6e Data Analysis Answers

Chapter1 Working With Graphs

1. The subject is income disparity among world regions
2. The independent variable is the year
3. The dependent variable is per capita income in constant dollars
4. Yes, the years follow a linear sequence independent of income
5. The X-axis units are years from 1970 to 2000
6. The Y-axis units are dollars per capita ranging from 0 to 25,000
7. The difference between the highest and lowest amounts in 1970 is from a few hundred dollars to nearly 5000 dollars. At the right end of the graph (2000)North America has a range from about 15,000 to 23,000 dollars, while Africa is still only a few hundred dollars per year.
8. The trend shows that rich regions (such as North America) have gotten richer, while poor regions (such as Africa) have remained nearly constant over this 30-year period.

Chapter 2 Nutrients in a Wetland

1. Two: N and P; depending on pH, they may form bonds with P
2. Atmosphere, surface water, ground water; atmosphere: airborne pollution, as from power plants; fertilizers to lawns and farm fields, pet waste on sidewalks entering surface water systems, septic systems release nutrients to ground water. Students may have a shorter or different list.
3. N2, N2O, NO3, NH4-N, organic N, NH3
4. Organic N is contained in C-based molecules, such as carbohydrates, proteins, lipids, or nucleic acids; NH4; litter fall and peat accretion
5. Denitrification
6. DIP; inorganic, it contains no C; yes

Cunningham 6e Answers to Practice Quizzes

Chapter 1

1. Apo Island's marine preserve allows fishing with hand-held lines, bamboo traps, large mesh nets, spear fishing without SCUBA gear, and hand netting. Fishing with dynamite, cyanide, trawling, and Muro-ami are forbidden. This has increased fish populations and made it easier to catch the fish needed to support a family. The healthy reef community now attracts ecotourists and provides jobs for islanders.
2. Science assumes that the world is knowable and that we can learn about it through careful observations. Some other principles of science are described in table 1.1.
3. A hypothesis is a testable, provisional explanation. A scientific theory is an explanation supported by a large body of empirical evidence and regarded by a majority of scientists as likely to be correct.
4. The scientific method involves 1) identifying a question, 2) forming a testable hypothesis, 3) collecting data, 4) interpreting results, 5) reporting results for peer review, 6) publishing findings. See figure 1.4.
5. Probability is a measure of how likely something is to occur. An example is flipping a coin. Each toss has a 50% probability of landing on a particular side.
6. By convention, we put the dependent variable on the vertical (Y) axis and the independent (or explanatory) variable on the horizontal (X) axis.
7. The first step in critical thinking is to ask, "What is the purpose of my thinking?"
8. Utilitarian conservation is pragmatic, efficient resource use for the greatest good for the greatest number for the longest time. Gifford Pinchott and Teddy Roosevelt were leaders in this movement. Biocentric preservation emphasizes the right of other organisms—and nature as a whole—to exist regardless of their usefulness to us. John Muir was a leading proponent of this philosophy.
9. Water is a critical resource because 1.1 billion people lack access to clean water, 15 million people die annually from diseases linked to polluted water or inadequate sanitation, and by 2025, the U.N. warns, three-quarters of all humans may live in water-stressed countries.
10. In figure 1.7, the most dramatic warming occurs at high latitudes, especially northern Canada, Siberia, and parts of the Arctic Ocean.
11. Marine reserves, such as Apo Island, are restoring fish populations; cities are cleaner and more livable; population growth has slowed or stabilized in most of the world; many infectious diseases are decreasing; food supplies have kept up with population growth; renewable energy is making progress; and information and technology for solving problems is spreading around the world at an ever increasing pace.
12. The poorest people are often both the victims and agents of environmental degradation. Forced to meet short-term survival needs at the cost of long-term sustainability, they suffer most from environmental damage because they have few other options.
13. Sustainability is a search for ecological stability and human progress that can last over the long term. Sustainable development is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."

Chapter 2

1. Three primary nutrients in fertilizers are nitrogen (N), phosphorus (P), and potassium (K).
2. Systems are networks of interactions among interdependent units or compartments as well as processes or flows that link those components. A positive feedback loop uses the output from a process to increase or enhance that process; in a negative feedback loop the output of a process to inhibit or reverse that process.
3. Carbon atoms, like all matter, are constantly cycled in living organisms. Given the huge number of carbon atoms in your body, it's almost certain that some of them were also part of some prehistoric organisms.
4. Water molecules are polar, which makes water a superb solvent. Water is the only inorganic liquid that exists at normal ambient temperatures. This provides a liquid medium for life processes. Water molecules are highly cohesive. This results in capillary action. Water expands when it crystallizes so that ice floats. Water has a high heat of vaporization, so we can remove a large amount of heat through evaporation. Water has a high specific heat, making it an ideal medium for storing heat and moderating the earth's temperature.
5. DNA (deoxyribonucleic acid) is a molecule made up of nucleotides (purines or pyrimidines coupled to phosphate and sugar molecules) linked together in long chains. The specific sequence of nucleotides in a DNA molecule carries the genetic information that codes for protein structure and gives each organism its unique heritable characteristics.
6. High-quality energy is intense, concentrated, high-temperature, and useful for work. Low-quality energy is diffused, dispersed, low temperature, and difficult to gather or use for productive work.
7. Materials always cycle in the biosphere because of the law of conservation of matter. Energy flows in a linear fashion because of the second law of thermodynamics, which says that in every energy exchange, some of the energy is converted from higher quality to lower quality. Thus, to keep living processes going, there has to be a constant energy input and a sink to which surplus waste energy can be dumped.
8. Our eyes are sensitive only to visible light (0.4 to 0.7 um), which happens to be the most common wavelengths in solar radiation. Short ultraviolet wavelengths (microwaves (10 nm or 10×10^{-9} m) are 1 million (1×10^{6}) times shorter than microwaves (1 mm or 1×10^{-3} m).
9. Extremophiles live in extreme conditions at the bottom of the ocean, in hot springs, or deep in the earth's crust. They get the energy they need to live by chemosynthesis: reactions that use chemicals, such as hydrogen sulfide or hydrogen gas as an energy source.
10. For most organisms on the earth's surface, the ultimate source of energy is the sun, and the sink for waste energy is outer space.
11. Green plants capture solar energy through photosynthesis, a series of chemical reactions that occur in chloroplasts. The energy captured in this process is used to create chemical bonds in organic molecules. These molecules serve both as an energy source and building material for all plants and animals.
12. A species is made of all the organisms of the same kind that are able to breed under natural conditions and produce live, fertile offspring. A population consists of all the

members of a species living in a given area at the same time. A biological community is made up of all the populations of different species living and interacting in a given area at a specific time.

13. Big, fierce animals (like grizzly bears, tigers, and great white sharks) are usually the top carnivores in their ecosystem. They need to be large and fierce to catch their prey. Because they are at the top of the ecological pyramid, it takes many organisms at lower trophic levels (and therefore, large home ranges) to support these big carnivores. Thus, there are never very many of them in a given area. Their adaptations as top predators make them dangerous to humans. They also often compete with us for food, so we tend to eliminate them either directly by hunting, or indirectly by reducing their food supplies or eliminating their habitat.
14. An example of an inverted ecological numbers pyramid might be a single large tree supporting many herbivorous insects, or a single coyote supporting many parasites.
15. Humans release about 7 GT of carbon annually compared to 100 GT released by respiration from land-based plants, animals, and microbes.

Chapter 3

1. Tolerance limits restrict the distribution and abundance of species by forcing them to live in a specific environment. Young desert pupfish, for example, only live in hot water (20-36°C), forcing them to remain near hot springs in the desert. By contrast, at all ages the common carp and European starling survive in a broad range of temperatures, and through human introduction now occupy every continent in the world except Antarctica (p 51-52).
2. Answer depends on specific biome, but should show understanding of productivity, diversity, complexity, resilience, and structure of ecosystems (see p 64-68).
3. Selective pressure is the effect of environmental factors that affect reproductive success and results in better competitors (those with greater reproductive potential or fitness) to survive and pass their genes along to their progeny (p 50). Selective pressures in your locality could include temperature, water, wind, predation, food, fire, or a number of other environmental factors.
4. A keystone species is one that plays a critical role in a biological community out of proportion to its abundance. They may provide unique shelter, food, population control, or other irreplaceable ecological service. In some cases, a group of species may all play decisive roles in a community and we call them a keystone set (p 60-61).
5. Intraspecific competition describes the struggle between members of the same species for food, water, sunlight, living space or other scarce resources (p 56).
6. Predator-prey relationships exert selection pressures that favor evolutionary adaptation. Predators become more efficient in catching prey, and prey become more effective at escape and avoidance. Toxic chemicals, body armor, extraordinary speed, and the ability to hide are a few strategies organisms evolve to protect themselves. We call this process coevolution (p 58).
7. Competition shapes both a species and its biological community by creating selective pressures that result in evolution of physical or behavioral characteristics. Individuals within a species or populations of different species tend to specialize in how or when they feed, live, migrate, or reproduce so as to minimize competition and use resources with the greatest possible efficiency (p 56-58).

8. Regrowth of a forest after a fire is an example of secondary succession. The first organisms to recolonize the burned forest are usually annual species, such as grasses and forbes that have highly mobile seeds and that can tolerate full sun and strong winds. Over time, organic material builds up the soil so that shrubs and, eventually, trees can survive. Some trees, such as lodgepole and jack pines, have seeds that are protected from fire and sprout profusely in the ashes, restoring the original forest very quickly after a fire. These communities may be dependent on periodic disturbance for their continued existence (p 70).
9. Tropical rainforests, estuaries, and coral reefs have the highest biological productivity of any natural ecosystem. They also generally have the highest species diversity. Deserts (because they're so dry) and the open ocean (lack of nutrients) have the lowest productivity of the major ecosystems (p 68).
10. Introducing new species into a biological community often upsets existing relationships and can drive indigenous species into decline or even extinction. Take the example of the cichlids in Lake Victoria, for example. When a new, powerful predator (Nile perch) was introduced to the lake, they quickly ate most of the cichlids. This allowed excess growth of algae and rotting detritus (which formerly were eaten by the cichlids) to accumulate and degrade the lake's water quality (p 54).

Chapter 4

1. The human population reached 1 billion in 1804. Diseases, famines, wars, and social factors restricted population growth before that time. In the past two centuries increased commerce and communications, agricultural developments, better power sources, health care, and hygiene all played a role in rapid human population growth.
2. 2Human population growth has been growing exponentially over the past 200 years. We called this a J-curve in chapter 3.
3. The ecological footprint is an estimate of our impacts on nature and natural resources. It is expressed as the area of "bioproductive" land needed to supply the goods and services we use. This is useful because it gives us a simple, single number to compare different lifestyles. Current estimates are that it would take about 3.5 additional earths to support all of humanity at American rates of consumption.
4. Some economists, such as Julian Simon, believe that humans are the "ultimate resource," and that there is no evidence that pollution, crime, unemployment, crowding, the loss of species, or any other resource limitation will worsen with population growth. Human ingenuity, he argues, can overcome obstacles, such as natural resource limitations.
5. As figure 4.4 shows, the vast majority of population growth in this century is expected to be in the less-developed regions of the world. Unmet needs for education, health care, civil rights, and family planning, together with cultural, religious, and economic factors are the driving forces behind this population growth.
6. The *crude birth rate* is the number of births in a year, per thousand persons. The *total fertility rate* is the number of children born to an average woman in a population during her entire reproductive life. The *crude death rate* is the number of deaths in a year per thousand persons. *Zero population growth* occurs when births plus immigration in a population just equal deaths plus emigration. In most developed countries this rate is usually about 2.1 children per couple because some people are infertile, have children who do not survive, or choose not to have children.

7. Life span is the maximum age to which a species is known to survive. Life expectancy is the average age that a newborn infant can expect to attain in any given society.
8. The dependency ratio is the number of nonworking people compared to the workers in a population. Those individuals under age 15 or over age 65 are generally considered to be dependent on others (to some degree) for support. The growing number of retired persons and shrinking numbers of workers in the United States (and other developed countries) may increase the dependency ratio.
9. Children can be a source of pleasure, pride, and comfort. They may support elderly parents, provide status in society, express parental creativity, help support the family, and do important chores. On the other hand, it's more difficult and expensive to raise and educate a child in an advanced society than in an agricultural one. This fact often causes parents to choose to have fewer children as incomes grow.
10. A demographic transition is usually caused by development that brings better jobs, medical care, sanitation, and a generally improved standard of living.

Chapter 5

1. Ecologists wanted to reintroduce a top predator to Yellowstone because the herbivores, elk, bison, and deer, were overgrazing, especially along stream banks, and mid-level predators were depleting populations of rodents and other small prey. The goals have largely been met: herbivore populations are slightly lower, and vegetation health has greatly improved. Coyotes and foxes are less numerous, and small mammals are more abundant. Overall the reintroduction of a major predator has stabilized biodiversity in the region.
2. Refer to biome descriptions for tropical moist forest, tropical seasonal forest, tropical savanna and grasslands, deserts, temperate grasslands, temperate shrublands, temperate forests (deciduous and coniferous), boreal forest, and tundra.
3. Climate graphs show yearly patterns of temperature and precipitation change. Temperature and precipitation are read on opposite vertical axes. Where temperatures are low and precipitation is high, there is usually a surplus of moisture; deficits occur when precipitation is low and/or temperatures are high.
4. Coral reefs occur near shallow, clear shorelines where there is little pollution, sediment, or nutrient runoff from shore. Mangroves occur on calm, shallow, muddy shorelines. Estuaries occur where rivers enter the ocean, usually rivers create large flat expanses where that make estuaries flat, including coastal saltmarshes. Tide pools occur in the rocky intertidal zone on rough, usually cold, shorelines.
5. Extreme temperatures and variable precipitation produce the biome know as prairie. Seasonal precipitation is sufficient to support grasses, herbs (forbs), and shrubs, many of which are perennial and deep-rooted to survive drought, fire, and cold winters. Slight rainfall and periodic fires prevent tree growth, especially in the western Great Plains. Cold and drought prevent rapid decomposition of organic matter in the soil, so soils are usually rich in organic matter and very fertile.
6. Swamps are forested wetlands; marshes contain emergent grasses and plants but few trees; bogs are saturated and usually acidic, with peat that accumulates because acids slow decay.
7. On mountains, high elevations are cooler, so that plants grow smaller; summer growing seasons are shorter, so plants must tolerate cold conditions. Tough, leathery leaves often

help plants survive cold, as well as the stronger ultraviolet light at altitude. In lakes and oceans, depth leads to colder temperatures and lower light levels. Organisms growing at depth must tolerate high pressure as well as cold temperatures. Photosynthesis is impossible at depth, so most organisms are predators or detritivores.

8. Ocean currents carry nutrients far across the open ocean near the equator. Around continental margins, nutrient runoff from shore supports organic activity. Temperate and tropical forested areas have abundant plant growth and appear dark green. Deserts occur in dry (yellow/orange) regions (see the discussion of climates, chapter 9 for further discussion).
9. Biodiversity is the variety of living things in an area. Three kinds of diversity that are essential to preserving ecosystems and ecological functions are genetic diversity, species diversity, and ecological diversity (variety of trophic levels, niches, and ecological processes)
10. Biodiversity hot spots are areas of unusually high diversity and/or with many endemic species that occur nowhere else, which are also threatened in some way. For a sample of important hot spots, see fig. 5.20.
11. Humans benefit from biodiversity in many ways: we derive food, medicines, ecosystem stability, and aesthetic and cultural benefits.
12. Threats to biodiversity include habitat destruction, fragmentation, introducing invasive species, pollution, overharvesting, and predator control programs (which have eliminated predators in many ecosystems and pollinators in other ecosystems).
13. In geologic time there have been many extinctions, including at least five mass extinctions, when large proportions of species or families were wiped out, in some cases by meteorite impacts. Current extinctions are not greater than ancient mass extinctions, but they are occurring very rapidly, in a span of decades or centuries rather than many thousands of years.
14. Invasive species spread rapidly; exotic invasive species often lack natural predators, so they are especially successful in displacing native species.
15. The Endangered Species Act (ESA) is intended to preserve and restore populations of especially rare species. The ESA lists species that require conservation efforts, develops strategies for protection, including Recovery Plans and Habitat Conservation Plans, aids private landowners with planning and financial assistance, and provides enforcement of protections for listed species. (Endangered species are considered likely to become extinct. Threatened species are likely to become endangered. Vulnerable species have low populations and are considered at risk.)

Chapter 6

1. In a closed canopy forest, tree crowns cover most or all of the ground. An old-growth forest covers a large enough area and has been undisturbed b human activities long enough that trees can live out a natural life cycle and ecological processes can occur in a relatively normal fashion.
2. Africa is experiencing the most extensive deforestation in the world (see Fig. 6.4). In Africa, conversion to small-scale permanent agriculture is the largest cause of deforestation. In Latin America, it's conversion to large-scale farms. In Asia, it's also conversion to large-scale farms although intesification of agriculture in shifting cultivation and "other" causes are nearly as important.

3. REDD stands for Reducing Emissions through Deforestation and Degradation. This international program links greenhouse gas emissions to deforestation and tries to combat both together. The program also acknowledges that degraded forests provide less carbon storage and fewer ecosystem services than do healthy, mature forests. Payment for ecosystem services is an important part of the REDD strategy.
4. Fire suppression is controversial because it allows dead wood and underbrush to accumulate and make it more likely that when a fire does start, it will be larger and more destructive. On the other hand, property owners demand that they be protected from fire no matter how risky their behavior.
5. According to the Natural Resources Defense Council, 55 percent of all U. S. rangelands are in poor or very poor condition and another 30 percent are in only fair condition. The grazing fees charged for use of public lands bring in only about one-quarter of the costs of administering and maintaining those lands. This doesn't take into account the costs of wildlife impacts, soil erosion, and water management. Thus, critics of the grazing program charge that it represents a massive hidden subsidy.
6. Rotational grazing involves confining animals so they graze a particular area thoroughly and then moving them to a new area on a regular basis. It is much like the grazing patterns of bison on the American plains or gnu on the African steppe.
7. For many species, survival can depend on preserve size, shape, and design. Protecting critical habitat and linking areas with travel corridors is essential. Some species only prosper in core (or deep interior) areas. Edges (boundaries between different habitats) are favored by some species but avoided by others. Small, highly convoluted areas have a relatively large amount of edge. Large, compact areas have more interior core.
8. About 11.6 percent of the world's land area is in some sort of protected status. Over the past half century, this area has increased nearly 20-fold.
9. Ecotourism is ecologically and socially sustainable tourism. It pays attention to environmental and cultural impacts and tries to reduce them as much as possible.
10. A biosphere reserve includes local or indigenous people in its design. A central core region is limited to scientific research, while a buffer zone allows ecotourism and research facilities, and a multiuse peripheral zone can have permanent habitation and sustainable resource harvesting. Most wilderness areas lack buffer or peripheral zones, while most wildlife refuges lack a true core area.

Chapter 7

1. Brazil's Cerrado is a huge savanna (grasslands and scattered trees) in the center of the country. It is being rapidly converted to cropland to grow soybeans, corn, cotton and other cash crops.
2. Brazilian soybeans are being eaten directly by Chinese people as tofu and other soy products. More importantly, it is being fed to livestock to satisfy the growing demand for meat in China.
3. Chronic undernourishment means a diet that doesn't provide the 2,200 kcal per day, on average, considered necessary for a healthy, productive life. About 850 million people worldwide are currently considered chronically undernourished.
4. Food security is the ability to obtain sufficient food on a day-to-day basis. In some countries nearly everyone has food insecurities. In other places, while the average food availability may be satisfactory, some individual communities, or particular families, or

individuals within families may not have enough to eat. Women and children are most likely to suffer from food insecurity.

5. Famines are large-scale food shortages that result in massive starvation, social disruption, and economic chaos. Although natural disasters usually trigger famine, Amartya Sen says that these factors have been around for a long time, and that people have coping mechanisms if they aren't thwarted by inept or corrupt governments and greedy elites. He presents several cases where equally bad weather occurred in neighboring countries. One of these countries had a famine, while the other did not. The difference between these countries, he says, is in economics, politics, and freedom of the press.
6. Malnutrition is an imbalance caused by lack of specific dietary components or an inability to absorb or utilize essential nutrients. Obesity is generally considered to be a body mass greater than 30 Kg/m^2, or roughly 30 pounds above normal for your height and age. Nearly two-thirds of Americans are considered overweight, and half of those people (one-third of the total population) are considered obese.
7. Wheat, rice, and maize (corn) provide about 60 percent of the calories eaten directly by humans, and an even larger fraction if you consider the amount of these grains fed to domestic animals, which are then eaten by humans.
8. Concentrated (or confined) animal feeding operations are facilities, such as feedlots or huge barns containing hundreds of thousands of animals while they are prepared for market. These complexes quite often cause serious air and water pollution, and disposal of the huge quantities of manure they produce can be a severe problem.
9. Soil is a complex mixture of weathered mineral materials from rocks, partially decomposed organic molecules, and a host of living organisms. Without living organisms, the earth would be covered with sterile mineral particles far different from the rich, living soil ecosystems on which we depend for most of our food. Soil organisms help create the structure, fertility and tilth of the soil.
10. It's estimated that 25 billion metric tons of soil are lost from croplands worldwide ever year as a result of wind and water erosion. This causes air and water pollution, crop production losses, siltation of reservoirs and harbors, smothering of wetlands and coral reefs, creation of dead zones in lakes and coastal regions, and clogging of water intakes.
11. The "green revolution" is the spread of new "miracle" crop varieties that produce much higher yields (given high amounts of fertilizer, water, and pest protection) than conventional varieties.
12. Genetic engineering involves using molecular techniques to move genes from one species to another. Entirely new genes can be created in the laboratory and implanted into species to create desired characteristics in transgenic organisms or genetically modified organisms. (GMOs). These techniques can reduce pesticide use and increase yields, but there are fears that it could also create superweeds or superbugs that would ultimately undermine agriculture.
13. Sustainable agriculture aims to produce food and fiber on a sustainable basis and to repair the damage caused by destructive practices. This means using renewable energy and water supplies, regenerating more soil than is lost, using crop species and cultivation techniques that leave the soil and surrounding ecosystem in at least as good a condition as before farming started.
14. Buying shade-grown, fair-trade, organic coffee or cocoa helps preserve forests because sun-grown coffee wears out the soil, requires more pesticides, doesn't provide habitat for

birds and other forest wildlife. Purchasing fair trade products ensures a livable wage to workers, helps shore up rural economies, and makes it possible to continue to operate small local plantations rather than to clear new areas of primary forest for sun-grown plantations.

15. Low-input farms often have lower total yields than their conventional neighbors, but because they have lower costs for fuel, water, fertilizer, and pesticides, they may have a higher net yield. They may be healthier and more satisfying for farm families, preserve soil, protect water quality, and can make farming sustainable on a long-term basis. Because their crops and animals are often organic, free-range, and raised under humane conditions, they may bring higher prices in the market, increasing the economic advantage over conventional farming.

Chapter 8

1. The WHO defines health as a state of complete physical, mental, and social well-being, not merely the absence of disease or infirmity. Disease is an abnormal change in the body's condition that impairs important physical or psychological functions.
2. Pneumonia, diarrhea, TB, measles, and Malaria were among the worst infectious diseases of the past. The world is now undergoing a dramatic epidemiological transition. Chronic conditions, such cardiovascular disease and cancer, no longer afflict only wealthy people. Diseases such as heart disease, depression, traffic accidents, stroke, and chronic lung disease that once were thought to occur only in rich countries are rapidly becoming the leading causes of disability and premature death everywhere and will probably be the leading cause of disability and disease burden by 2050.
3. Emergent diseases are those never known before or that have been absent for at least 20 years. Examples include SARS, AIDS, West Nile Virus, and Ebola.
4. Conservation medicine combines ecology with health care. It studies emergent diseases among plants and wildlife and also considers the relation between human disease and wildlife.
5. Toxins are poisons that damage or kill living tissues. Even at low concentrations many toxins are dangerous. Hazardous substances are dangerous because they're flammable, explosive, acidic, caustic, irritants, or sensitizers. Most hazardous materials can be diluted, neutralized, or treated to make them less dangerous. All the substances listed in Table 8.2 are toxic. Formaldehyde is a sensitizer. Although not mentioned specifically, gasoline, dynamite, sulfuric acid and lye also are examples of hazardous materials.
6. Endocrine disrupters are chemicals that disturb the function of normal endocrine hormone functions. They often interfere with normal growth, development, and physiology of a variety of animals. Some examples are pesticides, dioxins, and polycholorinated biphynels.
7. Bioaccumulation is the uptake and storage of toxins from the environment by living organisms. Biomagnification is the concentration of toxins through food chains. Organisms at the bottom of the food chain often have relatively low levels of toxins, but each higher trophic level tends to have about a ten-fold higher concentration because predators eat a large number of prey.
8. Atrazine is of special concern because so much is used as a herbicide on field crops (mainly corn), it is water soluble and persistent in the environment, and it disrupts endocrine hormone function in laboratory animals at extremely low levels.

9. An LD50 is an exposure at which 50 percent of a population of experimental organisms die.
10. Acute toxic effects are caused by a single exposure to the toxin and result in an immediate health crisis. Chronic effects are long lasting, perhaps even permanent. They may be caused by a single dose or by repeated sublethal exposures

Chapter 9

1. Pacala and Socolow's "stabilization wedges" are actions that each would reduce global CO2 emissions by 1 billion tons over 50 years. We need to implement 8 of these wedges (or their equivalents) to stabilize our climate.
2. The greenhouse effect results from the relative transparency of the atmosphere to visible light and its relative opacity to long-wave infrared radiation. Incoming solar radiation passes through the air and is absorbed by the earth's surface. Heat re-radiates back toward space as infrared radiation, it is then absorbed or reflected by greenhouse gases in the air, keeping the surface of the earth would be much colder than it is now.
3. We're worried about the greenhouse effect because we're adding excess heat-absorbing gasses to the atmosphere and warming the global climate. There could be catastrophic ecological, economic, and political effects if we continue to do this.
4. The thermohaline ocean conveyor is a system of global ocean currents by which warm, surface water moves from equatorial regions towards the poles. As this warm water evaporates and cools in polar regions, it becomes more salty and dense. It sinks to the ocean bottom, where it moves back toward the equator. This system redistributes enormous amounts of heat around the globe. Global warming appears to be disrupting this system. The deep return currents have slowed down in recent years. If this continues, it will bring disastrous climate changes to places like northern Europe.
5. . ENSO stands for the El Nino/Southern Oscillation, a periodic movement of a large pool of warm water every few years from the western Pacific eastward toward Tahiti. Trade winds, which normally blow westward across the Pacific die, and a upwelling of cold, deep water off the coast of South America is blocked during these El Nino events. Normal conditions are termed La Nina. The Pacific Decadal Oscillation (PDO) involves a long term (decades) movement of warmer and cooler water north to south in the Pacific.
6. CO2 makes the largest contribution to global warming. The largest source of anthropogenic CO2 is from burning fossil fuels (coal, oil, natural gas). The largest total CO2 emissions now come from China.
7. Between 1970 and 1998, atmospheric lead concentrations in the U.S. fell 98 percent. This is often considered the greatest air pollution control success in the U. S. Reductions in chloroflurocarbon (CFC) emissions following the Montreal Protocol is probably the greatest global success story.
8. Primary air pollutants are those released directly from the source into the air in a harmful form. Secondary air pollutants are modified to a hazardous form after they enter the air or are formed by chemical reactions as components of the air mix and interact. Photochemical oxidants are secondary pollutants created by interaction of sunlight and chemicals in the air. Point sources are specific origins for pollution, such as smokestacks. Fugitive emissions are diverse sources, such as dust storms or exhaust fumes from vehicles.

9. CFCs and other chlorine sources are destroying stratospheric ozone particularly in the Antarctic, where air temperatures are low enough during the winter to form ice crystals in the stratosphere, where they act as a catalyst for the ozone-destroying reactions. There is some stratospheric ozone loss in the Arctic as well.
10. The new source review was adopted in 1977, because industry argued that it would be intolerably expensive to install new pollution control equipment on old power plants and factories that were about to close down anyway. Congress agreed to "grandfather" or exempt existing equipment from new pollution limits with the stipulation that when they were upgraded or replaced, more stringent rules would apply. The result was that owners kept old facilities operating precisely because they were exempt from pollution control. In fact, corporations poured millions into aging power plants and factories, expanding their capacity rather than building new ones. A quarter of a century later, most of those grandfathered plants are still going strong and continue to be among the biggest contributors to smog and acid rain. President Bush says that determining which facilities are new and which are not represents a cumbersome and unreasonable imposition on industries and therefore ordered the EPA to abandon this program. Environmentalists argue that this decision will allow millions of pollutants to be emitted into our air and that owner's of old facilities are being allowed to buy political influence rather than clean up their effluents.

Chapter 10

1. Water evaporates from the ocean surface; if it doesn't fall back into the ocean, winds or convection currents carry it over the land. When it cools, t eh water condenses and falls as rain, snow, or fog. Water may run overland into streams and lakes, from which it eventually returns to the ocean, or it may seep into soil water or ground water, then return to the surface in streams or springs. Groundwater can have a residence times of thousands of years, however, before it leaves its rock formations.
2. Less than 1 percent of fresh water, and less than 0.02 percent of all water, is liquid, fresh surface water.
3. An aquifer is a water-bearing rock formation; water is stored in pores or cracks within the rocks. Water enters an aquifer in a *recharge zone*, someplace where permeable layers are near the surface. Water is usually held in an aquifer by aquicludes, impermeable layers that keep water in the permeable formation. Water pressure in an aquifer can create an *artesian well*, a well or spring that flows without pumping from water pressure. When water is extracted from an aquifer faster than it recharges, the pressure surface of the water dips around the well, creating a cone of depression
4. Withdrawal is the amount of water taken from a water body or aquifer. Consumption is the fraction of withdrawal that is lost to evaporation, absorption, chemical transformation, or otherwise made unavailable. Agricultural irrigation is by far the greatest water user. All sectors have increased withdrawal in the past century, but domestic and agricultural consumption has not increased substantially. Thus they have become more efficient. In agriculture, however, consumption has increased with withdrawal
5. Examples of water diversion include the Aral Sea, which has declined drastically as water was diverted to cotton and rice farms in arid Kazakhstan and Uzbekistan; and the Klamath River basin, where Oregon and California water users have waged highly politicized battles over water rights. Many other examples exist.

6. Point source pollution enters waterways at a localized point such as a pipe outfall. Nonpoint-source pollution is diffuse and enters waterways in large areas, for example, runoff from farm fields and streets. Such diffuse sources are extremely hard to control. In comprison, point sources are easier to control because we can usually locate the owner of an effluent pipe.
7. Nutrients are pollutants because they destabilize aquatic systems by fertilizing plant growth. Overabundant plants die and decompose, and decomposing bacteria use up available oxygen, which kills fish and aquatic invertebrates. This process of rapid plant growth leading to oxygen depletion is known as eutrophication. An oxygen sag occurs immediately downstream of a concentrated nutrient source, such as a contaminated effluent pipe. Nutrient enrichment supports a bloom of algae and other plants. An immediate rise in biochemical oxygen demand (ability to use up oxygen) occurs, as decomposers consume dying plant matter. With high demand the amount of saturated oxygen in the water falls rapidly ("sags" in a graph of oxygen levels). Some distance downstream, mixing and aeration increase oxygen availability, and the concentration of decomposers declines.
8. Primary treatment involves physically separating large solids from the wastewater using screens and settling tanks. Secondary treatment involves aeration, to allow bacteria to decompose organic compounds, settling to remove sludge, and usually disinfection with chlorine or UV light. Tertiary treatment uses filters and/or settling ponds to oxidize any remaining organics and to remove inorganic nutrients. Evaporation often reduces effluent volume.
9. Groundwater contamination sources include any contaminants that lie in recharge zones or near wells that reach into aquifers. Industrial, agricultural, and mining waste, household septic systems, and leaking underground fuel tanks are among the major pollution sources. Groundwater tends to be hard to access, so cleaning it is prohibitively expensive. Because it often resides in aquifers for many years, natural processes remove or dilute contamination extremely slowly.
10. A "Living Machine" is one type of natural wastewater treatment system. Natural wastewater treatment involves using plants and bacteria to capture nutrients and decontaminate water, rather than using chlorine and traditional sewage treatment systems. Several stages are involved, including anaerobic digestion, aerobic digestion, aeration, and vegetation beds.

Chapter 11

1. Ocean basins develop and expand as tectonic plates split apart. Most splitting happens in the relatively thin and plastic oceanic crust. Along the separating (diverging) plate margins, hot magma escapes, creating mid-ocean ridges. Where oceanic crust collides with continental crust, the lighter continental crust rides over the oceanic crust, forcing the oceanic crust to dive, sometimes steeply, toward the mantle. Heating causes the subsiding crust to melt and become relatively buoyant. Along subsidence zones, molten magma periodically bursts through the continental crust, forming volcanoes.
2. The ring of fire describes the string of volcanoes that mark subduction zones on the margins of most of the Pacific Ocean. As the Pacific spreads outward, its floor collides with surrounding continents, creating many active volcanoes.

3. The rock cycle describes the transformation of rocks from one to another of the three main classes of rocks, igneous, metamorphic, and sedimentary. Heat and pressure recrystallize minerals in sedimentary and igneous rock to produce metamorphic rocks. Weathering and erosion create sediment from metamorphic and igneous rock, which accumulates and hardens to produce sedimentary rock. (Limestone, however, is a sedimentary rock that develops from organic material, rather than from eroded mineral rocks.) Melting along subduction zones can produce igneous rock from either of the other types.
4. Metals are malleable elements, whose relative lightness and strength makes them extremely important. Non-metal mineral resources are all other resources, including sand, gravel, salts, limestone, and many other substances.
5. A mineral is a naturally occurring, inorganic solid with a specific chemical composition and a specific internal crystal structure. A rock is composed of aggregated minerals. Pure metals have no specific crystal structure, so they are not minerals.
6. The single largest producers are as follows: aluminum: Australia; nickel: Russia; iron ore: China; zinc: Canada; copper: China; mercury: China; lead: Australia; tin: China.
7. There are many examples of damage to water and air from mineral extraction. Water is used to wash ores, chemicals such as mercury and cyanide are mixed with water to separate metals from ores, acidic runoff from ore-bearing bedrock, or from sulfur-bearing coal mines, runs off and contaminates waterways. Air is contaminated by dust, by airborne emissions from smelting and processing, and by volatile chemicals used in processing.
8. Underground mining involves digging tunnels to reach seams. Because it is often dangerous to workers, it is less common today than it was historically. Open-pit mines dig deep pits to recover metal ores. For flat-lying deposits such as coal beds in the American West, strip mining is most common: upper layers ("overburden") are removed from large areas to expose expansive, flat layers of coal or other resources. Mountain-top removal is a recent development mainly used in Appalachian coal mining. Mountain ridges are scraped off, and the overburden is dumped aside, often in valleys, where it fills streams and occasionally collapses catastrophically.
9. Recycling saves energy, since re-melting materials takes much less energy than processing raw ore. Recycling also saves water, land, air pollution, scenery, and money.
10. Volcanoes produce deadly clouds of hot gases called nuees ardentes, as well as blankets of ash, catastrophic mudslides, and air pollution such as sulfuric acid.
11. Mass wasting is the scientific term for landslides, soil slumping, beach erosion, gully development, and other forms of downward soil movement.
12. Building on barrier islands is risky because these low-lying lands are frequently exposed to storms, waves, and erosion that can strip away miles of beach overnight. Furthermore, building often destroys vegetation that holds dunes in place, further exacerbating the danger of storm damage.
13. Floodplains are areas near rivers, lakes, or seashores that are frequently inundated. Many cities were built on floodplains and shorelines, where they were accessible to water and transportation. Furthermore, people often prefer homes and vacation cabins on floodplains because they want to be near water views and recreational opportunities. When the inevitable floods come, however, residents expect to be rescued and to receive public assistance to rebuild their homes. Others who have chosen to live in safer places

may believe that homes, businesses, and urban infrastructure should never have been built on the floodplain in the first place.

14. Mechanical weathering is the physical breakup of rocks into small particles by forces such as freezing and thawing. It doesn't result in a change in the chemical composition of the material. Chemical weathering is the selective removal or alteration of specific components that leads to weakening and disintegration of rock by processes such as oxidation or hydrolysis. Both of these processes break rocks down and contribute to the rock cycle.
15. The Precambrian era is characterized by single-celled plants and animals. Paleozoic strata contain crustaceans, fish, and the first reptiles. The Cenozoic contains mammals, including humans.

Chapter 12

1. Rizhao is in Shandong Province in eastern China. Solar water heaters provide nearly all water heating and space heating.
2. Energy is the capacity to do work. Power is the rate of doing work.
3. Oil provides 37% of all commercial energy. Coal supplies 26%. Gas contributes 24%. Nuclear and hydropower are each about 6%, and wind and other renewables are only about 1% of our supply.
4. Each person in the U.S., on average, consumes about 100 times as much energy as residents of very poor countries, such as Ethiopia, Nepal, or Bhutan. On the other hand, the U.S. consumes far less energy per person than oil rich countries such as Qatar. More importantly, the U.S. consumes about twice as much energy per capita than Denmark, France, or Japan, all of which have standards of living that are equal to or better than the U.S.
5. Mining and burning all the coal available would have disastrous social and environmental effects, chief among which is global warming caused by releasing all that CO_2.
6. The Middle East has nearly two-thirds of all known oil reserves. The proven reserves of liquid oil will last only about 40 years at current consumption rates.
7. Tar sands and oil shales are deposits of tar or kerogen in sand or rock. Canadian tar sands might produce as much oil as Saudi Arabia. American oil shales might contain more oil than all the known liquid oil deposits put together. Extracting oil from tar sands and oil shales could cause more air and water pollution and destroy more land than mining coal. They certainly would release huge amounts of CO_2.
8. The nuclear wastes from commercial power plants are being stored in pools of water inside the plants or in dry casks outside.
9. Passive solar systems use material or structures with no moving parts to absorb and store heat. Active systems use moving parts to absorb, store, or move heat around.
10. A photovoltaic cell captures solar energy and converts it directly into electrical current by separating electrons from their parent atoms and accelerating them across a one-way electrostatic barrier formed by the junction between two different types of semiconductor material.

Chapter 13

1. Construction and demolition waste can be ground, crushed, and sorted to produce a variety of materials, including compost, soil, biosolids for conversion to synthetic gas, recyclable glass and metals, and crushed aggregate for new construction projects.
2. Solid waste includes agricultural wastes such as crop residues and animal manure; industrial wastes including mine tailings, strip mine overburden, and metal slag; and municipal waste, which includes domestic and commercial refuse. Altogether, the U.S. produces some 11 billion tons of solid waste per year. Hazardous waste is a special category regulated by the EPA. It includes any discarded material, liquid or solid, that contains substances known to be fatal to humans or laboratory animals in low doses; toxic, carcinogenic, mutagenic, or teratogenic to humans or other life-forms; ignitable with a flash point less than 60^{o}C; corrosive, explosive, or highly reactive.
3. In an open dump, garbage is simply dumped in a pile on the ground. In a sanitary landfill, garbage is compacted and covered every day with a layer of dirt to exclude vermin, fires, and insects. In a modern, secure landfill, the pit is lined (top and bottom) with a thick cushion of clay and an impermeable plastic liner. Leachate standpipes are installed for removal of any water that leaks into the pit; methane pipes collect methane generated by decomposing garbage. Testing wells around and below the landfill monitor groundwater for evidence of leakage
4. Incinerating garbage in a safe and environmentally sustainable manner is difficult and expensive. Because most municipal waste contains a wide variety of materials, toxic metals, and carcinogenic chemicals or endocrine system disrupters are often emitted from incinerators. Because incinerators make most economic sense in the city center close to both generators of trash and markets for waste heat and electricity, these facilities often are close to large population centers and more people are potentially exposed to their effluents.
5. Recycling is beneficial in that it reduces the amount of waste needing disposal. It also reduces the demand for new material that must be produced by logging, mining, smelting, etc. Recycling generally consumes much less energy that it takes to produce materials in the first place. Recycling also provides more jobs and uses less space than does simply dumping our trash. One of the biggest problems in recycling is finding a use for materials that may not be pristine. Even a small amount of contamination in plastic, for example, can make it unsuitable for most uses. The spread of diseases through recycled materials is also a concern. It's also possible that an overemphasis on recycling may discourage people from using less stuff in the first place.
6. E-waste is electronic equipment, such as computers, televisions, and cell phones. E-waste contains myriad mixed and toxic compounds and metals. About 80 percent of U.S. e-waste is shipped overseas, mainly to developing countries, where it is demanufactured, often at great risk to workers and the local environment. Strategies for improving recycling rates include up-front charges when electronics are purchased (as in California, most of Europe, and Japan), or billing manufacturers at the time of disposal (as in Maine).
7. Composting is biological degradation or breakdown of organic matter under aerobic (oxygen-rich) conditions. The organic matter resulting from this process makes a nutrient-rich soil amendment that aids water retention, slows soil erosion, and improves crop yields. Composting can be done on a small scale in your backyard or in mammoth municipal facilities.

8. The most often recycled materials in the U. S. are, in order: Auto batteries, steel cans, yard trimmings, paper and paperboard, aluminum beer and soft drink cans, tires, plastic milk and water bottles, plastic soft drink bottles, and glass containers (fig 13.12).
9. Brownfields are properties that have been abandoned or are not being used up their potential because of real or suspected pollution. Cities want to redevelop them to create jobs, increase the tax base, and prevent needless destruction of open space.
10. Bioremediation is biological waste treatment. It involves using plants, bacteria, fungi, or other organism to absorb, accumulate, or detoxify toxic or hazardous substances. Phytoremediation is bioremediation using plants (phyto = plants). Often plants whose roots naturally extract trace minerals from the soil work well in phytoremediation. Plant material must often be land filled. Advantages of this method are that it is usually less expensive than other treatments, and it greatly reduces the amount of material that must be land filled.

Chapter 14

1. More than half the world's population, or about 3.25 billion people, lives in urban areas.
2. In 1900, only 13 cities had more than 1 million residents; now at least 300 do.
3. People move to urban areas because they are pushed out of rural areas when mechanization eliminates jobs, and they are pulled into the city by opportunities for jobs, housing, entertainment, and freedom.
4. Slums are legal but inadequate multifamily tenements or rooming houses usually built near the center of a city. Shantytowns are illegal settlements of shacks or huts built on empty land, which often is on city outskirts.
5. Sprawl is unlimited outward expansion of a city in low-density development on former farmland or open space. Sprawl usually incorporates many small governmental units with no centralized planning or zoning authority, and is dependent on freeways and private automobiles. Shopping is provided by strip malls and big-box retailers with lots of parking. It usually results in abandonment and decay of existing city centers.
6. Energy flows into and cities and is degraded and dispersed as it is used to do work. Waste energy (in the form of heat) radiates away from the city. Materials are used to create structures. Inhabitants compete for shelter, food, habitat, and other resources. Some materials are recycled and reused, others are deposited in sediments or removed from the area. A keystone species (us) determines to a large extent how and where other organisms live.
7. Smart growth makes effective use of land and existing infrastructure by encouraging in-fill development. It provides a variety of transportation choices, and respects local culture and natural features. It protects environmental quality, productive farmland, biodiversity, and open space, while seeking ecological sustainability, social justice, and sound economics.
8. A green roof grows grass, flowers, shrubs, or even trees on urban rooftops to cool buildings, improve air quality, reduce storm runoff, and beautify the city.
9. Vauban is noted as a car-free suburb: the town has bike routes and public transportation and limits car access. Residential and retail spaces are mixed, so that people don't need to travel far for shopping. The town also provides efficient, low-energy homes, many of which are so well insulated they don't need to pay for heating at all.

10. Sustainable development often is described as meeting the needs of the present without compromising the ability of future generations to meet their own needs.
11. Neoclassical economics assumes that growth is necessary for prosperity and that natural resources are necessary for growth but are interchangeable or substitutable. Ecological economics argues that natural resources and ecological services are essential and irreplaceable. We need to emulate nature where one species waste is another's food and the cycle of materials produces a steady-state system in which unlimited growth is impossible.
12. The total value of all the world's ecological services is estimated to be $33 trillion per year or about twice the world GNP.
13. The supply of non-renewable resources, such as metals, is finite. We can't create new supplies, but we can extend their use nearly indefinitely by recycling. Biological resources, on the other hand, continually reproduce themselves, but if we overharvest them or eliminate their habitat, can be driven into extinction, from which they will never recover.
14. Fig. 14.22 shows a trade-off between marginal social costs and benefits as increasing levels of pollution control are applied. When there are few pollution controls (far left of graph) a small investment in pollution abatement brings high social benefits. With increasing levels of control, however, costs rise while the marginal benefit falls. Eventually, you reach a point (P_o) beyond which the marginal costs exceed the marginal benefits.
15. In open access, there are no rules to manage resource use. In communal management there are rules on who, how, and when a resource can be used. Open access leads to a tragedy of the commons. Communal management can be sustainable over centuries of use.
16. GPI takes into account real per capita income, quality of life, distributional equity, natural resource depletion, environmental damage, and the value of unpaid labor. It produces a very different picture than traditional GNP or GDP.
17. Microlending is making small loans to poor people to help them establish a craft or business.

Chapter 15

1. A policy is a rule or decision about how to act or deal with problems. There are personal, public, and international policies. Policies could be created simply by personal preference or inaction. Public policy usually follows an established process known as the policy cycle in which a problem is identified, and agenda is set, proposals are developed, support is built, laws or rules are established, the policy is implemented, results are evaluated, and changes are suggested.
2. NEPA authorizes the Council on Environmental Quality (CEQ), directs federal agencies to take environmental consequences into account in decision-making, and requires environmental impact statements (EIS) for all major federal projects.
3. A list of major U.S. environmental laws and their provisions is presented in Table 15.1. Among the most important of these are the National Environmental Policy Act of 1969, the Clean Air Act of 1970, the Clean Water Act of 1972, the Coastal Zone Management Act of 1972, and the Endangered Species Act of 1973.

4. Unfortunately, many international environmental treaties and conventions constitute little more than vague, good intentions with no mechanism for enforcement. For example, the U.N convention on global climate change, at the insistence of U.S. negotiators, only *urges*—but does not require—nations to stabilize their release of greenhouse gases. By contrast, the 1987 Montreal Protocol on chlorofluorocarbons allowed a vote by two-thirds of the participating nations to amend the agreement. When it was shown that stratospheric ozone depletion was more serious than previously thought, an outright ban on CFC production was passed in spite of the objections of a few nations. Giving other treaties enforcement mechanisms and not insisting on consensus for passage could make them more effective.
5. The World Trade Organization was established to make international trade fairer and to encourage development, but it has been used more often to expand globalization and to weaken national environmental laws. Workers fear that this eliminates local jobs and threatens local economies.
6. The goals of the Environmental Education Act are (1) to improve understanding among the general public of the natural and built environment and the relationships between humans and their environment, including global aspects of environmental problems, and (2) to encourage postsecondary students to pursue careers related to the environment.
7. Citizen science is research in which ordinary people join with established scientists to answer real scientific questions. The Audubon Christmas Bird Count is a good example.
8. The What Can You Do? Box on p 367 suggests a number of ways to reduce your individual environmental impact including purchasing less, reducing excess packaging, avoiding disposable items, conserving energy, and saving water. There are many subcategories within each of these topics.
9. Students have organized to lobby for environmental laws and sustainable public policies. Schools have built energy efficient, "green" buildings. They also have installed wind mills and solar panels to generate electricity, and they have purchased water-saving appliances. Some schools feature local, fair-trade, organic food in cafeterias.
10. The most widely used definition of sustainable development is that from the World Commission on Environment and Development, which described it as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." The six goals of sustainable development include (1) a stable population size, (2) high efficiency energy use and a switch to renewable sources, (3) reliance on nature's income without depleting capital, (4) a broader sharing of wealth, (5) complementary interests between various world regions, (6) ethics that unite rather than separate us from other people or nature.

Answers to Practice Quizzes

Chapter 1

1. Apo Island's marine preserve allows fishing with hand-held lines, bamboo traps, large mesh nets, spear fishing without SCUBA gear, and hand netting. Fishing with dynamite, cyanide, trawling, and Muro-ami are forbidden. This has increased fish populations and made it easier to catch the fish needed to support a family. The healthy reef community now attracts ecotourists and provides jobs for islanders.
2. Science assumes that the world is knowable and that we can learn about it through careful observations. Some other principles of science are described in table 1.1.
3. A hypothesis is a testable, provisional explanation. A scientific theory is an explanation supported by a large body of empirical evidence and regarded by a majority of scientists as likely to be correct.
4. The scientific method involves 1) identifying a question, 2) forming a testable hypothesis, 3) collecting data, 4) interpreting results, 5) reporting results for peer review, 6) publishing findings. See figure 1.4.
5. Probability is a measure of how likely something is to occur. An example is flipping a coin. Each toss has a 50% probability of landing on a particular side.
6. By convention, we put the dependent variable on the vertical (Y) axis and the independent (or explanatory) variable on the horizontal (X) axis.
7. The first step in critical thinking is to ask, "What is the purpose of my thinking?"
8. Utilitarian conservation is pragmatic, efficient resource use for the greatest good for the greatest number for the longest time. Gifford Pinchott and Teddy Roosevelt were leaders in this movement. Biocentric preservation emphasizes the right of other organisms—and nature as a whole—to exist regardless of their usefulness to us. John Muir was a leading proponent of this philosophy.
9. Water is a critical resource because 1.1 billion people lack access to clean water, 15 million people die annually from diseases linked to polluted water or inadequate sanitation, and by 2025, the U.N. warns, three-quarters of all humans may live in water-stressed countries.
10. In figure 1.7, the most dramatic warming occurs at high latitudes, especially northern Canada, Siberia, and parts of the Arctic Ocean.
11. Marine reserves, such as Apo Island, are restoring fish populations; cities are cleaner and more livable; population growth has slowed or stabilized in most of the world; many infectious diseases are decreasing; food supplies have kept up with population growth; renewable energy is making progress; and information and technology for solving problems is spreading around the world at an ever increasing pace.
12. The poorest people are often both the victims and agents of environmental degradation. Forced to meet short-term survival needs at the cost of long-term sustainability, they suffer most from environmental damage because they have few other options.
13. Sustainability is a search for ecological stability and human progress that can last over the long term. Sustainable development is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."

Chapter 2

1. Three primary nutrients in fertilizers are nitrogen (N), phosphorus (P), and potassium (K).
2. Systems are networks of interactions among interdependent units or compartments as well as processes or flows that link those components. A positive feedback loop uses the output from a process to increase or enhance that process; in a negative feedback loop the output of a process to inhibit or reverse that process.
3. Carbon atoms, like all matter, are constantly cycled in living organisms. Given the huge number of carbon atoms in your body, it's almost certain that some of them were also part of some prehistoric organisms.
4. Water molecules are polar, which makes water a superb solvent. Water is the only inorganic liquid that exists at normal ambient temperatures. This provides a liquid medium for life processes. Water molecules are highly cohesive. This results in capillary action. Water expands when it crystallizes so that ice floats. Water has a high heat of vaporization, so we can remove a large amount of heat through evaporation. Water has a high specific heat, making it an ideal medium for storing heat and moderating the earth's temperature.
5. DNA (deoxyribonucleic acid) is a molecule made up of nucleotides (purines or pyrimidines coupled to phosphate and sugar molecules) linked together in long chains. The specific sequence of nucleotides in a DNA molecule carries the genetic information that codes for protein structure and gives each organism its unique heritable characteristics.
6. High-quality energy is intense, concentrated, high-temperature, and useful for work. Low-quality energy is diffused, dispersed, low temperature, and difficult to gather or use for productive work.
7. Materials always cycle in the biosphere because of the law of conservation of matter. Energy flows in a linear fashion because of the second law of thermodynamics, which says that in every energy exchange, some of the energy is converted from higher quality to lower quality. Thus, to keep living processes going, there has to be a constant energy input and a sink to which surplus waste energy can be dumped.
8. Our eyes are sensitive only to visible light (0.4 to 0.7 um), which happens to be the most common wavelengths in solar radiation. Short ultraviolet wavelengths (microwaves (10 nm or 10×10^{-9} m) are 1 million (1×10^{6}) times shorter than microwaves (1 mm or 1×10^{-3} m).
9. Extremophiles live in extreme conditions at the bottom of the ocean, in hot springs, or deep in the earth's crust. They get the energy they need to live by chemosynthesis: reactions that use chemicals, such as hydrogen sulfide or hydrogen gas as an energy source.
10. For most organisms on the earth's surface, the ultimate source of energy is the sun, and the sink for waste energy is outer space.
11. Green plants capture solar energy through photosynthesis, a series of chemical reactions that occur in chloroplasts. The energy captured in this process is used to create chemical bonds in organic molecules. These molecules serve both as an energy source and building material for all plants and animals.
12. A species is made of all the organisms of the same kind that are able to breed under natural conditions and produce live, fertile offspring. A population consists of all the

members of a species living in a given area at the same time. A biological community is made up of all the populations of different species living and interacting in a given area at a specific time.

13. Big, fierce animals (like grizzly bears, tigers, and great white sharks) are usually the top carnivores in their ecosystem. They need to be large and fierce to catch their prey. Because they are at the top of the ecological pyramid, it takes many organisms at lower trophic levels (and therefore, large home ranges) to support these big carnivores. Thus, there are never very many of them in a given area. Their adaptations as top predators make them dangerous to humans. They also often compete with us for food, so we tend to eliminate them either directly by hunting, or indirectly by reducing their food supplies or eliminating their habitat.
14. An example of an inverted ecological numbers pyramid might be a single large tree supporting many herbivorous insects, or a single coyote supporting many parasites.
15. Humans release about 7 GT of carbon annually compared to 100 GT released by respiration from land-based plants, animals, and microbes.

Cunningham 6e CRITICAL THINKING ANSWERS

Chapter 1

1. Apo Island's marine sanctuary fits the model for sustainable development because it involves objective scientific study of the success of a no-fishing zone, it provides income and jobs for local people, and it represents an equitable sharing of resources. If you were a scientist evaluating this project, you'd probably try to obtain objective data to support or refute each of these claims.
2. There are many existential questions, such as What is the meaning of life? Is there life after death? or Do we have a right to kill others? That science can't answer.
3. Keeping the identity of survey respondents secret from those who evaluate responses helps to maintain impartiality and objectivity. Still, if you believe, as many social scientists do, that there is no such thing as objective truth (other than the truth that there is no truth) in any field, then you probably believe that everything is socially constructed.
4. Are there enough resources? It depends on the patterns of production, consumption, and cooperation we adopt. It also depends on what you consider a decent, secure, happy life. As Paul Ehlich points out, the carrying capacity for saints might easily be 10 billion, but the number of selfish, wasteful, greedy, destructive individuals the world can tolerate is far lower. Some people believe that humans are perfectible and that we could all become saints. Others assume that most of us are unalterably flawed.
5. In studying the environmental impacts of a rich versus poor country, you ought to examine not only the local environment of each country, but also evaluate the impacts of extracting, shipping, and using resources from remote locations. In other words, what are the environmental impacts of wealthy lifestyles and political/economic systems on the countries that produce the goods and services they use?

Chapter 2

1. Obviously, the answer to this question depends on where you live. Are you familiar with the natural world around you? Have you considered both the biological community and the physical setting in describing your ecosystem? Are you defining only your immediate surroundings, or are you considering the wider world around you? Obviously, all ecosystems are open with regard to energy source (usually the sun), but what about other resources? Where does your water, air, food, building material, etc come from?
2. Did you think about rusting metal, machinery that wears out, water running down hill, death, or the impossibility of building a perpetual motion machine? Most of our disorganization is personal preference, but it does take energy to clean and organize, doesn't it?
3. If chemical bonds were extremely strong, everything would be solid and there would be no motion. If all chemical bonds were extremely week, no structures could exist. Life would be impossible in either case.
4. You'd need to find a way to measure the biomass weight of the different plants, animals, microbes (and the accumulated organic material they produce that's stored in sediments). For a very open system, you may need to devise a way to capture that leaves the system through rivers, air transport, or other ways that biomass escapes from the system.

5. Did you think of the carbon in wood, such as tree trunks? How about the carbon in soil or in living organisms? Which are the largest and longest lasting depends on where you live.