

Focus

Overview

In this section, students will learn how fossil fuels, such as petroleum, natural gas, and coal, form. Students will also learn where fossil-fuel deposits are found in the United States. The section discusses some of the ways we obtain fossil fuels and the environmental problems associated with obtaining and using fossil fuels.

Bellringer

Pose this question on the board: “What does the term *fossil fuels* imply about the source of these fuels?” (The term *fossil fuels* implies that these fuels are derived from the remains of ancient life.)

Motivate

Discussion GENERAL

Fossil-Fuel Use Lead students in a discussion about why fossil fuels are so widely used as energy resources. (Answers may include the cost, availability, amount of stored energy, and ease of use.) Challenge students to think about qualities an ideal fuel should have. (Sample answer: It should be abundant, be affordable, be easy to obtain, and produce little waste.) **LS Verbal**

READING WARM-UP

Objectives

- Describe what energy resources are.
- Identify three different forms of fossil fuels.
- Explain how fossil fuels form.
- Describe how fossil fuels are found and obtained.
- Identify four problems with fossil fuels.

Terms to Learn

| | |
|-------------|--------------------|
| fossil fuel | coal |
| petroleum | acid precipitation |
| natural gas | smog |

READING STRATEGY

Brainstorming The key idea of this section is fossil fuels. Brainstorm words and phrases related to fossil fuels.

fossil fuel a nonrenewable energy resource formed from the remains of organisms that lived long ago; examples include oil, coal, and natural gas

Fossil Fuels

How does a sunny day 200 million years ago relate to your life today?

Chances are that if you traveled to school today or used a product made of plastic, you used some of the energy from sunlight that fell on Earth several hundred million years ago. Life as you know it would be very different without the fuels or products formed from plants and animals that lived alongside the dinosaurs.

Energy Resources

The fuels we use to run cars, ships, planes, and factories and to generate electrical energy, shown in **Figure 1**, are energy resources. *Energy resources* are natural resources that humans use to generate energy. Most of the energy we use comes from a group of natural resources called fossil fuels. A **fossil fuel** is a nonrenewable energy resource formed from the remains of plants and animals that lived long ago. Examples of fossil fuels include petroleum, coal, and natural gas.

Energy is released from fossil fuels when they are burned. For example, the energy from burning coal in a power plant is used to produce electrical energy. However, because fossil fuels are a nonrenewable resource, once they are burned, they are gone. Therefore, like other resources, fossil fuels need to be conserved. In the 21st century, societies will continue to explore alternatives to fossil fuels. But they will also focus on developing more-efficient ways to use these fuels.



Figure 1 Light produced from electrical energy can be seen in this satellite image taken from space.

CHAPTER RESOURCES

Chapter Resource File

- Lesson Plan
- Directed Reading A **BASIC**
- Directed Reading B **SPECIAL NEEDS**

Technology

- **Transparencies**
- Bellringer
- **LINK TO PHYSICAL SCIENCE** Energy Conversions in a Car Engine
- Porous Rocks as Reservoirs for Fossil Fuels

Science Bloopers

Fossil-Fuel Fountain On January 10, 1901, oil from the famous Spindletop well near Beaumont, Texas, began to flow. In fact, the crude oil spewed higher than 90 m into the air! Drillers were caught off guard by the tremendous volume of petroleum—100,000 barrels per day. And drillers took 9 days to cap the well.



Figure 2 Some refineries use a process called distillation to separate petroleum into various types of petroleum products.

Types of Fossil Fuels

All living things are made up of the element carbon. Because fossil fuels are formed from the remains of plants and animals, all fossil fuels are made of carbon, too. Most of the carbon in fossil fuels exists as hydrogen-carbon compounds called *hydrocarbons*. But different fossil fuels have different forms. Fossil fuels may exist as liquids, gases, or solids.

Liquid Fossil Fuels: Petroleum

A liquid mixture of complex hydrocarbon compounds is called **petroleum**. Petroleum is also commonly known as *crude oil*. Petroleum is separated into several kinds of products in refineries, such as the one shown in **Figure 2**. Examples of fossil fuels separated from petroleum are gasoline, jet fuel, kerosene, diesel fuel, and fuel oil.

More than 40% of the world's energy comes from petroleum products. Petroleum products are the main fuel for forms of transportation, such as airplanes, trains, boats, and ships. Crude oil is so valuable that it is often called *black gold*.

Gaseous Fossil Fuels: Natural Gas

A gaseous mixture of hydrocarbons is called **natural gas**. Most natural gas is used for heating, but it is also used for generating electrical energy. Your kitchen stove may be powered by natural gas. Some motor vehicles, such as the van in **Figure 3**, use natural gas as fuel. An advantage of using natural gas is that using it causes less air pollution than using oil does. However, natural gas is very flammable. Gas leaks can lead to fires or deadly explosions.

Methane, CH_4 , is the main component of natural gas. But other components, such as butane and propane, can be separated from natural gas, too. Butane and propane are often used as fuel for camp stoves and outdoor grills.

✓ Reading Check What is natural gas most often used for? (See the Appendix for answers to Reading Checks.)

Answer to Reading Check

Natural gas is most often used for heating and generating electrical energy.

petroleum a liquid mixture of complex hydrocarbon compounds; used widely as a fuel source

natural gas a mixture of gaseous hydrocarbons located under the surface of the Earth, often near petroleum deposits; used as a fuel

Figure 3 Vehicles powered by natural gas are becoming more common.



CONNECTION ACTIVITY

Language Arts — ADVANCED



Creative Writing Petroleum is more than a fuel source; it is refined to make plastics and other petrochemical products we use every day. Petrochemicals are used to create medicines, inks, solvents, clothing, fertilizers, and many other products. Have students make a list of 20 products made from petroleum. Then, have students write a story about a world without petroleum products.

LS Verbal

Teach

CONNECTION to Physical Science — GENERAL

How Car Engines Work Use the teaching transparency entitled “Energy Conversions in a Car Engine” to show students how car engines convert the chemical energy of gasoline into thermal energy and kinetic energy through combustion. **LS Visual**



The Origin of Fossil Fuels

One characteristic all fossil fuels share is that they formed from the remains of organisms that lived long ago. Over millions of years, these remains are buried by sediment and rock. Rising pressure and temperature cause slow chemical changes that cause the formation of coal, petroleum, or natural gas. When hydrocarbons combust, or combine rapidly with oxygen, they release the energy stored in the carbon-carbon and carbon-hydrogen bonds made by organisms when they were alive.

Teach, *continued*

CONNECTION ACTIVITY Real World ADVANCED

Electrical Energy in Your Community

Have students find out what fuel sources are used to produce electrical energy in their community. Have students create a list of 15 ways electrical energy consumption in your community can be reduced. Have students create an anonymous survey to find out how many people would follow their 15-step energy conservation plan.

IS Interpersonal

Cultural Awareness GENERAL

Ancient Wells Natural gas seeps were first discovered in ancient Persia (now Iran) between 6000 and 2000 BCE. Records from China indicate that natural gas was used beginning about 900 BCE. The Chinese drilled the first known natural gas well by using bamboo poles and primitive drill bits. The well was 140 m deep. In Europe, natural gas was first discovered in England in 1659.

Answer to Reading Check

Coal was most commonly used to power trains.

Figure 4 This coal is being gathered so that it may be burned in the power plant shown in the background.



coal a fossil fuel that forms underground from partially decomposed plant material

INTERNET ACTIVITY

For another activity related to this chapter, go to go.hrw.com and type in the keyword **HZ5ENRW**.

Solid Fossil Fuels: Coal

The solid fossil fuel that humans use most is coal. **Coal** is a fossil fuel that is formed underground from partially decomposed plant material. Coal was once the major source of energy in the United States. People burned coal in stoves to heat their homes. They also used coal in transportation. Many trains in the 1800s and early 1900s were powered by coal-burning steam locomotives.

As cleaner energy resources became available, people reduced their use of coal. People began to use coal less because burning coal produces large amounts of air pollution. Now, people use forms of transportation that use oil instead of coal as fuel. In the United States, coal is now rarely used as a fuel for heating. However, many power plants, such as the one shown in **Figure 4**, burn coal to generate electrical energy.

✓ Reading Check In the 1800s and early 1900s, what was coal most commonly used for?

CONNECTION TO Chemistry

Hydrocarbons Both petroleum and natural gas are made of compounds called *hydrocarbons*. A hydrocarbon is an organic compound that contains only carbon and hydrogen. A molecule of propane, C_3H_8 , a gaseous fossil fuel, contains three carbons and eight hydrogens. Using a molecular model set, create a model of a propane molecule. (Hint: Each carbon atom should have four bonds, and each hydrogen atom should have one bond.)

ACTIVITY

INCLUSION Strategies

- Learning Disabled
- Attention Deficit Disorder
- Developmentally Delayed

Have students identify three fossil fuels on separate index cards. On the back of each card, students should describe the uses of the fuel and the advantages and disadvantages of using it. Students may also list ways to conserve the fuel. Have

students trade cards with a partner and quiz each other about the content of their cards. Encourage English language learners to write the information on their flash cards in English and in their first language. The cards can be used for studying or for a class presentation. **IS** Verbal/Visual **English Language Learners**

How Do Fossil Fuels Form?

All fossil fuels form from the buried remains of ancient organisms. But different kinds of fossil fuels form in different ways and from different kinds of organisms.

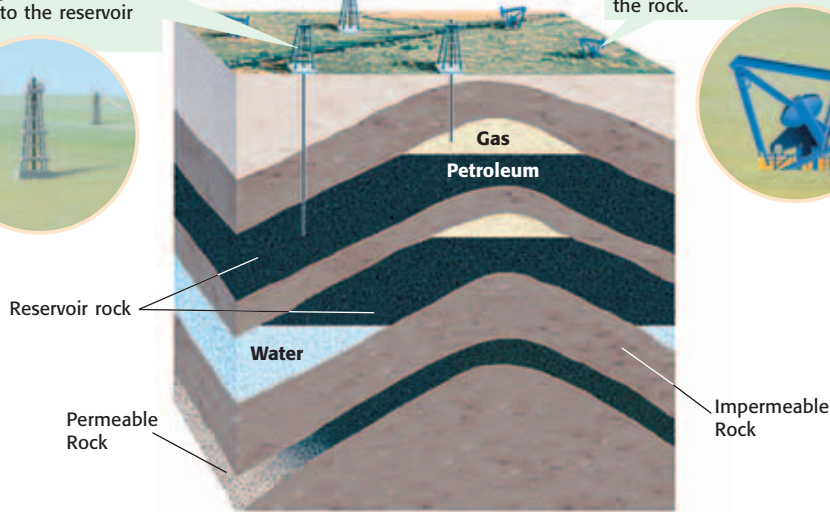
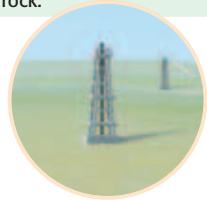
Petroleum and Natural Gas Formation

Petroleum and natural gas form mainly from the remains of microscopic sea organisms. When these organisms die, their remains settle on the ocean floor. There, the remains decay, are buried, and become part of the ocean sediment. Over time, the sediment slowly becomes rock, trapping the decayed remains. Through physical and chemical changes over millions of years, the remains become petroleum and gas. Gradually, more rocks form above the rocks that contain the fossil fuels. Under the pressure of overlying rocks and sediments, the fossil fuels can move through permeable rocks. *Permeable rocks* are rocks that allow fluids, such as petroleum and gas, to move through them. As shown in **Figure 5**, these permeable rocks become reservoirs that hold petroleum and natural gas.

The formation of petroleum and natural gas is an ongoing process. Part of the remains of today's sea life will become petroleum and natural gas millions of years from now.

Figure 5 Petroleum and gas move through permeable rock. Eventually, these fuels are collected in reservoirs. Rocks that are folded upward are excellent fossil-fuel traps.

To collect petroleum and gas, engineers must drill wells into the reservoir rock.



After fuels are successfully tapped, pumps are used to remove the fuels from the rock.



Quick Lab

Rock Sponge

1. Place **samples of sandstone, limestone, and shale** in separate **Petri dishes**.
2. Place **five drops of light machine oil** on each rock sample.
3. Observe and record the time required for the oil to be absorbed by each of the rock samples.
4. Which rock sample absorbed the oil fastest? Why?
5. Based on your findings, describe a property that allows fossil fuels to be easily removed from reservoir rock.

Demonstration — GENERAL

MATERIALS

- food coloring, red and blue
- jar, glass, clean, empty
- rubbing alcohol, 100 mL
- water, 100 mL
- vegetable oil, 100 mL

Simulating Reservoirs Natural gas often accumulates above an oil deposit, as shown in **Figure 5**. Use rubbing alcohol to represent natural gas and cooking oil to represent petroleum. Add a few drops of blue food coloring to the water and a few drops of red food coloring to the alcohol. Ask students to determine the correct order to add the liquids to the jar to match the layers in **Figure 5**. **Note:** Rubbing alcohol is being used here to represent natural gas because it is less dense than cooking oil. However, when found underground, natural gas is in a gaseous state. **LS Visual** **English Language Learners**

Quick Lab

MATERIALS

FOR EACH STUDENT

- machine oil, light
- Petri dishes (3)
- samples of sandstone, limestone, and shale

Teacher's Note: Use a light-colored shale. Shale has 2% or more organic matter, which will quickly soak up the oil.

Answers

4. Answers may vary. The rock sample that has the highest percentage of interconnected pore space should soak up the oil the fastest. Most reservoir rock is limestone, which has many connected pores.
5. Oil and gas move easily through reservoir rock that has a high percentage of interconnected pore space. This space allows for the easy removal of liquid fossil fuels.

CONNECTION ACTIVITY
Math **BASIC**

Percentage of Carbon A grade of coal contains a high percentage of carbon, such as anthracite, contains more usable energy and releases less pollution than a grade of coal that contains a low percentage of carbon, such as lignite. To find the percentage of carbon in a coal sample divide the mass of carbon by the total mass of the sample and multiply the result by 100. Have students answer the following questions:

- What is the percentage of carbon in a 10 g coal sample if the mass of carbon is 6.5 g? (65%)
- What is the percentage of carbon in a 15 g coal sample if the mass of carbon is 9.2 g? (61%)
- What is the percentage of carbon in an 8 g coal sample if the mass of carbon is 5.6 g? (70%)

LS Logical

Using the Figure **BASIC**

Coal Formation Have students answer the following questions:

- What kinds of organisms play an important role in coal formation? (bacteria, plants, and fungi)
- In a given area, which would be older: peat or lignite deposits? (lignite, because peat is an earlier stage of coal formation)

LS Visual

Coal Formation

Coal forms differently from the way petroleum and natural gas form. Coal forms underground from decayed swamp plants over millions of years. When the plants die, they sink to the bottom of the swamp. This begins the process of coal formation.

The four stages of coal formation, as shown in **Figure 6**, are peat, lignite, bituminous coal, and anthracite. Peat is a form of coal in which the remains of plants are only partially decomposed. Over time, the peat is buried under sediment. Water and gases are squeezed out of the peat. Pressure and high temperature then turn the peat into lignite. The process by which pressure and temperature increase due to the deposition of sediment creates different forms of coal. The percentage of carbon increases with each stage of coal formation. The higher the carbon content is, the more cleanly the material burns. Pollution controls can remove most of the pollutants produced by burning coal. However, when burned, all grades of coal pollute the air.

Figure 6 Coal Formation



Homework **ADVANCED**

Fuel-Efficient Cars In 1998, the United States consumed nearly 583 billion liters of liquid fossil fuels. More than 460 billion liters of this total was gasoline. After an average-sized car is driven 11,000 m, it has released its weight in carbon dioxide. Have students compare the fuel efficiency of commercially available cars and calculate the annual carbon dioxide reduction and fuel savings of a fuel-efficient car.

LS Logical

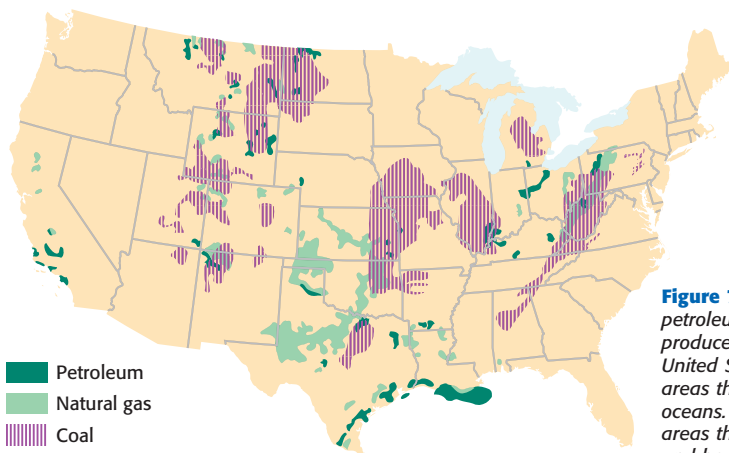


Figure 7 Most of the petroleum and natural gas produced in the continental United States comes from areas that were prehistoric oceans. Coal comes from areas that were swamps and bogs.

Where Are Fossil Fuels Found?

Fossil fuels are found in many parts of the world. Some fossil fuels are found on land, while other fossil fuels are found beneath the ocean. As shown in **Figure 7**, the United States has large reserves of petroleum, natural gas, and coal. Despite its large reserves of petroleum, the United States imports petroleum as well. About one-half of the petroleum used by the United States is imported from the Middle East, South America, Africa, Canada, and Mexico.

How Do We Obtain Fossil Fuels?

Humans use several methods to remove fossil fuels from the Earth's crust. The kind and location of fuel determine the method used to remove the fuel. People remove petroleum and natural gas from Earth by drilling wells into rock that contains these resources. Oil wells exist on land and in the ocean. For offshore drilling, engineers mount drills on platforms that are secured to the ocean floor or that float at the ocean's surface. **Figure 8** shows an offshore oil rig.

People obtain coal either by mining deep beneath Earth's surface or by surface mining. Surface mining, also known as *strip mining*, is the process by which soil and rock are stripped from the Earth's surface to expose the underlying coal that is to be mined.

✓ Reading Check How are natural gas and petroleum removed from Earth?



Figure 8 Large oil rigs, some of which are more than 300 m tall, operate offshore in many places, such as the Gulf of Mexico and the North Sea.

Debate ADVANCED

Drilling in a Wildlife Refuge

The U.S. Fish and Wildlife Service, which administers Alaska's Arctic National Wildlife Refuge, states that its primary mandate is "to protect the wildlife and habitats of this area for the benefit of people now and in the future." The refuge's coastal plain is the calving ground for the porcupine caribou herd, the most important land-based denning area for the entire Beaufort Sea polar bear population, home for 350 reintroduced musk oxen, and an important habitat for more than 180 bird species.

Encourage students to research the current status of the oil exploration and drilling projects in the Arctic National Wildlife Refuge. Divide the class into two teams, and assign one team the pros and assign one team the cons of drilling in the Arctic National Wildlife Refuge. Have the teams research and then debate the issue. **LS Verbal**

Answer to Reading Check

Natural gas and petroleum are removed from the Earth by drilling wells into rock that contains these resources.

CONNECTION to ADVANCED Climatology



Carbon Dioxide and the Greenhouse Effect

One of the products of burning fossil fuels is carbon dioxide. Scientists recognize carbon dioxide as a greenhouse gas—a gas that traps thermal energy and increases the temperature of the Earth's atmosphere. Scientists have determined that both carbon dioxide levels and global temperatures are increasing.

However, they have different opinions about the many possible ways increasing levels of carbon dioxide may be affecting the Earth's climate. Have students find newspaper and magazine articles that give examples of climate change. Have students write an essay discussing their predictions about greenhouse gases and climate change. **LS Intrapersonal**

Close

Reteaching BASIC

Resource Map Display a map of the United States. Have students use **Figure 7** to take turns marking the fossil fuel deposits in the United States and telling how these resources are extracted, how they are used, and what environmental problems are associated with them. **LS Verbal**

Quiz GENERAL

1. Explain why we use different methods to extract fossil fuels from the Earth's crust. (We use different methods because fossil fuels are found in different locations and have different compositions.)
2. When an oil and gas reservoir is drilled, which substance is generally encountered first—oil or natural gas? Why? (natural gas; because it is less dense than oil and migrates to the top of the reservoir)

Alternative Assessment GENERAL

Concept Mapping Have students construct concept maps that compare different fossil fuels. Their maps should include the formation of the fuel, the location of the fuel, and the extraction method. One type of fuel may have two or more locations and extraction methods. **LS Visual**



Figure 9 Notice how this statue looked before the effects of acid precipitation.

acid precipitation precipitation, such as rain, sleet, or snow, that contains a high concentration of acids, often because of the pollution of the atmosphere

smog photochemical haze that forms when sunlight acts on industrial pollutants and burning fuels

Figure 10 The oil spilled from the carrier, *Treasure*, endangered the lives of many animals including the blackfooted penguins.

Problems with Fossil Fuels

Although fossil fuels provide the energy we need, the methods of obtaining and using them can have negative effects on the environment. For example, when coal is burned without pollution controls, sulfur dioxide is released. Sulfur dioxide combines with moisture in the air to produce sulfuric acid. Sulfuric acid is one of the acids in acid precipitation. **Acid precipitation** is rain, sleet, or snow that has a high concentration of acids, often because of air pollutants. Acid precipitation negatively affects wildlife, plants, buildings, and statues, as shown in **Figure 9**.

Reading Check How can the burning of fossil fuels affect rain?

Coal Mining

The mining of coal can also create environmental problems. Surface mining removes soil, which some plants need for growth and some animals need for shelter. If land is not properly restored afterward, surface mining can destroy wildlife habitats. Coal mining can also lower water tables and pollute water supplies. The potential for underground mines to collapse endangers the lives of miners.

Petroleum Problems

Producing, transporting, and using petroleum can cause environmental problems and endanger wildlife. In June 2000, the carrier, *Treasure*, sank off the coast of South Africa and spilled more than 400 tons of oil. The toxic oil coated thousands of blackfooted penguins, as shown in **Figure 10**. The oil hindered the penguins from swimming and catching fish for food.

Smog

Burning petroleum products causes an environmental problem called smog. **Smog** is photochemical haze that forms when sunlight acts on industrial pollutants and burning fuels. Smog is particularly serious in cities such as Houston and Los Angeles as a result of millions of automobiles that burn gasoline. Also, mountains that surround Los Angeles prevent the wind from blowing pollutants away.



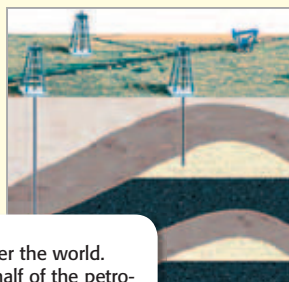
Answer to Reading Check

The sulfur dioxide released from the burning coal combines with moisture in the air to produce acid rain.

SECTION Review

Summary

- Energy resources are resources that humans use to produce energy.
- Petroleum is a liquid fossil fuel that is made of hydrocarbon compounds.
- Natural gas is a gaseous fossil fuel that is made of hydrocarbon compounds.
- Coal is a solid fossil fuel that forms from decayed swamp plants.
- Petroleum and natural gas form from decayed sea life on the ocean floor.
- Fossil fuels are found all over the world. The United States imports half of the petroleum it uses from the Middle East, South America, Africa, Mexico, and Canada.
- Fossil fuels are obtained by drilling oil wells, mining below Earth's surface, and strip mining.
- Acid precipitation, smog, water pollution, and the destruction of wildlife habitat are some of the environmental problems that are created by the use of fossil fuels.



Using Key Terms

- Use each of the following terms in a separate sentence: *energy resource*, *fossil fuel*, *petroleum*, *natural gas*, *coal*, *acid precipitation*, and *smog*.

Understanding Key Ideas

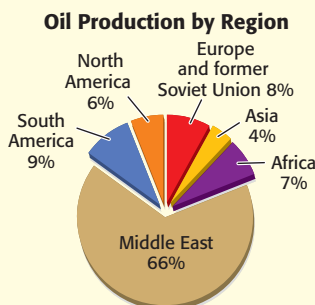
- Which of the following stages of coal formation contains the highest carbon content?
 - lignite
 - anthracite
 - peat
 - bituminous coal
- Name a solid fossil fuel, a liquid fossil fuel, and a gaseous fossil fuel.
- Briefly describe how petroleum and natural gas form.
- How do we obtain petroleum and natural gas?
- Describe the advantages and disadvantages of fossil fuel use.

Critical Thinking

- Making Comparisons** What is the difference between the organic material from which coal forms and the organic material from which petroleum and natural gas form?
- Making Inferences** Why can't carpooling and using mass-transit systems eliminate the problems associated with fossil fuels?

Interpreting Graphics

Use the pie chart below to answer the questions that follow.



Source: International Energy Agency.

- Which region produces the most oil?
- If the total sales of oil in 2002 were \$500 billion, what was the value of the oil produced in North America?

SciLinks
Developed and maintained by the
National Science Teachers Association

For a variety of links related to this chapter, go to www.scilinks.org

Topic: Fossil Fuels
SciLinks code: HSM0614

Answers to Section Review

- Sample answer: An energy resource is a resource that humans use to produce energy. Fossil fuels are formed from the remains of organisms that lived long ago. Petroleum is a liquid mixture of complex hydrocarbon compounds. Natural gas is a mixture of gaseous hydrocarbons. Coal is formed from partially decomposed plant material. The combination of sulfur dioxide and water vapor produces acid precipitation. Smog is a petrochemical haze that forms when sunlight acts on industrial pollutants and burning fuels.
- b
- Coal is a solid fossil fuel, petroleum is a liquid fossil fuel, and natural gas is a gaseous fossil fuel.
- Sample answer: Petroleum and natural gas both form when microscopic sea organisms die, settle to the ocean floor, and decay. The remains of organisms are buried, and after millions of years of pressure and heat they become natural gas and petroleum.
- We obtain petroleum and natural gas by drilling wells into rock formations that contain these resources.
- Answers may vary. Students may mention oil spills, loss of soil from strip mining coal, acid rain, the production of smog due to burning fossil fuels, and increasing atmospheric CO₂.
- Petroleum and natural gas form underwater from the decayed remains of aquatic microorganisms. Coal forms on land from partially decayed plant matter.
- Answers may vary. Accept any well supported answer.
- the Middle East
- $\$500,000,000,000 \times 0.06 = \$30,000,000,000$

CHAPTER RESOURCES

Chapter Resource File

- Section Quiz **GENERAL**
- Section Review **GENERAL**
- Vocabulary and Section Summary **GENERAL**
- Reinforcement Worksheet **BASIC**
- SciLinks Activity **GENERAL**

Workbooks

- Math Skills for Science
 - Parts of 100: Calculating Percentages **GENERAL**