CHAPTER

4 Earth's Resources

CONCEPTS in Action

Application Lab
Finding the Product that Best Conserves Resources

Understanding Earth
Bingham Canyon, Utah: The Largest Open-Pit Copper Mine

Discovery Channel School **Video Field Trip**

PET Clothes

Take a field trip to a recycling facility with Discovery Channel and find out how plastic bottles can be turned into clothes you can actually wear. Answer the following questions after watching the video.

1. Approximately how many plastic bottles end up in landfills every year?
2. Name two ways that using PET bottles in manufacturing clothes can help preserve the environment.

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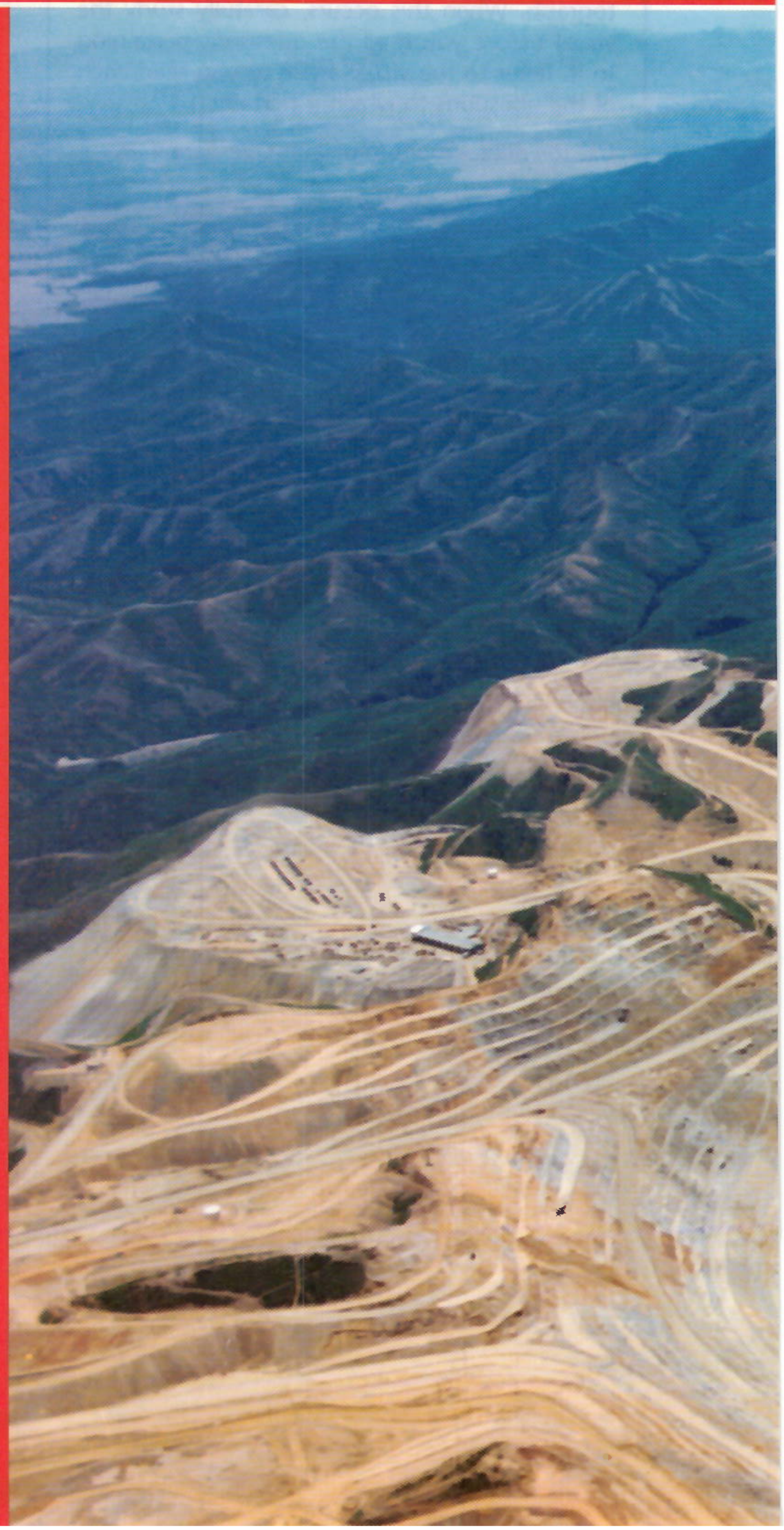
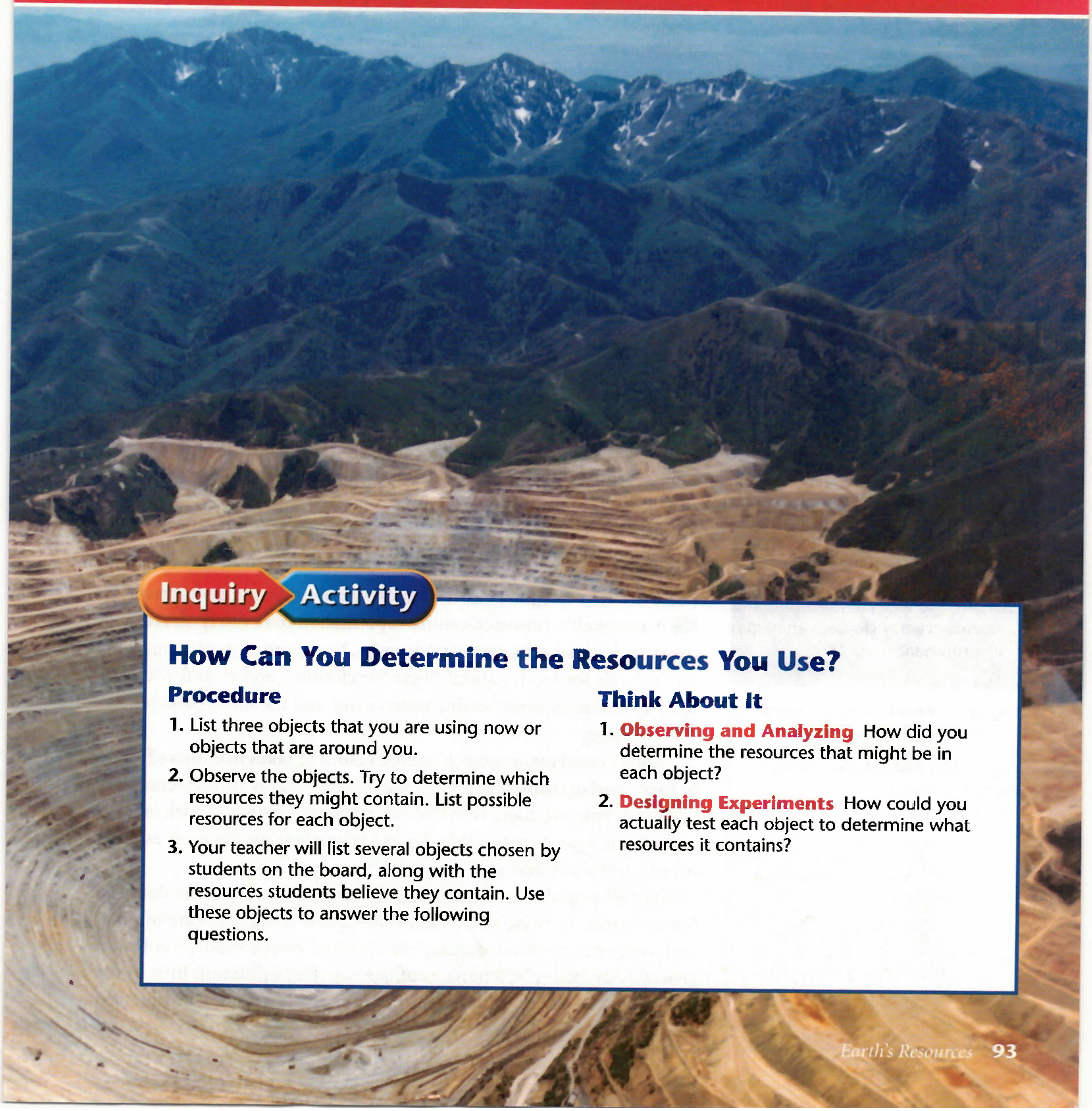


Once a mountain, this hole is now the ▶ world's largest open-pit mine.

Chapter Preview

4.1 Energy and Mineral Resources
4.2 Alternate Energy Resources
4.3 Water, Air, and Land Resources
4.4 Protecting Resources



Inquiry Activity

How Can You Determine the Resources You Use?

Procedure

1. List three objects that you are using now or objects that are around you.
2. Observe the objects. Try to determine which resources they might contain. List possible resources for each object.
3. Your teacher will list several objects chosen by students on the board, along with the resources students believe they contain. Use these objects to answer the following questions.

Think About It

1. **Observing and Analyzing** How did you determine the resources that might be in each object?
2. **Designing Experiments** How could you actually test each object to determine what resources it contains?

4.1 Energy and Mineral Resources

Reading Focus

Key Concepts

- What is the difference between renewable and nonrenewable resources?
- Which energy resources are fossil fuels?
- Which energy resources might replace dwindling petroleum supplies in the future?
- What processes concentrate minerals into deposits sufficiently large enough to mine?
- How are nonmetallic mineral resources used?

Vocabulary

- renewable resource
- nonrenewable resource
- fossil fuel
- ore

Reading Strategy

Monitoring Your Understanding Copy this table onto a separate piece of paper before you read this section. List what you know about energy and mineral resources in the first column and what you'd like to know in the second column. After you read, list what you have learned in the last column.

Energy and Mineral Resources		
What I Know	What I Would Like to Know	What I Learned
a. ___?___	c. ___?___	e. ___?___
b. ___?___	d. ___?___	f. ___?___

Figure 1 Mineral resources went into the construction of every building in this New York skyline. Energy resources keep the lights on, too.

Mineral and energy resources are the raw materials for most of the things we use. Mineral resources are used to produce everything from cars to computers to basketballs. Energy resources warm your home, fuel the family car, and light the skyline in Figure 1.

Renewable and Nonrenewable Resources

There are two categories of resources—renewable and nonrenewable. **A renewable resource can be replenished over fairly short time spans such as months, years, or decades.** Common examples are plants and animals for food, natural fibers for clothing, and trees for lumber and paper. Energy from flowing water, wind, and the sun are also renewable resources.

By contrast, a nonrenewable resource takes millions of years to form and accumulate. When the present supply of nonrenewable resources run out, there won't be any more. Fuels such as coal, oil, and natural gas are nonrenewable. So are important metals such as iron, copper, uranium, and gold.

Earth's population is growing fast which increases the demand for resources. Because of a rising standard of living, the rate of mineral and energy resource use has climbed faster than population growth. For example, 6 percent of the world's population lives in the United States, yet we use 30 percent of the world's annual production

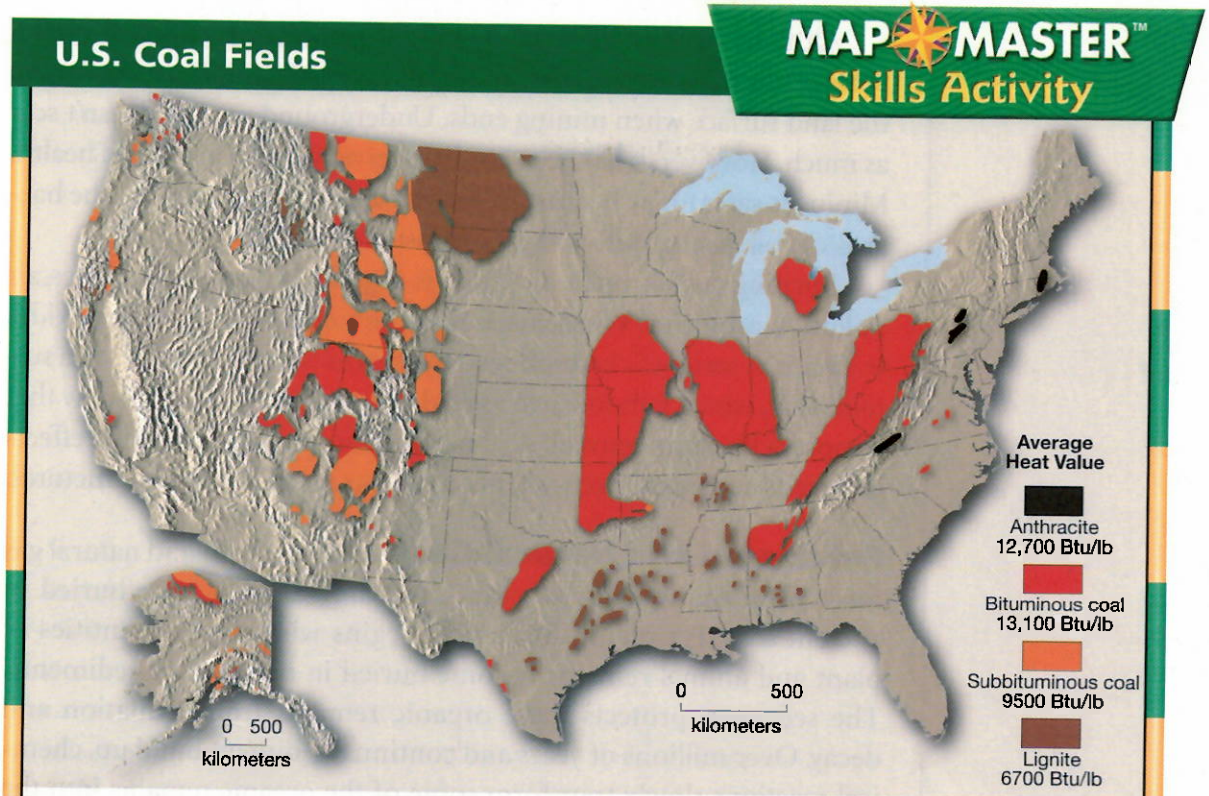


Figure 2

Location This map shows the location of major coal deposits in the United States. **Identify** Which type of coal is most plentiful? **Locate** Where are the anthracite deposits in the U.S. located?

of mineral and energy resources. How long can existing resources provide for the needs of a growing population?

Fossil Fuels

Nearly 90 percent of the energy used in the United States comes from fossil fuels. A **fossil fuel** is any hydrocarbon that may be used as a source of energy. **Fossil fuels include coal, oil, and natural gas.**

Coal Coal forms when heat and pressure transform plant material over millions of years. Coal passes through four stages of development. The first stage, peat, is partially decayed plant material that sometimes look like soil. Peat then becomes lignite, which is a sedimentary rock that is often called brown coal. Continued heat and pressure transforms lignite into bituminous coal, or soft coal. Bituminous coal is another sedimentary rock. Coal's last stage of development is a metamorphic rock called anthracite or hard coal. As coal develops from peat to bituminous, it becomes harder and releases more heat when burned.

Power plants primarily use coal to generate electricity. In fact, electric power plants use more than 70 percent of the coal mined today. The world has enormous coal reserves. Figure 2 shows coal fields in the United States.

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Although coal is plentiful, its recovery and use present problems. Surface mining scars the land. Today, all U.S. surface mines must restore the land surface when mining ends. Underground mining doesn't scar as much. However, it has been costly in terms of human life and health. Mining is safer today because of federal safety regulations. Yet, the hazards of collapsing roofs and gas explosions remain.

Burning coal—much of which is high in sulfur—also creates air pollution problems. When coal burns, the sulfur becomes sulfur oxides in the air. A series of chemical reactions turns the sulfur oxides into sulfuric acid, which falls to Earth as acid precipitation—rain or snow that is more acidic than normal. Acid precipitation can have harmful effects on forests and aquatic ecosystems, as well as metal and stone structures.

Petroleum and Natural Gas Petroleum (oil) and natural gas form from the remains of plants and animals that were buried in ancient seas. Petroleum formation begins when large quantities of plant and animal remains become buried in ocean-floor sediments. The sediment protects these organic remains from oxidation and decay. Over millions of years and continual sediment build up, chemical reactions slowly transform some of the organic remains into the liquid and gaseous hydrocarbons we call petroleum and natural gas.

These materials are gradually squeezed from the compacting, mud-rich sediment layers. The oil and gas then move into nearby permeable beds such as sandstone. The oil and gas are squeezed out of the sedimentary rock layers along with water. However, oil and natural gas are less dense than water, so they migrate upward through the water-filled spaces of the enclosing rocks. If nothing stops this migration, the fluids will eventually reach the surface.

Sometimes an oil trap—a geologic structure that allows large amounts of fluids to accumulate—stops upward movement of oil and gas. Several geologic structures may act as oil traps, but all have two things in common. First, an oil trap has a permeable reservoir rock that allows oil and gas to collect in large quantities. Second, an oil trap has a cap rock that is nearly impenetrable and so keeps the oil and gas from escaping to the surface. One structure that acts as an oil trap is an anticline. An anticline is an uparched series of sedimentary rock layers, as shown in Figure 3.

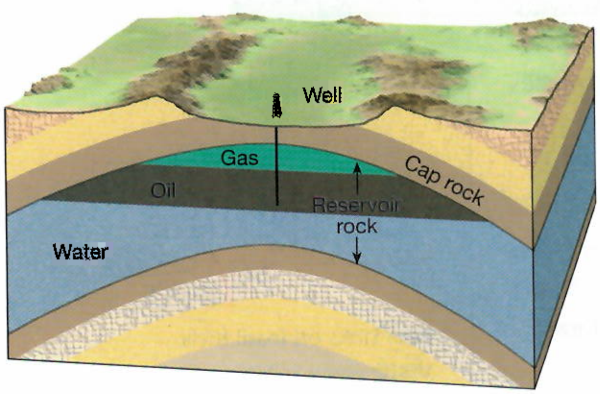

Figure 3 Anticlines are common oil traps. The reservoir rock contains water, oil, and gas. The fluids collect at the top of the arch with less dense oil and gas on top.
Interpreting Diagrams ***Why is the water located beneath the oil and gas?***

When a drill punctures the cap rock, pressure is released, and the oil and gas move toward the drill hole. Then a pump lifts the petroleum out.

Reading Checkpoint ***What two features must an oil trap have?***

Tar Sands and Oil Shale

In the years to come, world petroleum supplies will dwindle. **Some energy experts believe that fuels derived from tar sands and oil shales could become good substitutes for dwindling petroleum supplies.**

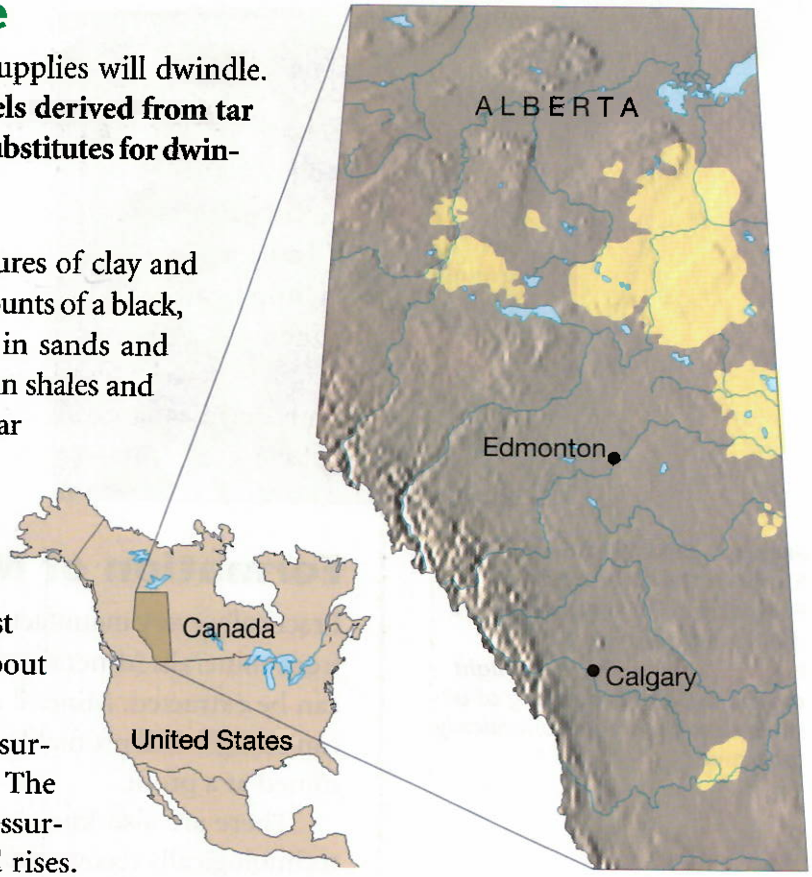

Figure 4 Tar Sand Deposits In North America, the largest tar sand deposits occur in the Canadian province of Alberta. They contain an estimated reserve of 35 billion barrels of oil.

Tar Sands

Tar sands are usually mixtures of clay and sand combined with water and varying amounts of a black, thick tar called bitumen. Deposits occur in sands and sandstones, as the name suggests, but also in shales and limestones. The oil in these deposits is similar to heavy crude oils pumped from wells. The oil in tar sands, however, is much more resistant to flow and cannot be pumped out easily. The Canadian province of Alberta (Figure 4) has the largest tar sand deposits, which accounts for about 15 percent of Canada's oil production.

Currently, tar sands are mined at the surface, much like the strip mining of coal. The excavated material is then heated with pressurized steam until the bitumen softens and rises. The material is processed to remove impurities, add hydrogen, and refine into oil. However, extracting and refining tar sand requires a lot of energy—nearly half as much as the end product yields.

Obtaining oil from tar sand has significant environmental drawbacks. Mining tar sand causes substantial land disturbance. Processing also requires large amounts of water. When processing is completed, contaminated water and sediment accumulate in toxic disposal ponds.

Only about 10 percent of Alberta's tar sands can be economically recovered by surface mining. In the future, other methods may be used to obtain the more deeply buried material, reduce the environmental impacts, and make mining tar sands more economical.

Reading Checkpoint *What are some environmental drawbacks to mining tar sands?*

Oil Shale

Oil shale is a rock that contains a waxy mixture of hydrocarbons called kerogen. Oil shale can be mined and heated to vaporize the kerogen. The kerogen vapor is processed to remove impurities, and then refined.

Roughly half of the world's oil shale supply is in the Green River Formation of Colorado, Utah, and Wyoming. See Figure 5 on page 98. The oil shales are part of sedimentary layers that accumulated at the bottom of two extremely large, shallow lakes 57 to 36 million years ago.

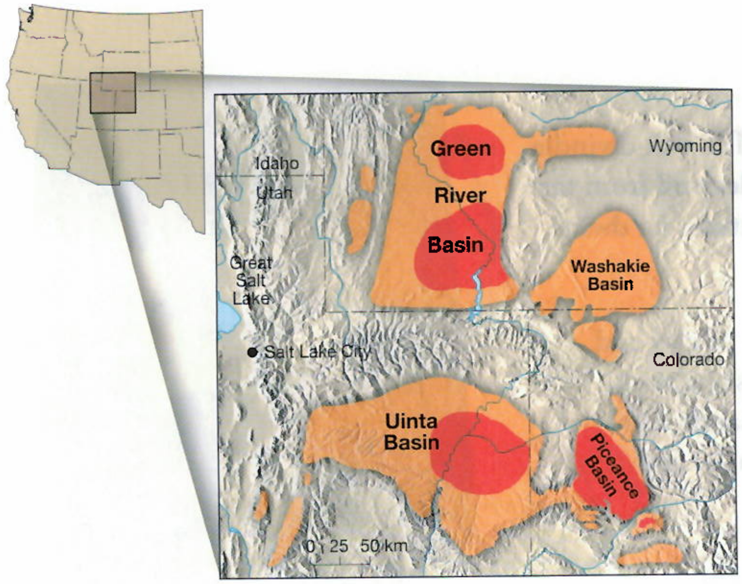

Figure 5 Distribution of Oil Shale in the Green River Formation The areas in red are the richest deposits.
Posing Questions ***How might the mining and processing of oil shale become more economically attractive?***

Some people see oil shale as a partial solution to dwindling fuel supplies. However, the heat energy in oil shale is only about one-eighth that in crude oil because oil shale contains large amounts of minerals. This mineral material adds costs to the mining, processing, and waste disposal of oil shale. The processing of it requires large amounts of water, which is scarce in the semi-arid region where the shales are found. Current technology makes mining oil shale an unprofitable solution.

Formation of Mineral Deposits

Practically every manufactured product contains substances that come from minerals. Mineral resources are deposits of useful minerals that can be extracted. Mineral reserves are deposits from which minerals can be extracted profitably. **Ore** is a useful metallic mineral that can be mined at a profit.

There are also known deposits that are not yet economically or technologically recoverable. These deposits, as well as deposits that are believed to exist, are also considered mineral resources.

The natural concentration of many minerals is rather small. A deposit containing a valuable mineral is worthless if the cost of extracting it exceeds the value of the material that is recovered. For example, copper makes up about 0.0135 percent of Earth's crust. However, for a material to be considered a copper ore, it must contain a concentration of about 50 times this amount.

Geologists have established that the occurrences of valuable mineral resources are closely related to Earth's rock cycle. The rock cycle includes the formation of igneous, sedimentary, and metamorphic rock as well as the processes of weathering and erosion. **Some of the most important mineral deposits form through igneous processes and from hydrothermal solutions.**

Mineral Resources and Igneous Processes Igneous processes produce important deposits of metallic minerals, such as gold, silver, copper, mercury, lead, platinum, and nickel. For example, as a large body of magma cools, heavy minerals crystallize early and settle to the bottom of the magma chamber. Chromite (chromium ore), magnetite, and platinum sometimes form this way. Such deposits produced layers of chromite at Montana's Stillwater Complex. Another deposit is found in the Bushveld Complex in South Africa. This deposit contains over 70 percent of the world's known platinum reserves.

Hydrothermal Solutions Hydrothermal (hot-water) solutions generate some of the best-known and most important ore deposits. Examples of hydrothermal deposits include the gold deposits of the Homestake Mine in South Dakota; the lead, zinc, and silver ores near Coeur D'Alene, Idaho; the silver deposits of the Comstock Lode in Nevada; and the copper ores of Michigan's Keweenaw Peninsula.

Most hydrothermal deposits form from hot, metal-rich fluids that are left during the late stages of the movement and cooling of magma. Figure 6 shows how these deposits form. As the magma cools and becomes solid, liquids and various metal ions collect near the top of the magma chamber. These ion-rich solutions can move great distances through the surrounding rock. Some of this fluid moves along openings such as fractures or bedding planes. The fluid cools in these openings and the metallic ions separate out of the solution to produce vein deposits, like those shown in Figure 7. Many of the most productive gold, silver, and mercury deposits occur as hydrothermal vein deposits.

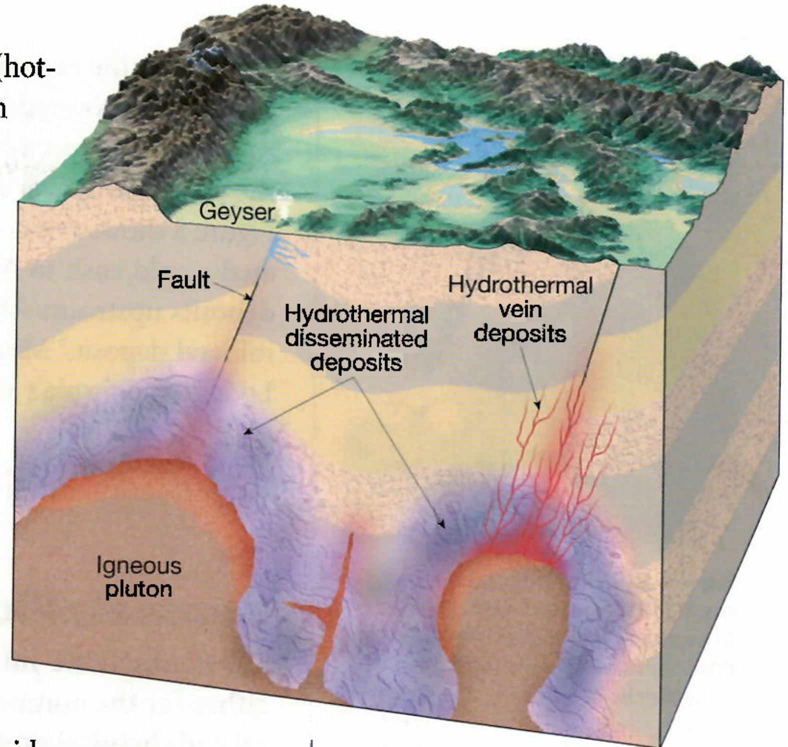

Figure 6 Mineral-rich hot water seeps into rock fractures, cools, and leaves behind vein deposits.

Placer Deposits Placer deposits are formed when eroded heavy minerals settle quickly from moving water while less dense particles remain suspended and continue to move. This settling is a means of sorting in which like-size grains are deposited together due to the density of the particles. Placer deposits usually involve minerals that are not only heavy but also durable and chemically resistant. Common sites of accumulation include point bars on the inside of bends in streams, as well as cracks, depressions, and other streambed irregularities.

Figure 7 Light veins of quartz lace a body of darker gneiss in Washington's North Cascades National Park.

Figure 8 Placer deposits led to the California gold rush. Here, a prospector in 1850 swirls his gold pan, separating sand and mud from flecks of gold.

Q&A

Q *How big was the largest gold nugget ever discovered?*

A The largest gold nugget ever discovered was the Welcome Stranger Nugget found in 1869 as a placer deposit in the gold-mining region of Victoria, Australia. It weighed a massive 2520 troy ounces (210 pounds, or 95 kilograms) and, at today's gold prices, was worth over $700,000. The largest gold nugget known to remain in existence today is the Hand of Faith Nugget, which was found in 1975 near Wedderburn, Victoria, Australia. It was found with a metal detector and weighs 875 troy ounces (73 pounds, or 33 kilograms). Sold in 1982, it is now on display in the Golden Nugget Casino in Las Vegas, Nevada.

Gold is the best-known placer deposit. In 1848, placer deposits of gold were discovered in California, sparking the famous California gold rush. Early prospectors searched rivers by using a flat pan to wash away the sand and gravel and concentrate the gold "dust" at the bottom. Figure 8 shows this common method. Years later, similar deposits created a gold rush to Alaska. Sometimes prospectors follow the placer deposits upstream. This method may lead prospectors to the original mineral deposit. Miners found the gold-bearing veins of the Mother Lode in California's Sierra Nevadas by following placer deposits.

Reading Checkpoint *What are mineral resources?*

Nonmetallic Mineral Resources

Nonmetallic mineral resources are extracted and processed either for the nonmetallic elements they contain or for their physical and chemical properties. People often do not realize the importance of nonmetallic minerals because they see only the products that resulted from their use and not the minerals used to make the products.

Examples of nonmetallic minerals include the fluorite and limestone that are part of the steelmaking process and the fertilizers needed to grow food, as shown in Table 1.

Nonmetallic mineral resources are divided into two broad groups—building materials and industrial minerals. For example, natural aggregate (crushed stone, sand, and gravel), is an important material used in nearly all building construction.

Some substances, however, have many uses in both construction and industry. Limestone is a good example. As a building material, it is used as crushed rock and building stone. It is also an ingredient in cement. As an industrial mineral, limestone is an ingredient in the manufacture of steel. Farmers also use it to neutralize acidic soils.

Many nonmetallic resources are used for their specific chemical elements or compounds. These resources are important in the manufacture of chemicals and fertilizers. In other cases, their importance is related to their physical properties. Examples include abrasive minerals such as corundum and garnet.

Although industrial minerals are useful, they have drawbacks. Most industrial minerals are not nearly as abundant as building materials. Manufacturers must also transport nonmetallic minerals long distances, adding to their cost. Unlike most building materials, which need a minimum of processing before use, many industrial minerals require considerable processing to extract the desired substance at the proper degree of purity.

Table 1 Occurrences and Uses of Nonmetallic Minerals		
Mineral	**Uses**	**Geological Occurrences**
Apatite	Phosphorus fertilizers	Sedimentary deposits
Asbestos (chrysotile)	Incombustible fibers	Metamorphic alteration
Calcite	Aggregate; steelmaking; soil conditioning; chemicals; cement; building stone	Sedimentary deposits
Clay minerals (kaolinite)	Ceramics; china	Residual product of weathering
Corundum	Gemstones; abrasives	Metamorphic deposits
Diamond	Gemstones; abrasives	Kimberlite pipes; placers
Fluorite	Steelmaking; aluminum refining; glass; chemicals	Hydrothermal deposits
Garnet	Abrasives; gemstones	Metamorphic deposits
Graphite	Pencil lead; lubricant; refractories	Metamorphic deposits
Gypsum	Plaster of Paris	Evaporite deposits
Halite	Table salt; chemicals; ice control	Evaporite deposits, salt domes
Muscovite	Insulator in electrical applications	Pegmatites
Quartz	Primary ingredient in glass	Igneous intrusions, sedimentary deposits
Sulfur	Chemicals; fertilizer manufacture	Sedimentary deposits, hydrothermal deposits
Sylvite	Potassium fertilizers	Evaporite deposits
Talc	Powder used in paints, cosmetics, etc.	Metamorphic deposits

Section 4.1 Assessment

Reviewing Concepts

1. What is the difference between a renewable and a nonrenewable resource?
2. What are the three major fossil fuels?
3. What are tar sands and oil shale?
4. How do hydrothermal deposits form?
5. What are the two broad categories of nonmetallic mineral resources?
6. Compare and contrast the formation of coal with that of petroleum and natural gas.

Critical Thinking

7. **Drawing Conclusions** Why isn't the use of tar sands more widespread in the United States?
8. **Applying Concepts** Explain how following placer deposits upstream would help prospectors find the original deposit.

Writing in Science

Compare-Contrast Paragraph Write a paragraph describing the difference in the use of nonmetallic building minerals and nonmetallic industrial minerals.

4.2 Alternate Energy Sources

Reading Focus

Key Concepts

- What are the advantages of using solar energy?
- How do nuclear power plants use nuclear fission to produce energy?
- What is wind power's potential for providing energy in the future?
- How do hydroelectric power, geothermal energy, and tidal power contribute to our energy resources?

Vocabulary

- hydroelectric power
- geothermal energy

Reading Strategy

Previewing Skim the section and start a concept map for the various alternate energy resources.

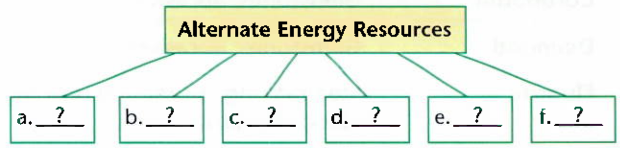

Figure 9 Solar One is a solar installation used to generate electricity in the Mojave Desert near Barstow, California.

There's no doubt that we live in the age of fossils fuels. These nonrenewable resources supply nearly 90 percent of the world's energy. But that can't last forever. At the present rates of consumption, the amount of recoverable fossil fuels may last only another 170 years. As the world population soars, the rate of consumption will climb as well. This will leave fossil fuel reserves in even shorter supply. In the meantime, the burning of huge quantities of fossil fuels will continue to damage the environment. Our growing demand for energy along with our need for a healthy environment will likely lead to a greater reliance on alternate energy sources.

Solar Energy

Solar energy is the direct use of the sun's rays to supply heat or electricity. **Solar energy has two advantages: the "fuel" is free, and it's non-polluting.** The simplest and perhaps most widely used solar energy systems are passive solar collectors such as south-facing windows. As sunlight passes through the glass, objects in the room absorb its heat. These objects radiate the heat, which warms the air.

More elaborate systems for home heating use an active solar collector. These roof-mounted devices are usually large, blackened boxes covered with glass or plastic. The heat they collect can be transferred to areas where it is needed by circulating air or liquids through piping. Solar collectors are also used to heat water for domestic and commercial needs. For example, solar collectors provide hot water for more than 80 percent of Israel's homes.

There are a few drawbacks to solar energy. While the energy collected is free, the necessary equipment and installation is not. A supplemental heating unit is also needed when there is less solar energy—on cloudy days or in the winter—or at night when solar energy is unavailable. However, over the long term, solar energy is economical in many parts of the United States. It will become even more cost effective as the prices of other fuels increase.

Research is currently underway to improve the technologies for concentrating sunlight. Scientists are examining a way to use mirrors to track the sun and keep its rays focused on a receiving tower. Figure 9 shows a solar collection facility with 2000 mirrors that was built near Barstow, California. This facility heats water in pressurized panels to over 500°C by focusing solar energy on a central tower. The superheated water is then transferred to turbines, which turn electrical generators.

Another type of collector, shown in Figure 10, uses photovoltaic (solar) cells. They convert the sun's energy directly into electricity.

Figure 10 Solar cells convert sunlight directly into electricity. This array of solar panels is near Sacramento, California.
Applying Concepts ***What characteristics would you look for if you were searching for a location for a new solar plant?***

Reading Checkpoint ***What are the two main advantages of using solar energy?***

Nuclear Energy

Nuclear power meets about 7 percent of the energy demand of the United States. The fuel for nuclear plants, like the one in Figure 11, comes from radioactive materials that release energy through nuclear fission. **In nuclear fission, the nuclei of heavy atoms such as uranium-235 are bombarded with neutrons. The uranium nuclei then split into smaller nuclei and emit neutrons and heat energy.** The neutrons that are emitted then bombard the nuclei of adjacent uranium atoms, producing a chain reaction. If there is enough fissionable material and if the reaction continues in an uncontrolled manner, fission releases an enormous amount of energy as an atomic explosion.

In a nuclear power plant, however, the fission reaction is controlled by moving neutron-absorbing rods into or out of the nuclear reactor. The result is a controlled nuclear chain reaction that releases great amounts of heat. The energy drives steam turbines that turn electrical generators. This is similar to what occurs in most conventional power plants.

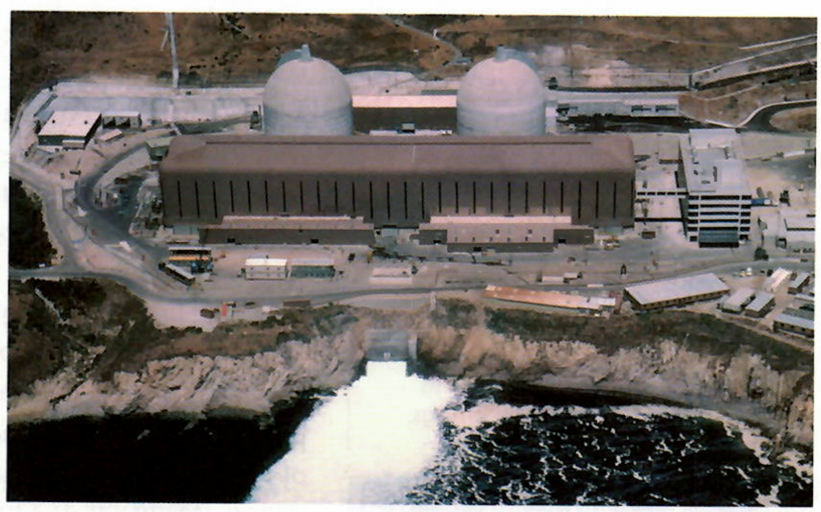

Figure 11 Diablo Canyon Nuclear Plant Near San Luis Obispo, California Reactors are in the dome-shaped buildings. You can see cooling water being released to the ocean.
Analyzing ***The siting of this plant was controversial because it is close to faults. Why would that be a cause for concern?***

At one time, energy experts thought nuclear power would be the cheap, clean energy source that would replace fossil fuels. But several obstacles have slowed its development. First, the cost of building safe nuclear facilities has increased. Second, there are hazards associated with the disposal of nuclear wastes. Third, there is concern over the possibility of a serious accident that could allow radioactive materials to escape. The 1979 accident at Three Mile Island in Pennsylvania made this concern a reality. A malfunction in the equipment led the plant operators to think there was too much water in the primary system. Instead there was not enough water. This confusion allowed the reactor core to lie uncovered for hours. Although there was little danger to the public, the malfunction resulted in substantial damage to the reactor.

Unfortunately, the 1986 accident at Chernobyl in Ukraine was far more serious. In this case, the reactor went out of control. Two small explosions lifted the roof of the structure, and pieces of uranium spread over the surrounding area. A fire followed the explosion. During the 10 days that it took to put out the fire, the atmosphere carried high levels of radioactive material as far away as Norway. Eighteen people died within six weeks of the accident. Thousands more faced an increased risk of death from cancers associated with the fallout.

Reading Checkpoint ***What is nuclear fission?***

Wind Energy

According to one estimate, if just the winds of North and South Dakota could be harnessed, they would provide 80 percent of the electrical energy used in the United States. Wind is not a new energy source. People have used it for centuries to power sailing ships and windmills for grinding grains.

Following the "energy crisis" brought about by the oil embargo of the 1970s, interest in wind power and other alternative forms of energy grew. In 1980, the federal government started a program to develop wind-power systems, such as the one shown in Figure 12. The U.S. Department of Energy set up experimental wind farms in mountain passes with strong, steady winds. One of these facilities, at Altamont Pass near San Francisco, now operates more than 7000 wind turbines. In the year 2000, wind supplied a little less than one percent of California's electricity.

Some experts estimate that in the next 50 to 60 years, wind power could meet between 5 to 10 percent of the country's demand for electricity. Islands and other isolated regions that must import fuel for generating power are major candidates for wind energy expansion.

The future for wind power looks promising, but there are difficulties. The need for technical advances, noise pollution, and the cost of large tracts of land in populated areas are obstacles to development.

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Figure 12 These wind turbines are operating near Palm Springs, California.

Figure 13 Glen Canyon Dam and Lake Powell on the Colorado River As dam operators release water in the reservoir, it passes through machinery that drives turbines and produces electricity.

Hydroelectric Power

Like wind, moving water has been an energy source for centuries. The mechanical energy that waterwheels produce has powered mills and other machinery. Today, the power that falling water generates, known as **hydroelectric power,** drives turbines that produce electricity. In the United States, hydroelectric power plants produce about 5 percent of the country's electricity. Large dams, like the one in Figure 13, are responsible for most of it. The dams allow for a controlled flow of water. **The water held in a reservoir behind a dam is a form of stored energy that can be released through the dam to produce electric power.**

Although water power is a renewable resource, hydroelectric dams have finite lifetimes. Rivers deposit sediment behind the dam. Eventually, the sediment fills the reservoir. When this happens, the dam can no longer produce power. This process takes 50 to 300 years, depending on the amount of material the river carries. An example is Egypt's Aswan High Dam on the Nile River, which was completed in the 1960s. It is estimated that half the reservoir will be filled with sediment by 2025.

The availability of suitable sites is an important limiting factor in the development of hydroelectric power plants. A good site must provide a significant height for the water to fall. It also must have a high rate of flow. There are hydroelectric dams in many parts of the United States, with the greatest concentration in the Southeast and the Pacific Northwest. Most of the best U.S. sites have already been developed. This limits future expansion of hydroelectric power.

Geothermal Energy

Geothermal energy is harnessed by tapping natural underground reservoirs of steam and hot water. **Hot water is used directly for heating and to turn turbines to generate electric power.** The reservoirs of steam and hot water occur where subsurface temperatures are high due to relatively recent volcanic activity.

Figure 14 The Geysers is the world's largest electricity-generating geothermal facility. Most of the steam wells are about 3,000 meters deep.

In the United States, areas in several western states use hot water from geothermal sources for heat. The first commercial geothermal power plant in the United States was built in 1960 at The Geysers, shown in Figure 14. The Geysers is an important source of electrical power for nearby San Francisco and Oakland. Although production in the plant has declined, it remains the world's premier geothermal field. It continues to provide electrical power with little environmental impact. Geothermal development is now also occurring in Nevada, Utah, and the Imperial Valley of California.

Geothermal power is clean but not inexhaustible. When hot fluids are pumped from volcanically heated reservoirs, the reservoir often cannot be recharged. The steam and hot water from individual wells usually lasts no more than 10 to 15 years. Engineers must drill more wells to maintain power production. Eventually, the field is depleted.

As with other alternative methods of power production, geothermal sources are not expected to provide a high percentage of the world's growing energy needs. Nevertheless, in regions where people can develop its potential, its use will no doubt grow.

Reading Checkpoint ***In what two ways is geothermal energy used?***

Q&A

Q *Is power from ocean waves a practical alternative energy source?*

A It's being seriously explored now. In November 2000, the world's first commercial wave power station opened on the Scottish island of Islay. It provides power for the United Kingdom. The 500-kilowatt power station uses an oscillating water column, in which incoming waves push air up and down inside a concrete tube that is partly under the ocean's surface. Air rushing in and out of the top of the tube drives a turbine to produce electricity. If the facility succeeds, it could open the door for wave power to become a significant contributor of renewable energy in some coastal areas.

Tidal Power

Several methods of generating electrical energy from the oceans have been proposed, yet the ocean's energy potential still remains largely untapped. The development of tidal power is one example of energy production from the ocean.

Tides have been a power source for hundreds of years. Beginning in the 12th century, tides drove water wheels that powered gristmills and sawmills. During the seventeenth and eighteenth centuries, a tidal mill produced much of Boston's flour. But today's energy demands require more sophisticated ways of using the force created by the continual rise and fall of the ocean.

Tidal power is harnessed by constructing a dam across the mouth of a bay or an estuary in coastal areas with a large tidal range. The strong in-and-out flow that results drives turbines and electric generators. An example of this type of dam is shown in Figure 15.

The largest tidal power plant ever constructed is at the mouth of France's Rance River. This tidal plant went into operation in 1966. It produces enough power to satisfy the needs of Brittany—a region of 27,000 square kilometers—and parts of other regions. Much smaller experimental facilities have been built near Murmansk in Russia, near Taliang in China, and on an arm of the Bay of Fundy in Canada.

Tidal power development isn't economical if the tidal range is less than eight meters or if a narrow, enclosed bay isn't available. Although the tides will never provide a high portion of the world's ever-increasing energy needs, it is an important source at certain sites.

Tidal Dam

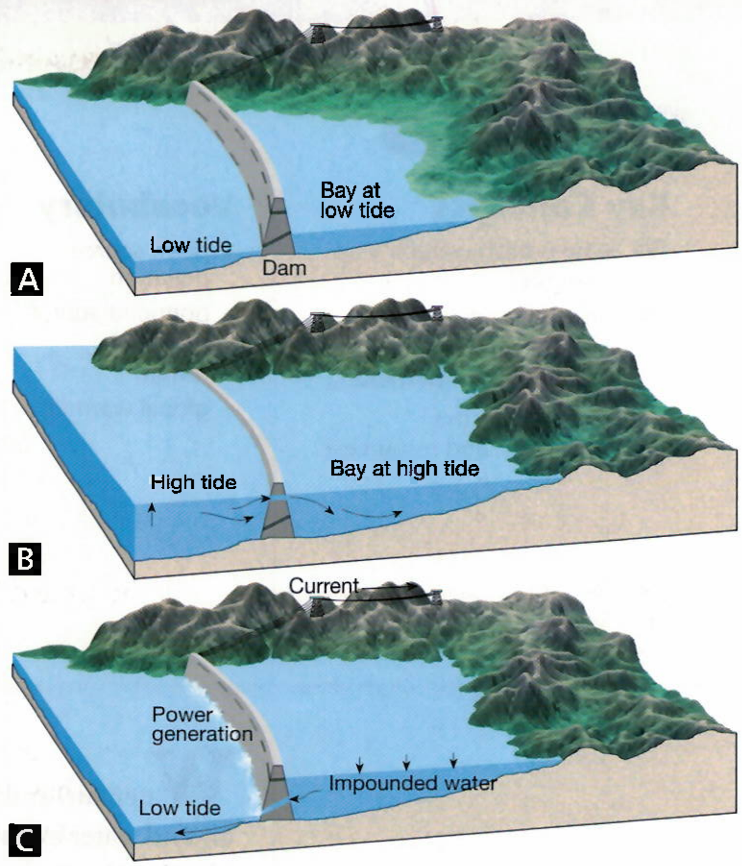


Figure 15 **A** At low tide, water is at its lowest level on either side of the dam. **B** At high tide, water flows through a high tunnel. **C** At low tide, water drives turbines as it flows back to sea through a low tunnel.
Analyzing Concepts ***Why is a large tidal range (difference in water level between high and low tide) needed to produce power?***

Section 4.2 Assessment

Reviewing Concepts

1. What are the advantages and drawbacks of using solar energy?
2. How do nuclear power plants produce energy?
3. What percentage of our energy might be met by wind power over the next 60 years?
4. What are the advantages and drawbacks of hydroelectric power, geothermal energy, and tidal power?

Critical Thinking

5. **Predicting** Why will the interest in alternate energy sources probably grow in the future?
6. **Classifying** Identify solar, nuclear, and wind power as renewable or nonrenewable energy sources. Explain your answers.

Writing in Science

Explain a Concept Write a letter to a family member explaining how tidal power works.

4.3 Water, Air, and Land Resources

Reading Focus

Key Concepts

- Why is fresh water a vital resource?
- Why is the chemical composition of the atmosphere important?
- What are Earth's important land resources?

Vocabulary

- point source pollution
- nonpoint source pollution
- runoff
- global warming

Reading Strategy

Building Vocabulary Copy the table below. As you read, add definitions and examples to complete the table.

Definitions	Examples
point source pollution: Pollution that can be traced to a location	factory pipes, sewer pipes
nonpoint source pollution: a. ?	b. ?
runoff: c. ?	d. ?
greenhouse gas: e. ?	f. ?

Water, air, and land resources are essential for life. You need clean air and water every day. What's more, soil provides nutrients that allow plants—the basis of our own food supply—to grow. How do people use—and sometimes misuse—these vital resources?

The Water Planet

Figure 16 shows Earth's most prominent feature—water. Water covers nearly 71 percent of Earth's surface. However, most of this water is saltwater, not fresh water. Oceans have important functions. Their currents help regulate and moderate Earth's climate. They are also a vital part of the water cycle, and a habitat for marine organisms. Fresh water, however, is what people need in order to live. **Each day, people use fresh water for drinking, cooking, bathing, and growing food.** While fresh water is extremely important, Earth's reserves are relatively small. Less than one percent of the water on the planet is usable fresh water.

Figure 16 Oceans cover almost three fourths of Earth surface, making Earth a unique planet.

Freshwater Pollution

Pollution has contaminated many freshwater supplies. In general, there are two types of water pollution sources—point sources and nonpoint sources. **Point source pollution** is pollution that comes from a known and specific location, such as the factory pipes in Figure 17. Other examples include a leaking landfill or storage tank.

Nonpoint source pollution is pollution that does not have a specific point of origin. **Runoff,** the water that flows over the land rather than seeping into the ground, often carries nonpoint source pollution. Runoff can carry waste oil from streets. It can wash sediment from construction sites or pesticides off farm fields and lawns. Water filtering through piles of waste rock from coal mines can carry sulfuric acid into rivers or lakes. This contaminated water can kill fish and other aquatic life.

As you can see in Table 2, water pollution has adverse health effects. Pollutants can damage the body's major organs and systems, cause birth defects, lead to infectious diseases, and cause certain types of cancers. Contaminated fresh water can sicken or kill aquatic organisms and disrupt ecosystems. What's more, fish and other aquatic life that live in contaminated waters often concentrate poisons in their flesh. As a result, it is dangerous to eat fish taken from some polluted waters.

Reading Checkpoint ***What is the difference between a point and non-point water pollution source?***

Figure 17 Pollution from point sources, such as these factory pipes, is easy to locate and control.

Table 2 Major Types of Water Pollution

Type	Examples	Sources	Effects
Disease organisms	Bacteria, viruses	Wastes from people and animals	Typhoid, cholera, dysentery, infectious hepatitis
Wastes that remove oxygen from water	Animal manure and plant debris that bacteria decompose	Sewage, animal feedlots	Great amounts of bacteria can remove oxygen from water, killing fish
Inorganic chemicals	Acids, toxic metals	Industrial effluent, urban runoff, household cleaners	Poisons fresh water and can sicken those who drink it
Organic chemicals	Oil, gasoline, plastic, pesticides, detergent	Farm and yard runoff, industrial waste, household cleaners	Some cancers, disorders of nervous and reproductive systems
Plant fertilizer	Water soluble compounds with nitrate, phosphorus ions	Sewage, manure, farm and garden runoff	Spurs rapid growth of algae that decay and deplete water's oxygen; fish die
Sediment	Soil	Erosion	Disrupts aquatic food webs, clogs lakes and reservoirs, reduces photosynthesis of aquatic plants
Radioactive substances	Radon, uranium, radioactive iodine	Nuclear power plants, uranium ore mining and processing	Some cancers, birth defects, genetic mutations

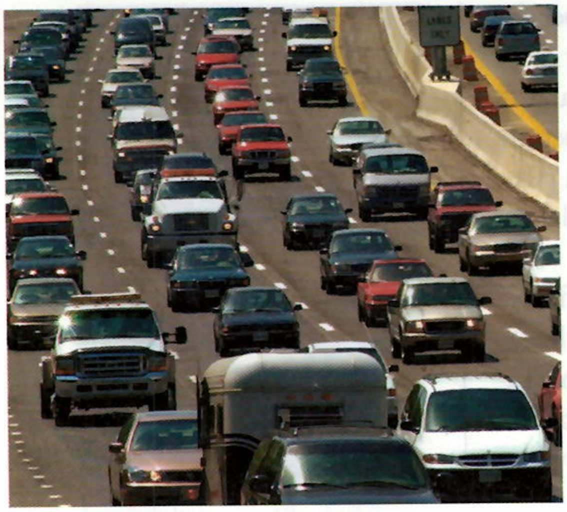


Figure 18 Cars, trucks, and buses are the biggest source of air pollution. Laws that control motor vehicle emissions have helped make the air cleaner in many areas.

Earth's Blanket of Air

Earth's atmosphere is a blanket of nitrogen, oxygen, water vapor and other gases. **The chemical composition of the atmosphere helps maintain life on Earth.** First and foremost, people and other animals could not live without the oxygen in Earth's atmosphere. But the atmosphere is also part of several other cycles, such as the carbon cycle, that make vital nutrients available to living things.

The atmosphere also makes life on land possible by shielding Earth from harmful solar radiation. There is a layer of protective ozone high in the air. Ozone is a three-atom form of oxygen that protects Earth from 95 percent of the sun's harmful ultraviolet (UV) radiation.

Certain greenhouse gases in the atmosphere—such as carbon dioxide, methane, and water vapor—help maintain a warm temperature near Earth's surface. When solar energy hits Earth, the Earth gives off some of this energy as heat. The gases absorb the heat Earth emits, keeping the atmosphere warm enough for life as we know it.

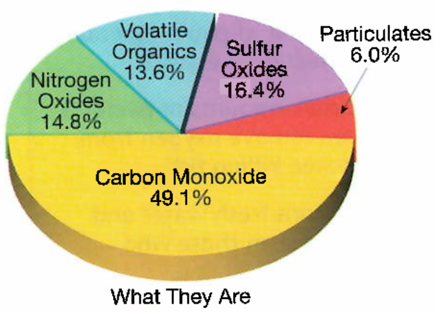
Reading Checkpoint ***What is the role of ozone in the atmosphere?***

Pollution in the Air Pollution can change the chemical composition of the atmosphere and disrupt its natural cycles and functions. Fossil-fuel combustion is the major source of air pollution. Most of this pollution comes from motor vehicles and coal or oil-burning power plants. Motor vehicles, like those in Figure 18, release carbon monoxide, nitrogen oxide, soot, and other pollutants. Some of the pollutants react to form smog. Power plants release sulfur dioxide and nitrogen oxides. These pollutants combine with water vapor in the air to create acid precipitation. Figure 19 shows the primary air pollutants and the sources of those pollutants.

The burning of fossil fuels also produces carbon dioxide, an important greenhouse gas. The amount of carbon dioxide in the atmosphere has increased since industrialization began in the nineteenth century. This increase has altered the carbon cycle and contributed to the unnatural warming of the lower atmosphere, known as **global warming.** Global warming could lead to enormous changes in Earth's environment. These changes could include the melting of glaciers, which would contribute to a rise in sea level and in the flooding of coastal areas.

Chlorofluorocarbons (CFCs) once used in air conditioners and plastic foam production destroy ozone in the stratosphere layer of the atmosphere. Researchers say that a significant loss of ozone could result in an increased incidence of health problems like cataracts and skin cancers because more of the sun's UV radiation would reach Earth's surface.

Primary Pollutants



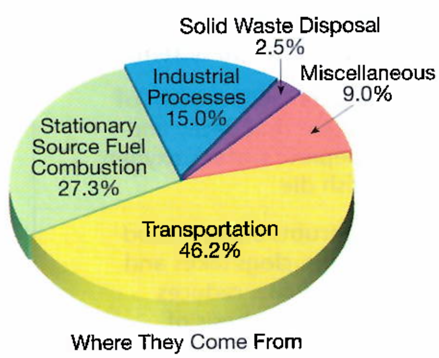


Figure 19 Major Primary Pollutants and Their Sources Percentages are calculated on the basis of weight.
Using Graphs ***What are the three major primary pollutants? What is the major source of air pollution?***

Air pollution is a major public health problem. It can cause coughing, wheezing, headaches, as well as lung, eye, and throat irritation. Long-term health effects include asthma, bronchitis, emphysema, and lung cancer. The U.S. Environmental Protection Agency estimates that as many as 200,000 deaths each year are associated with outdoor air pollution.

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Land Resources

Earth's land provides soil and forests, as well as mineral and energy resources. How do land resources impact your daily life? Soil is needed to grow the food you eat. Forests provide lumber for your home, wood for furniture, and pulp for paper. Petroleum provides energy and is in the plastic of your computer and CD boxes. Minerals such as zinc, copper, and nickel make up the coins in your pocket. Removing and using resources from Earth's crust can take a heavy environmental toll.

Damage to Land Resources There are an estimated 500,000 mines in the United States. Mines are essential because they produce many of the mineral resources we need. But mining tears up Earth's surface and destroys vegetation, as you can see in Figure 20. It can also cause soil erosion and create pollution that contaminates surrounding soil and water and destroys ecosystems.

Agriculture has many impacts on the land as well. Today, farmers can produce more food per hectare from their land. Extensive irrigation also has allowed many dry areas to be farmed for the first time. But heavy pumping for irrigation of dry areas is depleting the groundwater. And over time, irrigation causes salinization, or the build-up of salts in soil. When irrigation water on the soil evaporates, it leaves behind a salty crust. Eventually, the soil becomes useless for plant growth.

Figure 20 Surface mining destroys vegetation, soil, and the contours of Earth's surface. However, laws now require mine owners to restore the surface after mining operations cease.

MAP MASTER™ Skills Activity

Virgin Forests 1620–1992

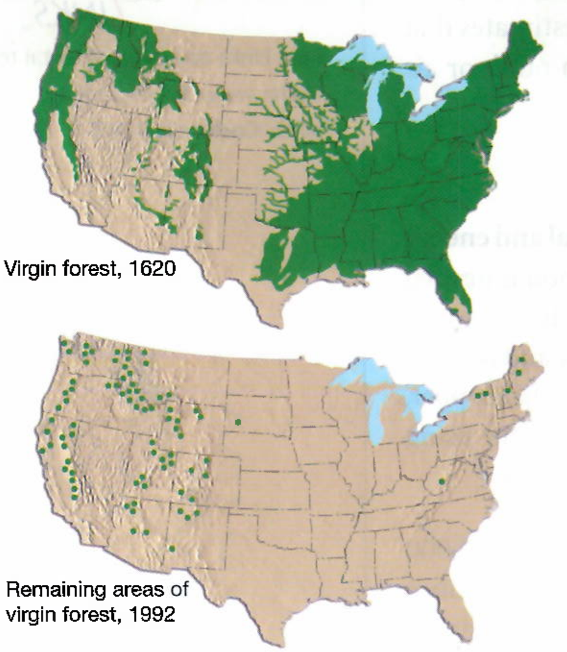


Figure 21

Location These maps compare the location of virgin forests in the contiguous 48 states of the U.S. in 1620 and in 1992. **Identifying Effects** How has the amount of virgin forest changed? How has the location of virgin forest changed?

Trees must be cut to supply our need for paper and lumber. But the removal of forests, especially through clear-cutting, can damage land. Clear-cutting is the removal of all trees in an area of forest. Cleared areas are susceptible to soil erosion. Forest removal also destroys ecosystems and wildlife habitat. The United States actually has more hectares of forest today than it did a century ago. That's because much of the virgin forest (forest that had never been cut down) that was cut long ago has regrown as second-growth forest. The forest is not as diverse as the virgin forest—it does not contain as much variety of plant species. Some forestland has also become tree plantations, with even fewer species. As you see in Figure 21, the United States has lost most of its virgin forest during the last few centuries.

Finally, land serves as a disposal site. You may have seen landfills and other waste facilities. When disposal is done correctly, there is minimal impact on land. But many old landfills leak harmful wastes that get into soil and underground water. The same is true of buried drums of chemicals, which were often disposed of illegally. Waste is inevitable. But there is a need for ways to reduce it and make the disposal safer.

Section 4.3 Assessment

Reviewing Concepts

1. Why is fresh water a vital resource?
2. Why is the chemical composition of Earth's atmosphere important?
3. What is the difference between point source pollution and nonpoint source pollution?
4. What do Earth's land resources provide?

Critical Thinking

5. **Applying Concepts** How would Earth be different if there were no greenhouse gases?
6. **Classifying** Which of the following is a nonpoint source pollution of water: rainwater pouring from an eroded bank into a river, a boat emptying a waste tank into a lake, or a sewage plant sending sewage into a river through a pipe?
7. **Relating Cause and Effect** How would the removal of sulfur from coal affect the type of air pollution in a local area? Explain your answer.

Connecting Concepts

Write a brief paragraph that connects the following: waste of paper, loss of species diversity of forests, and the increase in second-growth forest area.

4.4 Protecting Resources

Reading Focus

Key Concepts

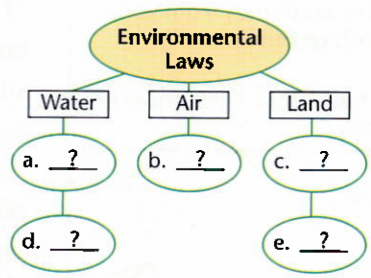
- When were the first laws passed to deal with water pollution?
- What was the most important law passed to deal with air pollution?
- What is involved in protecting land resources?

Vocabulary

- conservation
- compost
- recycling

Reading Strategy

Summarizing After reading this section, complete the concept map below to organize what you know about the major laws that help keep water, air, and land resources clean.



Each year, Americans throw out about 30 million cell phones, 18 million computers, 8 million TV sets, and enough tires to circle the Earth about three times. With just 6 percent of the world's population, Americans use about one third of the world's resources—and produce about one third of the world's garbage.

This high rate of consumption squanders resources, many of which are nonrenewable. The manufacture and disposal of these products uses enormous amounts of energy and creates pollution, as shown in Figure 22. Is there a way to have the products and services we want and still protect resources and create less pollution?

Many people think conservation and pollution prevention are the answer. **Conservation** is the careful use of resources. Pollution prevention means stopping pollution from entering the environment.

Between the late 1940s and 1970, a number of serious pollution problems got the public's attention. Severe air pollution events killed hundreds and sickened thousands in the United States and elsewhere. In the late 1960s, many beaches closed due to pollution. An oil spill off the California coast killed wildlife. Then in 1969, Americans watched news reports of Ohio's polluted Cuyahoga River catching fire and burning for days.

Figure 22 Strict laws have helped curb air pollution, though it remains a problem.

Table 3 How You Can Prevent Water Pollution
• Never pour household chemicals (paints, thinners, cleaners, pesticides, waste oil) down the drain or into the toilet.
• Never dump toxic chemicals in the gutter or onto the ground.
• Don't put items that contain hazardous substances, such as batteries or old computer monitors, into the trash.
• Find out about hazardous waste collection sites and times from your local sanitation or public works department.
• Avoid using hazardous substances in the first place.

Keeping Water Clean and Safe

Both the public and government officials became increasingly concerned about pollution. **Starting in the 1970s, the federal government passed several laws to prevent or decrease pollution and protect resources.**

America's polluted rivers and lakes got early attention. In 1972, the U.S. Congress passed the Clean Water Act (CWA). Among other provisions, the law requires industries to reduce or eliminate point source pollution into surface waters. It also led to a huge increase in the number of sewage treatment plants, which eliminated the discharge of raw sewage into many lakes, rivers, and bays. There are still water pollution problems. But because of the CWA, the percentage of U.S. surface waters safe for fishing and swimming increased from 36 percent to 62 percent between 1972 and the end of the 1990s.

The Safe Drinking Water Act of 1974 helped protect drinking resources. It set maximum contaminant levels for a number of pollutants that could harm the health of people. Public water resources are cleaner today because of this law. See Table 3 for ways that individuals can help conserve water and keep it clean.

Reading Checkpoint *What did the Clean Water Act do?*

Protecting the Air

As lawmakers were tackling water pollution in the 1970s, air pollution was also on the agenda. **In 1970, Congress passed the Clean Air Act, the nation's most important air pollution law.** It established National Ambient Air Quality Standards (NAAQS) for six "criteria" pollutants known to cause health problems—carbon monoxide, ozone, lead, sulfur dioxide, nitrogen oxides, and particulates (fine particles). Air monitors, such as the one in Figure 23, sample the air. If the maximum permissible level of pollutants in the air is exceeded, local authorities must come up with plans to bring these levels down. Between 1970 and 2001, the emissions of the six criteria pollutants regulated under the Clean Air Act decreased 24 percent. Over the same time span, energy consumption increased 42 percent and the U.S. population grew by 39 percent.

Today, power plants and motor vehicles use pollution control devices to reduce or eliminate certain byproducts of fossil fuel combustion. Power plants are also more likely to use low-sulfur coal. These controls cut down on emissions of sulfur and nitrogen oxides that often produce acid rain.

Figure 23 Air Sampler

Increased use of clean, alternate energy sources such as solar, wind, and hydroelectric power, can also help clear the air. These energy sources don't create air or water pollution, and they're based on renewable resources.

Cars with electric and hybrid (combination of electric and either natural gas, gasoline, or diesel) motors produce fewer or no tailpipe emissions. Several of these lower-emissions models are now available. Some of the hybrid models are also very efficient and get high gas mileage. When a car can go farther on a tank of gas, it uses less fuel and creates less pollution.

Energy conservation is an important air pollution control strategy. Fossil-fuel combustion produces most of the electricity in the United States. If we can use less electricity we would have to burn less fossil fuel. Less fossil-fuel combustion means less air pollution. You can see several energy conservation tips in Table 4.

Table 4 How You Can Save Energy

• Recycle when possible.
• Let the sun in on bright winter days using solar energy to warm rooms.
• Use energy-saving fluorescent bulbs instead of incandescent bulbs where you can.
• Turn off lights when you leave a room. Turn off the radio, TV, or computer when you're not using them.
• Walk or ride a bike when you can.
• When buying electric products, look for the Energy Star sticker which denotes energy-saving products.

Reading Checkpoint *What did the Clean Air Act do?*

Caring for Land Resources

Protecting land resources involves preventing pollution and managing land resources wisely. Farmers, loggers, manufacturers, and individuals can all take steps to care for land resources.

Farmers now use many soil conservation practices to prevent the loss of topsoil and preserve soil fertility. In contour plowing, farmers plow across the contour of hillsides. This method of farming decreases water runoff that washes away topsoil. Another conservation method is strip cropping—crops with different nutrient requirements are planted in adjacent rows. Strip cropping helps preserve the fertility of soil.

Selective cutting conserves forest resources. In this method of logging, some trees in an area of a forest are cut, while other trees remain. This practice preserves topsoil as well as the forest habitat. Clear-cutting, on the other hand, removes whole areas of forest and destroys habitats and contributes to the erosion of topsoil.

Some farmers and gardeners now use less pesticides and inorganic fertilizers to decrease chemicals in soil and on crops. Natural fertilizers such as compost or animal manure have replaced inorganic commercial fertilizers on some fields. **Compost** is partly decomposed organic material that is used as fertilizer. Integrated Pest Management (IPM) uses natural predators or mechanical processes (such as vacuuming pests off leaves) to decrease the number of pests. Pesticide use is a last resort.

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Figure 24 Recycling saves resources, reduces energy consumption, and prevents pollution.

Some laws reduce the possibility of toxic substances getting into the soil. Since 1977, sanitary landfills have largely replaced open dumps and old-style landfills. Sanitary landfills have plastic or clay liners that prevent wastes from leaking into the surrounding soil or groundwater. The Resource Conservation and Recovery Act (RCRA) of 1976 has decreased the illegal and unsafe dumping of hazardous waste. The law requires companies to store, transport, and dispose of hazardous waste according to strict guidelines. The 1980 Comprehensive Environmental Response, Compensation, and Liability Act (Superfund) mandates the cleaning up of abandoned hazardous waste sites that are a danger to the public or the environment.

Reading Checkpoint ***What is the RCRA and what does it do?***

Creating less waste by using fewer products and recycling products also helps preserve land resources. **Recycling** is the collecting and processing of used items so they can be made into new products, as Figure 24 shows. By conserving resources and producing less waste, everyone can contribute to a cleaner, healthier future.

Section 4.4 Assessment

Reviewing Concepts

1. When were the first laws passed to deal with water pollution?
2. Identify the most important air pollution control law.
3. What are National Ambient Air Quality Standards?
4. How does selective cutting of forests conserve topsoil?
5. How can gardeners care for land resources?

Critical Thinking

6. **Applying Concepts** How can turning off lights when you're not using them help decrease air pollution?
7. **Relating Cause and Effect** Explain how the Superfund law helps prevent pollution from entering underground water sources.

Writing in Science

Explanatory Paragraph Write a brief paragraph explaining how recycling your aluminum soda cans helps conserve resources and energy.

understanding EARTH

Bingham Canyon, Utah: The Largest Open-Pit Mine

This huge pit was once where a mountain stood. It's Bingham Canyon copper mine, the largest open-pit mine in the world. The mine, southwest of Salt Lake City, Utah, is 4 kilometers across and covers almost 8 square kilometers. It's so deep—900 meters—that if a steel tower were built at the bottom, it would have to be five times taller than France's Eiffel Tower to reach the pit's rim.

Figure 25 Aerial view of Utah's Bingham Canyon copper mine, the largest open-pit copper mine on Earth.

The pit began in the late 1800s as an underground silver and lead mine. Miners later discovered copper. There are similar deposits at several sites in the American Southwest and in a belt from southern Alaska to northern Chile.

The ore at Bingham Canyon formed after magma was intruded to shallow depths. After this, shattering created extensive fractures in the rock. Hydrothermal solutions penetrated these cracks, and ore minerals formed from the solutions.

Although the percentage of copper in the rock is small, the total volume of copper is huge. Ever since open-pit operations started in 1906, some 5 billion tons of material have been removed, yielding more than 1.2 million tons of copper. Miners have also recovered significant amounts of gold, silver, and molybdenum.

The ore body is far from exhausted. Over the next 25 years, the mine's owners plan to remove and process an additional 3 billion tons of material. This mining operation has generated most of Utah's mineral production for more than 80 years. People have called it the "richest hole on Earth."

Like many older mines, the Bingham pit was unregulated during most of its history. Development occurred before today's awareness of the environmental impacts of mining and prior to effective environmental laws. Today, problems of groundwater and surface water contamination, air pollution, and land reclamation are receiving long overdue attention at Bingham Canyon.

Application Lab

Finding the Product that Best Conserves Resources

When you buy a product, you usually consider factors such as price, brand name, quality, and how much is in the package. But do you consider the amount of resources the package uses? Many products come in packages of different types and materials. You might buy a larger pack if you use a lot, or a tiny pack if you like the convenience of individual servings. But how much cardboard, plastic, or glass are you using—or wasting—depending on your choice? How about the trees, petroleum, and other resources needed to make those packages? In this lab, you will compare three sets of packages that hold the same amount of juice to determine how your decisions about packaging affect the use of resources.

Problem Which packaging conserves resources the best?

Materials

- 1 1.89-L (64 fl. oz) cardboard juice carton
- 1 946-mL (32 fl. oz) cardboard juice carton
- 1 240-mL (8 fl. oz) cardboard juice carton
- scissors
- metric ruler

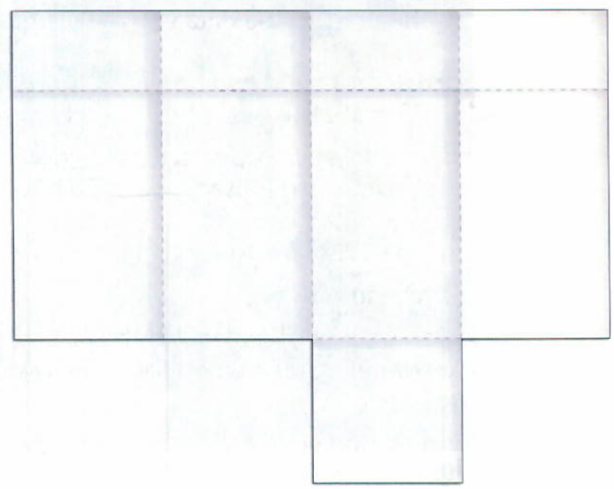
CAUTION *Be careful when using scissors.*

Skills Observing, Measuring, Calculating, Comparing and Contrasting, Relating Cause and Effect, Drawing Conclusions

Procedure

Part A: Determine the Amount of Material in Each Package

1. Work in groups of three or four. Use scissors to cut apart the three cartons your teacher gives your group. Then spread each one out as you see here.



2. Measure the dimensions of the cartons with the ruler.
3. Calculate the area of each carton on a separate sheet of paper. Use these equations:
   - Area of a rectangle:
     $A = l \times w$
     (l = length; w = width)
   - Area of a square:
     $A = s^2$
     (s = length of a side of the square)

Data Table			
	Area of Cardboard in One Carton	Number of Cartons Needed to Hold 1.89 L	Area of Cardboard to Hold 1.89 L
1.89 L		1	
946 mL		2	
240 mL		8	

4. Copy the data table above on a separate sheet of paper. Then record the data you calculated.

Part B: Compare the Amount of Material in the Packages

5. On a separate sheet of paper, calculate how much more cardboard is used when you buy 1.89 L of juice in the two 946-mL cartons instead of one 1.89-L carton.

   Use this procedure:

   a) Subtract the area of material in the 1.89-L carton from the area of material in the two 946-mL cartons.

   b) Divide the answer you get in part a by the area of material in the 1.89-L carton.

   c) Multiply the answer you get in part b by 100. This is how much more material is in the two containers, expressed as a percentage.

6. Repeat this procedure for the material in eight small containers.

Analyze and Conclude

1. **Comparing and Contrasting** Based on your data, does buying the juice in one large carton or in an 8-pack of small individual cartons use more cardboard? How does buying the juice in two medium-size cartons compare.
2. **Relating Cause and Effect** How does buying the juice in several cartons instead of one large carton impact the use of resources?
3. **Drawing Conclusions** Suppose you have determined which set of cardboard cartons uses the least resources. Then you find out that the same size carton of juice comes in plastic and glass as well as cardboard. How would you decide which of these containers would be the best choice, in terms of saving resources?

CHAPTER 4

Study Guide

4.1 Energy and Mineral Resources

Key Concepts

- A renewable resource can be replenished over fairly short time spans, whereas a nonrenewable resource takes millions of years to form and accumulate.
- Fossil fuels include coal, oil, and natural gas.
- Some energy experts believe that fuels derived from tar sands and oil shales could become good substitutes for dwindling petroleum supplies.
- Some of the most important mineral deposits form through igneous processes and from hydrothermal solutions.
- Nonmetallic mineral resources are extracted and processed either for the nonmetallic elements they contain or for their physical and chemical properties.

Vocabulary

renewable resources, *p. 94;* nonrenewable resource, *p. 94;* fossil fuel, *p. 95;* ore, *p. 98*

4.2 Alternate Energy Sources

Key Concepts

- Solar energy has two advantages: the "fuel" is free, and it's non-polluting.
- In nuclear fission, the nuclei of heavy atoms such as uranium-235 are bombarded with neutrons. The uranium nuclei then split into smaller nuclei and emit neutrons and heat energy.
- Some experts estimate that in the next 50 to 60 years, wind power could provide between 5 to 10 percent of the country's demand for electricity.
- The water held in a reservoir behind a dam is a form of stored energy that can be released through the dam to produce electric power.
- Hot water is used directly for heating and to turn turbines to generate electric power.
- Tidal power is harnessed by constructing a dam across the mouth of a bay or an estuary in coastal areas with a large tidal range. The strong in-and-out flow that results drives turbines and electric generators.

Vocabulary

hydroelectric power, *p. 105;* geothermal energy, *p. 105*

4.3 Water, Air, and Land Resources

Key Concepts

- Each day, people use fresh water for drinking, cooking, bathing, and growing food.
- The chemical composition of the atmosphere helps maintain life on Earth.
- Earth's land provides soil and forests, as well as mineral and energy resources.

Vocabulary

point source pollution, *p. 108;* nonpoint source pollution, *p. 109;* runoff, *p. 109;* global warming, *p. 110*

4.4 Protecting Resources

Key Concepts

- Starting in the 1970s, the federal government passed several laws to prevent or decrease pollution and protect resources.
- In 1970, Congress passed the Clean Air Act, the nation's most important air pollution law.
- Protecting land resources involves preventing pollution and managing land resources wisely.

Vocabulary

conservation, *p. 113;* compost, *p. 115;* recycling, *p. 116*

Assessment

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Reviewing Content

Choose the letter that best answers the question or completes the statement.

1. Nonrenewable resources are those that
   - **a.** will never run out.
   - **b.** take one or two decades to replace.
   - **c.** have finite supplies.
   - **d.** are contaminated by pollution.
2. Which of the following is a fossil fuel?
   - **a.** uranium
   - **b.** coal
   - **c.** wood
   - **d.** ozone
3. Petroleum and natural gas form from
   - **a.** the remains of plants and animals buried in seas long ago.
   - **b.** the decay of radioactive sediments underground.
   - **c.** plant material that collected millions of years ago in swamps.
   - **d.** heating and cooling of magma in underground chambers.
4. Hydroelectric power produces electricity using
   - **a.** the sun's rays.
   - **b.** wind.
   - **c.** moving water.
   - **d.** storms.
5. Which of the following substances is a fuel used in nuclear power plants?
   - **a.** sulfur dioxide
   - **b.** uranium
   - **c.** petroleum
   - **d.** carbon dioxide
6. Point source pollution comes from sources that are
   - **a.** basically unknown.
   - **b.** directly identifiable.
   - **c.** very small.
   - **d.** dumped illegally.
7. An unnatural warming of the atmosphere near Earth's surface is called
   - **a.** solar wind.
   - **b.** ozone accumulation.
   - **c.** acid precipitation.
   - **d.** global warming.
8. The careful use of resources is
   - **a.** conservation.
   - **b.** recycling.
   - **c.** composting.
   - **d.** deposition.
9. The Clean Air Act
   - **a.** makes all air pollution illegal.
   - **b.** limits greenhouse gases in outdoor air.
   - **c.** limits nonpoint source pollution.
   - **d.** set limits on certain pollutants in outdoor air.
10. What type of pollution did the Clean Water Act succeed in limiting?
    - **a.** carbon dioxide
    - **b.** sewage
    - **c.** solid waste
    - **d.** acid precipitation

Understanding Concepts

11. What are the three major types of fossil fuels?
12. What is a major negative impact of the use of fossil fuels?
13. What is the difference between a mineral resource and an ore?
14. Briefly explain how active solar collectors work.
15. Why do hydroelectric dams have limited lifetimes?
16. Explain why fresh water is a vital resource.
17. How can farmers help protect land resources?
18. When were some of the earliest laws passed to deal with water pollution? Why were they passed at that time?
19. Explain why an anticline might be a good place to search for petroleum and natural gas.
20. What are three things that you can do to prevent water pollution?
21. What are three things that you can do to save energy?

CHAPTER 4 Assessment *continued*

Critical Thinking

22. **Applying Concepts** Some people predict that tar sands and oil shale will one day supply much of our energy needs. Are tar sands and oil shale a good long-term energy solution? Explain.

23. **Relating Cause and Effect** What effect can recycling paper have on the use of resources and the creation of pollution?

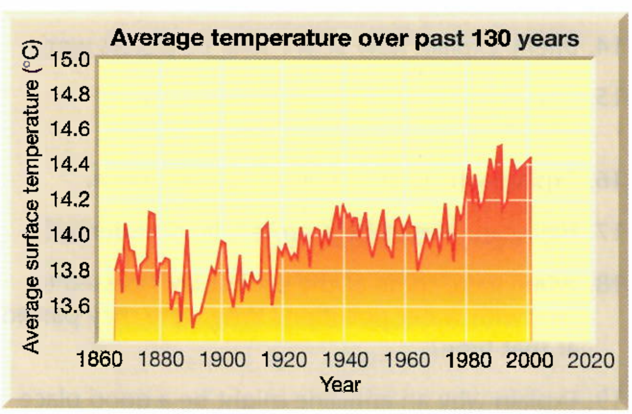
24. **Inferring** How might an increased use of alternate energy sources such as wind and solar radiation affect the lifetime of fossil fuel resources?

25. **Summarizing** Describe how a hydrothermal solution can produce a vein deposit of ore.

26. **Comparing and Contrasting** What is the difference between how electricity is produced with tides and how it's produced in a nuclear power plant?

Analyzing Data

Use the diagram below to answer Questions 27–29.



27. **Interpreting Graphs** What does this graph show?

28. **Using Graphs** What is the general temperature trend during the time period shown on the graph? What was the average temperature in 2000?

29. **Drawing Conclusions** How would you expect the graph to be different between 1700 and 1800, before the start of widespread industrialization? Explain.

Concepts in Action

30. **Classifying** Limestone is a nonmetallic mineral that has several uses: as a stone used for structures; as a substance used to neutralize acidic soils; as an ingredient in the manufacture of steel. Should limestone be classified as an industrial mineral or a building mineral? Explain.

31. **Analyzing Concepts** The factors in favor of the use of solar power include the fact that the fuel it uses is free, it's renewable, and it doesn't create pollution. Identify drawbacks of the use of solar power.

32. **Summarizing** What is the effect of the destruction of ozone on human life?

33. **Connecting Concepts** What is the relationship between petroleum production, the increased use of hybrid cars, and the level of air pollutants regulated by the Clean Air Act that are in the air?

Performance-Based Assessment

Drawing Conclusions Locate an electric power plant that is in or close to your community. Find out which method it uses to produce electricity. Take into consideration the way the plant produces power, its location, the pollution it produces, and the number of people it serves. Write a short essay on the plant's impact on the environment and on your community in general.

Standardized Test Prep

Test-Taking Tip

Make Logical Connections

A cause-and-effect statement may seem to be true when it is actually false. The statement may seem true because the stated cause and effect are both accurate. However, there may be no logical connection between the cause and the effect. In the question below, the opening phrase contains an accurate statement about fossil fuels. But only one answer provides a logical effect of the statement in the opening phrase.

Because fossil fuels are nonrenewable resources,

(A) solar energy is renewable.
(B) petroleum and natural gas often form together.
(C) supplies of coal, oil, and natural gas are finite.
(D) most power plants in the United States use fossil fuels to produce electricity.

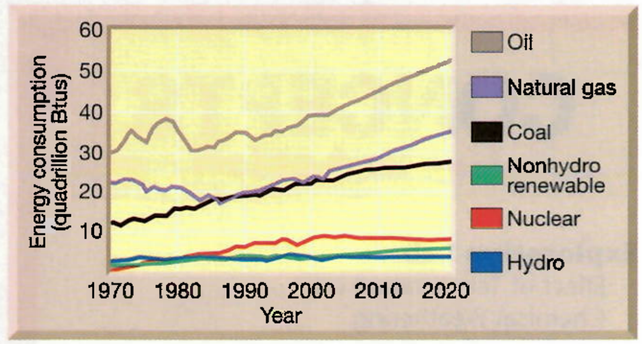
(Answer: C)

Choose the letter that best answers the question or completes the statement, or write a brief answer to the question.

1. Which one of the substances listed below is a fossil fuel?
 (A) uranium
 (B) petroleum
 (C) carbon dioxide
 (D) granite

2. Recycling is an important way to reduce resource consumption because
 (A) reducing waste is better than recycling it.
 (B) it decreases the use of new resources to make products.
 (C) recycling is not a new way to save resources.
 (D) curbside pick-up makes recycling more convenient in many communities.

Answer Questions 3–5 using the line graph below, which shows U.S. energy consumption between 1970 and 2000, and projected consumption between 2000 and 2020.



3. Which fuel source had the highest rate of consumption during this period?
 (A) coal
 (B) nuclear
 (C) oil
 (D) hydroelectric

4. Which renewable energy source is most widely used?
 (A) solar
 (B) hydroelectric
 (C) natural gas
 (D) nuclear

5. Look at the part of the graph that shows projections for U.S. energy consumption between 2000 and 2020. Explain why this pattern of consumption is, or is not, a good long-term energy strategy.

6. Explain how air pollutants can change the chemical composition of the atmosphere and how that affects Earth.