

Eldon D. Enger Bradley F. Smith

Environmental Science
A Study of Interrelationships
(Fourteenth Edition)

环境科学
—— **交叉关系学科**
(第14版)



大学环境教育丛书

(影印版)

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Environmental Science: A Study of Interrelationships, Fourteenth Edition

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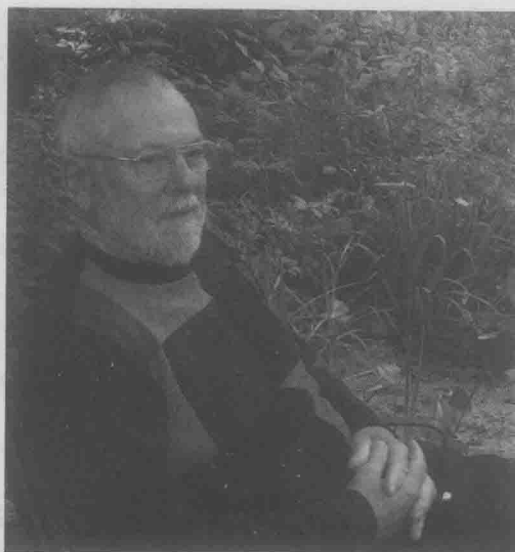
在 21 世纪之初，面临各种环境问题，人类清醒地认识到要走可持续发展之路。而发展环境教育是解决环境问题和实施可持续发展战略的根本。高等学校的环境教育，是提高新世纪建设者的环境意识，并向社会输送环境保护专门人才的重要途径。为了反映国外环境类教材的最新内容和编写风格，同时也为了提高学生阅读专业文献和获取信息的能力，我们精选了国外一些优秀的环境类教材，加以影印或翻译，组成大学环境教育丛书。所选教材均在国外被广泛采用，多数已再版，书中不仅介绍了有关概念、原理及技术方法，给出了丰富的数据，也反映了作者不同的学术观点。

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。

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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 curriculum contribution 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.



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 assess the possibility of reintroducing endangered marsupials from off-shore islands to mainland Australia, and helping with efforts to protect the nesting beaches of the leatherback turtle in Costa Rica, and assisting with on-going research on the sustainable use of fish, wildlife, and forest resources in the Amazon Basin in Peru. He also participated in a People to People program, which involved an exchange of ideas between U.S. and South African environmental professionals.

He has traveled extensively, which has allowed him first-hand experience with coral reefs, ocean coasts, savannas, mangrove swamps, tundra, prairies, tropical rainforests, cloud forests, deserts, temperate rainforests, coniferous forests, deciduous forests, and many other special ecosystems. These experiences have provided opportunities to observe the causes and consequences of many environmental problems from a broad social and scientific perspective.

He volunteers at a local nature center, land conservancy, and Habitat for Humanity affiliate. Since 2005, he and his wife have spent a month each year with other volunteers from their church repairing houses damaged by tornados, floods, and hurricanes throughout the United States.

Professor Enger and his wife Judy have two married sons and three grandchildren. He enjoys a variety of outdoor pursuits such as cross-country skiing, snowshoeing, hiking, kayaking, hunting, fishing, camping, and gardening. Other interests include reading a wide variety of periodicals, beekeeping, singing in a church choir, picking wild berries, and preserving garden produce.

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

Bradley F. Smith is the Dean Emeritus of Western Washington University in Bellingham, Washington, having served as Dean from 1994 to 2012. 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 15 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. He was awarded a NATO Fellowship to study the environmental problems associated with the closure of former Soviet military bases in Eastern Europe. He is a Fellow of the Royal Institute of Environmental Science in the U.K.



He also served on the Steering Committee of the Commission for Education and Communication for the International Union for the Conservation of Nature (IUCN) from 2004 to 2013.

Dean Smith is a trustee of the National Environmental Education Foundation, a member of the North Pacific Research Board, and is Vice-Chair of the Washington State Fish and Wildlife Commission. He also serves on the board of Washington Sea Grant. Previously, he served as the chair of the Washington Sustainability Council, as President of the Council of Environmental Deans and Directors, and as a member of the National Advisory Council for Environmental Policy and Technology for the EPA. He also 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. Our species has profoundly altered the Earth. Our use of fossil fuels to provide energy is altering climate, our use of Earth's soil resources to feed ourselves results in extinctions, overexploitation of fish populations has resulted in the population declines of many marine species, and freshwater resources are becoming scarce. At the same time we see significant improvement in other indicators. Energy-efficient and alternative energy technologies are becoming mainstream, population growth is beginning to slow, air and water pollution problems are being addressed in many parts of the world, and issues of biodiversity loss, climate change, and human health are beginning to be addressed on a worldwide basis.

However, there are still major challenges and there are additional opportunities to lighten our impact on Earth. Understanding the fundamental principles that describe how the Earth's systems work is necessary knowledge for everyone, not just scientists who study these systems. It is particularly important for political, industrial, and business leaders because the political, technical, and economic decisions they make affect the Earth.

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.

Environmental science is also a global science. While some environmental problems may be local in nature—pollution of a river, cutting down a forest, or changing the flow of a river for irrigation—other problems are truly global—climate change, overfishing of the oceans, or loss of biodiversity. In addition, individual local events often add together to cause a worldwide problem—the actions of farmers in China or Africa can result in

dust storms that affect the entire world, or the individual consumption of energy from fossil fuels increases carbon dioxide concentrations in the Earth's atmosphere. Therefore, another aspect of the interrelationships theme of this text is to purposely include features that highlight problems, issues, and solutions involving a variety of cultures.

This text has been translated and published in Spanish, Chinese, and Korean. Therefore, students in Santiago, Shanghai, Seoul, or Seattle are learning the "hows and whys" 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.

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** feature at the end of each chapter presents real-world, current issues and provides questions that prompt students to think about the complex social, political, and scientific interactions involved.



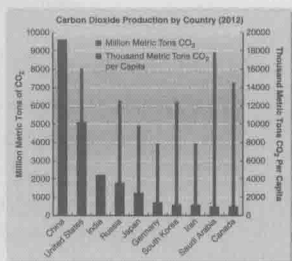
Issues & Analysis

Who Should Reduce CO₂ Emissions?

The chart below shows the top ten countries in terms of CO₂ emissions in 2011. These ten countries account for 67 percent of world CO₂ emissions. Thus, what these countries do will have a great impact on future CO₂ emissions and the severity of the climate change impacts that will occur as a result of an increase in the amount of CO₂ in the atmosphere. China is responsible for over 25 percent of global CO₂ emissions and the United States is responsible for about 17 percent of global emissions. However, both China and the United States have large populations so we should expect them to release more carbon dioxide than countries with small populations. Another way to look at emissions is to compare the emissions produced per person. On a per capita basis the United States releases 2.3 times more CO₂ per person than China. Some economically developed countries, like Japan and Germany, have per capita CO₂ emissions much lower than the United States. Japan's per capita CO₂ production is 50 percent and Germany's per capita production is half that of the United States. India and Russia are both countries with large populations that currently have low per capita CO₂ emissions. If they were to undergo an economic growth similar to that of China, world CO₂ emissions would increase greatly. If we want to reduce worldwide CO₂ emissions, it is obvious that those countries that are responsible for the greatest total emissions must reduce emissions. It is also obvious that countries that wish to develop economically (Russia, India, and many others) must do so without increasing carbon dioxide emissions.

- What actions could the United States and China take to reduce their carbon dioxide emissions?
- What actions could the international community take to encourage economically emerging nations to develop economically without increasing carbon dioxide emissions?

• Would you support a treaty that imposed a carbon tax on all countries?



Source: Data from United Carbon Atlas

- The **What's Your Take?** feature found in each chapter asks students to take a stand on a particular issue and develop arguments to support their position, helping students develop and enhance their critical thinking skills.

What's Your Take?

Climate change will increase the incidence of flooding in several ways, rising sea levels will threaten low-lying coastal areas, intense storms will cause coastal storm surges that can affect areas not normally considered to be in a flood plain. Heavy rain storm events will cause streams and rivers to rise and flood areas adjacent to water courses. Most insurance policies do not cover flood damage. The federal government has made flood insurance available for those in areas at risk of floods; however, many people do not

purchase the flood insurance because it is expensive. When flooding occurs victims seek help from government sources and charitable organizations. One way to reduce the cost of flooding is to prevent people from building in areas that are likely to flood. This could be done by federal or state laws or local ordinances. Draw up a law or ordinance that would reduce flood damage to homes and businesses. List at least three criteria that would be used to prevent building in flood-prone areas and justify your selection of each criterion.

We recognize that environmental problems are global in nature.

Three features of the text support this concern:

- Throughout the text, the authors have made a point to use **examples** from around the world as well as those from North America.
- Many of the boxed readings—**Focus On**; **Going Green**; **Science, Politics, & Policy**; and **Issues & Analysis**—are selected to provide a global flavor to the basic discussion in the text.

Focus On

Biomass Fuels and the Developing World

Although most of the world uses fossil fuels as energy sources, much of the developing world relies on biomass as its source of energy. The biomass can be wood, grass, agricultural waste, or dung. According to the United Nations, 2 billion people (30 percent of the world's population) use biomass as fuel for cooking and heating dwellings. In developing countries, nearly 40 percent of energy used comes from biomass. In some regions, however, the percentage is much higher. For example, in sub-Saharan Africa, fuelwood provides about 80 percent of energy consumed. Worldwide, about 60 percent of wood removed from the world's forests is used for fuel.

- This dependence on biomass has several major impacts:
- Often women and children must walk long distances and spend long hours collecting firewood and transporting it to their homes.
 - Because the fuel is burned in open fires or inefficient stoves, smoke contaminates homes and affects the health of the people. The World Health Organization estimates that in the developing world, 40 percent of acute respiratory infections are associated with poor indoor air quality related to burning biomass. A majority of those who become ill are women and children because the children are in homes with their mothers who spend time cooking food for their families.
 - Often the fuel is harvested unsustainably. Thus, the need for an inexpensive source of energy is a cause of deforestation. Furthermore, deforested areas are prone to soil erosion.
 - When dung or agricultural waste is used for fuel, it cannot be used as an additive to improve the fertility or organic content of the soil. Thus, the use of these materials for fuel negatively affects agricultural productivity.



Nepali woman carrying brushwood.

- The presence of easily accessible **Foldout World Maps** at the back of the text allows students to quickly locate a country or region geographically.

We recognize that many environmental issues involve complex social, economic, and cultural aspects.

- The first three chapters focus on the underlying social, economic, health, and ethical aspects involved in understanding how people view environmental issues.
- The **Science, Politics, & Policy** feature shows how the scientific understanding of environmental problems is filtered through the lens of social and political goals to determine policy.

Science, Politics, & Policy

Disposal of Waste from Nuclear Power Plants

The disposal of spent fuel rods from nuclear power plants has been a continuing issue since the first commercial power reactor went on line in 1957. In the more than 50 years since then, it has been clear that there are only two methods of dealing with the nuclear waste from spent nuclear fuel: reprocessing the fuel to reduce the amount of waste or storing the waste at a safe site. U.S. policy has been to store rather than reprocess nuclear waste. Federal law requires the U.S. government to provide a solution to the storage of spent nuclear fuel. All nuclear power plants in the United States have been operating with the assumption that eventually their waste would be stored in a secure federal facility. The National Academy of Sciences recommended underground storage as the best way to deal with waste from nuclear power plants.

- The history of U.S. efforts to establish a repository for high-level radioactive waste is long and complicated. The following provides a brief chronology of major steps in the process:
- 1982—The U.S. Congress passed legislation that gave the responsibility for finding, building, and operating a nuclear waste site to the Department of Energy with completion by 1998.
 - 1987—Initially several sites were considered and Yucca Mountain was selected to receive further study.
 - 1994–1997—A five-mile-long, U-shaped tunnel (the Exploratory Studies Facility) was constructed to study the suitability of the Yucca Mountain site.
 - 2002—President George W. Bush signed a joint resolution of Congress designating Yucca Mountain as the site for the nuclear repository.
 - 2008—The Department of Energy filed a license application with the Nuclear Regulatory Commission to construct a repository for spent nuclear fuel and high-level radioactive waste at Yucca Mountain. The citizens and political leaders of Nevada opposed the designation.

- 2010—President Obama withdrew funding for Yucca Mountain and the Department of Energy withdrew its request to the Nuclear Regulatory Commission to operate the facility. President Obama also established the Blue Ribbon Commission on America's Nuclear Future.
- 2012—The report of the Blue Ribbon Commission on America's Nuclear Future 2012 included the following statement:
Recommendation #1: The United States should undertake an integrated nuclear waste management program that leads to the timely development of one or more permanent deep geological facilities for the safe disposal of spent fuel and high-level nuclear waste.
- 2013—A U.S. Court of Appeals ruling stated that the designation of Yucca Mountain as the nation's nuclear repository is still in effect and the Nuclear Regulatory Commission and the President cannot ignore the law and proceed with plans to close Yucca Mountain.
- The future—the future is uncertain, but it is clear that no permanent solution for storing spent nuclear fuel is likely for decades.



Yucca Mountain

- Critical Thinking questions appear at the end of each chapter and require students to evaluate information, recognize bias, characterize the assumptions behind arguments, and organize information.

We recognize that it is important to focus on the positive.

Environmental science often seems to focus on the negative, since one of the outcomes of any analysis of an environmental situation is to highlight problems and point out where change is needed. We often overlook the many positive actions of individuals and organizations. Therefore, each chapter has two features that call attention to the positive:

- **Going Green** boxes describe actions that are having a positive environmental impact. Some of these actions are taken by governments, some are by corporations, and some are individual efforts.

Going Green

Increasing Populations of Red-Cockaded Woodpeckers

The red-cockaded woodpecker (*Picoides borealis*) is listed as an endangered species. This medium-sized bird (about the size of a cardinal) is a cooperative colony nester—the dominant male and female raise young with the support of nonbreeding members of the colony. They are only found in the southeastern United States—southern Virginia to eastern Texas—where native southern yellow pine forests occur. Several pine species, including slash pine, shortleaf pine, loblolly pine, and longleaf pine, are typical of this region. The original forests were fire-adapted in that mature trees were able to withstand moderate ground fires. This resulted in a rather open forest type. The woodpeckers typically construct their nesting cavities in older, diseased longleaf pine trees.

The trees these birds use for nesting are also commercially important. Thus, the amount of suitable breeding habitat has been severely reduced as older trees are harvested and natural stands of pines have been replaced with plantations, where large tracts are planted to a single species and the trees are harvested before they reach old age. Since much of the suitable habitat is privately owned, protecting populations of red-cockaded woodpeckers requires the cooperation of private landowners, conservation organizations, state and federal governments, and commercial forest products companies.

In 1998, International Paper entered into an agreement with the U.S. Fish and Wildlife Service, which is responsible for monitoring the status of endangered species, to increase the amount of suitable nesting habitat on its lands. International Paper agreed to set aside particular parcels of forest to maintain colonies of red-cockaded woodpeckers. One of these parcels was the Southlands Experimental Forest near Lawrenceville, Georgia. When the agreement was signed in 1998, there were three male red-cockaded woodpeckers at the site. By 2008, there were over 50 individuals. The increase is attributable to protection and improvement of the birds' habitat and transfer of birds to the area from other locations. Today there are about 15,000 red-cockaded woodpeckers throughout its range. In 2006, the company decided to sell nearly all of its land holdings in the United States. Many environmentally sensitive lands were sold to conservation organizations such as The Nature Conservancy and the Conservation Fund, as well as state governments. The Southlands Experimental Forest was sold to the state of Georgia with some funding assistance from the Conservation Fund. This land transfer protects the population gains made by this population of red-cockaded woodpeckers.



Red-cockaded woodpecker habitat



Red-cockaded woodpecker

- **Acting Green** is an end-of-chapter feature that asks students to consider making personal changes that are relatively simple and will have a positive environmental impact.

Acting Green

1. Eat less meat—cows produce methane.
2. Purchase green energy from your electric utility.
3. Use less energy and less carbon dioxide will be released.
4. Walk or ride a bike as often as practical.

New to This Edition

The fourteenth 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.

New Chapter Opening Feature This feature presents an example of a current issue that is germane to the chapter content. The issues involved in the example are easy to visualize and serve as an introduction to the topics covered in the chapter. In many cases, the material in the opening feature is specifically addressed or expanded upon in the chapter.

The Adaptation of Wildlife to Urban Environments

Climate change and habitat loss are driving coyotes, bears and mountain lions out of their habitats, but that is only part of the reason why so many animals are now moving into urban areas. While some animals such as raccoons, squirrels, and rodents may seem as much a part of the urban landscape as cars and streetlights, there are growing populations of non-wild inhabitants that are a bit more unusual.

Coyotes have rapidly adapted to suburban and urban environments. Coyotes have appeared in cities from Los Angeles to New York. They have learned to live in much smaller territories than they do in rural areas and thrive in a city by hunting enough small rodents and sometimes cats to feed themselves and their young. In 2012, biologists in Los Angeles radio-collared the first mountain lion ever found in Griffith Park. Complaints about bears in Hawaii around Lake Tahoe increased between 2002 and 2012. Some of those bears were so well fed on a continuous supply of garbage that they migrated to hibernates in the winter. In 2011, workers found a fox living on the 72nd floor of an unfinished building in London, England. The fox had been living on the construction workers' food scraps.

At South Florida urban sprawl continues, there are increased interactions between people and alligators. While alligators are not as predatory toward humans as popular lore might say, it is nonetheless unsettling to come face to face with one in your backyard. Alligators are invading towns and cities inland from the coast because the decline of the fishing industry means they can no longer feed off the scraps from fishing boats. In addition, changes in how landfills are managed has eliminated a previous source of food for alligators.

Although many animals are moving to the city because they are being displaced by climate change and habitat destruction, there are also other factors involved. One of the biggest factors with regard to the large carnivores is that there are more of them because of successful conservation efforts. In addition, as we make cities greener they become more attractive to humans and animals alike. Another factor is that the relationship between humans and large predators

is changing. There are now generations of certain carnivores that have experienced low amounts of predation by people. These carnivores may view cities differently than their ancestors, who associated human encounters with a good chance of being shot.

While the new wild inhabitants keep their distance from people most of the time, conflict is inevitable when these animals and humans share space. Sometimes the conflict is between the invading predators and domesticated pets. More serious clashes are rare but not unheard of. In 2011, for example, a coyote attacked children in a Denver suburb on three separate occasions. Suburban grade schools in many states have ordered lockdowns in response to black bears prowling near the premises. Bears are growing fat on human hospitality from the outskirts of Los Angeles to the Parkway of Washington D.C.

There is no doubt that many different species of wildlife are adapting to urban life. Perhaps a bigger question is: Will humans be able and willing to adapt to the presence of these new neighbors?



Current Content As with previous editions the authors have incorporated the most recent information available at the time of publication.

Revised Art Program More than 100 new photos have been added or substituted throughout the text to depict real-life situations. Over 60 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 Every chapter has a new chapter opening feature. In addition, many chapters have other significant changes, including:

Chapter 1 Environmental Interrelationships The section on Emerging Global Issues has three new sections: Population Growth, Maintaining Functional Ecosystems, and Food Security. The section on Environment and Health was completely revised. Sections on air pollution, water pollution, malaria, and accidental deaths were added, since they are major environmental health issues in the developing world. The section on Emerging Diseases was rewritten.

Chapter 2 Environmental Ethics The section on Environmental Ethics was substantially rewritten and there were significant additions to the section on Environmental Justice.

Chapter 3 Risk, Economics, and Environmental Concerns The chapter was completely rewritten around the central theme that risk and cost are intimately intertwined. Environmental risk factors and human health are used throughout the chapter to show how risks and costs are related. The sections on Perception of Risk, Ecosystem Services, Environmental Costs, Cost-Benefit Analysis, and Economics and Sustainable Development were substantially revised. The boxed readings Going Green: Green Collar Jobs and Science, Politics, & Policy: The Developing Green Economy were rewritten and the Issues & Analysis: The Economics and Risks of Mercury Contamination was updated to include recent changes in regulations of emissions from power plants.

Chapter 4 Interrelated Scientific Principles: Matter, Energy, and Environment There is a new Science, Politics, & Policy: The Return of Salmon to the Elwha River and a new Issues & Analysis: The End of the Incandescent Light Bulb.

Chapter 5 Interactions: Environments and Organisms There is a new Issues & Analysis on Wildlife and Climate Change. There are updates to the Going Green: Phosphorus-free Lawn Fertilizer and Science, Politics, & Policy: Emotion and Wolf Management.

Chapter 7 Populations: Characteristics and Issues The content was updated with the most recent data from the Population Reference Bureau and there is a new Science, Politics, & Policy: Funding the Unmet Need for Family Planning. The topic of invasive species is also discussed.

Chapters 8, 9, and 10 all deal with aspects of energy. These chapters have been updated with the most current data available. Significant new concepts include the impact of newly industrialized countries on energy demands and evaluating energy alternatives through an accounting of energy return on investment. There are also expanded discussions of hydraulic fracturing, unconventional sources of oil and gas, and the renewable fuel mandate.

Chapter 16 Air Quality Issues Chapter 16 has been significantly changed, since the section on climate change was moved to its own chapter, Chapter 17 Climate Change: A Twenty-first Century Issue. The remaining content was reorganized to create a more logical progression of topics. The section on Control of Air Pollution was moved to follow discussions of Photochemical Smog, Acid Precipitation, and Ozone Depletion. There is a new section, 16.8 Air Pollution in the Developing World, that points out that air pollution is still a major problem in much of the developing world. There is a new Going Green: Going Solvent Free and a new Science, Politics, & Policy: A History of Mercury Regulations. Data on the amounts of air pollutants in the U.S. were updated to best available data.

Chapter 17 Climate Change: A Twenty-first Century Issue

Chapter 17 is a new chapter. Material about climate change was consolidated into a separate chapter as requested by reviewers. In addition, there are several new sections including:

- 17.1 Earth Is a Greenhouse Planet describes the role of atmospheric gases in making the Earth habitable.
- 17.2 Geologic Evidence for Global Warming and Climate Change discusses evidence for past climate changes and their relevance to understanding current changes.
- 17.3 Growth in Knowledge of Climate Change lists the many kinds of research that contributed to our understanding of climate change.
- 17.5 The Current State of Knowledge about Climate Change incorporates information from the most recent report of IPCC Working Group I—*Climate Change 2013: The Physical Science Basis*.
- 17.6 Consequences of Climate Change describes the many disruptions to the hydrologic cycle that occur with climate change.

The section on International Agreements has an updated section on the meeting in Doha, Qatar in 2012 in which participating countries were unable to come to agreement on how to limit greenhouse gas emissions.

There is a new Focus On: Doubters, Deniers, Skeptics, and Ignorers that describes reasons why people question the science related to climate change and the techniques people use to refute climate change science.

Other new or significantly updated content occurs throughout the text and includes: information on wolf hunting, conflicting regulations concerning sea lions and salmon, the role of sanitation and safe drinking water to world health, the adaptation of wildlife species to urban environments, the impact of invasive species, concerns about overfishing of marine fisheries, water ownership rights, the growth of megacities, the use of plants to remediate polluted sites, and the economic and political value of biodiversity.

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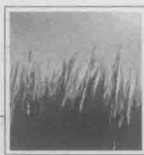
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