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大学环境教育丛书

影印版

Eldon D. Enger Bradley F. Smith

Environmental Science
A Study of Interrelationships

(Eleventh Edition)

环境科学
——交叉关系学科

（第11版）

清华大学出版社

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出版前言

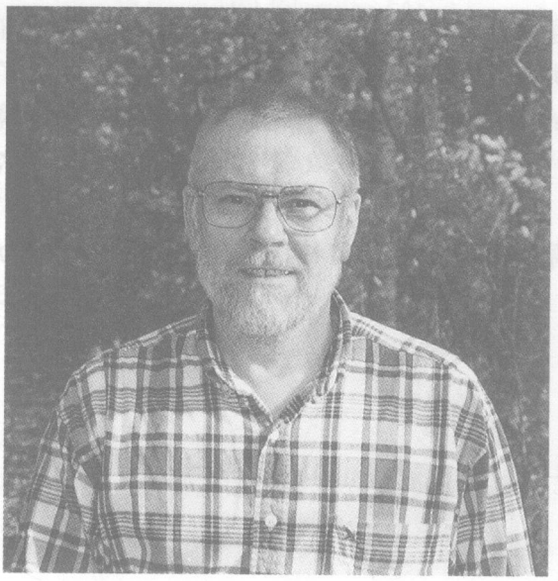
在21世纪之初，面临各种环境问题，人类清醒地认识到要走可持续发展之路。而发展环境教育是解决环境问题和实施可持续发展战略的根本。高等学校的环境教育，是提高新世纪建设者的环境意识，并向社会输送环境保护专门人才的重要途径。为了反映国外环境类教材的最新内容和编写风格，同时也为了提高学生阅读专业文献和获取信息的能力，我们精选了国外一些优秀的环境类教材，加以影印或翻译，组成大学环境教育丛书。所选教材均在国外被广泛采用，多数已再版，书中不仅介绍了有关概念、原理及技术方法，给出了丰富的数据，也反映了作者不同的学术观点。

我们希望这套丛书的出版能对高等院校师生和广大科技人员有所帮助，并为我国的环境教育事业作出贡献。

清华大学出版社

2008年10月

ABOUT THE AUTHORS

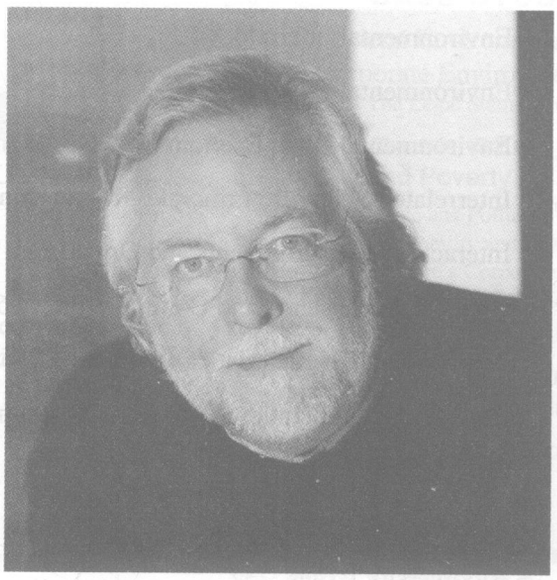


ELDON D. ENGER is an emeritus professor of biology at Delta College, a community college near Saginaw, Michigan. He received his B.A. and M.S. degrees from the University of Michigan. Professor Enger has over 30 years of teaching experience, during which he has taught biology, zoology, environmental science, and several other courses. He has been very active in curriculum and course development. A major contribution to the curriculum was the development of an environmental technician curriculum and the courses that support it. He was also involved in the development of learning community courses in stream ecology, winter ecology, and plant identification. Each of these courses involved students in weekend-long experiences in the outdoors that paired environmental education with physical activity—stream ecology and canoeing, winter ecology and cross-country skiing, and plant identification with backpacking.

Professor Enger is an advocate for variety in teaching methodology. He feels that if students are provided with varied experiences, they are more likely to learn. In addition to the standard textbook assignments, lectures, and laboratory activities, his classes included writing assignments, student presentation of lecture material, debates by students on controversial issues, field experiences, individual student projects, and discussions of local examples and relevant current events. Textbooks are very valuable for presenting content, especially if they contain accurate, informative drawings and visual examples. Lectures are best used to help students see themes and make connections, and laboratory activities provide important hands-on activities.

Professor Enger received the Bergstein Award for Teaching Excellence and the Scholarly Achievement Award from Delta College and was selected as a Fulbright Exchange Teacher twice—to Australia and Scotland. He has participated as a volunteer in several Earthwatch Research Programs. These include: studying the behavior of a bird known as the long-tailed manakin in Costa Rica, participating in a study to reintroduce endangered marsupials from islands to mainland Australia, and efforts to protect the leatherback turtle in Costa Rica. He also served as a participant in a People to People program which allowed for an exchange of ideas between U.S. and South African environmental professionals. While traveling he has spent considerable time visiting coral reefs, ocean coasts, mangrove swamps, alpine tundra, prairies, tropical rainforests, cloud forests, deserts, temperate rainforests, coniferous forests, deciduous forests, and many other special ecosystems. This extensive experience provides the background to look at environmental issues from a broad perspective.

Professor Enger is married, has two grown sons, and enjoys a variety of outdoor pursuits such as cross-country skiing, hiking, hunting, fishing, camping and gardening. Other interests include reading a wide variety of periodicals, beekeeping, singing in a church choir, and preserving garden produce.



BRADLEY F. SMITH is the Dean of Huxley College of Environmental Studies at Western Washington University in Bellingham, Washington. Prior to assuming the position as Dean in 1994, he served as the first Director of the Office of Environmental Education for the U.S. Environmental Protection Agency in Washington, D.C. from 1991 to 1994. Dean Smith also served as the Acting President of the National Environmental Education and Training Foundation in Washington, D.C. and as a Special Assistant to the EPA Administrator.

Before moving to Washington, D.C., Dean Smith was a professor of political science and environmental studies for fifteen years, and the executive director of an environmental education center and nature refuge for five years.

Dean Smith has considerable international experience. He was a Fulbright Exchange Teacher to England and worked as a research associate for Environment Canada in New Brunswick. He is a frequent speaker on environmental issues worldwide and serves on the International Scholars Program for the U.S. Information Agency. He also served as a U.S. representative on the Tri-Lateral Commission on environmental education with Canada and Mexico. In 1995, he was awarded a NATO Fellowship to study the environmental problems associated with the closure of former Soviet military bases in Eastern Europe. Dean Smith is an Adjunct Professor at Far Eastern State University in Vladivostok, Russia and is a member of the Russian Academy of Transport. He also serves as a commissioner for the International Union for the Conservation of Nature (IUCN) and is the President of the World Conservation Learning Network for the IUCN.

Nationally, Dean Smith serves as a member/advisor for many environmental organizations' boards of directors and advisory councils, including the National Environmental Education and Training Foundation. He served as the chair of the Washington State Sustainability Council and is the past President of the Council of Environmental Deans and Directors. He previously served on President Clinton's Council for Sustainable Development (Education Task Force).

Dean Smith holds B.A. and M.A. degrees in Political Science/International Relations and Public Administration and a Ph.D. from the School of Natural Resources and the Environment at the University of Michigan.

Dean Smith and his wife, Daria, live along the shores of Puget Sound in Bellingham, Washington, and spend part of the summer at their summer home on the shores of Lake Huron in the Upper Peninsula of Michigan. He has two grown children and is an avid outdoor enthusiast.

PREFACE

THE ROLE OF ENVIRONMENTAL SCIENCE IN SOCIETY

We live in a time of great change and challenge. A quick read of the headlines of any newspaper provides images of disease, hunger, poverty, natural disasters, and pollution. Challenges, however, are also opportunities. Opportunities exist because of the changes the global society must make. Simply put, we cannot continue with business as usual. Such a path is not sustainable. What does that mean? In short, we must do things differently. For example, different farming practices will allow crops to be raised with fewer chemicals and less water. Buildings can be constructed with new, more sustainable methods. Transportation can be provided while using less energy. In other words, we must think differently. Environmental science is a discipline that fosters new ways of thinking. Environmental science is an applied science designed to help address and solve the challenges the world faces. It is also by its very nature a global science. This text, for example, has been translated and published in China and Korea. Therefore, students in Shanghai, Seoul, or Seattle are learning the "how's and why's" involved in thinking and acting sustainably. At the end of the day we all share the same air, water, and one not-so-big planet. It's important for all of us to make it last.

WHY "A STUDY OF INTERRELATIONSHIPS"?

Environmental science is an interdisciplinary field. Because environmental problems occur as a result of the interaction between humans and the natural world, we must include both scientific and social aspects when we seek solutions to environmental problems. Therefore, the central theme of this book is interrelatedness. It is important to have a historical perspective, to appreciate economic and political realities, to recognize the role of different social experiences and ethical backgrounds, and to 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.

WHAT MAKES THIS TEXT UNIQUE?

We present a balanced view of issues, diligently avoiding personal biases and fashionable philosophies.

It is not the purpose of this textbook to tell readers what to think. Rather, our goal is to provide access to information and the conceptual framework needed to understand complex issues so that readers can comprehend the nature of environmental problems and formulate their own views. Two features of the text encourage readers to think about issues and formulate their own thoughts.

- The **Issues & Analysis** box near the end of each chapter presents real-world examples of environmental problems and prompts students to think about the issues involved and respond to a series of questions.
- The new **What's Your Take?** feature found at the end of each chapter asks students to take a stand on a particular issue and develop arguments to support their position.

We recognize that environmental problems are global in nature.

Three features of the text support this concern:

- **Global Perspectives** provide specific examples that ask students to consider how problems might be viewed differently in other countries, to compare approaches to environmental problems, or to provide examples of environmental problems not typical of North America.
- Real-world **Case Studies** provide examples of specific situations that allow students to see how the concepts discussed in the chapter can be applied to everyday situations.
- The presence of easily accessible **Foldout World Maps** at the back of the text allows students to quickly locate a country or region geographically.

Two guest authors bring their special expertise to this edition of the text.

Christopher J. Preston's rewriting of Chapter 2, Environmental Ethics, has broadened the coverage and given the chapter greater force and clarity.

Christopher J. Preston is Visiting Assistant Professor in the department of philosophy at the University of Montana, Missoula. He has over a dozen publications in the areas of environmental

philosophy, ethics, and the philosophy of mind. He teaches classes in ethics, environmental ethics, ecofeminism, ecological citizenship, and contemporary moral issues.

Jacob W. Van Houten's knowledge of environmental regulations and the handling of hazardous materials has greatly enhanced Chapter 3, Environmental Risk: Economics, Assessment, and Management, and Chapter 18, Environmental Regulations: Hazardous Substances and Wastes.

Jacob W. Van Houten is an Associate Professor of biology at Delta College. As the Environmental Technology Program Coordinator, he is responsible for the development and implementation of the Environmental Technology curriculum, which prepares students for careers as environmental health and safety professionals in industry and government. He also teaches Integrated Biology, General Biology, and several field biology courses that involve students in hands-on experiences in nature. In addition, he is an environmental trainer for business and industry, most recently being involved in training people who worked in the cleanup of New Orleans following Hurricane Katrina.

NEW TO THIS EDITION

The eleventh edition of *Environmental Science: A Study of Interrelationships* is the result of extensive analysis of the text and the evaluation of input from environmental science instructors who conscientiously reviewed chapters during the revision. We have used the constructive comments provided by these professionals in our continuing efforts to enhance the strengths of the text. The following is a list of global changes we have made, along with a description of significantly revised chapters. To see a more detailed list of chapter-by-chapter changes, please contact your McGraw-Hill sales representative.

New Student Learning Tools

Two new features that promote active learning have been added at the end of each chapter.

- The **Experience This** feature asks students to extend their learning by undertaking simple activities that relate to the content of the chapter.
- The **What's Your Take?** feature asks students to reflect on the content of the chapter by taking a position on an issue and to prepare arguments to support their position.

Also in this edition, new and revised **Case Studies** provide students with expanded treatment of specific examples that help to show how the broad concepts presented in the chapter apply to specific environmental issues.

Revised Art Program

Nearly 300 new photos have been added throughout the text to depict real-life situations. Several illustrations, graphs, and charts are new or revised to present detailed information in a form that is easier to comprehend than if that same material were presented in text form.

Several Significantly Revised Chapters

- **Chapter 2, Environmental Ethics** has been completely revised and reorganized by guest author Christopher J. Preston. New information has been added to reflect the history, development, and maturation of thinking about environmental ethics.
- **Chapter 3.** Revised by guest author Jacob W. Van Houten, this retitled chapter, **Environmental Risk: Economics, Assessment, and Management,** has new sections on Risk Assessment and Risk Management, and Risk Tolerance. Important implications of Risk-Based Corrective Action (RBCA), energy savings cost/benefit analysis, and the Great Lakes Resource Management are topics addressed in this chapter through detailed discussion and case studies. Also included are the most current environmental liability protection issues and grants through the new Environmental Protection Agency (EPA) Small Business Liability Relief and Brownfield Revitalization Act (SBLRBRA or "Brownfield Law") as it relates to economics, assessment, and management.
- **Chapter 7, Populations: Characteristics and Issues** is the result of the combination of two separate chapters from previous editions (chapters 7 and 8). In response to reviewer requests, several sections such as those on carrying capacity, limiting factors, and r- and K-strategists have been rewritten.
- **Chapter 10, Nuclear Energy** has been completely reorganized. New material has been added on the biological effects of ionizing radiation, measuring radiation, radiation protection, radioactive decay series, and dirty bombs.
- **Chapter 18.** Written by guest author Jacob W. Van Houten, this retitled chapter, **Environmental Regulations: Hazardous Substances and Wastes** has been thoroughly updated with two new sections and information about recent changes in legislation. Environmental site assessments, vital in determining current environmental conditions/liabilities associated with property, are discussed. Specifically, topics such as the latest ASTM Phase I Environmental Site Assessment Standard; the benefits of implementing an Environmental Management System (ISO 14000); and difficulties with determining cleanup criteria for hazardous waste sites are also included. New case studies covering specific issues affecting our environment and the regulated community include pollution prevention in micro-scale chemistry and dioxin contamination in a river/floodplain system.

ACKNOWLEDGMENTS

The creation of a textbook requires a dedicated team of professionals who provide guidance, criticism, and encouragement. It is also important to have open communication and dialogue to deal with the many issues that arise during the development and production of a text. Therefore, we would like to thank Publisher Marge Kemp; Developmental Editors Joan Weber and Brian Loehr; Marketing Manager Tami Petsche; Project Manager Lora Kalb; Production Supervisor Sandy Ludovissy; Photo Research Coordinator Lori Hancock; Designer John Joran, Media Project

Manager Judi David; and Media Producer Dan Wallace for their suggestions and kindnesses. Finally, we'd like to thank our many colleagues who have reviewed all, or part, of *Environmental Science: A Study of Interrelationships.* Their valuable input has continued to shape this text and help it meet the needs of instructors around the world.

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Eldon D. Enger
Bradley F. Smith

GUIDED TOUR

CURRENT AND UP-TO-DATE COVERAGE—GUARANTEED!

The study of environmental science is an ever-changing field. That's why it is so important to be as current and up-to-date as possible.

CASE STUDY 19.1

THE ENVIRONMENTAL EFFECTS OF HURRICANE KATRINA

Hurricane Katrina, which hit the Gulf of Mexico coast of the United States in the autumn of 2005, is perhaps the worse environmental catastrophe ever to befall the country as a result of a natural disaster. The scope and magnitude of the hurricane was massive, and the environmental impact will be felt for years to come.

According to U.S. Coast Guard and EPA data there were 575 Katrina-related spills of petroleum or hazardous chemicals reported. It is estimated that the oil spills totaled 20 million liters.

It is also estimated that there were 350,000 or more ruined automobiles and other vehicles damaged by the flooding. The amount of gasoline and hazardous fluids in these vehicles could add another 12 million liters to the figure mentioned previously. By comparison, some 40 million liters of oil were released in the Exxon Valdez disaster.

At least four Superfund hazardous-waste sites in the New Orleans area were hit by Katrina. Across the storm-ravaged areas of Louisiana, Mississippi, and Alabama, dozens of other toxic waste sites, major industrial facili... of oil and ... addition ... or indust... toxic sed... rivers, ar...

The scope of devastation caused by Hurricane Katrina is difficult to comprehend.

1. Maintaining the integrity of natural ecosystems should be a priority: Indiscriminate economic development and ecologically destructive policies have left many communities more vulnerable to disasters than they realize. This, together with rapid population growth in vulnerable areas, has contributed to worldwide economic losses from weather—related catastrophes totaling $567 billion over the last 10 years, exceeding the combined losses from 1950 through 1989. Losses in 2004 exceeded $100 billion for the second time ever, and a new record will certainly be set once Katrina's damages are totaled.
2. Short-term thinking is a dangerous approach to policy. During the past few years, the U.S. government has diverted funding from disaster preparedness and has reduced protections for wetlands in order to spur economic development. Both decisions are now exacting costs that far exceed the money saved. Natural ecosystems

CASE STUDY 11.2

MILLENNIUM ECOSYSTEM ASSESSMENT REPORT AND THE MILLENNIUM DECLARATION

In 2005 a major study called the Millennium Ecosystem Assessment (MA) Synthesis Report was published. Involving some 1300 of the world's leading experts, the MA is a partnership among several international organizations including the United Nations, the World Bank, and the International Union for the Conservation of Nature (IUCN). The study was conducted over four years and involved experts from 95 countries. The MA is recognized by governments as a mechanism to meet part of the assessment needs of four international environmental treaties—the UN Convention on Biological Diversity, the Ramscar Convention on Wetlands, the UN Convention to Combat Desertification, and the Convention on Migratory Species. Following are highlights of the main findings of the report.

- Humans have changed ecosystems more rapidly and extensively in the last 50 years than in any other period. This was done largely to meet rapidly growing demands for food, freshwater, timber, fiber, and fuel. More land was converted to agriculture since 1945 than in the eighteenth and nineteenth centuries combined. Experts say that this resulted in a substantial and largely irreversible loss in diversity of life on Earth, with some 10 to 30 percent of the mammal, bird, and amphibian species currently threatened with extinction.
- Ecosystem changes that have contributed substantial net gains in human well-being and economic development have been achieved at growing costs in the form of degradation of other services. Only three ecosystem services have been enhanced in the last 50 years—increases in crop, livestock, and aquaculture production. Two services—capture fisheries and freshwater—are now well beyond levels that can sustain current, much less future, demands.
- The degradation of ecosystem services could grow significantly worse during the first half of this century. In all the plausible futures explored by the scientists, they project progress in eliminating hunger, but at a slower rate than needed to halve the number of people suffering from hunger by 2015. Experts warn that changes in ecosystems such as deforestation influence the abundance of human pathogens such as malaria and cholera, as well as increasing the risk from emerging new diseases.
- The challenge of reversing the degradation of ecosystems while meeting increasing demands can be met under some scenarios with significant policy and institutional changes. However, these changes will be large and are not currently under way. The report mentions options that exist to conserve or enhance ecosystem services that reduce negative trade-offs or that will positively affect other services. Protection of natural forests, for example, not only conserves wildlife but also supplies freshwater and reduces carbon emissions.

The major conclusion of this assessment is that it lies within the power of human societies to ease the strains we are putting on the nature services of the planet, while continuing to use them to bring better living standards to all. Achieving this, however, will require major changes in the way nature is treated at every level of decision-making and new forms of cooperation between government, business and civil society.

VALUES UNDERLYING THE MILLENNIUM DECLARATION

The Millennium Declaration—which outlines 60 goals for peace; development; the environment; human rights; the vulnerable, hungry, and poor; Africa; and the United Nations—is founded on a core set of values described as follows:

"We consider certain fundamental values to be essential to international relations in the twenty-first century. These include:

- **Freedom.** Men and women have the right to live their lives and raise their children in dignity, free from hunger and from the fear of violence, oppression or injustice. Democratic and participatory governance based on the will of the people best assures these rights.
- **Equality.** No individual and no nation must be denied the opportunity to benefit from development. The equal rights and opportunities of women and men must be assured.
- **Solidarity.** Global challenges must be managed in a way that distributes the costs and burdens fairly in accordance with basic principles of equity and social justice. Those who suffer or who benefit least deserve help from those who benefit most.
- **Tolerance.** Human beings must respect one other, in all their diversity of belief, culture and language. Differences within and between societies should be neither feared nor repressed, but cherished as a precious asset of humanity. A culture of peace and dialogue among all civilizations should be actively promoted.
- **Respect for nature.** Prudence must be shown in the management of all living species and natural resources, in accordance with the precepts of sustainable development. Only in this way can the immeasurable riches provided to us by nature be preserved and passed on to our descendants. The current unsustainable patterns of production and consumption must be changed in the interest of our future welfare and that of our descendants.
- **Shared responsibility.** Responsibility for managing worldwide economic and social development, as well as threats to international peace and security, must be shared among the nations of the world and should be exercised multi-laterally. As the most universal and most representative organization in the world, the United Nations must play the central role."[1]

The Millennium Ecosystem Assessment Report is available at http://www.maweb.org/en/Article.aspx?id=58

1. United Nations General Assembly, "United Nations Millennium Declaration," Resolution 55/2, United Nations A/RES/55/2, 18 September 2000, page x.

for the loss of biodiversity is greatest in tropical, developing countries. Many biologists estimate that there may be as many species in the tropical rainforests of the world as in the rest of the world combined. Unfortunately, loss of biodiversity is not a high priority for the general public in developing countries, even though their national governments have ratified the biodiversity treaty. This difference in level of concern is understandable since the developed world has surplus food, higher

CASE STUDIES

Case Studies, which are found in each chapter, are an innovative way to learn about current, global environmental issues.

GLOBAL PERSPECTIVES

Ever wonder how environmental problems might be handled in other countries? **Global Perspectives** compare different approaches to environmental problems and provide examples of environmental issues not typically found in North America.

GLOBAL PERSPECTIVE

SUSTAINABLE DEVELOPMENT OF THE MEKONG RIVER DELTA

The Mekong River's watershed includes parts of six nations: Cambodia, Lao People's Democratic Republic (Laos), Thailand, Vietnam, Myanmar (Burma), and China.

Many demands are made on the river—to provide water for industrial and agricultural development, to sustain subsistence fishing, for transport, and to maintain delicate ecological and hydrological balances. Inevitably, there are conflicting demands on the resource and very different views as to how the water should (or should not) be used.

Disparities in the power and wealth of the countries involved pose problems in reaching solutions that are acceptable to all. This is especially true in determining how to balance economic development opportunities (such as dam construction) with the river's livelihood benefits to the 60 million people who live in the river basin. Around 30 percent of these people live below the poverty line and rely, for example, on the fish they catch from the river for their food. Similarly, the silt load that the river produces is crucial for intensive farming systems in Vietnam and Cambodia but less important elsewhere.

In 1995, Cambodia, Lao People's Democratic Republic, Thailand, and Vietnam signed the Agreement on Cooperation for the Sustainable Development of the Mekong River Basin. Although they were not signatories of the original agreement, China and Myanmar have participated as "dialog partners" in deliberations of the commission and provide information important to discussions. Potential benefits of regional action include the equitable sharing of regional electricity grid and a regional growth plan. The agreement could also have environmental advantages by encouraging countries to consider the downstream effects of their activities.

The Agreement on Cooperation specifies that the countries involved have neither the right to use nor to veto the use of the water of the Mekong, implying that consensus is necessary to move forward. An outgrowth of the agreement was the establishment of a Mekong River Commission with representatives of the four participating countries. The solution for the Mekong seems to be a balance: the careful selection and construction of environmentally "good" dams over "bad" ones, for example. However, cooperation is often difficult to achieve. Differences in historical use patterns, financial benefits, and political power will all be involved in determining the success or failure of this agreement.

Mekong River Fact Sheet	
Length	4200 km (2610 mi)
Countries	China, Myanmar, Thailand, Laos, Cambodia, and Vietnam
Basin population	60 million
Per capita GDPppp	Varies from US$ 8200 (Thailand) to US$ 1850 (Cambodia)
Uses	Irrigation, fisheries, power generation, transportation, industrial and domestic supply
Primary legal agreement	Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin, Chiang Rai, Thailand, April 5, 1995 (Thailand, Laos, Cambodia, and Vietnam)

Source: International Union for the Conservation of Nature (IUCN). Gland, Switzerland.

Critical Thinking—An Important Learning Goal!

Critical thinking skills will be improved by taking part in the in-text activities and end-of-chapter questions and readings.

Issues & Analysis Readings

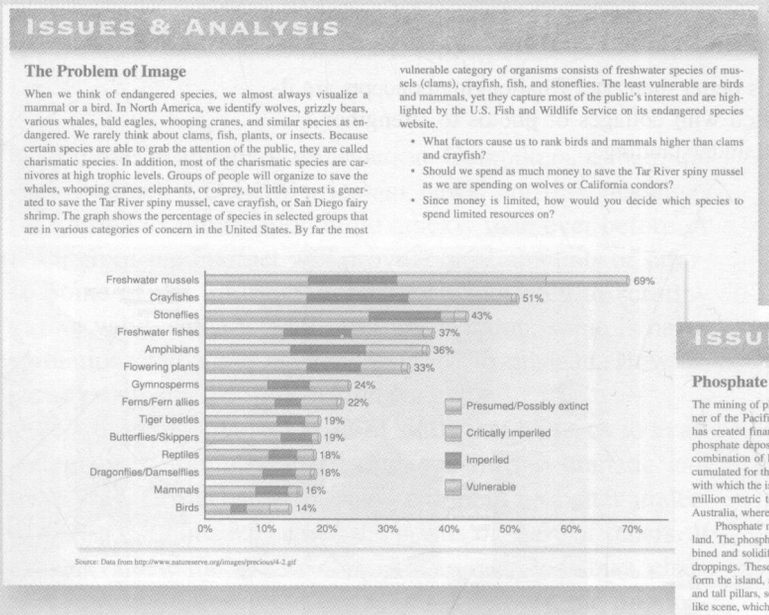
Issues & Analysis boxed readings present real-world examples of environmental problems and prompt students to think about the issues involved and respond to a series of questions.

What's Your Take?

By having students take stands on issues and develop arguments to support their positions, this tool will allow students to develop and enhance their critical thinking skills.

Critical Thinking Questions

Critical Thinking questions can be found in every chapter of *Environmental Science.* By answering these questions, students will become better at evaluating information, opinions, and arguments so they can learn to recognize bias, characterize the assumptions behind arguments, and avoid jumping to conclusions.



ISSUES & ANALYSIS

The Problem of Image

When we think of endangered species, we almost always visualize a mammal or a bird. In North America, we identify wolves, grizzly bears, various whales, bald eagles, whooping cranes, and similar species as endangered. We rarely think about clams, fish, plants, or insects. Because certain species are able to grab the attention of the public, they are called charismatic species. In addition, most of the charismatic species are carnivores at high trophic levels. Groups of people will organize to save the whales, whooping cranes, elephants, or osprey, but little interest is generated to save the Tar River spiny mussel, cave crayfish, or San Diego fairy shrimp. The graph shows the percentage of species in selected groups that are in various categories of concern in the United States. By far the most vulnerable category of organisms consists of freshwater species of mussels (clams), crayfish, fish, and stoneflies. The least vulnerable are birds and mammals, yet they capture most of the public's interest and are highlighted by the U.S. Fish and Wildlife Service on its endangered species website.

- What factors cause us to rank birds and mammals higher than clams and crayfish?
- Should we spend as much money to save the Tar River spiny mussel as we are spending on wolves or California condors?
- Since money is limited, how would you decide which species to spend limited resources on?

Source: Data from http://www.natureserve.org/images/precious/4-2.gif

ISSUES & ANALYSIS

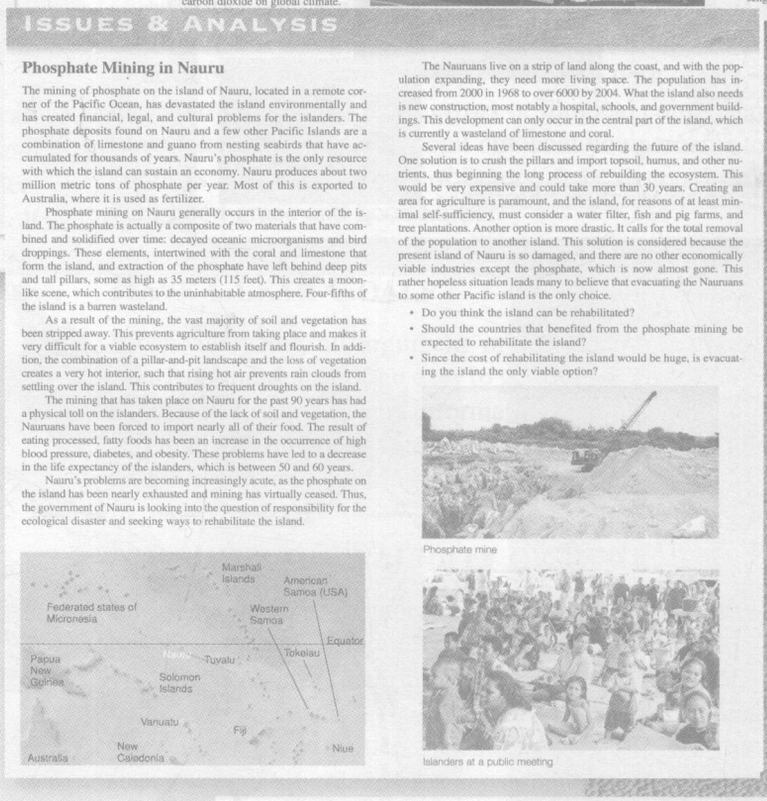
Diesel Engine Trade-offs

In the United States nearly all automobiles have gasoline engines. Only about 1 percent have diesel engines. In Europe about 50 percent of new automobiles sold have diesel engines. Automobile diesel engines are much more efficient than gasoline engines. They have an efficiency of 35 to 42 percent compared to gasoline engines with an efficiency of 25 to 30 percent. This means that they go much farther on a liter of fuel than do equivalent gasoline engines. Furthermore diesel engines last longer than gasoline engines.

Since gasoline engines are less efficient than diesel engines, gasoline engines produce 20 to 40 percent more carbon dioxide than diesel engines for the same distance driven. Increased carbon dioxide is known to cause a warming of the Earth's atmosphere. One of the reasons for the popularity of diesel engines in Europe is concern about the effect of carbon dioxide on global climate.

Current diesel engines produce more particulate matter and nitrogen oxides than do gasoline engines. However, current air quality guidelines for particulate matter and nitrogen oxides in Europe are more stringent than those in the United States. The World Health Organization has estimated that thousands of people die each year because of particulate air pollution. Changes are being made in fuels, engine design, and pollution control devices that reduce the amount of particulate matter and nitrogen oxides produced.

- Should U.S. automakers switch to diesel engines as the Europeans have?
- Is global climate change an important reason to use diesel engines?
- Should problems with particulate emissions prevent the development of diesel engines for passenger vehicles?



ISSUES & ANALYSIS

Phosphate Mining in Nauru

The mining of phosphate on the island of Nauru, located in a remote corner of the Pacific Ocean, has devastated the island environmentally and has created financial, legal, and cultural problems for the islanders. The phosphate deposits found on Nauru and a few other Pacific Islands are a combination of limestone and guano from nesting seabirds that have accumulated for thousands of years. Nauru's phosphate is the only resource with which the island can sustain an economy. Nauru produces about two million metric tons of phosphate per year. Most of this is exported to Australia, where it is used as fertilizer.

Phosphate mining on Nauru generally occurs in the interior of the island. The phosphate is actually a composite of two materials that have combined and solidified over time: decayed oceanic microorganisms and bird droppings. These elements, intertwined with the coral and limestone that form the island, and extraction of the phosphate have left behind deep pits and tall pillars, some as high as 35 meters (115 feet). This creates a moonlike scene, which contributes to the uninhabitable atmosphere. Four-fifths of the island is a barren wasteland.

As a result of the mining, the vast majority of soil and vegetation has been stripped away. This prevents agriculture from taking place and makes it very difficult for a viable ecosystem to establish itself and flourish. In addition, the combination of a pillar-and-pit landscape and the loss of vegetation creates a very hot interior, such that rising hot air prevents rain clouds from settling over the island. This contributes to frequent droughts on the island.

The mining that has taken place on Nauru for the past 90 years has had a physical toll on the islanders. Because of the lack of soil and vegetation, the Nauruans have been forced to import nearly all of their food. The result of eating processed, fatty foods has been an increase in the occurrence of high blood pressure, diabetes, and obesity. These problems have led to a decrease in the life expectancy of the islanders, which is between 50 and 60 years.

Nauru's problems are becoming increasingly acute, as the phosphate on the island has been nearly exhausted and mining has virtually ceased. Thus, the government of Nauru is looking into the question of responsibility for the ecological disaster and seeking ways to rehabilitate the island.

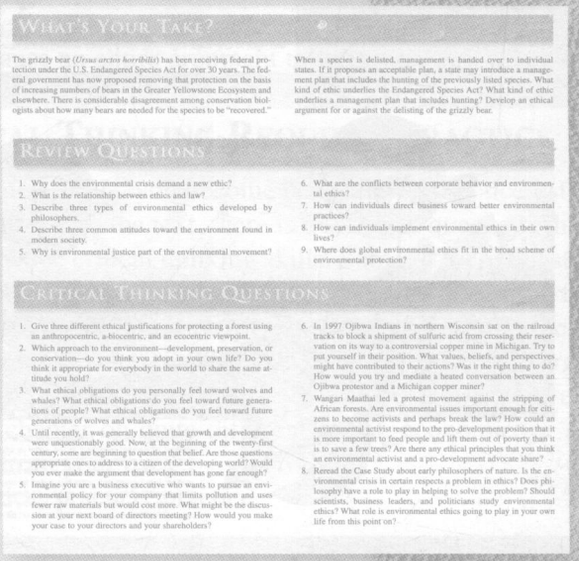
The Nauruans live on a strip of land along the coast, and with the population expanding, they need more living space. The population has increased from 2000 in 1968 to over 6000 by 2004. What the island also needs is new construction, most notably a hospital, schools, and government buildings. This development can only occur in the central part of the island, which is currently a wasteland of limestone and coral.

Several ideas have been discussed regarding the future of the island. One solution is to crush the pillars and import topsoil, humus, and other nutrients, thus beginning the long process of rebuilding the ecosystem. This would be very expensive and could take more than 30 years. Creating an area for agriculture is paramount, and the island, for reasons of at least minimal self-sufficiency, must consider a water filter, fish and pig farms, and tree plantations. Another option is more drastic. It calls for the total removal of the population to another island. This solution is considered because the present island of Nauru is so damaged, and there are no other economically viable industries except the phosphate, which is now almost gone. This rather hopeless situation leads many to believe that evacuating the Nauruans to some other Pacific island is the only choice.

- Do you think the island can be rehabilitated?
- Should the countries that benefited from the phosphate mining be expected to rehabilitate the island?
- Since the cost of rehabilitating the island would be huge, is evacuating the island the only viable option?

Phosphate mine

Islanders at a public meeting



WHAT'S YOUR TAKE?

The grizzly bear (*Ursus arctos horribilis*) has been receiving federal protection under the U.S. Endangered Species Act for over 30 years. The federal government has now proposed removing that protection on the basis of increasing numbers of bears in the Greater Yellowstone Ecosystem and elsewhere. There is considerable disagreement among conservation biologists about how many bears are needed for the species to be "recovered."

When a species is delisted, management is handed over to individual states. If it proposes an acceptable plan, a state may introduce a management plan that includes the hunting of the previously listed species. What kind of ethic underlies the Endangered Species Act? What kind of ethic underlies a management plan that includes hunting? Develop an ethical argument for or against the delisting of the grizzly bear.

REVIEW QUESTIONS

1. Why does the environmental crisis demand a new ethic?
2. What is the relationship between ethics and law?
3. Describe three types of environmental ethics developed by philosophers.
4. Describe three common attitudes toward the environment found in modern society.
5. Why is environmental justice part of the environmental movement?
6. What are the conflicts between corporate behavior and environmental ethics?
7. How can individuals direct business toward better environmental practices?
8. How can individuals implement environmental ethics in their own lives?
9. Where does global environmental ethics fit in the broad scheme of environmental protection?

CRITICAL THINKING QUESTIONS

1. Give three different ethical justifications for protecting a forest using an anthropocentric, a biocentric, and an ecocentric viewpoint.
2. Which approach to the environment—development, preservation, or conservation—do you think you adopt in your own life? Do you think it appropriate for everybody in the world to share the same attitude you hold?
3. What ethical obligations do you personally feel toward wolves and whales? What ethical obligations do you feel toward future generations of people? What ethical obligations do you feel toward future generations of wolves and whales?
4. Until recently, it was generally believed that growth and development were unquestionably good. Now, at the beginning of the twenty-first century, some are beginning to question that belief. Are those questions appropriate ones to address to a citizen of the developing world? Would you ever make the argument that development has gone far enough?
5. Imagine you are a business executive who wants to pursue an environmental policy for your company that limits pollution and uses fewer raw materials but would cost more. What might be the discussions at your next board of directors meeting? How would you make your case to your directors and your shareholders?
6. In 1997 Ojibwa Indians in northern Wisconsin sat on the railroad tracks to block a shipment of sulfuric acid from crossing their reservation on its way to a controversial copper mine in Michigan. Try to put yourself in their position. What values, beliefs, and perspectives might have contributed to their actions? Was it the right thing to do? How would you try and mediate a heated conversation between an Ojibwa protestor and a Michigan copper miner?
7. Wangari Maathai led a protest movement against the stripping of African forests. Are environmental issues important enough for citizens to become activists and perhaps break the law? How could an environmental activist respond to the pro-development position that it is more important to feed people and lift them out of poverty than it is to save a few trees? Are there any ethical principles that you think an environmental activist and a pro-development advocate share?
8. Reread the Case Study about early philosophers of nature. Is the environmental crisis in certain respects a problem in ethics? Does philosophy have a role to play in helping to solve the problem? Should scientists, business leaders, and politicians study environmental ethics? What role is environmental ethics going to play in your own life from this point on?

Instructional Art—Painting Conceptual Pictures for Students!

Enger/Smith's revised and improved art program offers students another way to study the many concepts of environmental science.

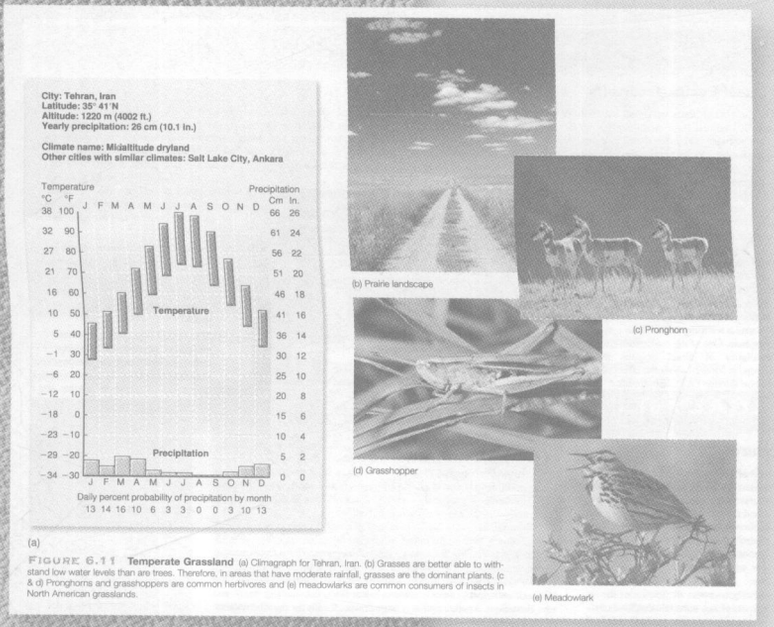


FIGURE 6.11 **Temperate Grassland** (a) Climagraph for Tehran, Iran. (b) Grasses are better able to withstand low water levels than are trees. Therefore, in areas that have moderate rainfall, grasses are the dominant plants. (c & d) Pronghorns and grasshoppers are common herbivores and (e) meadowlarks are common consumers of insects in North American grasslands.

Combination Photos

Five is better than one! Challenging concepts are illustrated with collages of photos to strengthen students' understanding.

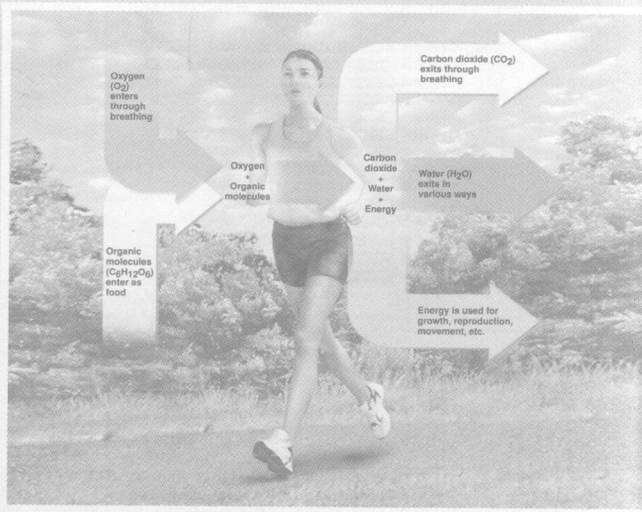


FIGURE 4.10 **Respiration** Respiration involves the release of energy from organic molecules when they react with oxygen. In addition to provid ing energy in a usable form, respiration produces carbon dioxide and water.

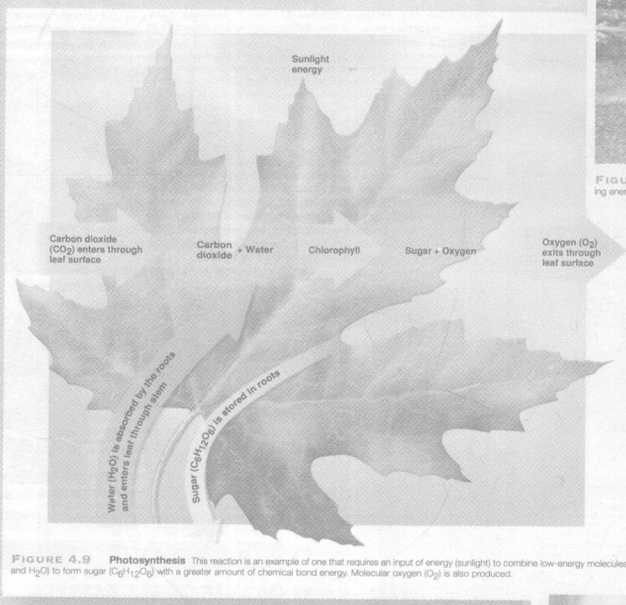


FIGURE 4.9 **Photosynthesis** This reaction is an example of one that requires an input of energy (sunlight) to combine low-energy molecules (CO_2 and H_2O) to form sugar ($C_6H_{12}O_6$) with a greater amount of chemical bond energy. Molecular oxygen (O_2) is also produced.

New! More Realistic Art

New multidimensional images offer students a more-detailed level of instruction.

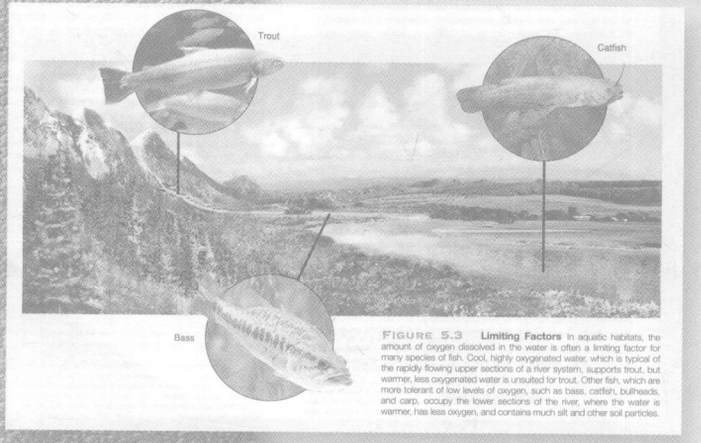


FIGURE 5.3 **Limiting Factors** In aquatic habitats, the amount of oxygen dissolved in the water is often a limiting factor for many species of fish. Cool, highly oxygenated water, which is typical of the rapidly flowing upper sections of a river system, supports trout, but warmer, less oxygenated water is unsuited for trout. Other fish, which are more tolerant of low levels of oxygen, such as bass, catfish, bullheads, and carp, occupy the lower sections of the river, where the water is warmer, has less oxygen, and contains much silt and other soil particles.

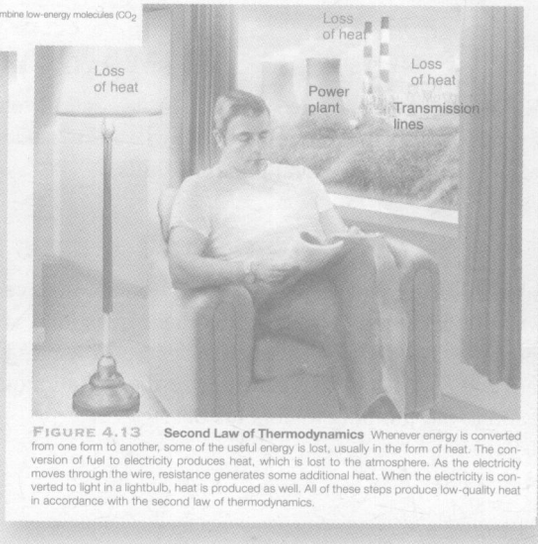
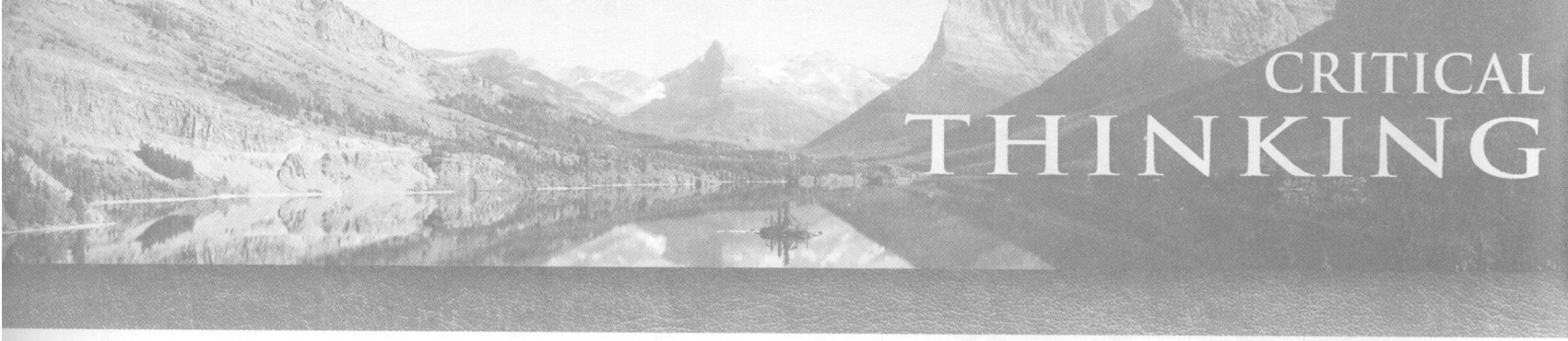


FIGURE 4.13 **Second Law of Thermodynamics** Whenever energy is converted from one form to another, some of the useful energy is lost, usually in the form of heat. The conversion of fuel to electricity produces heat, which is lost to the atmosphere. As the electricity moves through the wire, resistance generates some additional heat. When the electricity is converted to light in a lightbulb, heat is produced as well. All of these steps produce low-quality heat in accordance with the second law of thermodynamics.



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 helps 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 allow us to sort information in a meaningful way and discard invalid or useless information while recognizing that which is valuable. Some key components of critical thinking are:

Recognize the Importance of Context

All information is based on certain assumptions. 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 is 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.

BRIEF CONTENTS

CONTENTS

CHAPTER 7

POPULATIONS: CHARACTERISTICS AND ISSUES 136

CHAPTER 8

ENERGY AND CIVILIZATION: PATTERNS OF CONSUMPTION 166

CHAPTER 9

ENERGY SOURCES 179