference in affecting our environment.

Profiles of ordinary people in environmental careers are scattered throughout the text. Giving students models with whom they can identify will help them consider how they might pursue a career in an environmental area.



what can you do?

Tips for Staying Healthy

- Eat a balanced diet with plenty of fresh fruits, vegetables, legumes, and whole grains. Wash fruits and vegetables carefully, they may well have come from a country where pesticide and sanitation laws are lax.
- Use unsaturated oils such as olive or cannola rather than hydrogenated or semisolid fats such as margarine.
- Cook meats and other foods at temperatures high enough to kill pathogens; clean utensils and cutting surfaces; store food properly.
- Wash your hands frequently. You transfer more germs from hand to mouth than any other means of transmission.
- When you have a cold or flu, don't demand antibiotics from your doctor—they aren't effective against viruses.
- If you're taking antibiotics, continue for the entire time prescribed—quitting as soon as you feel well is an ideal way to select for antibiotic-resistant germs.
- Practice safe sex.
- Don't smoke and avoid smoky places.
- If you drink, do so in moderation. Never drive when your reflexes or judgment are impaired.
- Exercise regularly: walk, swim, jog, dance, garden. Do something you enjoy that burns calories and maintains flexibility.
- Get enough sleep. Practice meditation, prayer, or some other form of stress reduction.
- Make a list of friends and family who make you feel more alive and happy. Spend time with one of them at least once a week.

react with specific cellular components to kill cells. Because of this specificity, they often are harmful even in dilute concentrations. Toxins can be either general poisons that kill many kinds of cells, or they can be extremely specific in their target and mode of action. Ricin, for instance, is a protein found in castor beans and one of the most toxic organic compounds known. Three hundred picograms (trillionths of a gram) injected intravenously is enough to kill an average mouse. A single molecule can kill a cell. This is about two hundred times more lethal than any dioxin, which often are claimed to be the most toxic substances known. Table 9.3 shows some of the toxic chemicals and elements of greatest concern to the EPA.

Allergens are substances that activate the immune system. Some allergens act directly as **antigens;** that is, they are recognized as foreign by white blood cells and stimulate the production of specific antibodies. Other allergens act indirectly by binding to other materials and changing their structure or chemistry so they become antigenic and cause an immune response.

Formaldehyde is a good example of a widely used synthetic chemical that is a powerful sensitizer. It is both directly and indirectly allergenic. Some people who are exposed to formaldehyde in plastics,

TABLE 9.3 Toxic Chemicals in the United States Causing the Greatest Risk to Human Health

Benzene	Methyl ethyl ketone
Cadmium	Methyl isobutyl ketone
Carbon tetrachloride	Nickel
Chloroform	Tetrachloroethylene
Chromium	Toluene
Cyanides	Trichloroethane
Dichloromethane	Trichloroethylene
Lead	Xylene(s)
Mercury	

Source: Data from Environmental Protection Agency.

wood products, insulation, glue, fabrics, and a variety of other products become hypersensitive not only to formaldehyde itself but also to many other materials in their environment, sometimes called the "sick building" syndrome. These individuals may have to go to great lengths to protect themselves from these allergenic substances.

Immune system depressants are pollutants that seem to suppress the immune system rather than activate it. Little is known about how this occurs or which chemicals are responsible. Immune system failure is thought to have played a role, however, in widespread deaths of seals in the North Atlantic and of dolphins in the Mediterranean. These dead animals generally contain high levels of pesticide residues, polychlorinated biphenyls (PCBs), and other contaminants, that may disrupt normal endocrine hormone functions (see What Do You Think, chapter 12) and make them susceptible to a variety of opportunistic infections. Similarly, some humans with "sick house" syndrome or other environmental illnesses seem to have defective immune responses. Demonstrating a clear cause-and-effect relationship in these cases usually is difficult, however. Exactly which pollutants affect which people often remains unclear.

Neurotoxins are a special class of metabolic poisons that specifically attack nerve cells (neurons). The nervous system is so important in regulating body activities that disruption of its activities is especially fast-acting and devastating. Different types of neurotoxins act in different ways. Heavy metals such as lead and mercury kill nerve cells and cause permanent neurological damage. Anesthetics (ether, chloroform, halothane, etc.) and chlorinated hydrocarbons (DDT, Dieldrin, Aldrin) disrupt nerve cell membranes necessary for nerve action. Organophosphates (Malathion, Parathion) and carbamates (carbaryl, zeneb, maneb) inhibit acetylcholinesterase, an enzyme that regulates signal transmission between nerve cells and the tissues or organs they innervate (for example, muscle). Most neurotoxins are both extremely toxic and fast-acting.

Mutagens are agents, such as chemicals and radiation, that damage or alter genetic material (DNA) in cells. This can lead to birth defects if the damage occurs during embryonic or fetal growth. Later in life, genetic damage may trigger neoplastic (tumor) growth.

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PROFILE

Fisheries Biologist

Robyn Angliss

Would you like a job that includes field surveys of whales and porpoises in Alaska and developing marine policy? Robyn Angliss has done both in her job at the United States National Marine Fisheries Service (NMFS). Although her title is fisheries biologist, Robyn specializes in mammals, especially marine mammals.

How can you get work that takes you to beautiful places to study charismatic animals? Robyn was in her junior year of college and was thinking about a career in marine intertidal ecology when a friend invited her to be part of a summer field study in Prince William Sound, Alaska, to photograph whales and examine the effects of the *Exxon Valdez* oil spill on killer whales and humpback whales. Although the offer came just days before she was scheduled to go home for summer vacation, she accepted and headed north for a wilderness adventure. While working in Alaska, Robyn met the researcher from NMFS who was funding her project. The next fall, back in Seattle for her final year at the University of Washington, Robyn offered to volunteer for the NMFS researcher she met in Alaska to get some experience and to continue to learn more about marine wildlife. After a few months of volunteering, a part-time paid position became available, and by the time she graduated, Robyn was working full time as a biological technician (wildlife) at NMFS.

For three years, Robyn spent about
the Alaska coast from Ketchikan to Poin
bowhead, gray, and beluga whales from th
bor porpoise and killer whales from boats.
in Seattle, she cataloged and analyzed pho
ies, and wrote reports. While employed n
Robyn also worked on a masters of scien
versity of Washington, which she finishe

Although she loved her job on the W
summer field work in Alaska, and the var
she was involved, Robyn decided that ga

icy and administration would be a good idea. She transferred to a job at NMFS headquarters in Washington, DC, where she worked on regulations to manage interactions between marine mammals and U.S. commercial fisheries, briefed staff members of the U.S. House and Senate on marine mammal issues, and held workshops on policy issues for scientists, environmental advocates, and representatives of the commercial fishing industry. Robyn enjoyed being involved in policy formulation and she feels that her improved understanding of the policy process and important legislation will be invaluable during her future career.

Currently, Robyn is back in Seattle as a fisheries biologist for NMFS. In addition to her continuing work on harbor seal populations in Alaska, she has recently been involved in a project on wildlife management funded by Yellowstone National Park. Ranchers who raise cattle on lands surrounding Yellowstone worry that bison migrating out of the park during the winter may carry brucellosis, a disease that causes cattle to abort their calves. Part of Robyn's duty is to analyze management alternatives designed to reduce the probability that bison will transmit the disease to local cattle herds.

How could you get a job like Robyn's? A solid biology educ-

At the end of each chapter, a **Summary** and a set of **Questions for Review** provide an opportunity for students to test their understanding of the material just covered, while **Questions for Critical Thinking** are designed to stimulate creative, analytical thinking and to serve as a springboard for class discussions. **Additional Information on the Internet** lists important chapter topics for which there are hyperlinks, available on the accompanying website, to help students with study and research.

SUMMARY

Any physical, biological, or chemical change in water quality that adversely affects living organisms or makes water unsuitable for desired uses can be considered pollution. Worldwide, the most serious water pollutants, in terms of human health, are pathogenic organisms from human and animal wastes. We have traditionally taken advantage of the capacity of ecosystems to destroy these organisms, but as population density has grown, these systems have become overloaded and ineffective. Effective sewage treatment systems are needed that purify wastewater before it is released to the environment.

In industrialized nations, toxic chemical wastes have become an increasing problem. Agricultural and industrial chemicals have been released or spilled into surface waters and are seeping into groundwater supplies. The extent of this problem is probably not yet fully appreciated.

Ultimately, all water ends up in the ocean. The ocean is so large that it would seem impossible for human activities to have a significant impact on it, but pollution levels in the ocean are increasing. Major causes of ocean pollution are oil spills from tanker bilge pumping or accidents and oil well blowouts. Surface runoff and sewage outfalls discharge fertilizers, pesticides, organic nutrients, and toxic chemicals that have a variety of deleterious effects on marine ecosystems. We usually think of eutrophication (increased productivity due to nutrient addition) as a process of inland waterways, but this can occur in oceans as well.

The major water pollutants in terms of quantity are silt and sediments. Biomass production by aquatic organisms, land erosion, and refuse discharge all contribute to this problem. Addition of salts and metals from highway and farm runoff and industrial activities also damage water quality. In some areas, drainage from mines and tailings piles deliver sediment and toxic materials to rivers and lakes. Water pollution is a major source of human health problems. As much as 80 percent of all disease and some 25 million deaths each year may be attributable to water contamination.

Appropriate land-use practices and careful disposal of industrial, domestic, and agricultural wastes are essential for control of water pollution. Natural processes and living organisms have a high capacity to remove or destroy water pollutants, but these systems become overloaded and ineffective when pollution levels are too high. Municipal sewage treatment is effective in removing organic material from wastewater, but the sewage sludge is often contaminated with metals and other toxic industrial materials. Reducing the sources of these materials is often the best solution to our pollution problems.

QUESTIONS FOR REVIEW

1. Define *water pollution.*
2. List eight major categories of water pollutants and give an example for each category.
3. Describe eight major sources of water pollution in the United States. What pollution problems are associated with each source?
4. What is *Pfiesteria* and why is it dangerous?
5. What is eutrophication? What causes it?
6. What are the origins and effects of siltation?
7. Describe primary, secondary, and tertiary processes for sewage treatment. What is the quality of the effluent from each of these processes?
8. Why do combined storm and sanitary sewers cause water quality problems? Why does separating them also cause problems?
9. What pollutants are regulated by the Clean Water Act? What goals does this act set for abatement technology?
10. Describe remediation techniques and how they work.

QUESTIONS FOR CRITICAL THINKING

1. How precise is the estimate that 2 billion people lack access to clean water? Would it make a difference if the estimate is off by 10 percent or 50 percent?
2. How would you define *adequate* sanitation? Think of some situations in which people might have different definitions for this term.
3. Do you think that water pollution is worse now than it was in the past? What considerations go into a judgement like this? How do your personal experiences influence your opinion?
4. What additional information would you need to make a judgement about whether conditions are getting better or worse? How would you weigh different sources, types, and effects of water pollution?
5. Imagine yourself in a developing country with a severe shortage of clean water. What would you miss most if your water supply were suddenly cut by 90 percent?
6. Why has the EPA changed to total maximum daily pollution loads and watershed management? What are the major implications of this change?
7. Proponents of deep well injection of hazardous wastes argue that it will probably never be economically feasible to pump water out of aquifers more than 1 kilometer below the surface. Therefore, they say, we might as well use those aquifers for hazardous waste storage. Do you agree? Why or why not?
8. Under what conditions might sediment in water or cultural eutrophication be beneficial? How should we balance positive and negative effects?
9. Suppose that part of the silt in a river is natural and part is human-caused. Is one pollution but the other not?
10. Suppose that you own a lake but it is very polluted. An engineer offers options for various levels of cleanup. As you increase water quality, you also increase costs greatly. How clean would you want the water to be—fishable, swimmable, drinkable—and how much would you be willing to pay to achieve your goal? Make up your own numbers. The point is to examine your priorities and values.

KEY TERMS

atmospheric deposition 448
best available, economically achievable technology (BAT) 469
best practicable control technology (BPT) 469
biochemical oxygen demand (BOD) 450
coliform bacteria 449
cultural eutrophication 450
dissolved oxygen (DO) content 450
effluent sewerage 467
eutrophic 450
nonpoint sources 448
oligotrophic 450
oxygen sag 450
point sources 448
primary treatment 466
red tide 451
secondary treatment 467
tertiary treatment 467
thermal plume 455
total maximum daily loads (TMDL) 456

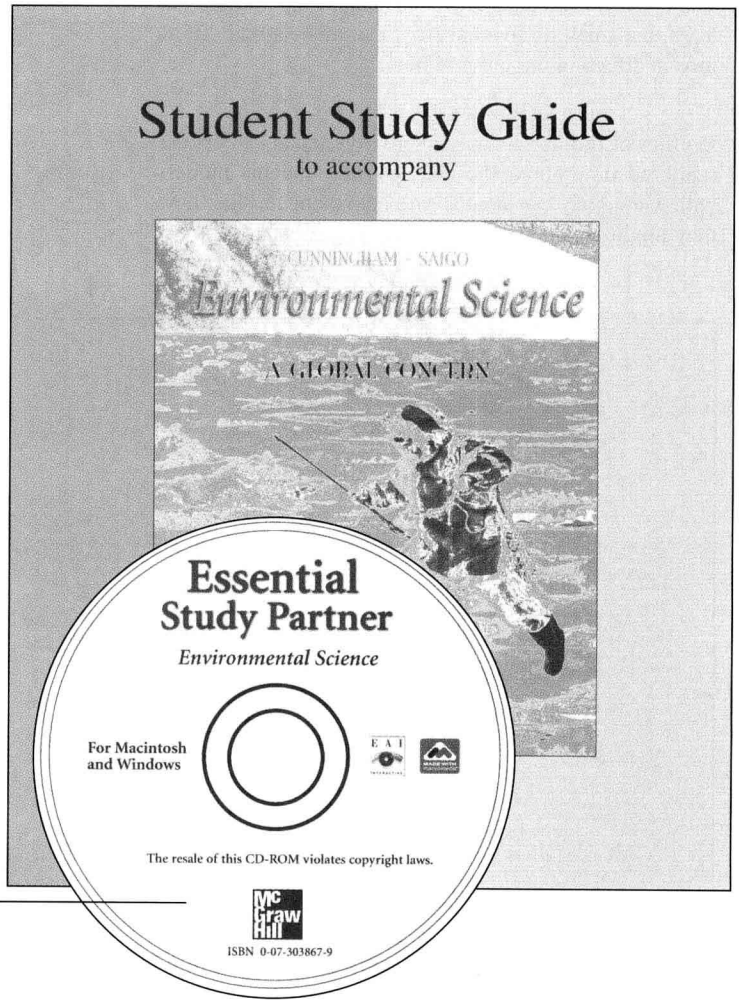
ADDITIONAL INFORMATION ON THE INTERNET

Visit our website at http://www.mhhe.com/environmentalscience/ for specific information about each of the topics below:

Hogwatch: Water Pollution and Industrial Farming
Pfiesteria, the Deadly Dinoflagellate
Office of Water, Environmental Protection Agency
Campaigns to Clean Up European rivers
International Rivers Network: linking human rights and environmental protection.
The EPA Office of Wetlands, Oceans, and Watersheds
"Red Tides" and Harmful Algal Blooms (Woods Hole Oceanographic Institute)
NOAA Office of Response and Restoration: oil spill remediation
Coral Reef Bleaching
Water Quality in the US, by State
EPA Drinking Water Quality Standards
Gound Water Quality
Water and Waste International

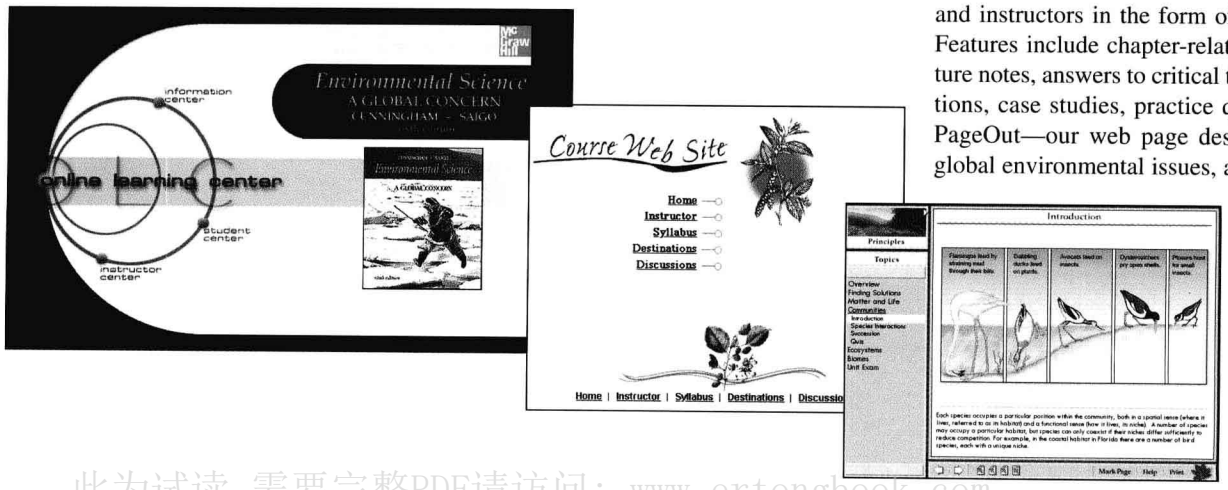
SUPPLEMENTS

1. **Class Activities and Assessment Guide (CAAG).** Proper assessment is critical to your grading system, and this brand new (free) ancillary for instructors reflects the most recent studies of assessment and ways that students learn. Available in print, or on the website, key components of this invaluable text include:
   - a "Resource Locator" that pulls together appropriate material from numerous sources to help instructors get the most out of every chapter
   - a variety of classroom activities, all cross-referenced in the Resource Locator and complete with assessment guides
   - guidelines for constructing a good test
   - Bloom's taxonomy for identifying levels of questions
   - objective test questions with answers
   - short answer/essay questions with assessment guides
2. **Computerized Testing Software** offers the objective test questions that are in the CAAG in electronic format for ease in class testing and grading.
3. A set of **100 Transparencies** is available to users of the text. These acetates include key figures from the text, including new art from this edition.
4. **Environmental Science and Ecology Visual Resource Library (VRL) CD-ROM.** This classroom presentation CD includes images from an ecology text and two environmental science textbooks, plus hundreds of photographs.
5. The **Student Study Guide** is completely reworked for this edition, linked to the ESP and to the Online Learning Center, and includes activities based on both of these resources. The student study guide is available in print and on the website.



The **Essential Study Partner** (ESP) CD-ROM is a student tutorial CD containing high-quality 3-D animations, interactive study activities, illustrated overviews of key topics in environmental science, and self-quizzes and exams for each important unit.

A comprehensive **Website** (http://www.mhhe.com/environmentalscience/) offers numerous resources for both students and instructors in the form of our Online Learning Center. Features include chapter-related hyperlinks, interactive lecture notes, answers to critical thinking questions, study questions, case studies, practice quizzing, key term flashcards, PageOut—our web page design tool, animations, current global environmental issues, and much more.



The Online Learning Center

Your Password to Success

www.mhhe.com/environmentalscience (click on cover)

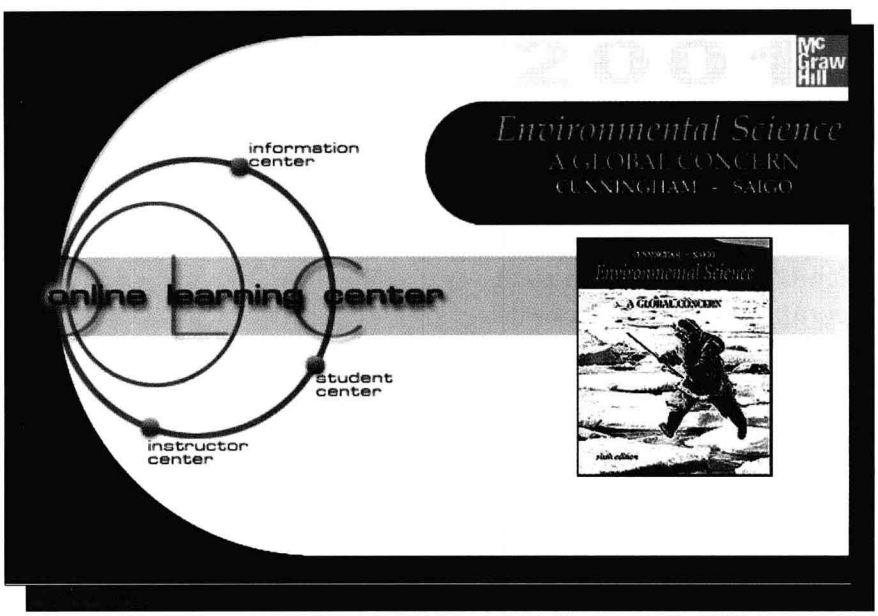
This text-specific website allows students and instructors from all over the world to communicate. Instructors can create a more interactive course with the integration of this site, and students will find tools such as practice quizzing, key term flashcards, case studies, global environmental issues, and chapter-related hyperlinks, that will help them improve their grades.

Student Resources

Study questions
Practice quizzing
Hyperlinks to chapter topics
Case studies
Global environmental issues
Key term flashcards

Instructor Resources

Class activities and assignment guide
Links to related websites to expand on particular topics
Interactive lecture outlines
Case studies
Test item file
Global environmental issues
Sample syllabi



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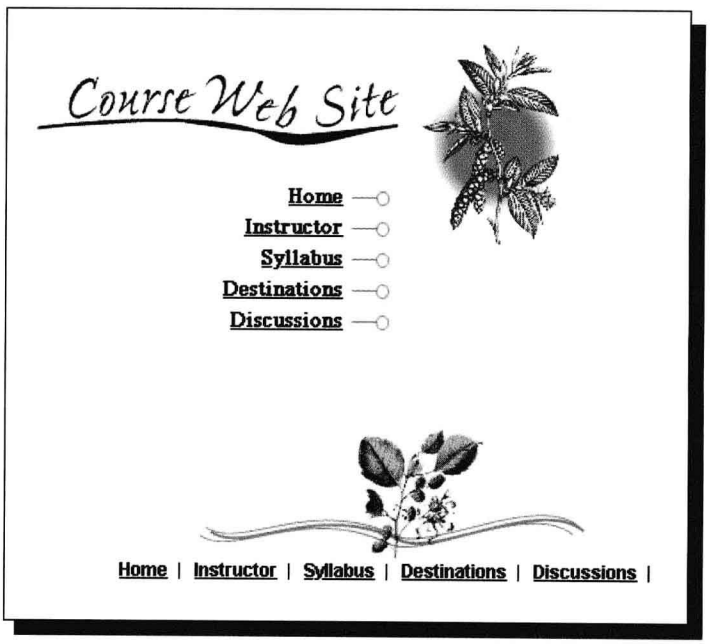

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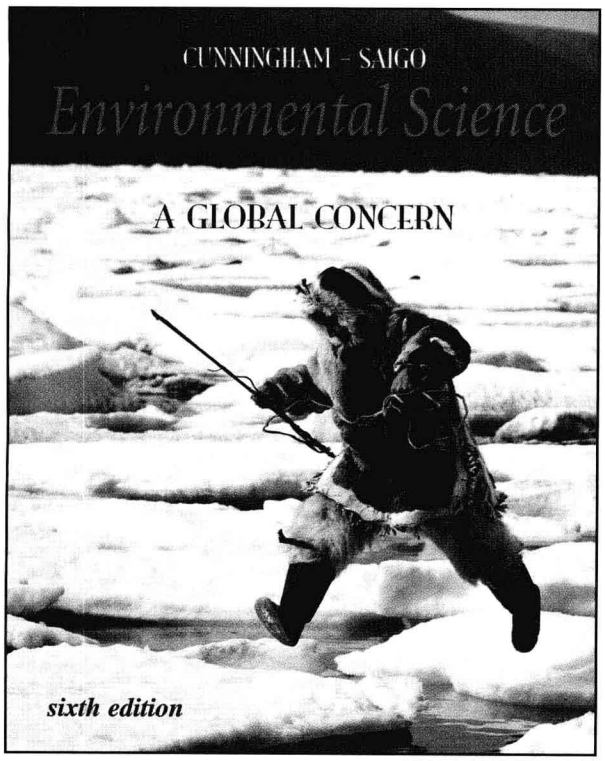

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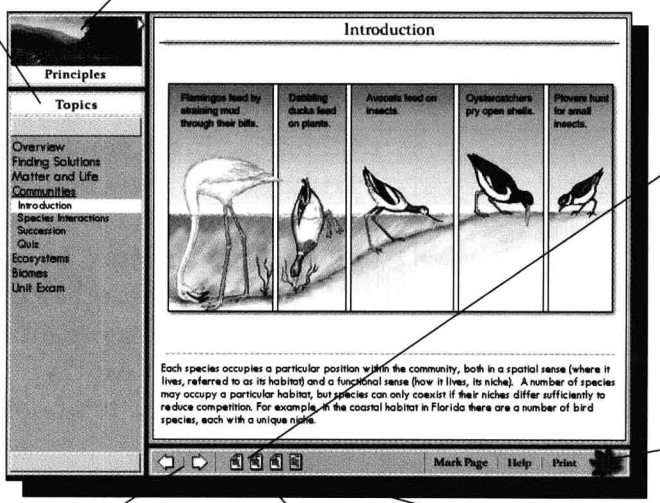

To the right of the arrows is a row of icons that represent the number of screens in a concept. There are three different icons, each representing different functions that a screen in that section will serve. The screen that is currently displayed will highlight yellow and visited ones will be checked.

The activity icon represents an interactive learning activity.

Along the bottom of the screen you will find various navigational aids. At the left are arrows that allow you to page forward and backward through text screens or interactive exercise screens. You can also use the LEFT and RIGHT arrows on your keyboard to perform the same function.

The page icon represents a page of informational text.

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