CHAPTER 1
ENVIRONMENTAL INTERRELATIONSHIPS

CHAPTER OVERVIEW

Environmental science is an interdisciplinary field which includes traditional science, societal values, and political awareness. The author gives a brief history of the field from ancient cultures to current college course offerings. Mexico-Texas air pollution and the many international environmental summits are provided as examples of the field's interrelated nature. An ecosystem is defined as the region in which organisms interact with their environment. The ecosystem approach is illustrated by examining six resource-based regions of North America: the wilderness North, industrial Northeast, agricultural Middle, diverse South, dry West, and forested West.

Environmental Case Studies include management of Keoladeo National Park and the impact of reintroduced wolves on Yellowstone's ecosystem.

THE CONCEPTS

Environmental issues are interrelated because the natural world is organized into non-political relational units between organisms and their environment called ecosystems.

Managing environmental issues requires a regional, rather than political, approach because each region of the world has a unique combination of culture, resources, and economy.

Solving environmental problems involves compromise between groups who have different views on how a resource should be managed.

Solutions often incorporate economic decisions because most resources provide an income to one of the groups in the debate.

KEY TERMS

ecosystem	environmental science	
environment	science	wilderness

ANSWERS TO REVIEW QUESTIONS

1. Finding solutions is difficult because different groups have different political and economic views on what constitutes an environmental problem. Finding solutions has not always been complicated because in the past the economy was less complicated and few people understood the long-term environmental consequences of their actions.

2. The natural world is organized into relational units between organisms and their environment called ecosystems. An ecosystem approach requires consideration of these relational units. It is the right approach because it looks at the natural world in its natural state—without cultural or political bias.

3. The wilderness North: the protection of rights and beliefs of native peoples and the role of government in managing wilderness. The agricultural Middle: erosion of exposed soil and the threat of pesticides and fertilizers entering the groundwater. The dry West: salt build-up in soil from dry-land irrigation and increased conflict between management of land for livestock and the desire to preserve what remains of the "wilderness." The forested West: land-use debate over government-owned land and destruction of the old-growth forest ecosystem. The Great Lakes and industrial Northeast: solid waste disposal issues and contamination of waterways. The diverse South: development of housing on fragile coastal sites and pollution of the Mississippi River.

4. The environment is the surrounding conditions that affect people and organisms. More broadly, it means everything that affects an organism during its lifetime. For example, the environment of the grizzly bear includes the physical conditions, such as climate and habitat, as well as political and social decisions that affect its life. An ecosystem is a region in which organisms and their physical environment form an interacting unit. An example is the old-growth forest of the forested West.

5. Environmental conflicts arise when groups disagree on what constitutes an environmental problem. Some people may feel justified in their use of a natural resource while others may feel there is a diminished environment. Compromise between the groups is necessary. Government should assist in assuring that all points of view are recognized and that a fair decision is made. Economic and regional issues and long-term impact should be taken into consideration when reaching the final compromise.

6. Answers will vary.

SUGGESTED ACTIVITIES AND RESOURCES

Students often do not bring their textbook to class, so an oversized map of North America would be helpful to discuss the six major regions discussed in the chapter. A climate or biome map might also be helpful to illustrate the relationship between environmental issues and the ecosystems and climate of each region.

In order to help students relate directly to the concept of regional environmental issues, obtain newspaper articles covering local environmental issues for class discussion. This is an activity which could be assigned to the students and continued throughout the semester in the form of an environmental notebook. It will assist students in becoming more aware of the issues in their local community.

Have student's visit Environmental Radio at http://www.enn.com/ and write a report on a news story they heard.

FURTHER READING AND VIEWING

"Exploring Antarctic Ice." Jane Ellen Stevens. *National Geographic*. May, 1996.

Visit *The Green Guide* for more information on sustainable living and products (http://www.thegreenguide.com/).

CHAPTER 2
ENVIRONMENTAL ETHICS

CHAPTER OVERVIEW

This chapter focuses on the various views and attitudes toward nature and how these views are transformed into individual, corporate, and global ethics. Issues such as international transportation of radioactive materials and the greenhouse effect illustrate the need for global management of the planet's resources.

Environmental ethics are divided into three theories: anthropocentric, which is derived from human interests; biocentric, which assumes the rights of every organism; and ecocentric, which considers the environment as a whole. In addition, three ethical views are presented: the development ethic, which is based on the human benefit derived from natural resources; the preservation ethic, which is based on the inherent worth and aesthetic value of nature; and the conservation ethic, which works toward a balance between resource use and preservation.

Corporate and industrial ethics and actions are reviewed with emphasis on their desire for economic growth and resource exploitation, and the pollution which results from industrial energy use and production of waste. As a result of public pressure, many corporations have adopted the CERES principles to guide them in making decisions regarding proper waste disposal and ethical profitability.

THE CONCEPTS

Some people believe that undeveloped resources should be used for the welfare of mankind and to not exploit the resource is wasteful; others believe that natural resources have an inherent value which should not be destroyed.

There are three basic views of environmental ethics: development, preservation, and conservation.

There are three philosophical theories of applied ethics: anthropocentrism, biocentrism, and ecocentrism.

The prevailing societal attitude of developed nations has been one of economic growth and resource exploitation.

Industry is responsible for pollution because it consumes energy and resources, and produces waste.

Environmental justice refers to the impartiality that should guide human health and environmental decisions.

National Capitalism refers to the idea that businesses can sustain a profit while still protecting the environment.

The U.S. consumes large amounts of the world's resources. Each person can change their consumer behavior to reduce their ecological footprint.

KEY TERMS

anthropocentric	ecocentrism	natural capitalism
biocentrism	ecological footprint	preservationist
conservationist	environmental justice	profitability
corporation	ethics	resource exploitation
cultural relativism	externalize the costs	sustainable development
development	industrial ecology	water ethics

ANSWERS TO REVIEW QUESTIONS

1. Ethical approaches to the environment have historically been anthropocentric. Ethics that consider only human interests do not have a good track record for protecting the environment. A new environmental ethic can help create a deeper appreciation of the need to care for the natural environment.

2. The laws of a democratic country should map the ethical commitments of its citizenry. An alternative way to look at the relationship is to think of the laws coinciding with a vision of what makes for a good society. Not every action that is ethically correct can have a law supporting it. Some actions will inevitably have to rely upon the ethics of individuals.

3. Anthropocentric ethics view all moral value in the world as derived from humans and their interests. Biocentric ethics recognize the presence of moral value in all living creatures. Ecocentric ethics find moral value in systemic wholes made up of both biotic and non-biotic parts.

4. A pro-development attitude tends to adopt an anthropocentric approach to nature. It sanctions any manipulation of nature that furthers human goals and interests. Preservationism seeks to keep natural areas ecologically intact and as free from human interference as possible. A conservationist approach seeks a balance between preservation and development. This third approach looks for arrangements in which a broad range of long-term human interests can be sustainability met.

5. The environmental justice movement recognizes that civil rights issues can connect directly to environmental issues. Environmental destruction affects people. Environmental justice has been a valuable corrective to the idea that environmentalism is about saving wilderness areas for the recreational benefit of elite groups.

6. Manufacturing goods for use and consumption by humans is often likely to incur some environmental cost. Corporations are set up with an obligation to manufacture goods as

profitably as possible. These profit margins can sometimes be directly impacted by the expense of pollution controls.

7. Since corporations do not themselves have obligations to the environment, it must be their executives, their shareholders, or their workers who move corporate behavior in a more environmentally sustainable direction. On many occasions, corporations can also be persuaded that it is in their economic interest to treat the environment kindly. Individual consumers can also influence corporate behavior with their purchasing power.

8. Informed individuals can educate themselves about the environmental cost of their consumer choices. Individuals can often make a big difference in their environmental footprint by making a few responsible choices about how and how much they consume. Environmentalists argue that better consumer choices also increase one's quality of life, bringing a payoff both for the environment and for the individual. Citizens living in democracies can also implement their environmental ethics with their voting power.

9. Since we all live on one planet, the choices of people in one part of the world can end up affecting the lives of those who live on the other side of the world. Since it is hard to directly feel a moral obligation to those you will never know or see, global environmental ethics requires international cooperation on a number of environmental issues. National self interest might sometime have to give way to global environmental interest. In the long run, what is good for the global environment will also be good for every nation that calls this planet home.

SUGGESTED ACTIVITIES AND RESOURCES

Assign further writings of the naturalist-authors (or even their biography) to give students a more comprehensive view of the philosopher's background and beliefs. *Sand County Almanac*, by Aldo Leopold, and *Silent Spring*, by Rachel Carson, are both easy to read, inexpensive in paperback form, and available in bookstores.

Another suggestion is to compare the views of these earlier authors with those of modern writers. Assign excerpts from modern works and discuss with students the current naturalist philosophy.

The authors provide a thorough review of GM's environmental principles. Have students contact local companies to obtain annual reports on their environmental policies. Find out if these companies participate in any local stewardship programs or if they have their own local environmental programs.

Have students visit www.myfootprint.org and take the ecological footprint quiz. The quiz calculates how many Earths it would take if everyone lived like YOU. Ask for reactions. In what areas can they really improve their footprint?

FURTHER READING AND VIEWING

"A Typology of Corporate Environmental Policies," by Michel Dion. *Environmental Ethics*. Summer, 1998.

"Indigenous Rights and Environmental Justice," by Ray Perrett. *Environmental Ethics*. Winter, 1998.

"Environmental Ethics in an Urbanized World," by Alastair Gunn. *Environmental Ethics*. Winter, 1998.

Got to Zero Emissions Research & Initiatives (ZERI) at http://www.zeri.org/index.htm or Conservation Economy at http://www.conservationeconomy.net/ to read about cutting edge sustainability projects and sustainable land use plans.

Video – "Strange Days on Planet Earth" by National Geographic (2008)

Video – "The Human Footprint" by National Geographic (2008)

Video – "Bill Moyers' Journal: 9/21/2007: Rachel Carson's Legacy" (2007)

Seventh Annual Message to Congress Dec. 3, 1907 by Theodore Roosevelt – access conservation statement at http://www.pbs.org/weta/thewest/resources/archives/eight/trconserv.htm.

CHAPTER 3
ENVIRONMENTAL RISK: ECONOMICS, ASSESSMENT, AND MANAGEMENT

CHAPTER OVERVIEW

Chapter Three begins with a discussion of how we calculate risks in relation to the environment and how individuals and corporations incorporate environmental impacts into their economic decisions. In addition to supply and demand economics, pollution, health risks, and environmental costs must be considered during decision making processes. This is difficult because of the differences in the economic and ecological points of views. Globally, however, there is a trend toward a new green economy where sustainable development is a priority and "green" collar jobs are becoming the norm.

Chapter Three continues by introducing governmental tools that can encourage environmental stewardship. Examples include subsidies and governmental funds to revitalize "brownfields." Market based policies include information programs, tradable emissions permits, emission fees and taxes, deposit-refund programs, and performance bonds. Requiring an understanding an entire product's life cycle, including disposal, adds an additional layer of corporate responsibility.

Chapter Three concludes on issues and examples of global sustainable development. There are five characteristics of sustainability: renewability, substitution, interdependence, adaptability, and institutional commitment.

THE CONCEPTS

A risk assessment or calculation of probable harm to human health or the environment is used in the decision making process in addition to social, economic, and political concerns.

Cost-benefit analysis can be used to help assign economic value to natural resources or calculate environmental costs; however, it reduces all aspects of the issue into economic terms and there is often inconsistencies when translating ecology into economics.

The tragedy of commons theory argues that when there is shared ownership of a resource individuals have a tendency to overharvest because they feel others will use all the resource. However, the idea of green economics is gaining in global popularity leading to a new economic transformation.

There are many market based approaches to encourage companies to address environmental issues. These include subsidies, grants and liability protection, information programs, tradable emission permits, emission fees and taxes, deposit programs, performance bonds, and life cycle analysis.

Sustainable development policies are increasing in importance worldwide and programs like debt-for-nature are helping developing nations to conserve valuable natural resources.

KEY TERMS

biodegradable
brownfields
cost-benefit analysis
debt for nature exchanges
deferred cost
demand
environmental costs
extended product responsibility
external costs
life cycle analysis
natural resources
negligible risk
nonrenewable resources
pollution
pollution costs
pollution prevention costs
price
probability
renewable resources
resources
risk
risk assessment
risk management
subsidy
supply
supply/demand curve
sustainable development

ANSWERS TO REVIEW QUESTIONS

1. Risk assessment provides an orderly, clearly stated, and consistent way to deal with scientific issues when evaluating whether a hazard exists and what the magnitude of the hazard may be. It includes the probability of risk, the consequences of risk, and the economics of risk.

2. A cost-benefit analysis includes identification of the project to be evaluated, determination of favorable and unfavorable impacts, determination of the values of those impacts, and calculation of the net benefit.

3. Criticism of the cost-benefit analysis is based on the question of whether everything has an economic value. If economic thinking dominates society, then even noneconomic values, like beauty, can survive only if a monetary value is assigned to them.

4. Sustainable development is criticized as being ambiguous and open to a wide range of interpretations. There is confusion between the terms sustainable growth, sustainable use, and sustainable development. In addition, since it requires a balance between economic requirements and ecological concerns worldwide, some believe that the world should not impose environmental protection standards upon poorer nations without also helping them move into the economic mainstream.

5. External costs are costs not borne by the entity the causes the problem. Pollution of air and water are often external costs since the people who cause the problem do not pay to clean it up. Erosion damage by improper logging and abandoned waste sites are other examples.

6. Pollution-prevention costs are those incurred either in the private sector or by government to prevent the pollution that would otherwise result from some production or consumption activity.

7. Common-property resource development generally leads to overexploitation and misuse because effectively no one owns the resource. Common ownership of air makes it virtually

costless for any industry or individual to dispose of wastes by burning them. There is also a lack of enforceable property rights to commonly owned resources.

8. In 1987, Conservation International bought $650,000 of Bolivia's foreign debt in exchange for Bolivia's promise to establish a national park.

9. Subsidies may include consumer rebates for purchases of environmentally friendly goods, loans for businesses planning to implement environmental products, and other monetary incentives designed to reduce the costs of improving environmental performance. The cost of government management of federal forests is a subsidy to the forest products industry. Market-based instruments include: Information programs provide consumers with information about the environmental consequences of purchasing decisions; Tradable emissions permits; Emission fees and taxes; Deposit-refund programs; and Performance bonds. Life cycle analysis is the process of assessing the environmental effects associated with the production, use, re-use, and disposal of a product over its entire useful life. It includes assigning dollar costs to such items as: pollution, disposal, energy costs, and useful length of life.

10. People generally willingly accept risks with which they are familiar and which they encounter daily, such as: the risks associated with automobile travel and the risk associated with alcohol use.

11. Renewable: wildlife, soil, forests, freshwater, etc. Nonrenewable: iron ore, oil, coal, land, mountains, etc.

12. The economic cost of environmental degradation is often not included as a factor in economic analysis used to justify a project or action. However, the costs become obvious with the passage of time. For example, cutting the trees on a hillside often leads to increased erosion, which affects down-slope environments.

13. Manufactured products are required to be "taken back" from the consumer to the manufacturer for recycling/reclaiming.

14. It might be able to gain environmental liability relief and/or grant funding and tax incentives.

15. A variety of reasons: differences in liability tolerance; money; experience with environmental issues; and/or perception differences.

16. It utilizes ecological risk factors to assess "true" vs. perceived risk, thus "risk based corrective action (RBCA)."

17. Perception is reality when dealing with economic and environmental issues, as well as health and safety.

18. Design for Environment (DfE) is preventative in that it allows for environmental protection to be built into the design of a product (pre-production), thus potentially avoiding environmental problems.

19. Governments enact and/or enforce regulations that can help promote development of sustainable products… as well as through tax incentives, grants, and other programs.

SUGGESTED ACTIVITIES AND RESOURCES

A good way to get students to comprehend the complexity of management decisions is to have them choose a local environmental issue (building of a new factory, power plant, shopping center, etc., or the passing of new environmental laws) and cast students as the stakeholders. Have them research their assigned stakeholder's viewpoint and voice it in class stakeholder meeting.

Have students research an example of sustainable development (preferable local) and present their information to the class. Questions for them to ponder: How is the project sustainable? Is it economically feasible? Why or why not? Did any government policy help propel the project?

Plan a field trip to local environmental hearing. Or plan a trip to your county's or city's commissioner meeting when they are discussing an issue related to environmental science.

FURTHER READING AND VIEWING

Visit Science Daily for articles, videos, and books on issues related to environmental science http://www.sciencedaily.com/news/earth_climate/.

Talk of the Nation's Science Friday regularly has environmental science programs. Students can download audio and video podcasts from the website at http://www.sciencefriday.com/. Examples: How Subaru is Going Green http://www.sciencefriday.com/newsbriefs/read/169 and Green Packaging http://www.sciencefriday.com/newsbriefs/read/170.

"Carbon Capture and Sequestration" by David Hawkins Testimony before the Committee on House Energy and Commerce, Subcommittee on Energy and Air Quality (March 6, 2007) – access article online at http://www.nrdc.org/globalWarming/glo_07030601.asp.

"Carbon Capture & Storage: Blue-Sky Technology or Just Blowing Smoke" by Charles Schmidt in *Environmental Health Perspectives* (November 2007) – access article online at http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2072827.

CHAPTER 4
INTERRELATED SCIENTIFIC PRINCIPLES: MATTER, ENERGY AND ENVIRONMENT

CHAPTER OVERVIEW

Chapter Four begins with the definition of science which is the gathering and evaluation of information. The scientific method includes observation, hypothesis formation, testing, evaluation, and sharing of information.

Matter is defined as anything that takes up space, has mass, and is made of moving particles called atoms. Chemical solutions of particular interest are acids which release hydrogen ions, and bases which release hydroxyl ions.

Two important chemical reactions are photosynthesis in which plants convert sunlight, water, and carbon dioxide into sugars, and respiration in which organisms break down large organic molecules thereby releasing energy. The laws of thermodynamics state that energy can neither be created nor destroyed, but can be converted into different forms. Energy conversion can change the quality of the energy and during conversion some energy is lost, usually in the form of heat.

THE CONCEPTS

Science is an exact body of knowledge in which observations are tested, evaluated, and reviewed.

Environmental science is a discipline that includes both applied and theoretical aspects of traditional science, and includes economic, social, and political considerations.

Matter is composed of small particles called atoms which have a specific subatomic structure of protons, neutrons, and electrons. Atoms may be combined and held together by chemical bonds to produce molecules.

The formation of chemical bonds between different molecules occurs during chemical reactions which are associated with energy change. Two important biological reactions are photosynthesis which forms large organic molecules from inorganic substances, and respiration in which large molecules are broken down.

Energy can be neither created nor destroyed but can be converted from one form to another and can be of a different quality than its original form.

KEY TERMS

acid	hydroxide ion	respiration
activation energy	hypothesis	scientific method

atom
base
catalyst
cause and effect relationship
chemical bond
compound
controlled experiment
electron
element
endothermic reactions
entrophy
enzyme
exothermic reactions
experiment
first law of thermodynamics
ion
isotope
kinetic molecular theory
law of conservation of mass
matter
mixture
molecule
neutron
nucleus
observation
pH
photosynthesis
proton
reproducibility combustion
science
scientific law
second law of thermodynamics
theory
variables

ANSWERS TO REVIEW QUESTIONS

1. Scientific disciplines use a process whereby information is gathered through repeated experiments, evaluation, and review by professional scientists. This information, in the form of laws and theories, is shared with the scientific community through publications. Non-scientific disciplines generally do not use regimented experimentation; instead, they use observation, facts already in existence, and supposition.

2. A hypothesis is a logical statement that explains an event or answers a question. It is important to scientific thinking because it must be testable—the scientist must be able to support it or disprove it.

3. Sometimes the results from a one-time experiment are inconclusive—they neither support nor disprove the hypothesis. A new experiment must be conducted or more information collected. Repeatability is the process whereby scientists eliminate bias and test their results by having independent investigators repeat their experiment. If a hypothesis is supported by many experiments and different investigators, it is considered reliable.

4. The scientific method is the process of gathering information, and generally involves observation, hypothesis formation, hypothesis testing, critical evaluation of results, and the publishing of findings.

5. When energy is converted from one form to another, there is a loss of useful energy. This loss is a form of pollution. An example would be the emissions from power plants.

6. See figure 4.2.

7. The atoms in a molecule are held together by chemical bonds which result from the interaction of the electrons. During a reaction, electronic attractions are rearranged and bonds between them are either broken or new ones formed.

8. The first law of thermodynamics states that energy can be neither created nor destroyed. The second law states that when energy is transformed from one form to another there is a loss of useful energy.

9. In solids, molecules have a low amount of energy and vibrate close to one another. In liquids, higher-energy molecules are farther apart and flow over each other. In gases, the molecules move rapidly and are far apart.

10. Five kinds of energy are heat, light, electricity, chemical energy, potential, and kinetic energy.

11. Different energy forms are of different quality. Electrical energy is of high quality and can be easily transformed to perform a variety of useful actions. Heat in ocean water is of low quality because of the small temperature difference between the ocean and its surroundings. It can do little work for us.

SUGGESTED ACTIVITIES AND RESOURCES

Students often have difficulty understanding the abstract three-dimensional structure of atoms, molecules and chemical bonds. There are several molecular model kits available from the biological supply houses such as Carolina Biological which can help illustrate their structure.

The process of photosynthesis is a prerequisite for life on Earth and its importance can not be overstated. There are several aspects that can be easily demonstrated. First of all, the general equation for photosynthesis is:

$$CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6H_2O + 6O_2.$$

It should be noted that although this is the equation for green plants, some primitive bacteria use H_2S instead of water as the hydrogen acceptor. This adaptation is related to the presence of sulfur in the oceans and atmosphere of early Earth.

The role of light and the liberation of oxygen in photosynthesis can be demonstrated by tying a healthy sprig of the common aquarium plant, elodea (*Anacharis*), to a glass rod (for support) and placing it in a test tube filled with water and 1/8 teaspoon of sodium bicarbonate (baking soda). The baking soda will provide a source of carbon dioxide. When the apparatus is placed under a gooseneck lamp, it should release bubbles of oxygen from photosynthesis which can be counted over a period of time. For comparison, a second tube can be set up in the dark.

To illustrate energy efficiency, obtain the bright yellow and black energy use/cost stickers which come on new appliances. Compare different brands and various types of appliances.

Plan a field trip to a nuclear power plant, hydro-electric dam, gas company, electric company, or other utility to discuss energy sources, energy quality, and energy transformation.

FURTHER READING AND VIEWING

Video – "Concepts in Science: Energy Flow," by Carolina Biological. (Six 10-minute programs on topics such as Photosynthesis and Energy Flow in the Biosphere.)

CHAPTER 5
INTERACTIONS: ENVIRONMENT AND ORGANISMS

CHAPTER OVERVIEW

Chapter Five introduces basic ecological principles and terminology describing the interactions between organisms and their environment. Ecology is defined as the scientific study of the interactions between different organisms and the interactions between organisms and their environment. Successful interaction with the environment depends on biotic (living) and abiotic (non-living) limiting factors specific to an organism's needs.

Discussed are the concepts of habitat, or the space in which an organism lives and which contains the particular requirements for success, and niche which is the functional role of an organism in its habitat. Several niches and organismal relationships are discussed including predation, inter- and intraspecific competition, symbiosis, parasitism, commensalism, and mutualism.

In the process known as natural selection, individuals possessing a close fit with their environment are usually successful at survival, reproduce in large numbers, and pass on to the next generation the characteristics that made them successful.

Each group of organisms has a specific role in an ecosystem which is related to the way they produce or consume energy. The three broad categories are producers, consumers, and decomposers. Producers are plants, that make organic compounds from inorganic ones. Consumers are animals, that consume the organic molecules produced by plants as a source of energy. Decomposers, such as bacteria, return the organic molecules to the inorganic form.

Energy passes from one group of organisms, or trophic level, to the next by way of a food chain. When several food chains overlap they form a food web. As energy is transferred from one group to another, so are nutrients. Carbon, nitrogen, and phosphorus are discussed as examples of cycled nutrients.

THE CONCEPTS

Ecology is the study of the way organisms interact with the biotic and abiotic factors in their surroundings or environment.

The success of an organism depends on its range of tolerance and the amount of limited resources available.

Habitat, or the space in which an organism lives, and the niche which is an organism's role in its environment, help us to understand an organism as part of its environment.

Successful individuals produce large numbers of offspring and pass on the characteristics that made them successful in the process known as natural selection.

Organisms interact in a variety of ways: predation, competition, symbiosis, parasitism, commensalism, and mutualism.

In an ecosystem, energy flows from producers, or plants, through various trophic levels of consumers, such as herbivores, carnivores, omnivores, and decomposers.

The sequence of organisms through which energy flows is known as a food chain. Interconnecting food chains constitute a food web.

KEY TERMS

abiotic factors
biogeochemical cycles
biomass
biotic factors
carbon cycle
carnivore
coevolution
commensalism
community
competition
competitive exclusion principle
consumer
decomposer
denitrifying bacteria
detritus
ecology
ecosystem
ectoparasite
endoparasite
environment
evolution
extinction
food chain
food web
free-living nitrogen-fixing bacteria
genes
habitat
herbivore
host
interspecific competition
intraspecific competition
keystone species
limiting factor
mutualism
mycorrhizae
natural selection
niche
nitrogen cycle
nitrogen-fixing bacteria
omnivore
parasite
parasitism
polyploidy
population
predator
prey
primary consumer
producer
range of tolerance
secondary consumer
speciation
species
symbiosis
symbiotic nitrogen-fixing bacteria
trophic level

ANSWERS TO REVIEW QUESTIONS

1. An organism's environment is everything affecting it during its lifetime. It includes both biotic (living) and abiotic (non-living) elements.

2. A niche is the functional role of an organism in its environment. The role of humans is one of consumer, specifically omnivore. Humans modify their surroundings, harness energy, produce waste, and control their population.

3. Natural selection is the process whereby successful organisms pass on the characteristics which made them successful to their offspring. In this way, each organism is finely tuned to a particular habitat and niche, and unfit organisms are removed from the population.

4. Predator/prey relationships include lion and zebras, eagles and mice, osprey and fish, robins and worms, frogs and insects, baleen whales, and zooplankton.

5. A community is composed of interacting populations of organisms in a given area, and an ecosystem is composed of interacting groups of organisms and their physical environment.

6. Humans raising cattle for food is technically a form of predation. Humans are secondary consumers feeding on the cattle which are primary consumers feeding on the plants which are primary producers. It could be argued however, that it is a type of mutualistic relationship in which both populations benefit, because the cattle has been so changed that it cannot survive without human interaction.

7. Examples of herbivores include seed-eating birds, deer, rabbits, and zooplankton.
   Examples of carnivores include wolves, falcons, and sharks.
   Examples of omnivores include humans, bears, and raccoon.

8. Trophic levels in an ecosystem include producers, herbivores, carnivores, and decomposers.

9. In the carbon cycle, plants incorporate carbon into organic molecules through the process of photosynthesis. The organic molecules in plants are consumed by herbivores and the molecules are further passed on to carnivores. Decay organisms convert organic carbon waste and dead organisms into inorganic carbon during respiration.

   In the nitrogen cycle, atmospheric nitrogen is converted by nitrogen-fixing bacteria into a form that plants use to make proteins and other compounds. These compounds are passed to consumers. Decomposers convert dead organisms and waste into ammonia which is reused by plants.

   In the phosphorous cycle, phosphate found in rocks dissolves and becomes available to plants which are then eaten by consumers. The phosphate is recycled by decomposers and through leaching from waste into the soil.

10. The major biotic factors in an aquarium are light, temperature, salinity, dissolved oxygen, and nutrients. The biotic factors include all of the living organisms in the aquarium. Producers include aquatic plants, algae, and possibly photosynthetic bacteria. Primary consumers include snails, protozoans, small crustaceans, and plant-eating fish. Secondary consumers include larger fish. Decomposers include bacteria and fungi.

SUGGESTED ACTIVITIES AND RESOURCES

To illustrate the various nutrient cycles and the use of nutrients by plants, obtain and share with the class labels from various types of fertilizers (rose, strawberry, corn, etc.). Discuss the meaning of the initials "N-P-K" and why different plants require different amounts (5-10-5, for example). Also, discuss the use of compost and nitrogen-fixing green manures in agriculture. How are these practices part of the various nutrient cycles?

The text does a great job of illustrating terrestrial food chains and webs. Discuss with students the various marine food chains, such as those involving baleen whales and sharks.

To illustrate mutualism, find a patch of clover (common in fields and back yards) and dig up a large, mature specimen, making sure to get the whole root system. Gently rinse the soil from the roots and observe the nodules which contain beneficial nitrogen-fixing bacteria. Share this with the class. You can also use bean or pea plants from a garden or farm.

To illustrate the relationship of plants and soil, decomposition on the forest floor, nutrient cycling, and soil food webs, collect a sample from the forest floor of a deciduous woodland. Include in your sample the leaf layer, humus layer, top layer of soil, and materials at various stages of decomposition. From this sample, decomposers, herbivorous and carnivorous consumers (insects, spiders, millipedes), and some plants can be observed and discussed.

FURTHER READING AND VIEWING

"Typecasting," by Kenn Kaufman. *Audubon*. January, 1999.

Video – "Yellowstone: Realm of the Coyote." (Young coyote learns to survive in wilderness). *National Geographic*. 1995.

Video – "Adaptation: Survival in a Changing World." Carolina Biological. (An illustration of natural selection.)

Video – "Planet Earth" by Discovery Channel (2007)

Video – "Wolves: A Legend Returns to Yellowstone" by National Geographic (2007)

CHAPTER 6
KINDS OF ECOSYSTEMS AND COMMUNITIES

CHAPTER OVERVIEW

Chapter Six discusses community change and the various types of communities and ecosystems. Over time, terrestrial communities progress through a series of predictable changes in a process known as succession. Succession which begins on bare rock or standing water is primary succession, and that which occurs after a fire or flood is secondary succession.

The relatively stable, long-lasting climax community that extends over large regions is called a biome and is determined by yearly rainfall distribution and temperature. Climatograms and descriptions of seven biomes are presented: desert, grassland, savanna, tropical rainforest, temperate deciduous forest, temperate rainforest, taiga, and tundra.

The major aquatic ecosystems fall into two categories: marine and freshwater. Marine systems are classified according to the amount of light they receive and their association with the ocean floor or coast. They include pelagic or open ocean, benthic or ocean floor, and estuarine or the area where freshwater meets the ocean. Freshwater ecosystems are divided into two categories: those with stationary water, such as lakes and ponds, and those with running water such as streams and rivers.

THE CONCEPTS

The series of regular changes that take place in a community as one kind of organism replaces another is called succession, and is considered primary when it occurs on bare mineral surfaces or secondary when it occurs after a disturbance.

Each step in succession is called a seral stage, and the entire sequence of stages from pioneer to climax is called a sere.

Terrestrial climax communities called biomes extend over wide geographic areas as a result of yearly precipitation and temperature. There are seven major biomes each having a specific set of organisms that is adapted to the area climate.

The pelagic ecosystem is composed of free-swimming crustaceans, fish, and mammals that swim actively as they pursue food.

The benthic ecosystem consists of organisms that live on the ocean floor, such as clams, sponges, sea anemones, and some fish. The composition of the ocean floor determines the ecosystem and can include mud, sand, and rocks.

Lakes and ponds are examples of freshwater ecosystems with stationary water. The productivity of these systems is determined by light, temperature, and oxygen.

Streams and rivers are examples of freshwater ecosystems with running water. These systems are generally high in oxygen and the source of nutrients is terrestrial.

KEY TERMS

abyssal ecosystem
alpine tundra
benthic
benthic ecosystem
biochemical oxygen demand (BOD)
biome
boreal forest
climax community
coral reef ecosystem
desert
emergent plants
estuary
eutrophic
euphotic zone
freshwater ecosystem
grassland
lake
limnetic zone
littoral zone
mangrove swamp ecosystem
marine ecosystem
marsh
Mediterranean shrublands
oligotrophic lake
pelagic
pelagic ecosystem
periphyton
permafrost
phytoplankton
pioneer community
plankton
prairie
primary succession
savanna
secondary succession
seral stage
sere
steppe
submerged plants
succession
successional stage
swamp
taiga
temperate deciduous
temperate rainforest
tropical dry forest
tropical rain forest
tundra
zooplankton

ANSWERS TO REVIEW QUESTIONS

1. Succession is a series of regular, predictable changes in the structure of a community over time. Primary succession takes place with bare mineral surfaces or water, whereas secondary succession begins with the destruction or disturbance of an existing ecosystem.

2. A climax community is a relatively stable, long-lasting, complex and interrelated group of many different organisms. A successional community is a stage in the successional process.

3. Tropical rainforest: high diversity, high rainfall, no frost.
   Desert: low rainfall, sparse vegetation, high evaporation.
   Tundra: permafrost, low rainfall, short growing season.
   Taiga: coniferous trees, soil freezes in winter, bogs.
   Savanna: occasional or patches of trees, seasonally structured ecosystem, mound-building termites.
   Mediterranean shrublands: dry summer, wet winter, drought resistant plants.
   Tropical dry forest: monsoon climate, extensive dry periods, drought resistant plants.
   Temperate grassland: low rainfall, few trees, grazing animals.
   Temperate rainforest: high rainfall, large evergreen trees, slow evaporation.
   Temperate deciduous forest: deciduous trees, evenly distributed rainfall, migrating birds.

4. The two primary factors in determining biomes are temperature and precipitation.

5. As altitude increases, the average temperature decreases. The change in biomes from sea-level to mountain top is similar to the change from equator to the North Pole.

6. The areas that are most productive are those where light and nutrients are most abundant. These would include areas where currents bring nutrients up from the bottom of the ocean or where currents or rivers deposit sediment.

7. Sand tends to shift making it difficult for plants and algae to become attached, although burrowing worms and clams and crustaceans find it suitable. Mud is more suitable for some plants and algae and many burrowing organisms. Rocks are a good substrate for plants and large algae which in turn make a good habitat for a wide variety of motile and attached animals.

8. Phytoplankton: free-floating photosynthetic primary producers in the euphotic zone.
   Zooplankton: free-floating primary consumers found deeper than phytoplankton.
   Algae: attached primary producers in shallow, coastal water.
   Coral organisms: mutualistic relationship between coral and algae; form calcareous substrate for other organisms.
   Fish: nektonic higher order consumers.

9. Freshwater ecosystems differ from marine by having much less salt, greater temperature variability, and different organisms.

10. An estuary consists of a shallow partially enclosed area where freshwater enters the ocean. Estuaries are high in transported sediment from up-river and their salinity varies with the change in tides.

SUGGESTED ACTIVITIES AND RESOURCES

To illustrate the specific adaptations that organisms have for living in their particular climate or biome, obtain plants from different ecosystems and have students compare the anatomical differences. Freshwater aquatic plants include elodea and water lily; desert plants include cactus and aloe; grassland plants include corn, rye, rice, and various other grasses; and marine plants include seaweeds and eel grass.

Many students have never experienced biomes other than the one in which they live. Biome slide sets are available from the biological supply houses.

Annual precipitation and temperature data are available from NOAA or from the Internet. Obtain data from a variety of cities and have students determine the biome of each city by using the graph in Figure 5.8.

FURTHER READING AND VIEWING

"In the Line of Fire: Our National Forests," by John G. Mitchell. *National Geographic*. March, 1997.

"Treasure Islands," by Stephen Gorman. *Audubon*. January, 1999.

Video – "Okavango: Africa's Savage Oasis." (Kalahari's seasonal cycle of fire, rain, and flood.) *National Geographic*. 1996.

Video – "Jewels of the Caribbean Sea." Howard and Michele Hall. (Marine life in reefs, sandbanks, and prairies). *National Geographic*. 1995.

Carolina Biological has a wide array of videos on biomes, succession, ecology, and nutrient cycling. Some of the titles include: "The Ecology of a Stream," "Energy and Nutrients in Ecology," and "The Environment Shapes the Forest."

"Our Good Earth" by Charles C Mann in September 2008 National Geographic – access the article online at http://ngm.nationalgeographic.com/2007/02/mangroves/warne-text.

Video – "Deep Jungle" by Nature (2005)

CHAPTER 7
POPULATIONS: CHARACTERISTICS AND ISSUES

CHAPTER OVERVIEW

In this chapter the authors introduce concepts, terms, and trends of population growth. A population, or group of individuals of the same species. The increase in size is called population growth and, although it is influenced by many factors, it is ultimately determined by subtracting the number of individuals leaving the population through death and emigration, from the number entering the population through birth and immigration. Other factors influencing the growth rate are the ratio between males and females, the age distribution, and the density and spatial distribution of the population.

Population growth tends to follow a particular pattern consisting of a lag, or slow-growth phase, an exponential, or increased growth phase, and a stable equilibrium phase. The final stage is the result of carrying capacity which is the optimum number of individuals that can be supported in a given area. Most organisms can be divided into two broad categories based on their reproductive strategies. K-strategists are typically large organisms that have long lives, produce few offspring, and provide care for the offspring. r-strategists are typically small organisms that have a short life, produce many offspring, and do not provide much care after birth.

Human population growth continues to increase, especially in less-developed nations where the gross national product and standard of living are low. The causes of population growth are complex and include biological reasons, such as the number of children each woman has, social reasons, such as religion, education and economics, and political factors such as immigration and national population goals.

The post-World War II baby boom created a bulge in the U.S. population which continues to age and affect industrial, educational, health, and government services. The U.S. population also increases as the result of immigration from less developed nations. In countries that are unable to raise enough food for their people and are unable to buy the food they need, humanitarian efforts need to focus not on food donations but on helping these nations become self-sufficient.

THE CONCEPTS

Natality is the number of individuals added to the population through reproduction, and is usually described in terms of the birthrate or the number of individuals born per one thousand.

Mortality is the number of deaths in the population, and is discussed in terms of the death rate or the number who die per one thousand.

Population growth is the difference between death rate and birthrate, or the net rate of increase in the population.

Sex ratio, age distribution, population density, and the spatial distribution of individuals in a population influence the rate of population growth.

Population growth tends to go through a period of slow growth or lag phase, followed by a period of rapid growth, or exponential growth phase, and finally through a leveling off, or stable equilibrium stage.

Stable population size is determined by carrying capacity which is influenced by the availability of raw materials and energy, accumulation of waste, and the interactions among organisms.

Demography is the study of human populations, their characteristics, and what happens to them.

The most important determinant of human population growth is the total fertility rate; zero population growth occurs when the number of births equals the number of deaths.

In general, population growth is higher in less-developed nations because women marry earlier, few couples use contraception, and children have economic value as workers and caregivers.

Demographic transition is the theory that economies proceed through a series of stages, resulting in stable populations and high economic development.

The total U.S. population, its average age, and racial composition will continue to increase.

KEY TERMS

age distribution
birthrate
carrying capacity
deathrate
death phase
deceleration
demographic transition
demography
density-dependent limiting factors
density-independent limiting factors
dispersal
ecological footprint
emigration
environmental resistance
exponential growth phase
extrinsic limiting factors (log phase)
gross national income (gni)
immigration
intrinsic limiting factors
k-strategists
lag phase
less-developed countries
limiting factors
more-developed countries
mortality
natality
population
population density
population growth rate
post-war baby boom
r-strategists
replacement fertility
sex ratio
stable equilibrium phase
standard of living
survivorship curve
total fertility rate
zero population growth

ANSWERS TO REVIEW QUESTIONS

1. Biotic potential is the ability of each species to produce offspring; it is directly dependent on the number of individuals, especially females, of reproductive age.

2. Characteristics of a population include natality, mortality, sex ratio, age distribution, growth rate, density, and spatial distribution.

3. Populations have an inherent tendency to increase in size. Population growth is determined by the combined effects of birthrate and death rate. Other factors include emigration, immigration, sex ratio, and age distribution.

4. A death phase occurs when there is a decline in population size. This occurs as the result of disease, increased predation, low food supply, toxins entering the ecosystem, or any other limiting factor.

5. Four factors determining carrying capacity are availability of raw materials, availability of energy, accumulation of waste products, and interactions among organisms.

6. Birthrate is defined as the number of individuals born into a population, whereas population growth is the result of birthrate and immigration minus death rate and emigration, or the total net increase in the population size.

7. Population growth of bacteria growing in a petri dish begins with a lag phase, continues through an exponential growth, and then levels off due to an accumulation of toxic waste. Human population growth has a long lag phase followed by a sharply rising exponential growth phase that is still rapidly increasing.

8. K-strategists are typically large, long-lived organisms that reach a stable carrying capacity. r-strategists are generally small, short-lived organisms that reproduce very quickly.

9. As the human population increases it expands its domain and displaces other species from their habitat. Eventually, habitat becomes less available and the organisms become more rare. In order to feed the increased human population, there is over-harvesting of many species which leads to decreases and possibly extinction of the food species.

10. Overproduction is advantageous to ensure population density, dispersal, and colonization of a habitat. The disadvantage is high mortality due to environmental resistance factors. In the case of human overproduction, the physical environment, and food animals can be over utilized.

11. Demography is the study of human populations, their characteristics, and changes.

12. Demographic transition is the hypothesis that economies proceed through a series of stages, resulting in stable populations and high economic development. The model is based on the historical, social, and economic development of Europe and North America.

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

14. Differences in North America include: higher gross national product, higher individual income, lower infant mortality rate, higher age expectancy, lower birth rate, greater

availability of food, higher consumption of energy, greater access to education, greater availability of jobs, and greater waste.

15. People who live in overpopulated countries use plants as their main source of food because they cannot afford the 90-percent energy loss that occurs when plants are fed to animals. The same amount of grain can support ten times more people at the herbivore level than at the carnivore level.

16. Africa, Asia, and South America have the highest population growth rates and the lowest standard of living.

17. Women in poor countries are usually poorly educated, do not have disposable income, and depend on their husband's income. They are more likely to have children they do not want because they cannot afford or understand birth control, and because they view children as workers and caregivers.

18. Children are valued as workers and provide an income. Children provide for parents in their old age, and some cultures and religions encourage large families.

SUGGESTED ACTIVITIES AND RESOURCES

Culture fruit flies for one month in a closed container. Record population size as often as possible, graph the results and discuss the population growth curve and possible reasons for population decrease. Kits for this type of culture are available from Wards and Carolina Biological.

Assign readings from Thomas Malthus, the eighteenth century economist who published "An Essay on the Principle of Population," which predicted that the world's burgeoning human population would overwhelm the Earth's capacity to feed it.

Discuss with students the effects of immigration on the population of the U.S. and other developed nations. Is there a connection between the large population of less-developed nations, their ability to provide food and jobs for the population, and their emigration to more-developed nations? Is it ethical for the U.S. to place limits on the number of immigrants entering the country? If the U.S. does not allow immigration, then what happens to the population, economy, and environment of the less-developed nation?

Related to this issue is the recent increase in refugees from war-torn areas such as Bosnia and Africa. What are the ethical and moral responsibilities of the neighboring nations? What are the consequences?

Discuss the idea of government mandated birth control as practiced in China. What is the purpose of the regulation? What is its origin? Has it been effective in decreasing population growth? Would such as a regulation work in the United States?

FURTHER READING AND VIEWING

"Mammalian Herbivore in the Boreal Forests," by Kjell Danell, et al. *Conservation Ecology*. December, 1998.

"Key Deer in the Headlights," by Deborah Straw. *Amicus Journal*. Summer, 1998.

Video – "Population Ecology." Carolina Biological. (Population density, growth, and distribution are reviewed.)

"2000: Tough Choices for Planet Earth," by Jim Motavalli. *E/The Environmental Magazine*. January, 1999.

Video – "Decisions: Teens, Sex, and Pregnancy." Carolina Biological. (Teens discuss the choices they made regarding pregnancy.)

Video – "The World in Balance" by NOVA (2008)

Video – "Muhammad Yunus" by Nobel Prizes – access biography at http://nobelprize.org/nobel_prizes/peace/laureates/2006/yunus-docu.html.

CHAPTER 8
ENERGY AND CIVILIZATION: PATTERNS OF CONSUMPTION

CHAPTER OVERVIEW

Chapter Eight begins with a history of energy consumption from the time of primitive hunter-gatherers, through the wood-based cultures, and finally to the use of fossil fuels. The use of fossil fuels is linked to the Industrial Revolution, which ultimately led to massive mechanization, manufacturing, and transportation.

Highly industrialized countries use most of the world's energy for three purposes: residential and commercial uses, industrial uses, and transportation. Electricity represents a large proportion of a nation's energy consumption and is produced through the burning of fossil fuels.

Future trends in energy consumption depend on political stability in parts of the world that supply oil, and the price of that oil, since the behavior of most people is motivated by economics rather than a desire to conserve energy.

THE CONCEPTS

Human and animal energy was replaced with inexpensive, easy-to handle, and highly efficient fossil fuel energy during the Industrial Revolution.

Economic growth is directly linked to the availability of inexpensive energy.

The automobile industry played a major role in the economic development of the industrialized world by creating more jobs, services, and products related to the automobile.

Industrialized nations use energy for three purposes: residential and commercial uses, industrial uses, and transportation.

Electrical energy which is a large proportion of consumed energy, results from the burning of fossil fuel, and is the major step in economic development of a country.

KEY TERMS

fossil fuels Industrial Revolution

ANSWERS TO REVIEW QUESTIONS

1. The sun was able to provide all energy requirements because before the Industrial Revolution animals furnished transportation, farming, and food, and wood was a source of

fuel for heating and cooking, and provided building materials. The ultimate source of the energy in wood and animals is the sun.

2. A civilization requires energy for heating, cooking, transportation, and industry.

3. Nations that did not have a source of fossil fuel, specifically coal, did not participate in the Industrial Revolution.

4. The shift from wood to coal was caused by a decline in the local supplies of wood, mainly in Europe and North America. Also, coal has more energy per unit weight and was more easily transported.

5. World War II greatly increased the energy demand for manufacturing and transportation, resulting in the construction of federally financed oil pipelines from refineries in the southwest to factories in the east. After the war, the pipelines were sold to private companies which converted them for the transport of natural gas.

6. The government encourages the consumption of gas and oil by subsidizing transportation and storage facilities, and by regulating prices.

7. Initially, 90 percent of the natural gas produced from oil wells was burned off as waste because there was little demand for the product and a lack of transportation and storage facilities.

8. The initial use of oil was to make kerosene or lamp oil. The automobile dramatically increased the demand.

9. Civilization uses energy for residential and commercial uses, transportation, and industry.

10. The Organization of Petroleum Exporting Countries (OPEC) controls over 75% of the world's oil reserves. They have the power to fix production and prices according to their economic and political needs. As the demand for foreign oil has decreased, OPEC nations have been unable to repay loans to western banks, thereby causing financial loss to the lending institutions which in turn "trickles down" through the economy.

11. The taxes paid on gasoline are low in the United States compared to other countries. Therefore, gasoline usage is higher in the United States. OPEC countries control much of the world's oil and therefore, have the ability to determine oil prices. Political pressures have been brought to bear on OPEC to increase production when oil prices rise. Economic downturns result in less energy use and prices fall.

SUGGESTED ACTIVITIES AND RESOURCES

Most people take electricity for granted without realizing that it comes with an environmental price tag. In Northern New England and the Pacific Northwest, hydroelectric dams block

anadromous fish passage. Dams such as the ones on the Tennessee River were formed as the result of flooding massive river valleys, destroying native plant and animal habitat, and in some cases the loss of a species (the snail darter). Some areas have nuclear-power plants or coal-burning plants – both with their own set of environmental problems. Discuss with students the source of electricity in their area and what environmental price they pay for this luxury.

Plan a visit to the local utility company to better understand electricity generation, natural gas storage and transportation, or nuclear power generation.

If students have not had biology or botany, they may not fully understand the origin of fossil fuels. Discuss the conditions that led to the carboniferous period and how fossils are formed.

FURTHER READING AND VIEWING

"Energy for the Next Century," by Tracey Rembert. *E/The Environmental Magazine*. November, 1998.

Video – "Fossil Fuels." Scott Resources, Carolina Biological. (See how petroleum, gas, and coal were formed over millions of years.)

"World Oil" by Paul Roberts in June 2008 National Geographic – access the article online http://ngm.nationalgeographic.com/2008/06/world-oil/roberts-text.

"Curse of Black Gold" by Tom O'Neill in February 2007 National Geographic – access the article online at http://ngm.nationalgeographic.com/2007/02/nigerian-oil/oneill-text.

CHAPTER 9
ENERGY SOURCES

CHAPTER OVERVIEW

Chapter Nine discusses the source, efficiency, and feasibility of various forms of energy. The energy sources most commonly used by industrial nations are non-renewable fossil fuels. Fossil fuels are the remains of once living organisms that were preserved and altered as a result of geologic forces. They include coal, oil, and natural gas.

The extraction, transportation, processing, and use of each fuel type has its own environmental issues: coal is a very efficient source of fuel but mining disrupts the landscape; oil extraction causes less damage, and is a more concentrated energy source; and natural gas is the least disruptive, and causes the least amount of air pollution.

Renewable energy sources replace themselves or are continuously present as a feature of the solar system. Biomass conversion converts plant material into energy sources including wood, solid waste, ethanol, anaerobic digestion, etc. Hydroelectric power is generated at plants near artificially created water reservoirs which displace residents and cause a loss of the natural ecosystem. Solar energy systems can either passively transform light to heat when it is absorbed by a surface, or actively pump the heat through a system of pipes to the area to be heated. Tidal power is generated when ocean water flows from a high level to a lower one. Wind energy is growing and is suited for some areas however it must be coupled with other more reliable energy sources. Geothermal power is generated from the heat energy of the Earth's molten core.

THE CONCEPTS

Non-renewable resources are those materials that are either not replaced or not replaced faster than they are used, whereas renewable resources are continuously present.

A resource is a naturally occurring substance that can potentially be extracted using current technology, and a reserve is a known deposit from which materials can be extracted profitably with existing technology under present economic conditions.

Fossil fuels are the remains of once living organisms that were preserved and altered as a result of geologic forces.

Coal is the most abundant fossil fuel, and is extracted through mining, which disrupts the landscape, and causes water and air pollution, black lung disease, and waste heaps.

Oil is in limited supply, is more easily extracted than coal, but its use causes water and air pollution.

Natural gas is the least disruptive of the fossil fuels, produces little air pollution, but is dangerous and expensive to transport.

Renewable resources furnish about 13.5% of the world's commercially traded energy, and includes hydroelectric power, tidal power, geothermal power, wind power, solar energy, biomass conversion, fuelwood, and solid waste.

KEY TERMS

acid mine drainage
active solar system
biomass
black lung disease
geothermal energy
liquefied natural gas
nonrenewable energy sources
overburden
passive solar system
photovoltaic cell
primary recovery
renewable energy sources
reserves
resources
secondary recovery
surface mining
tertiary recovery
underground mining

ANSWERS TO REVIEW QUESTIONS

1. The energy sources most commonly used by industrialized nations are fossil fuels: coal, oil, and natural gas. Energy for manufacturing, transportation, household, and commercial electricity all use non-renewable fossil fuels. Renewable energy sources have remained less developed and only reflect 3% of the world's commercially traded energy.

2. Reserves are known deposits from which materials can be extracted profitably with existing technology under present economic conditions. Resources are naturally occurring substances of use to humans that can potentially be extracted using current technology.

3. Surface mining can be more efficient than underground mining because it removes 100 percent of the coal in a vein and can be used profitably for a seam of coal as thin as half a meter. The disadvantage of surface mining is that it disrupts the landscape, and reclamation is expensive and often not successful.

4. Mining coal is more disruptive to the environment than drilling and extracting oil. Coal is dirty and its mining generates a great deal of dust causing local air pollution. Burning coal releases millions of metric tons of material, carbon dioxide, and acid deposition into the atmosphere. Environmental impacts of oil use include oil spills and air pollution.

5. Limiting factors in the development of hydroelectric sites include displacement of people and plant and animal species from the site, loss of farmland, destruction of the natural ecosystem, and a reduction of nutrient-rich silt deposition.

6. The cost, low energy output, and disruption of the normal estuary limit the development of tidal power. Power plant sites are limited to those sites with the greatest tidal change, such as narrow bays and estuaries which are near the poles.

7. Geothermal energy is available in areas where molten material from the Earth's core is near enough to the surface to heat underground water and form steam. The United States has about half of the world's geothermal electrical generating capacity.

8. The sun heats the Earth's atmosphere and creates air currents that cause wind.

9. A passive solar system is a design that allows for the entrapment and transfer of heat from the sun to a building without the use of moving parts or machinery. An active system is one that traps sunlight energy as heat energy and uses mechanical means to move it to another location.

10. Problems with using solid waste include the need for sorting burnables from non-burnables, the need for a large and dependable supply, and the air pollution produced when it is burned.

11. Energy conservation techniques include the use of fluorescent bulbs, energy-efficient appliances, and low-emissive glass.

SUGGESTED ACTIVITIES AND RESOURCES

Many communities are participating in alternative energy production systems such as wind power and trash power. Have students research what is being done in their community.

Most utility companies have consumer education personnel who will come to your home and evaluate your consumption needs and suggest conservation techniques. Invite such personnel to your classroom for a presentation.

Find out if there are any private homes or public or commercial buildings using solar energy and have a representative come to your class and discuss the design and the advantages and disadvantages of its use.

FURTHER READING AND VIEWING

"Oil on Ice: Economic Boon, Environmental Disruption — Alaska Weighs the Problem," by John G. Mitchell. *National Geographic*. April, 1997.

"China's Three Gorges: Before the Flood," Arthur Zich. *National Geographic*. September, 1997.

"Landscapes of Power," by Peter Asmus. *Amicus Journal*. Winter, 1998.

Video – "Energy for Tomorrow." Carolina Biological. (Solar, nuclear, and geothermal energy are discussed.)

Video – "Solar Energy: Saved by the Sun" by NOVA (2008)

Video –"Bill Moyers' Journal: 9/7/2007: Christians and the Environment" (2007)

Video – "Scientific American Frontiers: Hydrogen Hopes" (2005)

"Warning: The Hydrogen Economy May be More Distant Than It Appears" by Michael Behar in *Popular Science* (January 2008) – access article online at http://www.popsci.com/cars/article/2006-03/warning-hydrogen-economy-may-be-more-distant-it-appears.

"Green Dreams" by Joel K. Bourne, Jr. in October 2007 National Geographic – access the article online http://ngm.nationalgeographic.com/2007/10/biofuels/biofuels-text.

"Ethanol: Train Wreck Ahead" by Robbin Johnson and Ford Runge in *Issues in Science and Technology* – access article online at http://www.issues.org/24.1/p_johnson.html.

CHAPTER 10
NUCLEAR ENERGY

CHAPTER OVERVIEW

Chapter Ten is dedicated to the thorough coverage of the nature, benefits, and risks of nuclear energy. Nuclear energy is the energy released from the radioactive isotopes of some atoms which have unstable and spontaneously decomposing nuclei. Two materials commonly used in nuclear reactions are uranium 235 and plutonium 239.

A nuclear reactor is a device that allows for a controlled chain reaction of splitting nuclei which releases energy until the fuel is spent. U-235 is commonly used in reactors to heat water to produce steam that generates electricity. There are several different types of reactors including breeder reactors, pressurized-water reactors, gas-cool reactors, and boiling-water reactors. All types contain a core of fuel, a moderator to control the rate of the reaction, and a cooling mechanism to prevent overheating.

Nuclear power currently provides over 16 percent of the electrical energy consumed worldwide and is on the increase due to the rise of energy prices and concern over carbon emissions. The authors provide fascinating details of the Chernobyl and Three-mile Island accidents. Other dangers include exposure to radiation from mining sites and by workers, thermal pollution from the production of waste heat, and radioactive waste disposal.

THE CONCEPTS

Nuclear energy is released from disintegrating atomic nuclei of radioactive isotopes, and has the potential to provide energy for electricity, medical uses, engineering work, and military weapons.

All nuclear reactors are composed of a fuel core, a cooling mechanism, and a moderator to control the rate of the reactions.

Nuclear fuel is mined, enriched, or concentrated, and fabricated, or converted into powder, before it is placed in a reactor.

Nuclear power concerns include accidents, exposure to radiation in soil, water, and air, thermal pollution, radioactive waste disposal, and the costs of construction, decommissioning, and clean-up.

KEY TERMS

absorbed dose
alpha radiation
beta radiation
boiling-water reactor
decommissioning costs
light water reactor (LWR)
liquid metal fast-breeder reactor (LMFBR)
low level radioactive waste
moderator
radiation
radioactive
radioactive half-life
thermal pollution
transuranic nuclear waste

dose equivalent
fissionable
gamma radiation
gas-cooled reactor (GCR)
heavy-water reactor (HWR)
high level radioactive waste
ionizing radiation
nuclear breeder reaction
nuclear chain reaction
nuclear fission
nuclear fusion
nuclear reactor
plutonium-238 (Pu-238)
pressurized-water reactor (PWR)
uranium-235 (U-235)
uranium mining and milling waste

ANSWERS TO REVIEW QUESTIONS

1. A nuclear power plant generates electricity when the nuclei of radioactive atoms disintegrate and release energy which is used to heat water and produce steam. The steam turns a turbine that generates electricity.

2. The steps in the nuclear fuel cycle include uranium mining, milling to concentrate the ore, enrichment to increase the percent of U-235, fabrication which converts it to powder, and use in the reactor. The spent fuel can then be either reprocessed or undergo waste storage.

3. A rem is a measure of the biological damage to tissue caused by certain amounts of radiation.

4. A nuclear chain reaction occurs when the neutrons released from a splitting nucleus strike the nuclei of other atoms causing those atoms to split. This results in more neutrons being released which causes other atoms to split; thus causing a chain reaction.

5. The rising cost of energy is making nuclear energy look more favorable even with all the associate costs of mining, production, and disposal.

6. The accident at Chernobyl was the result of a nuclear reactor meltdown in association with a test and several safety violations and mistakes. The immediate consequences were 31 deaths, 500 persons hospitalized, and 116,000 people evacuated. Delayed effects include an increase in thyroid cancer in exposed children and fetuses.

7. A boiling-water reactor is a type of light-water reactor that produces steam to directly power the turbine and produce electricity. Water is used as a moderator and as a reactor-core coolant.

8. Plutonium-239 is produced when a fast-moving neutron hits a nonradioactive uranium-238 nucleus and is absorbed. The result is a new substance, P-239.

9. Plutonium-239 is considered dangerous because it is extremely radioactive and hazardous to human health. Also, because it can be made into nuclear weapons, it must be transported, processed, and produced under very close security.

10. The energy released during the combination of two lightweight atomic nuclei to form a heavier nucleus is known as nuclear fusion. Fusion is currently not being used as a source of energy because several technical difficulties prevent its commercial use. The main technical problem is containment of the nuclei since their positive charges cause them to repel each other.

11. The major environmental problems associated with nuclear power is the disposal of high-level radioactive waste, exposure to radioactivity during mining, processing, and transportation, and the threat of accidents.

12. The construction and de-emphasis of nuclear weapons causes the contamination of production sites and the surrounding lands, the contamination of test sites, and the problem of storing both new material and waste.

SUGGESTED ACTIVITIES AND RESOURCES

The best way to understand nuclear power is by visiting a nuclear power reactor. Plan a tour of one in your area. Most have education centers on site for the public.

At this point in the text you should summarize the section on energy. Discuss with students the advantages and disadvantages of each of the energy sources covered. As an exercise or assignment, have students design a chart comparing each energy source with respect to cost, environmental harm, human health hazards, feasibility, public sentiment, current usage, and future trends.

FURTHER READING AND VIEWING

"Living With the Monster — Chernobyl," by Mike Edwards. *National Geographic*. August, 1994.

"Ten Years of the Chernobyl Era," by Yuri M. Shcherbak. *Scientific American*. April, 1996.

There are many videos on nuclear power, nuclear weapons, and nuclear winter. The video, "Concepts in Science: Nuclear Physics," available from Carolina Biological, illustrates fission and fusion, and how a reactor works, as well as the difficulties created by nuclear waste. Also try "The Biology of Nuclear War" from Carolina Biological, which shows the effects nuclear explosions have on life.

"Nuclear Power" by John Grossenbacher Testimony before the US House Committee of Science and Technology Hearing on Opportunities and Challenges for Nuclear Power (April 23, 2008) access article online at https://inlportal.inl.gov/portal/server.pt/gateway/PTARGS_0_200_810_257_0_43/http%3B/.../grossenbachertestimony.pdf or view testimony online at http://www.youtube.com/watch?v=9nzSlCiVWqE.

"Statement of Nuclear Fuel Reprocessing" by Phillip Finck Before the House Committee on Science, Energy Subcommittee Hearing on Nuclear Fuel Reprocessing (June 16, 2005) – access statement at http://www.anl.gov/Media_Center/News/2005/testimony050616.html.

"Plan Could Reduce Waste Sent to Yucca Mountain" by David Kestenbaum http://www.npr.org/templates/story/story.php?storyId=4705689.

"Rethinking Nuclear Fuel Recycling" by Frank N. von Hippel in *Scientific American* (May 2008) – access article online at http://www.sciam.com/article.cfm?id=rethinking-nuclear-fuel-recycling.

CHAPTER 11
BIODIVERSITY ISSUES

CHAPTER OVERVIEW

Chapter Eleven examines the importance of biodiversity and human contributions to biodiversity loss. Genetic, species, and ecosystem diversity is very valuable to our health and survival, however, there are many threats to biodiversity including habitat loss, introduction of exotic species, pest control, and climate change.

Humans exploit ecosystems for food, shelter, and water. Forests are utilized for fuel and building materials, and are cleared for farmland. Arid and semiarid areas are used as rangeland for domesticated animals. Aquatic ecosystems such as coastal oceans, lakes, and rivers are used for drinking water, industry, and food, and are subject to sediment, thermal, chemical, and biological pollution, over-harvesting of many fish species, and pressure from the introduction of exotic species.

Many terrestrial areas are managed for specific, desirable wildlife which requires habitat management, and species protection.

THE CONCEPTS

Our species is dependent on a diversity of organisms and ecosystems. Services provided by ecosystems and species diversity include cultural uses, waste treatment, food and raw materials, soil formation, etc.

Almost all ecosystems on Earth, except those classified as wilderness, are modified for human use, and include forests, rangeland, oceans, lakes, and rivers. This modification threatens biodiversity through habitat loss, introduction of exotic species, and pest control.

Forest management practices include clear-cutting, patch-work clear-cutting, selective harvesting, and reforestation.

Desertification occurs when arid or semiarid land is overgrazed or farmed improperly, and results in a loss of vegetation in the area. Overexploitation or harvesting faster than an organism can reproduce threatens many species especially over harvested fish species.

Introduction of exotic or non-native species, pest control, and climate change can threaten the balance of ecosystems and lead to the extinction of organisms.

There are international efforts to stop biodiversity loss. In the U.S., the Endangered Species Act has given some protection to threatened and endangered species.

Additionally, there are several sustainable wildlife management techniques being used to enhance many populations and ecosystems.

KEY TERMS

biodiversity
bush meat
clear-cutting
cover
deforestation
desertification
ecosystem diversity
endangered species
extinction
genetic diversity
habitat management
migratory birds
mutations
overexploitation
patchwork clear-cutting
reforestation
selective harvesting
species diversity
threatened species

ANSWERS TO REVIEW QUESTIONS

1. We change ecosystems by replacing them with agricultural ecosystems, we alter species mixtures by introducing plants and animals, and we reduce populations by harvesting trees and animals for our use.

2. The impact of humans is greater today because the population is greater than it has ever been, and our technology is more harmful to the environment.

3. Mutations, migration, selective breeding, population size, and sexual reproduction.

4. Habitat loss due to agriculture, urban development, logging, and other activities. Over-exploitation of fish, wildlife, and forestry resources. Introduction of exotic species that reduce or eliminate native species. Campaigns against organisms considered to be pests.

5. Over-exploitation by fishers. Destructive harvesting practices such as trawls.

6. Problems associated with forest exploitation are exposure of soil to increased erosion, loss of animal habitat and biodiversity, stream-bank erosion, stream siltation, increased water temperature, and a loss of scenery.

7. Desertification is the process of converting arid and semiarid land to desert because of improper use by humans. It is caused by overgrazing, unsuccessful farming practices, and removal of vegetation for fuelwood.

8. * Develop national strategies for the conservation and sustainable use of biological diversity.
   * Identify components of biological diversity important for its conservation.
   * Monitor biological diversity.
   * Identify activities, which have adverse impacts on the conservation and sustainable use of biological diversity.
   * Establish a system of protected areas.
   * Rehabilitate and restore degraded ecosystems and promote the recovery of threatened species.
   * Develop or maintain necessary legislation for the protection of threatened species and populations.

* Integrate consideration of the conservation and sustainable use of biological resources into national decision-making.

9. Six techniques used by wildlife managers include game and habitat analysis, population census methods, stocking areas with game species, predator control, establishing refuges, and habitat management.

10. Special problems associated with waterfowl management include protection of summer nesting areas, prevention of pond and lake drainage, the development of refuges as havens from hunters, and the protection of food and shelter in the overwintering areas.

11. Extinction is the death of a species or the elimination of all the individuals of a particular kind. Natural extinction can occur in areas where there is a low population density, a small habitat area, a specialized niche, and low reproductive rates. Human-accelerated extinctions occur wherever humans become the dominant organism.

12. Production of food and raw materials
Soil formation
Recreation
Nutrient cycling and waste treatment
Water services
Climate regulation
Refuges for biodiversity
Disturbance regulation and erosion control
Genetic resources
Atmospheric gas balance
Pollination and pest control

13. Actions that can be taken to prevent extinctions include legislation to protect species that are in danger of becoming extinct, the preservation of the habitat required by the endangered species, and education of the local population about the need to protect endangered species.

SUGGESTED ACTIVITIES AND RESOURCES

Most areas have access to natural resource managers, either at the state, local, or private level who can be invited to the class room for a discussion of local natural resource issues. Depending on where you live, this might include cattle or sheep ranchers, wildlife refuge managers, state or private foresters, marine resource officers, and commercial fishermen. Many of these groups or agencies produce newsletters that can be obtained and shared with the class. Likewise, local environmental groups may be willing to discuss similar issues.

FURTHER READING AND VIEWING

"Climbing an Ecological Frontier: Tree Giants of North America," by Mark W. Moffett. *National Geographic.* January, 1997.

"Dead or Alive: The Endangered Species Act," by Douglas Chadwick. *National Geographic*. April, 1995.

"Rainforest Pharmacist," by Christopher Hallowell. *Audubon*. January, 1999.

Video – "Warnings From the Ice" by NOVA (2008)

Video – "Crash: A Tale of Two Species" by Nature (2008)

"Still Waters: The Global Fish Crisis" by Fen Montaigne in April 2007 National Geographic – access the article online http://ngm.nationalgeographic.com/2007/04/global-fisheries-crisis/montaigne-text.

CHAPTER 12
LAND-USE PLANNING

CHAPTER OVERVIEW

Chapter Twelve discusses the issues related to various forms of land use and its planning. The chapter begins with a history of the development of cities and the changes over time in the relative amounts of land used for crops, livestock, forests, and urban centers. Location to water was the leading element in urban development specifically for drinking water, transportation, and industry. As cities grew they converted surrounding farmland to suburbia, and in areas that were unplanned the result was urban sprawl and floodplain and wetland mismanagement.

In some cases land-use decisions are irreversible, such as when a highway is constructed. In the case of multiple land use, several different uses for land can take place at the same time. Most urban areas are recognizing the need to designate some land for recreational use, but sometimes disagreement occurs when designating land for specific recreational uses.

Steps in the development of a land-use plan include gathering biological, geological, and sociological information, projecting future human needs, and developing mechanisms for implementation. Included in land-use planning decisions are zoning, regional planning, and urban transportation planning.

THE CONCEPTS

Land is a nonrenewable resource because once it is used for certain activities it cannot be used for other purposes.

Increased population growth caused an increase in unplanned development of most urban areas that has resulted in urban sprawl, ribbon sprawl, and tract development.

Problems associated with unplanned urban growth include loss of farmland, floodplain problems, and wetlands misuse.

Land-use planning is the construction of an orderly list of priorities for land use and includes zoning, local and regional planning, and transportation planning.

KEY TERMS

brownfields
brownfields development
floodplains
floodplain zoning ordinances
infrastructure
land-use planning
megalopolis
nature centers
outdoor recreation
ribbon sprawl
tract development
urban growth limit
urban sprawl
wetlands
zoning

ANSWERS TO REVIEW QUESTIONS

1. Urban centers developed near waterways because they needed a means of transportation, drinking water, and waste disposal. They are still located on waterways, but roads and railway systems have also allowed cities to develop off waterways.

2. Changes that have occurred in cities include the use of water for industrial uses, the use of neighboring farmland for housing and expanded development, the increase in migration to cities by people from rural areas and by immigrants, and the development of a more complex transportation system.

3. People move to suburbs because industrial pollution and urban crowding turned the core of many cities into undesirable living areas. Also, the development of automobiles and improved roadways enabled people to travel more easily from their homes in suburbia to their jobs in the city.

4. Farmers sell their land because they are taxed on its commercial value rather than on its value as farmland. This policy encourages development and forces people out of farming.

5. A megalopolis is the development of one large urban area as the result of several cities growing together.

6. Land uses suitable for floodplains include agriculture, recreation, and wildlife refuges.

7. Multiple land use occurs any time two or more uses of land occur at the same time. Yes, land can be used for multiple purposes if they are not exclusionary or irreversible.

8. Recreation is a basic human need. Urban dwellers, especially, value open space because it provides a place for recreation. Urban planners are now beginning to realize the need for parks, urban recreation centers, and open spaces.

9. An example of how recreation damages the environment are areas which have been "loved to death." This occurs when the pressure people place on the resources becomes so great that the wilderness quality becomes tarnished. Also, some forms of recreation, such as off-road vehicles, may actually cause erosion and damage to the ecosystem.

10. When land is used for recreational purposes instead of grazing or development, it is taxed at a lower rate and is, therefore, less profitable to the community. Also, when the land is used for recreation, no one can make a profit through development or agriculture.

11. Urban related recreational uses include bowling centers, amusement parks, theaters, play grounds, nature centers, and public swimming pools.

12. Conflicts over recreational land use develop because some activities cannot occur in the same place at the same time. There is also a basic conflict between those who prefer to use motorized vehicles and those who prefer to use muscle power.

13. Development of a land-use plan includes gathering biological, geological, and sociological information, making projections about future human needs, and developing mechanisms for implementing the plan.

14. Regional planning is more effective than local planning because political boundaries seldom reflect the geological and biological data base used in planning.

15. Benefits of land-use planning include the protection of desirable land by zoning, meeting the needs of many people in the community as opposed to only a few, and the benefit derived by citizens when they participate in community decision making.

16. Smart growth emphasizes the concept of developing "livable" cities and towns. This includes the quality of the built environment and how well we preserve the natural environment. Both affect our quality of life.

SUGGESTED ACTIVITIES AND RESOURCES

Invite a person from the land-use planning office in your community to talk to your class about current issues.

Using a topographic map of your area, identify the wetlands, floodplains, and other sensitive areas in your community. How are these lands being used? Are they being used correctly? How can problems in these areas be remedied?

Discuss with your class the current urban transportation planning in your area. Is there sufficient public transportation? Is car pooling encouraged? Does traffic flow properly? How can these problems be fixed?

FURTHER READING AND VIEWING

"Challenges in Adaptive Management of Riparian and Coastal Ecosystems," by Carl Walters. *Conservation Ecology*. December, 1997.

Video – "The Beaches are Moving." Environmental Media, Carolina Biological. (The conflict between coastal development and natural succession is charted.)

Video – "Pale Male" by Nature (2007)

"Our Vanishing Night" by **Kennedy Warne** in February 2007 National Geographic – access the article online at http://ngm.nationalgeographic.com/2008/11/light-pollution/klinkenborg-text.

CHAPTER 13
SOIL AND ITS USES

CHAPTER OVERVIEW

Chapter Thirteen discusses the formation, properties, misuse, and conservation of soil. A mixture of organic and inorganic components, soil is a thin covering over the land which supports plant life. It is formed through the physical and chemical weathering of parent material and the decaying of organic matter that becomes mixed with the top layer of soil. The properties of soil include the size of the particles, or texture, the ability to clump together, or structure, and the profile which is development of recognizable layers in the soil.

The misuse of soil generally leads to its erosion which is the transportation of soil by water or wind. Erosion removes about 25.4 billion tons of soil each year and occurs wherever vegetation has been removed. The most productive layer of soil is the topsoil, and when it is lost, soil fertility decreases.

Soil conservation measures are necessary to reduce the loss of topsoil and minimize the effects of moving water and high winds. The authors review six different agricultural techniques designed to prevent soil erosion. Contour farming is tillage at right angles to the slope; strip farming is the use of strips of alternating crops; terraces are level areas constructed at right angles to the slope; waterways are vegetated depressions on sloping land for the collection of water; windbreaks are plantings of trees that protect bare soil from the wind; conservation tillage is a series of techniques which reduce the amount of cultivation used on a field.

THE CONCEPTS

Soil is a mixture of minerals, organic material, living organisms, air, and water that together support plant life.

Soil is formed by the physical fragmentation and chemical change of the parent material in a process known as weathering.

Soil properties include texture, structure, and the composition of the various horizons in a profile.

Erosion occurs any time there is an absence of vegetation, and can be caused by flowing water and wind.

Techniques to prevent erosion of topsoil include contour farming, strip farming, terraces, windbreaks, waterways, and conservation tillage.

KEY TERMS

asthenosphere
chemical weathering
conservation tillage
contour farming
crust
erosion
friable
horizon
humus
land
leaching
lithosphere
litter
loam
mantle
mechanical weathering
parent material
plate tectonics
reduced tillage
soil
soil profile
soil structure
soil texture
strip farming
terraces
waterways
weathering
windbreak

ANSWERS TO REVIEW QUESTIONS

1. Land is the part of the world not covered by the oceans, while soil is a mixture of minerals, organic material, living organisms, air, and water. Soil is a thin covering over the land.

2. The five major components of soil are mineral, organic material, living organisms, air, and water.

3. Soil is formed by the physical fragmentation and chemical changes in the parent material through a process known as mechanical and chemical weathering.

4. Physical processes include freeze and thaw, glaciers, wind, and moving water. Chemical weathering includes hydrolysis and the growth of lichens.

5. Other characteristics that determine a soil's usefulness include the size of the particles, or texture, the way the soil clumps together, or structure, its moisture content, biotic content, and chemical composition.

6. Soil composed of particles of various sizes, has spaces for both air and water, and allows excess water to drain out. Soil composed of uniformly small particles, has less space for air, and water will not drain out. Since roots require both air, water, and good drainage, the soil with the various-sized particles would be better able to support crops. Soil with only large particles has a tendency to lose all of the water it receives.

7. A soil profile is a series of horizontal layers of different chemical composition, particle size, and amount of organic material.

8. Erosion is the wearing away and transportation of soil by water or wind.

9. Soil conservation practices include contour farming in which tilling is performed at right angles to the slope of the land, strip farming in which strips of closely sown crops like wheat are alternated with strips of row crops like corn, and terracing in which level areas are constructed at right angles to the slope to retain water.

10. Other uses of soil include grazing, wood production, wildlife production, and recreational purposes.

SUGGESTED ACTIVITIES AND RESOURCES

There are many activities for demonstrating soil properties and soil life cited in general biology and ecology lab manuals. Presented here are a few old favorites. There are also several soil-testing kits (pH, nutrients, etc.) available from your local nursery which can be demonstrated in the classroom.

Water-holding ability of soils: Prepare three funnels with gauze taped or tied to the bottom of the mouth and place each one over a graduated cylinder. Pack one funnel with sand, one with clay, and one with humus-rich soil. Pour equal amounts of water into each funnel and watch the water run through the soil. Measure the amount of "runoff" water collected in each cylinder. Which soil permits water to run through most quickly? Which soil retains the water?

Capillarity of soil: Prepare three funnels with gauze taped or tied to the bottom of the mouth. Pack one with dry sand, one with dry clay, and one with dry humus-rich soil. Fill three graduated cylinders with equal amounts of water and make sure that the stem of each funnel reaches the water in each cylinder. Place each funnel on a graduated cylinder and watch the rate of water absorption in each preparation. Through which kind of soil does water rise fastest?

Soil for best plant growth: Obtain three plant pots. Fill one with sand, one with clay, and one with rich loam. Sow soaked seeds of fast-growing plants, such as mustard, oats, or radish in each pot. Compare the growth of seedlings in each kind of soil. Water sparingly but equally for about two weeks. In what ways do the texture and composition of soil affect plant growth?

FURTHER READING AND VIEWING

The Emergence of Agriculture. Bruce D. Smith. 1998. Scientific American Library, New York.

Video – "Erosion: Carving the Landscape." Carolina Biological. (Documents the work of erosion in Nevada and Utah.)

Video – "Soils: Profiles and Processes." Carolina Biological. (The processes that produce different soil types.)

"Our Good Earth" by Charles C Mann in September 2008 National Geographic – access the article online at http://ngm.nationalgeographic.com/2008/09/soil/mann-text.

CHAPTER 14
AGRICULTURAL METHODS AND PEST MANAGEMENT

CHAPTER OVERVIEW

Chapter Fourteen reviews the various forms of agriculture and pest management, and their associated environmental problems. Three agricultural methods are discussed: slash and burn in which a small area is cleared and the vegetation burned; manual labor that is used when the site or crop is unsuitable for mechanization; and mechanized farming that is used when there is an abundance of money and level land. The last technique leads to monoculture in which large tracts of land are planted with the same crop. This method is efficient but can lead to increased soil erosion and reduced soil fertility.

Fertilizers can be used to replace human labor and can be attributed to 25 percent of the world's crop yield. Soil chemicals that plants need in large supply are called macronutrients, and include potassium, phosphorous, and nitrogen. Chemicals that are needed in small supply are called micronutrients.

Pesticides can be categorized into broad groups based on their effects, and include insecticides, herbicides, fungicides, and rodenticides. Problems associated with pesticides include biological amplification, resistance of pests to pesticides, and human health concerns. As a result of the problems and costs of chemicals, some farmers are using organic farming methods and integrated pest management that uses a series of pest control methods, rather than relying on pesticides alone.

There are many alternate forms to conventional agriculture emerging. Sustainable agricultural techniques attempt to provide crops without sacrificing the health of the land or related ecosystems. Sustainable techniques include organic farming, precision agriculture, integrated pest management, and genetically modified foods.

THE CONCEPTS

The majority of the world's food is grown on large, mechanized farms that use energy rather than human muscle for tilling, planting, fertilizer and pesticide application, and harvesting of crops.

Monoculture involves planting large areas of the same crop year after year, and is dependent upon the use of chemicals to control pests and soil fertility.

There are four types of pesticides: insecticides control insects, herbicides control unwanted plants, fungicides control fungi, and rodenticides control rodents.

Problems associated with pesticides include biomagnification, resistance of pests to pesticides, and human health concerns.

To reduce the harmful effects of pesticides, many farmers use organic farming or integrated pest management.

KEY TERMS

alternative agriculture
auxins
bioaccumulation
biomagnifications
biotechnology
carbamates
chlorinated hydrocarbon
fungicides
genetic engineering
genetically modified foods
Green revolution
herbicides
insecticides
integrated pest management
macronutrient
micronutrient
monoculture
nonpersistent pesticides
nontarget organisms
organically grown
organophosphates
persistent pesticides
pest
pesticides
pheromone
polyculture
precision agriculture
rodenticide
sustainable agriculture
target organism
weeds

ANSWERS TO REVIEW QUESTIONS

1. A monoculture is the practice of planting large tracts of land with the same crop year after year. It is an efficient method of producing food but requires mechanized farming and the use of agricultural chemicals.

2. Fossil fuels are necessary in mechanized farming for tilling, planting, harvesting, and pumping irrigation water. Energy is also needed to manufacture fertilizers and pesticides.

3. Pesticides are commonly used in mechanized agriculture because planting the same crop repeatedly encourages the growth of insect and fungus pest populations because they have a huge food supply at their disposal.

4. Fertilizers are used in mechanized farming because the lack of crop rotation depletes certain essential soil nutrients. A problem associated with fertilizer use is increased nutrients in waterways which lead to increased aquatic plant growth.

5. Persistent pesticides are stable chemical compounds that are long-lasting in the environment. They can be applied once and be effective for a long time, but tend to accumulate in the soil and in nontarget animals. Nonpersistent pesticides decompose to harmless products in a few hours or days and do not accumulate in the environment. They are disadvantageous because they require more applications.

6. Biomagnification is the phenomenon of acquiring increasing levels of a substance in the bodies of higher trophic-level organisms.

7. Organic farms produce crops without using pesticides and chemical fertilizers. They are willing to accept lower yields because they do not have to pay for fertilizers and pesticides. Farms also receive higher prices for products that are organically grown.

8. Nonchemical methods for controlling pests include the use of natural predators or parasites, the development of resistant crops, the use of natural pesticides, the modification of farming practices, and the use of sex attractants.

9. The advantage of integrated pest management is the decrease in the amount of pesticides used. The disadvantage is that farmers must make modifications to their farming technique.

10. Three uses of food additives include: to prolong the storage life of food, to make the food more attractive, and to modify its nutritive value.

11. Actions that farmers can take to reduce the effect of pesticides on the environment include the use of genetically modified crops, organic farming, and integrated pest management.

SUGGESTED ACTIVITIES AND RESOURCES

If you have not discussed *Silent Spring* by Rachel Carson, now may be a good time to do so. The book discusses the problems associated with biological amplification, specifically with regard to the effects of DDT on birds of prey. The history of this revelation is important to the study of environmental science.

In order to better understand how herbicides and insecticides work, review the life cycle of some common insect pests, and the stage that is targeted by particular pesticides. Also review the basic anatomy of plants, how herbicides affect plant physiology and growth, and the difference between broadleaf weeds and grass crops, such as wheat. A textbook on introductory plant physiology should help answer these questions.

Your state cooperative extension office should be able to supply you with ample information on pests specific to the area and the pesticides used on them. Ask for fact sheets on the crops grown in your area, specific weeds, diseases, insects, and rodents, and the pesticides used to control them. Also, inquire about integrated pest management and organic farming practiced in your area. Many areas will have organic farms close by that are willing to let you visit.

FURTHER READING AND VIEWING

"A Farming Revolution: Sustainable Agriculture," by Verlyn Klinkenborg. *National Geographic*. December, 1995.

"Rice, the Essential Harvest," by Peter T. White. *National Geographic*. May, 1994.

"Moving Mountains in Nepal," by Don Hinrichsen. *Amicus Journal*. Winter, 1994.

"An Organic Coup in Cuba," by Joel Simon. *Amicus Journal*. Winter, 1997.

Video – "The Incredible Heap: The Story of Garden Compost." Oxford Scientific Films, Carolina Biological. (Shows how garden compost is made and used.)

Turning Freshwater Farm Ponds Into Crab Farms by Science Daily – access article online at http://www.sciencedaily.com/releases/2008/10/081003191417.htm.

CHAPTER 15
WATER MANAGEMENT

CHAPTER OVERVIEW

Chapter Fifteen is concerned with the nature and use of water, the sources of pollution, and its treatment. Water is important because all organisms are composed of 60-percent water. Also, water acts as a solvent, can store heat, and is an important sink for greenhouse gases. Water is constantly recycled by evaporation, precipitation, infiltration, runoff, and underground storage known as aquifers. Water is used for domestic use, such as bathing and drinking, agricultural use, such as irrigation, and industrial use, such as for cooling.

Water pollution is directly linked to water use. Several types of water pollution are reviewed. Municipal water pollution consists of industrial waste and household sewage. Industrial water pollution consists of petroleum products, metals, acids, and organic material. Thermal pollution occurs when industry uses water for cooling purposes. Sources of groundwater pollution include agricultural products, underground storage tanks, landfills, septic tanks, and surface impoundments.

Water-use planning issues include preserving scenic waters and wildlife habitats, groundwater mining, stormwater control, salinization, water diversion, and managing urban water use. Wastewater treatment is used to clean water before it is released. It consists of a physical settling out process or primary treatment, biological degradation or secondary treatment, and a chemical process or tertiary treatment.

THE CONCEPTS

The hydrologic cycle is a process whereby water cleanses itself and includes solar evaporation, precipitation, infiltration, runoff, and groundwater storage.

Water that accumulates in underground porous strata is called an aquifer. They can be confined or unconfined.

Water use can be classified into four categories: domestic use, agricultural use, in-stream use, and industrial use.

Sources of water pollution include municipal, industrial, thermal, and marine.

Water-use planning issues include an increased reuse of existing supplies, salinization, groundwater mining, water diversion, and managing urban water use.

KEY TERMS

activated sludge sewage treatment
industrial water uses
in-stream uses
secondary sewage treatment

aquiclude
aquifer
aquitard
artesian wells
biochemical oxygen demand (BOD)
confined aquifer
domestic water
eutrophication
evapotranspiration
fecal coliform bacteria
groundwater
groundwater mining
hydrologic cycle
irrigation
limiting factors
nonpoint source
point source
porosity
potable waters
primary sewage treatment
runoff
salinization
saltwater intrusion
sewage sludge
storm-water runoff
tertiary sewage treatment
thermal pollution
trickling filter system
unconfined aquifer
water diversion

ANSWERS TO REVIEW QUESTIONS

1. In the hydrologic cycle, the sun causes water to evaporate from surfaces and to transpire from plants. The water is then condensed in the upper atmosphere where it turns to precipitation that falls back to the surface. The precipitation either infiltrates the soil and is stored in underground reservoirs or it runs-off to enter a river system.

2. Water withdrawal is the amount of water taken from a source. Water that is incorporated into a product or lost to the atmosphere is said to be consumed.

3. Industry and municipalities use water to transport waste materials, and both need to maintain an adequate and suitable supply of water at all times. In-stream use does not consume water, nor does it add waste products to it.

4. Land use is directly related to water quality and quantity because some uses can withdraw water, disrupt flow, and contribute to siltation, pollution, and salinization. Examples include the location of industry near a body of water or the construction of a dam.

5. Biological oxygen demand is the amount of oxygen required to decay a certain amount of organic matter. It is one way to determine how polluted a body of water is. If too much organic matter is added to the water, all of the available oxygen will be used up. Anaerobic bacteria begin to break down wastes that, in turn, produce chemicals that have a foul odor and taste.

6. Additional nutrients act as fertilizer and increase the rate of growth of aquatic plants. As the organic matter decays, oxygen levels decrease through the process of decomposition.

7. Pollution that comes from a single effluent pipe or series of pipes is called point source pollution. Diffuse pollutants, such as agricultural runoff, road salt, and acid rain, are collectively called nonpoint source pollution.

8. Most industries dispose of their waste through municipal sewage treatment systems. As of 1972, industries are no longer allowed to use water and return it to its source in poor condition. The water must be cleaned before it is returned to its source.

9. Thermal pollution occurs when an industry removes water from a source, uses it for cooling purposes, and then returns the heated water to its source. Methods of controlling it include cooling ponds, cooling towers, and dry towers.

10. Primary sewage treatment removes larger particles by filtering water through large screens, then settling it in ponds or lagoons. Secondary treatment follows primary treatment and involves holding the wastewater until bacteria have degraded the organic material. Tertiary treatment involves a variety of techniques to remove dissolved pollutants left after primary and secondary treatments.

11. Agricultural waste includes animal manure, excess feed, and fertilizer and pesticide spillage.

12. Storm-water runoff from streets and buildings is often added directly to the sewer system and sent to the municipal wastewater treatment facility. In rural areas, storm-water runoff either infiltrates the soil or runs into river systems.

13. Groundwater mining means that water is removed from an aquifer faster than it is replaced.

14. When irrigated plants extract the water they need, salts are left behind and cause the natural water to become more concentrated.

15. Metropolitan areas must provide a water supply for human and industrial needs, wastewater collection and treatment, and storm-water collection and management.

SUGGESTED ACTIVITIES AND RESOURCES

Discuss water quality issues specific to your area. These may include groundwater contamination, the safety of municipal drinking water, the increased use of bottled water, acid precipitation, local industrial uses, and agricultural uses.

The best way to understand the fate of wastewater is to follow its route from its source (probably a municipal reservoir or well), to your home, to the wastewater treatment plant, and back to its source. Plan a visit to a wastewater treatment facility as well as drinking water treatment plant in your community.

Another activity related to wastewater treatment is to measure the BOD of your community water source before and after its use. This will require locating and testing the source of city drinking water, followed by locating and testing the point of treated wastewater effluent. BOD kits are available from most the biological supply houses. Other tests, such as pH, temperature, dissolved oxygen, and phosphates, can also be performed. Are there any differences in the water

above and below the point of extraction and treatment? Or before and after it is used for municipal purposes? What do the differences mean?

Obtain a topographic map of your area to illustrate the concept of a watershed. Find the source of your communities' drinking water. Determine the geographic boundaries of your watershed. Are there any industries or agricultural practices contributing to the watershed? Are they upstream or downstream from your community? This could be given as a research assignment.

FURTHER READING AND VIEWING

"The Imperiled Nile Delta," by Peter Theroux. *National Geographic*. January, 1997.

"Our Polluted Runoff: Widespread as Rain and Deadly as Poison," by John G. Mitchell. *National Geographic*. February, 1996.

"Trashed Urban Rivers and the People Who Love Them," by Will Nixon. *Amicus Journal*. Fall, 1995.

"Resilience and Restoration of Lakes," by Stephen Carpenter, et al. *Conservation Ecology*. June, 1997.

Video – "Affluent Effluent." Carolina Biological. (Various forms of wastewater treatment are discussed.)

"Yellow River" by Brook Larmer in May 2008 National Geographic – access the article online at http://ngm.nationalgeographic.com/2008/05/china/yellow-river/larmer-text.

"Drying of the West" by Robert Kunzig in February 2008 National Geographic – access the article online at http://ngm.nationalgeographic.com/2008/02/drying-west/kunzig-text.

CHAPTER 16
AIR QUALITY ISSUES

CHAPTER OVERVIEW

Chapter Sixteen begins with a review of global wind patterns and the various layers of the atmosphere affecting air pollution. Primary air pollutants are those released directly into the atmosphere and include carbon monoxide, hydrocarbons, particulates, sulfur dioxide, and oxides of nitrogen. Photochemical smog develops when hydrocarbons and oxides of nitrogen are trapped by thermal inversions.

Control of air pollution is achieved by fuel efficient automobiles, catalytic converters, smokestack scrubbers, and filters. Acid rain results from emissions of sulfur dioxide and oxides of nitrogen that form acids and fall in the form of precipitation. It can cause damage to limestone structures and ecosystems.

Greenhouse gases include carbon dioxide, methane, and chlorofluorocarbons, and are thought to increase the temperature of the Earth by trapping heat within the Earth's atmosphere. Chlorofluorocarbons are also thought to lead to the destruction of the ozone layer in the upper atmosphere, which can increase the amount of sunlight and subsequently damage living tissues.

THE CONCEPTS

Primary air pollutants are released directly into the atmosphere and include carbon monoxide, hydrocarbons, particulates, sulfur dioxide, and oxides of nitrogen.

Secondary air pollutants are compounds that result from the interaction of various primary air pollutants and include photochemical smog and ozone.

Acid deposition is the accumulation of acid-forming particles on a surface, and is classified as wet when it is in the form of precipitation and dry when its precursor settles on a surface.

Global warming is believed to be caused by an accumulation of greenhouse gases, such as carbon dioxide, chlorofluorocarbons, methane, and nitrous oxide.

KEY TERMS

acid deposition
acid rain
air toxics
carbon dioxide (CO_2)
carbon monoxide (CO)
greenhouse gases
hazardous air pollutants
hydrocarbons
methane
nitrogen dioxide (NO2)
particulate matter
photochemical smog
primary air pollutants
radon
secondary air pollutants

carcinogenic
criteria air pollutants
decibels
greenhouse effect
nitrogen monoxide (NO)
nitrous oxide
oxides of nitrogen
ozone
sulfur dioxide (SO_2)
thermal inversion
volatile organic compounds (VOC)

ANSWERS TO REVIEW QUESTIONS

1. Primary air pollutants include carbon monoxide from the burning of organic materials, hydrocarbons from automobile exhaust, particulates from industrial plants, sulfur dioxide from electric generation facilities using high sulfur fuels, and oxides of nitrogen from internal combustion engine exhaust.

2. The 6 criteria air pollutants and their primary sources are:
   carbon monoxide—burning of fossil fuels (Automobiles are the primary source.);
   nitrogen dioxide—secondary air pollutant formed from nitrogen monoxide released from automobiles;
   sulfur dioxide—burning of sulfur-containing fossil fuels, primarily coal in power plants;
   volatile organic compounds (hydrocarbons)—evaporation or incomplete burning of hydrocarbons, primarily automobiles;
   ozone—a secondary air pollutant formed by the interaction of volatile organic carbons and nitrogen oxides released from cars; and
   lead—primary sources today are industrial processes (Formerly, leaded gasoline was a primary source.).

3. Secondary air pollutants are compounds that result from the interaction of various primary air pollutants. Photochemical smog forms when hydrocarbons and oxides of nitrogen are trapped by thermal inversion and react with ultraviolet light.

4. Health effects of air pollution include bronchial inflammation, allergic reactions, irritation of the mucous membranes of the eyes and nose, and asthmatic problems.

5. Increased pollution in industrialized urban areas is due to the large number of industrial plants, the large concentration of automobile traffic in these areas, and temperature inversions that cause large amounts of pollution to accumulate.

6. Photochemical smog is a secondary pollutant caused by the interaction of nitrogen oxide, nitrogen dioxide, and hydrocarbons with ultraviolet light. It is caused by exhaust from internal combustion engines and is intensified in valleys that produce temperature inversions.

7. Air pollution can be controlled by building taller smokestacks, installing emission control devises in automobiles, and legislating to control or eliminate open burning.

8. Acid rain is the deposition of wet acidic solutions or dry acidic particles from air. Detrimental consequences include abnormal bone development in fish, damage to

limestone structures and monuments, damage to metal surfaces, and death of many kinds of trees and other vegetation.

9. Although carbon dioxide is a naturally occurring substance, much larger quantities are put into the atmosphere as a waste product of energy production. This increased amount allows light and heat to pass through the atmosphere to the Earth's surface but hinders its reradiation back into space.

10. If the ozone layer was destroyed, more ultraviolet light would reach the Earth's surface, causing increased skin cancers and cataracts in humans and increased mutations in all organisms.

11. Since most air pollution results from the burning of fossil fuels, energy conservation would decrease the amount of fossil fuels burned and reduce the amounts of carbon monoxide, HC, sulfur dioxide, and other pollutants in the atmosphere.

SUGGESTED ACTIVITIES AND RESOURCES

There are a number of air-quality activities that can be done in the classroom or in the field. For an environmental resource guide on the subject, contact the Public Education Department of the Air and Waste Management Association, PO Box 2861, Pittsburgh, PA 15230.

One of the activities in the above resource involves using lichens as an indicator of air quality. Shrubby and leaf-like lichens prefer clean air, whereas smaller, crusty lichens can tolerate some air pollution. Also, lichens accumulate metals and other elements from the rainwater and are therefore analyzed to determine the effects of pollution. The reference for this activity is "Lichen Looking" in the Outdoor Biological Instructional Series (OBIS) from the Lawrence Hall of Science, University of California, Berkeley, California.

Evaluate your region's air quality. What are the sources of air pollution? Does your region have air quality warnings during certain times of year? If so, why?

FURTHER READING AND VIEWING

"Lichens: More Than Meets the Eye," by Sylvia Duran Sharnoff. *National Geographic*. February, 1997.

"Cleaning the Air," by Renee Skelton. *Amicus Journal*. Summer, 1997.

"Stratospheric Maintenance," by Don Hinrichsen. *Amicus Journal*. Fall, 1996.

There are a number of videos from Carolina Biological on the subject of air quality: "The Two Faces of Ozone," "The Greenhouse Effect," "Paul Ehrlich's Earth Watch," "Acid Rain," and "After the Warming: Episodes #1 and #2."

"Clean Coal" Testimony before the Senate Finance Committee (April 26, 2007) – access the article online at finance.senate.gov/hearings/testimony/2007test/042607testnf.pdf or http://finance.senate.gov/sitepages/hearing042607.htm Dr. Nina French.

"Coal Rush!" by Susan Moran in *World Watch* (2007) purchase article online at http://www.worldwatch.org/node/4776.

CHAPTER 17
SOLID WASTE MANAGEMENT AND DISPOSAL

CHAPTER OVERVIEW

Chapter Seventeen focuses on the policies associated with solid waste management and disposal. The amount of municipal solid waste has increased with the growing population and the increased amount of disposable consumer products. The problems associated with solid waste include the growing amount of waste, the lack of suitable sites for the various disposal methods, air pollution, and groundwater leaching.

Methods of disposal include landfills, incineration, source reduction, and recycling. Landfills are the primary method of waste disposal today. Historically, it was the cheapest means of disposal but has become an area of environmental debate for many communities. Modern sanitary landfills are sealed and monitored, but are very costly.

Incineration was the most popular method of disposal prior to 1940 but their numbers have decreased due to air quality and residual ash concerns. Source reduction is the most fundamental way to reduce waste. Examples of this method include making products in a concentrated form, reducing the amount and weight of the packaging, and composting. Recycling has diverted about 30% of solid waste from landfills.

THE CONCEPTS

The disposable lifestyle that began in the 1950s has created an increased amount of solid waste, resulting in a shortage of landfill space and increased air and water pollution.

The four methods of waste disposal are landfills, incineration, source reduction, and recycling.

Future management of waste disposal will require integration of landfill, incineration, source reduction, and recycling.

KEY TERMS

agricultural waste
composting
incineration
industrial solid waste
leachate
mass burn
mining waste
mulch
municipal solid waste
municipal solid waste landfill
recycling
solid waste
source reduction

ANSWERS TO REVIEW QUESTIONS

1. The solid waste problems of today began with the post-World War II economic boom in which consumers were encouraged to buy and toss away products. Four decades of throwaway living has led to increased amounts of solid waste for which there are no methods of healthful disposal.

2. Integrated waste management includes landfill, incineration, source reduction, and recycling.

3. Modern landfills require very specific sites, massive construction, complex technology, constant monitoring, and a large investment of capital.

4. Concerns associated with incineration include foul odors, noxious gases, gritty smoke, and ash disposal.

5. Examples of source reduction include reduced amount of packaging, reduced packaging weight, product concentration, and municipal composting.

6. Every recycling or reduction effort from each of us could have the cumulative result of a significant reduction in municipal solid waste.

7. Recycling could be encouraged by legislating container laws, tax incentives, and the development of products manufactured from recycled materials.

8. There are three common methods of large scale composting:
   -Windrow systems involve placing compostable materials in long rows and periodically mechanically mixing the material.
   -Aerated piles are large piles of compostable materials that have air pumped into them.
   -Enclosed vessels involve controlled environments and mechanical methods of mixing the materials.
   Composting is an important ingredient in solid waste management because it converts a waste into a useable product and prevents these wastes from taking up space in landfills.

SUGGESTED ACTIVITIES AND RESOURCES

A visit to your community landfill or incinerator is the best method to illustrate the problem of solid waste in the United States. In addition, visit your recycling facility to find out which materials are recyclable and which are not. Also discuss the current market for recyclable material in your area.

FURTHER READING AND VIEWING

"Recycling," by Noel Grove. *National Geographic*. July, 1994.

"Poor Economics and Trash Shortage Force Incineration Industry Changes," by Jeff Bailey. *Wall Street Journal*. August 11, 1993.

"Talking Trash," by Alice Horrigan & Jim Motavalli. *E/The Environmental Magazine*. March, 1997.

"Assessment of Biomass Burning in the Conterminous United States," by Bill Leenhouts. *Conservation Ecology*. June, 1998.

"Viable alternative: Engineer works to turn waste management byproduct from hog farms into fuel source" by Dee Shore in *Perspectives: The Magazine of College of Agriculture and Life Sciences* access article online at http://www.cals.ncsu.edu/agcomm/magazine/winter07/viable.html.

CHAPTER 18
ENVIRONMENTAL REGULATIONS: HAZARDOUS SUBSTANCES AND WASTES

CHAPTER OVERVIEW

Chapter Eighteen begins by identifying sources of hazardous materials in our environment, and by defining terminology, such as corrosiveness, ignitability, reactivity, and toxicity that are used to describe hazardous substances. Setting regulations for the handling, storage, and disposal of hazardous substances involves many issues including: identification of what is toxic or hazardous; the determination of threshold limits; and the determination of severity and persistence of the toxin.

Prior to 1976, disposal of hazardous waste was unregulated, and as a result, it was often buried or dumped without concern for environmental or health risks. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also called the Superfund, was established to clean up hazardous-waste sites and to protect the public from the dangers of such sites.

The EPA fosters a pollution prevention hierarchy for the management of hazardous waste. The hierarchy involves source reduction, waste recycling, waste treatment, and as a last resort, disposal on land or incineration.

THE CONCEPTS

The benefits gained from using hazardous materials must be weighed against the environmental and health risks associated with their use.

Hazardous materials are defined by the EPA as having one or more of the following characteristics: ignitability, corrosiveness, reactivity, or toxicity.

The issues involved in regulating the use and disposal of hazardous substances include identification of the material, determination of exposure limits, and determination of toxicity and persistence of the substance.

The management of hazardous waste involves prevention, waste minimization, recycling, treatment, and land disposal.

KEY TERMS

acute toxicity
chronic toxicity
Comprehensive Environmental Response,
hazardous wastes
ignitability
incineration
land disposal
reactivity
Resource Conservation and Recovery Act (RCRA)
Superfund

Compensation and Liability Act (CERCLA)
corrosiveness
hazardous
hazardous substances or materials
National Priority List
nonpersistent pollutant
persistent pollutant
pollution prevention hierarchy
synergism
threshold levels
toxic
toxicity
waste minimization

ANSWERS TO REVIEW QUESTIONS

1. Many hazardous waste sites are located in environmentally sensitive areas, such as floodplains or wetlands. When the sites became full or were abandoned, they frequently were left uncovered. The locations for these sites were selected more for convenience and expedience than environmental concern.

2. Acute toxicity is a serious effect, such as a burn, illness, or death, that occurs shortly after exposure to a hazardous substance. Chronic toxicity is a serious effect, such as an illness or death, that occurs after prolonged exposure to small doses of a toxic substance.

3. Regulating hazardous substances is difficult because they affect the air, water, and soil; and some can be hazardous in extremely low concentrations. In addition, definitions of hazardous and toxic wastes differ among countries, as do the concentrations of those wastes that are considered hazardous to human health.

4. Hazardous wastes pollute the air, water, or soil simply by the way they are stored or contained.

5. Industrial landfills, surface impoundments, and special facilities are all used to dispose of hazardous wastes. The toxins in such sites can leach into the soil and cause groundwater contamination.

6. The problem of linking a particular chemical or other hazardous waste to specific injuries or diseases is complicated by the lack of toxicity data on most hazardous substances. There is disagreement on how much of a hazardous substance may be harmful.

7. The National Priority List is a listing of hazardous-waste dumpsites in the United States that require urgent attention under the Superfund Program.

8. Five technologies for managing wastes are: thermal treatment, or incineration; neutralization, which mixes the toxins with a neutral element; immobilization, which converts it to a solid form; waste separation, which separates components of the waste; and air stripping, which removes volatile chemicals from the waste.

9. Pollution prevention is the process of preventing, entirely or partially, the pollution that would otherwise result from some production or consumption activity. Waste minimization is a process that reduces the amount of waste produced.

10. The first step in the pollution prevention hierarchy is to reduce the amount of pollution at the source. Second is to recycle wastes wherever possible. Third is to treat wastes to reduce their hazard or volume. Fourth is to dispose of the waste on land or incinerate the waste as a last resort.

11. RCRA is the Resource Conservation and Recovery Act. It defines hazardous and toxic materials and regulates their production. CERCLA is the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund). It is the 1980 law that addressed the issue of cleanup of hazardous-waste sites.

12. RCRA: Resource Conservation and Recovery Act, day to day management of hazardous waste (cradle to grave); not flexible; prospective; process driven. CERCLA: Comprehensive environmental response, compensation and Liability Act; past mismanagement of hazardous waste, flexible, retrospective, money driven.

13. To determine potential environmental liabilities associated with a property prior to purchase so as to conduct "due diligence" and showing that you had "no reason to know" the property was contaminated.

14. Strict: liability without fault; joint and several: any one party could be held liable to pay the entire cost of cleanup including third party liability.

15. Many ways including: better environmental image for marketing, reduction in environmental liabilities, less regulatory requirements, better insurance rates, quality control, pollution prevention, internal auditing.

SUGGESTED ACTIVITIES AND RESOURCES

Discuss with students their personal responsibility in the production of hazardous waste. What products do they use that contribute to the amount of hazardous waste in their community?

Have students investigate how local industries manage their hazardous waste. Is it recycled? Is it treated? Is it landfilled in your state, or is it in someone else's "backyard"?

Most large universities have personnel responsible for campus hazardous waste. Have someone from that department speak to the class. Have them demonstrate the various methods of disposal and transportation techniques used and the paperwork involved.

FURTHER READING AND VIEWING

Nuclear Waste: The Problem that Won't Go Away. By Nicholas Lenssen. 1991. World Watch Institute. Washington, DC.

Nuclear Legacy, An Overview of the Places, Problems and Politics of Radioactive Waste. By Scott Saleska, et al. 1989. Public Citizen. Washington, DC.

Website – Visit www.wnj.com for information on dealing with hazardous solid and liquid industrial waste.

For a guide to common household hazardous waste products write to:

Illinois EPA
Waste Reduction Unit
Solid Waste Management Section
2200 Churchill Rd
Springfield, IL 62794

"High Tech Trash" by Chris Carroll in January 2008 National Geographic – access the article online at http://ngm.nationalgeographic.com/2008/01/high-tech-trash/carroll-text.

"Carbon Trading" by James Allen and Anthony White in *Electric Perspectives* (Sept/Oct 2005)

CHAPTER 19
ENVIRONMENTAL POLICY AND DECISION MAKING

CHAPTER OVERVIEW

The last chapter of the book discusses the structure of the U.S. government and the development of policies and laws. Making policies at the federal level requires an understanding of the roles of the legislative, judicial, and executive branches of government.

Before 1970, the U.S. had few environmental programs. After the first Earth Day, the Congress tackled many environmental problems such as air-quality standards, cleaning up rivers, protecting coastal areas, and regulating pesticides. International cooperation is becoming more important in environmental policies and laws.

Environmental or "green" politics has become a major political movement in many areas, and is not restricted to developed nations. Economic progress in the Third World raises major environmental issues, and in order to avert problems, the environment will need to become a foreign policy tool.

THE CONCEPTS

The United States government is structured into three separate branches: the legislative, judicial, and executive.

The first Earth Day was April 22, 1970, and it is believed to have initiated the modern environmental movement.

There is a growing interest in international environmentalism which is leading to increased cooperation among both developed and undeveloped nations.

KEY TERMS

environmental terrorism	executive branch	legislative branch
policy	judicial branch	

ANSWERS TO REVIEW QUESTIONS

1. The major responsibility of the legislative branch is to develop and approve policies and laws. The major responsibility of the judicial branch is to interpret laws. The major responsibility of the executive branch is to lead members of Congress and the people they represent toward respect for and appreciation of the quality of their surroundings.

2. Enforcement policies have focused on a "command and control" approach in which restrictive and highly specific legislation are implemented by centralized authorities and used to achieve narrowly defined ends.

3. Environmental law is governed by administrative law, which defines how governmental organizations develop and implement regulatory programs. All actions of federal agencies must comply with the 1946 Administrative Procedure Act.

4. "Eco-conflicts" between the industrialized North and the developing South may pose a comparable challenge to world peace. Issues include transboundary water supply, pollution, acid precipitation, and global climate change.

5. The modern environmental movement had its start with Earth Day I in 1970. As a result of this demonstration, the government made great strides in tackling many environmental issues. The Reagan Administration and economic hard-times resulted in reduced interest in environmental issues in the mid-1980s. A renewed interest in the environment began with the second Earth Day held in 1990. Also at this time, the number of and membership in nongovernment environmental organizations increased. By 1995, however, these organizations had become large and bureaucratized, and lost many members. This was offset by an increase in small, local, grassroots organizations and international organizations. Anti-environmental backlash began to grow in 1995, and led to such groups as the "wise-use" movement. Today, there is increased interest in global environmentalism.

6. Many developing nations have resource-poor or ineffective governments which lead to the private sector controlling the resource and policies. NGOs with different goals are joining together to advance environmentally sound economic development.

7. International conventions and treaties include the 1972 United Nations Conference in Stockholm, the 1982 Third United Nations Conference on the Law of the Sea, the Antarctic Treaty of 1961, the 1979 Convention on Long-Range Transboundary Air Pollution, and the 1989 Accord on Chlorofluorocarbon Emissions.

SUGGESTED ACTIVITIES AND RESOURCES

As an assignment, have students draft a letter to their congressman or senator concerning an environmental issue that is important to them.

Visit your state's House of Representatives and/or Senate to see first hand how the system works.

Discuss with students the process used by Congress to create laws. A synopsis of the process is listed below. Discuss the influence that interest groups and lobbyists have on this process.

Introduction: a bill is introduced to the House or Senate by a sponsoring representative or senator.

Committees: the bill is referred to the House and Senate Committees that deal with specific kinds of legislation. Here it either receives support or "dies."

Hearings: the subcommittee invites testimony from interested witnesses.

Markup: the original bill is changed through amendments proposed by subcommittee members.

Floor Action: amendments are accepted or rejected and a vote for final passage is taken.

Have students bring in newspaper articles or summarize news stories that are related to environmental laws and regulations.

FURTHER READING AND VIEWING

American Environmental History. By Joseph Petulla. 1988. Merrill Publishing Co., Columbus, Ohio. 428 pp.

"Happy 25th Birthday, Clean Water Act," by the Editorial Staff. *Amicus Journal.* Fall, 1997.

"Taking a Green Leap Forward," by Seth Dunn. *Amicus Journal*. Winter, 1997.

"From Yellowstone to the Yukon," by Tracey Rembert. *E/The Environmental Magazine.* January-February, 1999.