Chapter 13

Exploring Space

CALIFORNIA Standards Preview

S 8.2 Unbalanced forces cause changes in velocity. As a basis for understanding this concept:

e. Students know that when the forces on an object are unbalanced, the object will change its velocity (that is, it will speed up, slow down, or change direction).

S 8.4 The structure and composition of the universe can be learned from studying stars and galaxies and their evolution. As a basis for understanding this concept:

d. Students know that stars are the source of light for all bright objects in outer space and that the Moon and planets shine by reflected sunlight, not by their own light.

Framework Various types of exploratory missions have yielded much information about the reflectivity, structure, and composition of the Moon and the planets. Those missions have included spacecraft flying by and orbiting those bodies, the soft landing of spacecraft fitted with instruments, and, of course, the visits of astronauts to the Moon.

An astronaut working on the International Space Station in orbit around Earth

Video Preview
Discovery Channel School
Exploring Space

S 8.4.d

Focus on the **BIG Idea**

How do scientists learn more about the solar system?

Check What You Know

Look at the photo of an astronaut below. The astronaut and other objects seem to be floating. Why do you think astronauts appear to float when in orbit?

Build Science Vocabulary

The images shown here represent some of the key terms in this chapter. You can use this vocabulary skill to help you understand the meaning of some key terms in this chapter.

Vocabulary Skill

High-Use Academic Words

Knowing these academic words will help you read and write in many different subjects. Look for these words in context as you read the chapter.

Word	Definition	Example Sentence
source (sawrs) p. 517	*n.* That from which something comes into existence	Gasoline is the source of power for most cars.
consumer (kun SOOM ur) p. 522	*n.* A person who buys goods and services for personal needs	People who buy food, clothing, and TVs are consumers.
benefit (BEN uh fit) p. 523	*v.* To bring help; aid	Daily exercise benefits nearly everyone.
technology (tek NAHL uh jee) p. 523	*n.* A way of changing the natural world to meet human needs	The technology of personal computers has changed the way people communicate.

Apply It!

From the list above, choose the word that best completes the sentence.

1. When you buy new clothes, you are a ______ .

2. DVD players are an example of a new ______.

3. Medicines ______ people who are sick.

Chapter 13 Vocabulary

Section 1 (page 502)
rocket
thrust
velocity
orbital velocity
escape velocity

Section 2 (page 510)
satellite

Section 3 (page 515)
space shuttle
space station
space probe
rover

Section 4 (page 520)
vacuum
microgravity
space spinoff
remote sensing
geostationary orbit

Interactive Textbook
Build Science Vocabulary *Online*
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How to Read Science

Reading Skill

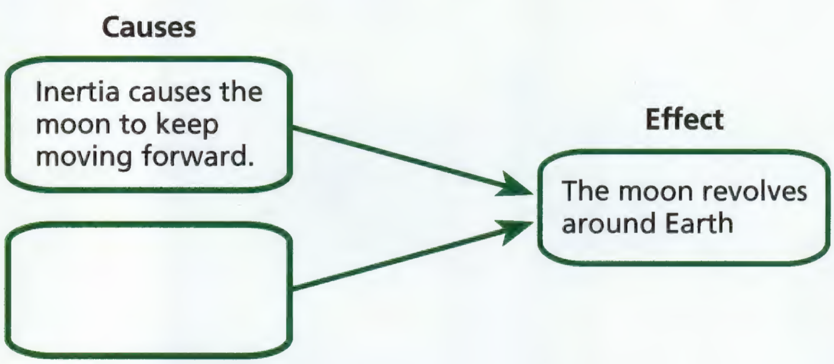
Relate Cause and Effect

Many passages in science textbooks describe cause-and-effect relationships. A cause makes something happen. An effect is what happens. As you read a passage, look for words that signal cause and effect. Signal words and phrases include *because, due to, for this reason, result of, so that,* and *therefore*.

Read the following paragraph, noting the words that signal cause and effect.

> The moon's orbit is *the result of* two factors—inertia and gravity. The moon keeps moving ahead *because* of inertia. At the same time, gravity keeps pulling the moon toward Earth. *For this reason*, the moon does not travel in a straight line. The combined effects of inertia and gravity cause the moon to revolve around Earth.

The cause-and-effect relationships in this passage can be illustrated with a graphic organizer like the one below.



Apply It!

Complete the cause-and-effect graphic organizer above. Then complete the following sentence in your own words.

The moon revolves around Earth because _______.

Create cause-and-effect graphic organizers for Sections 1 and 2.

Lab zone

Standards Investigation

S 8.4.d, 8.4.e

Design and Build a Space Exploration Vehicle

How do scientists study the other planets in our solar system? One way is to send a remotely operated vehicle to explore the surface, as was done recently by two Mars rovers. Such a vehicle must be designed to meet specific requirements, such as communicating with scientists on Earth and being able to operate in a variety of environments.

Your Goal

To design, build, and test a vehicle for exploring the surface of a planet

You will

- identify the geological features that are found on the planets and moons of the solar system
- select a planet or moon, and brainstorm ways to build a vehicle that can move around its surface
- design and sketch a model of the vehicle
- build and test a model vehicle, and present your vehicle to the class
- follow the safety guidelines in Appendix A

Plan It!

Begin by identifying the different types of planetary surfaces found in the solar system. Next, brainstorm how a vehicle could move over some of these surfaces. You may want to think about how all-terrain vehicles on Earth are designed. Consider how you would build a model of the vehicle, and what materials you will need. Then build and test your vehicle.

Section 1

Integrating Physics

The Science of Rockets

CALIFORNIA
Standards Focus

S 8.2.e Students know that when the forces on an object are unbalanced, the object will change its velocity (that is, it will speed up, slow down, or change direction).

- How were rockets developed?
- How does a rocket work?
- What is the main advantage of a multistage rocket?

Key Terms

- rocket
- thrust
- velocity
- orbital velocity
- escape velocity

Lab zone

Standards Warm-Up

What Force Moves a Balloon?

1. Put on your goggles. Blow up a balloon and hold its neck closed with your fingers.
2. Point the far end of the balloon in a direction where there are no people. Put your free hand behind the balloon's neck, so you will be able to feel the force of the air from the balloon on your hand. Let go of the balloon. Observe what happens.
3. Repeat Steps 1 and 2 without your free hand behind the neck of the balloon.

Think It Over

Inferring What happened when you let go of the balloon? Which direction did the balloon move in comparison to the direction the air moved out of the balloon? What do you think caused the balloon to move in that direction? Did the position of your free hand affect the balloon's movement?

People have dreamed of traveling through space for centuries. Although the moons and planets of our solar system are much closer than the stars, they are still very far away. How could someone travel such great distances through space?

In the 1860s, the science fiction writer Jules Verne envisioned a spacecraft shot to the moon out of a huge cannon. When people finally did travel to the moon, though, they used rockets rather than cannons. Although Verne was wrong about how humans would reach the moon, he did anticipate many aspects of the space program. By the late 1900s, rocket-powered spacecraft were able to travel to the moon and to many other places in the solar system.

FIGURE 1
Jules Verne's Spacecraft
Jules Verne imagined that a spacecraft and crew were shot to the moon by a cannon.

A History of Rockets

You've probably seen rockets at fireworks displays. As the rockets moved skyward, you may have noticed a fiery gas rushing out of the back. A **rocket** is a device that expels gas in one direction to move in the opposite direction. **Rocket technology originated in China hundreds of years ago and gradually spread to other parts of the world.** Rockets were developed for military use as well as for fireworks.

FIGURE 2
Chinese Rockets
According to a Chinese legend, around 1500 an official named Wan-Hoo tried to fly to the moon by tying a number of rockets to his chair. The rockets exploded with a tremendous roar. Once the smoke cleared, there was no trace of Wan-Hoo or his chair.

Origins of Rockets The first rockets were made in China in the 1100s. These early rockets were very simple—they were arrows coated with a flammable powder that were lighted and shot with bows. By about 1200, the Chinese were using gunpowder inside their rockets.

The British greatly improved rocketry in the early 1800s. British ships used rockets against American troops in the War of 1812. The *Star-Spangled Banner* contains the words "the rockets' red glare, the bombs bursting in air." These words describe a British rocket attack on Fort McHenry in Baltimore, Maryland.

Development of Modern Rockets Modern rockets were first developed in the early 1900s. They owe much of their development to a few scientists. One was the Russian physicist Konstantin Tsiolkovsky. In the early 1900s, Tsiolkovsky described in scientific terms how rockets work and proposed designs for advanced rockets. The American physicist Robert Goddard also designed rockets. Beginning around 1915, Goddard went a step further and built rockets to test his designs.

Rocket design made major advances during World War II. Military rockets were used to carry explosives. The Germans used a rocket called the V2 to destroy both military and civilian targets. The V2 was a large rocket that could travel about 300 kilometers. The designer of the V2, Wernher von Braun, came to the United States after the war was over. Von Braun used his experience to direct the development of many rockets used in the United States space program.

Reading Checkpoint **Name three scientists who contributed to the development of modern rockets.**

Lab zone Try This **Activity**

Be a Rocket Scientist

You can build a rocket.

1. Use a plastic or paper cup as the rocket body. Cut out a paper nose cone. Tape it to the bottom of the cup.
2. Obtain an empty film canister with a lid that snaps on inside the canister. Go outside to do Steps 3–5.
3. Fill the canister about one-quarter full with water.
4. Put on your goggles. Now add half of a fizzing antacid tablet to the film canister and quickly snap on the lid.
5. Place the canister on the ground with the lid down. Place your rocket over the canister and stand back.

Observing What action happened inside the film canister? What was the reaction of the rocket?

How Do Rockets Work?

A rocket can be as small as your finger or as large as a skyscraper. An essential feature of any rocket, though, is that it expels gas in one direction. **A rocket moves forward when gases shooting out the back of the rocket push it in the opposite direction.**

A rocket works in much the same way as a balloon that is propelled through the air by releasing gas. In most rockets, fuel is burned to make hot gas. The gas pushes outward in every direction, but it can leave the rocket only through openings at the back. The movement of gas out of these openings moves the rocket forward. Figure 3 shows how rockets move.

Action and Reaction Forces The movement of a rocket demonstrates Newton's third law of motion: For every force, or action, there is an equal and opposite force, or reaction. The force of the air moving out of a balloon is an action force. An equal force—the reaction force—pushes the balloon forward.

The reaction force that propels a rocket forward is called **thrust.** The amount of thrust depends on several factors, including the mass and speed of the gases propelled out of the rocket. The greater the thrust, the greater a rocket's velocity. Recall that **velocity** is speed in a given direction.

Orbital and Escape Velocity In order to lift off the ground, a rocket must have more upward thrust than the downward force of gravity. Once a rocket is off the ground, it must reach a certain velocity in order to go into orbit. **Orbital velocity** is the velocity a rocket must achieve to establish an orbit around Earth. If the rocket moves slower than orbital velocity, Earth's gravity will cause it to fall back to the surface.

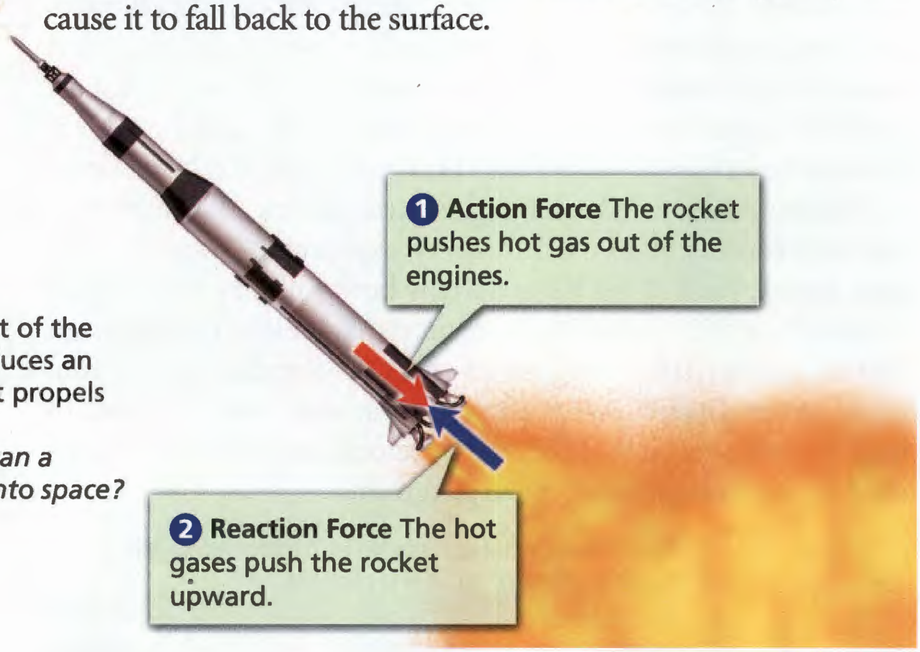


FIGURE 3
Rocket Action and Reaction
The force of gas propelled out of the back of a rocket (action) produces an opposing force (reaction) that propels the rocket forward.
Interpreting Diagrams *How can a rocket rise from the ground into space?*

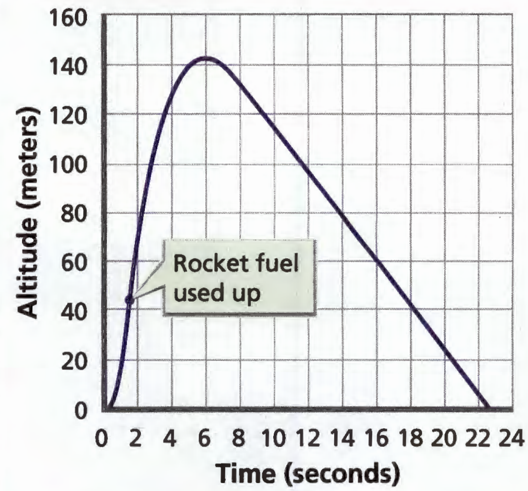
Math Analyzing Data

Rocket Altitude

A rocket's altitude is how high it is above the ground. Use the graph at the right to answer the following questions about how a model rocket's altitude changes over time.

1. **Reading Graphs** What two variables are being graphed? In what unit is each measured?
2. **Reading Graphs** What was the rocket's altitude after 2 seconds? After 4 seconds?
3. **Reading Graphs** At what time did the rocket reach its greatest altitude?
4. **Inferring** Why do you think the rocket continued to rise after it ran out of fuel?

Rocket Flight



Reviewing Math: Algebra and Functions 7.1.5

If the rocket has an even greater velocity, it can fly off into space. **Escape velocity** is the velocity a rocket must reach to fly beyond a planet's gravitational pull. The escape velocity a rocket needs to leave Earth is about 40,200 kilometers per hour. That's more than 11 kilometers every second!

Rocket Fuels Rockets create thrust by ejecting gas. Three types of fuel are used to power modern spacecraft: solid fuel, liquid fuel, and electrically charged particles of gas (ions). Solid-fuel and liquid-fuel rockets carry oxygen that allows the fuel to burn.

In a solid-fuel rocket, oxygen is mixed with the fuel, which is a dry explosive chemical. A fireworks rocket is a good example of a solid-fuel rocket. For such a simple rocket, a match can be used to ignite the fuel. Large solid-fuel rockets have a device called an igniter that can be triggered from a distance. Once a solid-fuel rocket is ignited, it burns until all the fuel is gone.

In a liquid-fuel rocket, both the oxygen and the fuel are in liquid form. They are stored in separate compartments. When the rocket fires, the fuel and oxygen are pumped into the same chamber and ignited. An advantage of liquid-fuel rockets is that the burning of fuel can be controlled by regulating how much liquid fuel and oxygen are mixed together.

Ion rockets do not burn chemical fuels. Rather, they expel gas ions out of their engines at very high speeds. Ion rockets generally create less thrust than solid-fuel or liquid-fuel rockets. But they are very fuel efficient.

Reading Checkpoint What are the three types of rocket fuel?

FIGURE 4
Rocket Velocity
This artist's view shows a NASA rocket rising into space.

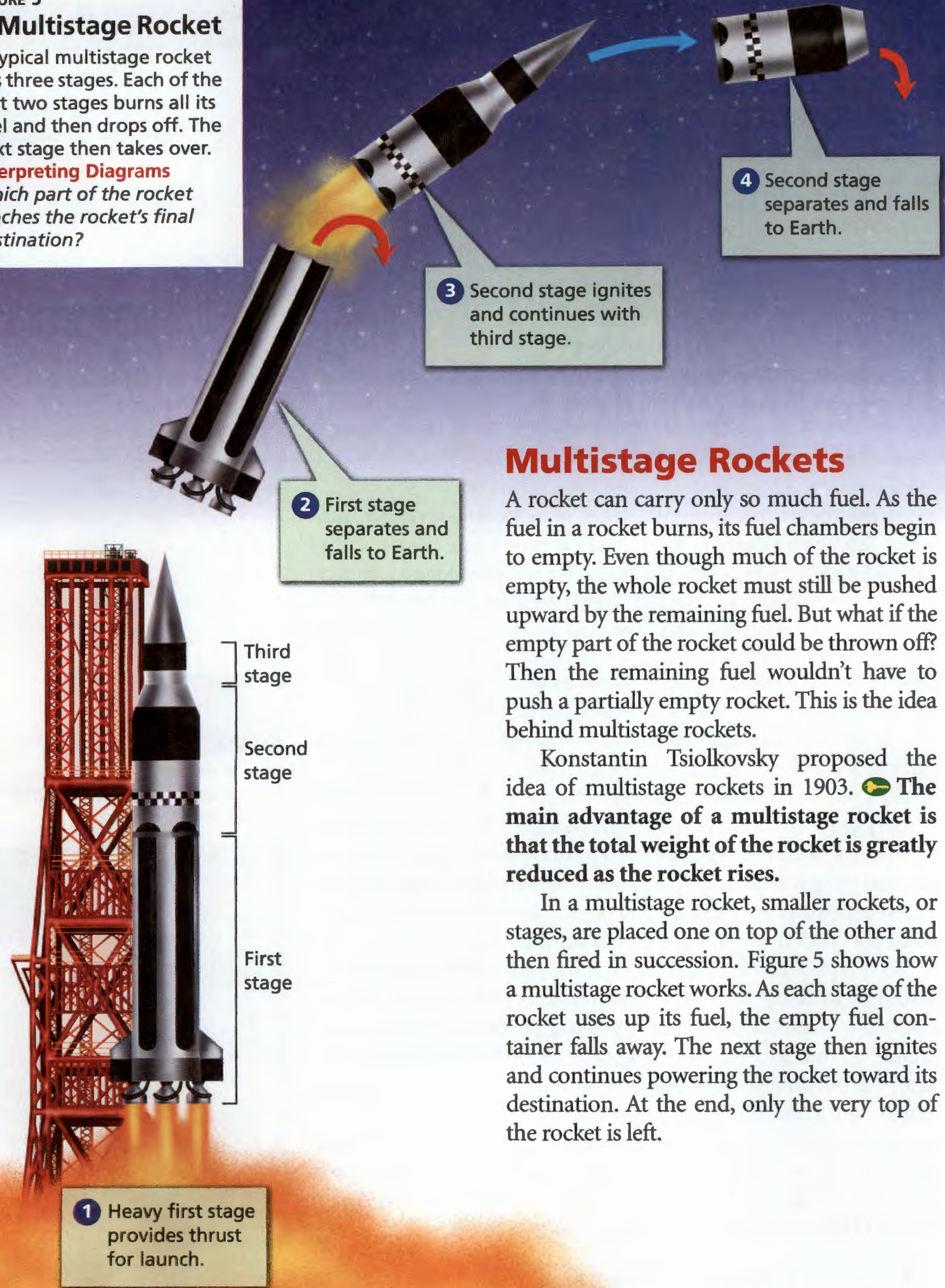


FIGURE 5

A Multistage Rocket

A typical multistage rocket has three stages. Each of the first two stages burns all its fuel and then drops off. The next stage then takes over.

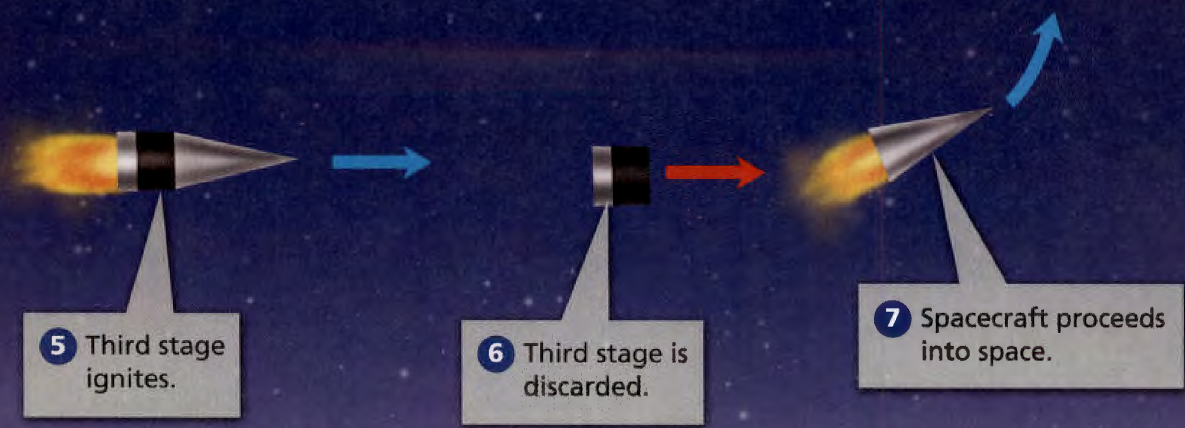
Interpreting Diagrams *Which part of the rocket reaches the rocket's final destination?*

Multistage Rockets

A rocket can carry only so much fuel. As the fuel in a rocket burns, its fuel chambers begin to empty. Even though much of the rocket is empty, the whole rocket must still be pushed upward by the remaining fuel. But what if the empty part of the rocket could be thrown off? Then the remaining fuel wouldn't have to push a partially empty rocket. This is the idea behind multistage rockets.

Konstantin Tsiolkovsky proposed the idea of multistage rockets in 1903. **The main advantage of a multistage rocket is that the total weight of the rocket is greatly reduced as the rocket rises.**

In a multistage rocket, smaller rockets, or stages, are placed one on top of the other and then fired in succession. Figure 5 shows how a multistage rocket works. As each stage of the rocket uses up its fuel, the empty fuel container falls away. The next stage then ignites and continues powering the rocket toward its destination. At the end, only the very top of the rocket is left.



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In the 1960s, the development of powerful multistage rockets such as the Saturn V made it possible to send spacecraft to the moon and the solar system beyond. The mighty Saturn V rocket stood 111 meters tall—higher than the length of a football field. It was by far the most powerful rocket ever built. Today, multistage rockets are used to launch a wide variety of satellites and space probes.

Reading Checkpoint **What is a multistage rocket?**

Section 1 Assessment

S 8.2.e, E-LA: Reading 8.2.0 Writing 8.2.0

Target Reading Skill **Relate Cause and Effect** Reread *A History of Rockets* on page 503. Create a cause-and-effect graphic organizer that shows the development of modern rockets. Include the contributions of the Chinese, Tsiolkovsky, Goddard, and von Braun.

Reviewing Key Concepts

1. a. **Defining** What is a rocket?
   b. **Reviewing** Where and when were rockets first developed?
   c. **Summarizing** For what purposes were rockets initially developed?
2. a. **Explaining** What is thrust?
   b. **Explaining** How do rockets create thrust?
   c. **Interpreting Diagrams** Use Figure 3 to explain how a rocket moves forward.
3. a. **Describing** Describe how a multistage rocket works.
   b. **Comparing and Contrasting** What is the main advantage of a multistage rocket compared to a single-stage rocket?
   c. **Relating Cause and Effect** Why can the third stage of a multistage rocket go faster than the first stage of the rocket, even though it has less fuel?

Writing in Science

Interview Suppose you were able to interview one of the scientists who helped to develop modern rockets. Choose one of the scientists identified in the section and write a series of questions that you would like to ask this person. Then use what you've learned to construct likely answers to these questions.

Lab zone

Technology Lab

• Tech & Design •

Design and Build a Water Rocket

S 8.2.e, 8.9

Problem

Can you design and build a rocket propelled by water and compressed air?

Design Skills

observing, evaluating the design, redesigning

Materials

- large round balloon
- tap water
- graduated cylinder
- modeling clay
- 50 paper clips in a plastic bag
- empty 2-liter soda bottle
- poster board
- scissors
- hot glue gun or tape
- bucket, 5 gallon
- stopwatch
- rocket launcher and tire pump (one per class)

Procedure

PART 1 Research and Investigate

1. Copy the data table onto a separate sheet of paper.

Data Table

Volume of Water (mL)	Motion of Balloon
No water	

2. In an outdoor area approved by your teacher, blow up a large round balloon. Hold the balloon so the opening is pointing down. Release the balloon and observe what occurs. ***CAUTION:*** *If you are allergic to latex, do not handle the balloon.*
3. Measure 50 mL of water with a graduated cylinder. Pour the water into the balloon. Blow it up to about the same size as the balloon in Step 2. Hold the opening down and release the balloon. Observe what happens.
4. Repeat Step 3 twice, varying the amount of water each time. Record your observations in the data table.

PART 2 Design and Build

5. You and a partner will design and build a water rocket using the materials provided or approved by your teacher. Your rocket must
   - be made from an empty 2-liter soda bottle
   - have fins and a removable nosecone
   - carry a load of 50 paper clips
   - use air only or a mixture of air and water as a propulsion system
   - be launched on the class rocket launcher
   - remain in the air for at least 5 seconds
6. Begin by thinking about how your rocket will work and how you would like it to look. Sketch your design and make a list of materials that you will need.
7. Rockets often have a set of fins to stabilize them in flight. Consider the best shape for fins, and decide how many fins your rocket needs. Use poster board to make your fins.
8. Decide how to safely and securely carry a load of 50 paper clips in your rocket.
9. Based on what you learned in Part 1, decide how much, if any, water to pour into your rocket.
10. After you obtain your teacher's approval, build your rocket.

◀ Rocket launcher


PART 3 Evaluate and Redesign

11. Test your rocket by launching it on the rocket launcher provided by your teacher. **CAUTION:** *Make sure that the rocket is launched vertically in a safe, open area that is at least 30 m across. All observers should wear goggles and stay at least 8–10 m away from the rocket launcher. The rocket should be pumped to a pressure of no more than 50 pounds per square inch.*
12. Use a stopwatch to determine your rocket's flight time (how long it stays in the air.)
13. Record in a data table the results of your own launch and your classmates' launches.
14. Compare your design and results with those of your classmates.

Analyze and Conclude

1. **Observing** What did you observe about the motion of the balloon as more and more water was added?
2. **Drawing Conclusions** What purpose did adding water to the balloon serve?
3. **Designing a Solution** How did your results in Part 1 affect your decision about how much water, if any, to add to your rocket?
4. **Evaluating the Design** Did your rocket meet all the criteria listed in Step 5? Explain.
5. **Evaluating the Design** How did your rocket design compare to the rockets built by your classmates? Which rocket had the greatest flight time? What design features resulted in the most successful launches?
6. **Redesigning** Based on your launch results and your response to Question 5, explain how you could improve your rocket. How do you think these changes would help your rocket's performance?
7. **Evaluating the Impact on Society** Explain how an understanding of rocket propulsion has made space travel possible.

Communicate

Write a paragraph that describes how you designed and built your rocket. Explain how it worked. Include a labeled sketch of your design.

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Section 2

The Space Program

CALIFORNIA Standards Focus

S 8.4.d Framework Various types of exploratory missions have yielded much information about the reflectivity, structure, and composition of the Moon and the planets. Those missions have included spacecraft flying by and orbiting those bodies, the soft landing of spacecraft fitted with instruments, and, of course, the visits of astronauts to the Moon.

- What was the space race?
- What were the major events in human exploration of the moon?

Key Term

- satellite

Lab zone Standards Warm-Up

Where on the Moon Did Astronauts Land?

1. Use a large map of the moon to find these locations: Sea of Tranquility, Ocean of Storms, Fra Mauro, Apennine Mountains, Descartes Highlands, and Valley of Taurus-Littrow.
2. American astronauts landed on and explored each of the locations you found. Using what you know about the moon and what you can see on the map, describe what you think astronauts saw at each place.

Think It Over

Inferring Did the names of the moon locations seem to fit with what you could see? Do you think the astronauts had to use boats to explore the Sea of Tranquility and the Ocean of Storms?

Sometimes competition results in great achievements. Maybe you've been motivated to try harder in a foot race when someone passed you by. Perhaps watching a friend accomplish a feat made you determined to do it, too. Competition resulted in one of the greatest achievements in history: In 1969 the first human set foot on the moon. This competition, though, was not between friends, but between the two most powerful nations in the world, the United States and the Soviet Union. Their rivalry in the exploration of space was called the "space race."

The Race for Space

The space race began in the 1950s. At that time, the Soviet Union was the greatest rival to the United States in politics and military power. The tensions between the two countries were so high that they were said to be in a "cold war." These tensions increased when the Soviets launched a satellite into space. **The space race began in 1957 when the Soviets launched the satellite *Sputnik I* into orbit. The United States responded by speeding up its own space program.**

◀ The first living creature sent into space was a dog named Laika. She orbited Earth aboard the Soviet spacecraft *Sputnik II* in November 1957.

FIGURE 6
John Glenn
Friendship 7 lifted off from Cape Canaveral, Florida, in February 1962. It carried astronaut John Glenn, the first American to orbit Earth. The closeup photo shows Glenn climbing into the *Friendship 7* space capsule.
Observing *Where on the rocket was the space capsule located?*

The First Artificial Satellites A **satellite** is an object that revolves around another object in space. The moon is a natural satellite of Earth. A spacecraft orbiting Earth is an artificial satellite. *Sputnik I* was the first artificial satellite. This success by the Soviets caused great alarm in the United States.

The United States responded in early 1958 by launching its own satellite, *Explorer 1,* into orbit. Over the next few years, both the United States and the Soviet Union placed many more satellites into orbit around Earth.

Later in 1958, the United States established a government agency in charge of its space program, called the National Aeronautics and Space Administration (NASA). NASA brought together the talents of many scientists and engineers who worked together to solve the many difficult technical problems of space flight.

Humans in Space In 1961 the space race heated up even more when the Soviets launched the first human into space. Yuri Gagarin flew one orbit around Earth aboard *Vostok 1.* Less than a month later, astronaut Alan Shepard became the first American in space. His tiny spacecraft, called *Freedom 7,* was part of the U.S. Mercury space program. Other Soviet cosmonauts and American astronauts soon followed into space.

The first American to orbit Earth was John Glenn, who was launched into space in 1962 aboard *Friendship 7.* The spacecraft he traveled in was called a space capsule because it was like a small cap on the end of the rocket. The tiny capsule orbited Earth three times before returning to the surface.

Reading Checkpoint **Who was the first American in space?**

Lab zone Skills Activity

Calculating

If you went to the moon, your weight would be about one sixth of your weight on Earth. Recall that in SI, weight is measured in newtons (1 lb ≈ 4.5 N). To find the approximate weight of an object on the moon, divide its weight on Earth by six.

An astronaut weighs 667 N on Earth. She wears a spacesuit and equipment that weigh 636 N on Earth. What is the astronaut's total weight on the moon?

Missions to the Moon

"I believe that this nation should commit itself to achieving the goal, before the decade is out, of landing a man on the moon and returning him safely to Earth." With these words from a May 1961 speech, President John F. Kennedy launched an enormous program of space exploration and scientific research. **The American effort to land astronauts on the moon was named the Apollo program.**

Exploring the Moon Between 1964 and 1972, the United States and the Soviet Union sent many unpiloted spacecraft to explore the moon. When a U.S. spacecraft called *Surveyor* landed on the moon, it didn't sink into the surface. This proved that the moon had a solid surface. Next, scientists searched for a suitable place to land humans on the moon.

The Moon Landings In July 1969, three American astronauts circled the moon aboard *Apollo 11.* Once in orbit, Neil Armstrong and Buzz Aldrin entered a tiny spacecraft called *Eagle.* On July 20, the *Eagle* descended toward a flat area on the moon's surface called the Sea of Tranquility. When Armstrong radioed that the *Eagle* had landed, cheers rang out at the NASA Space Center in Houston. A few hours later, Armstrong and Aldrin left the *Eagle* to explore the moon. When Armstrong first set foot on the surface, he said, "That's one small step for man, one giant leap for mankind." Armstrong meant to say, "That's one small step for *a* man," meaning himself, but in his excitement he never said the "a."

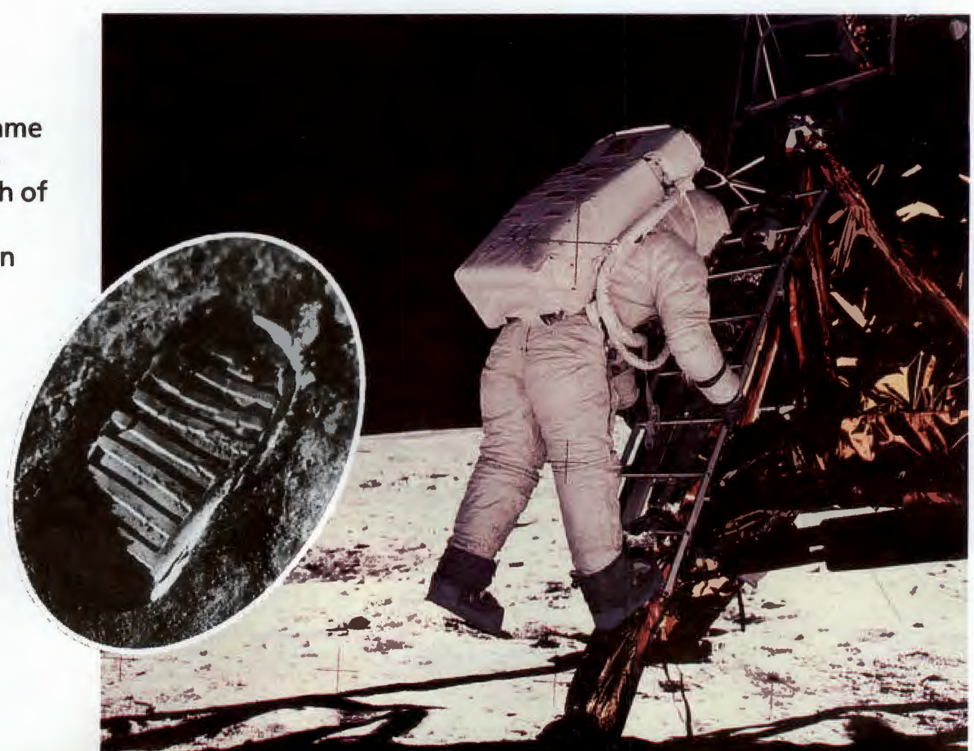

FIGURE 7
Apollo 11
On July 20, 1969, *Apollo 11* astronaut Neil Armstrong became the first person to walk on the moon. He took this photograph of Buzz Aldrin. The inset photo shows Armstrong's footprint on the lunar soil.

On the Moon's Surface Everything that the *Apollo 11* astronauts found was new and exciting. For about two hours, Armstrong and Aldrin explored the moon's surface, collecting samples to take back to Earth. They also planted an American flag.

Over the next three years, five more Apollo missions landed on the moon. In these later missions, astronauts were able to stay on the moon for days instead of hours. As shown in Figure 8, some astronauts even used a lunar rover, or buggy, to explore larger areas of the moon.

Figure 8
Lunar Buggy
Astronauts on the later Apollo missions had a lunar buggy.
Inferring *How could a lunar buggy help the astronauts to explore the moon's surface?*

Moon Rocks and Moonquakes The astronauts collected nearly 400 kilograms of lunar samples, commonly called "moon rocks." When scientists analyzed these samples, they learned a great deal about the moon. For instance, they learned that the minerals that make up moon rocks are the same minerals that are found on Earth. However, in some moon rocks these minerals combine to form kinds of rocks that are not found on Earth. Scientists were also able to calculate the ages of the moon rocks. With that information, they could better estimate when different parts of the moon's surface formed.

One way that Apollo astronauts explored the structure of the moon was to purposely crash equipment onto the moon's surface. Instruments they left behind measured the "moonquake" waves that resulted. Using data collected from these artificial moonquakes, scientists determined that the moon may have a small core of molten rock at its center.

Reading Checkpoint **What did scientists learn from analyzing moon rocks?**

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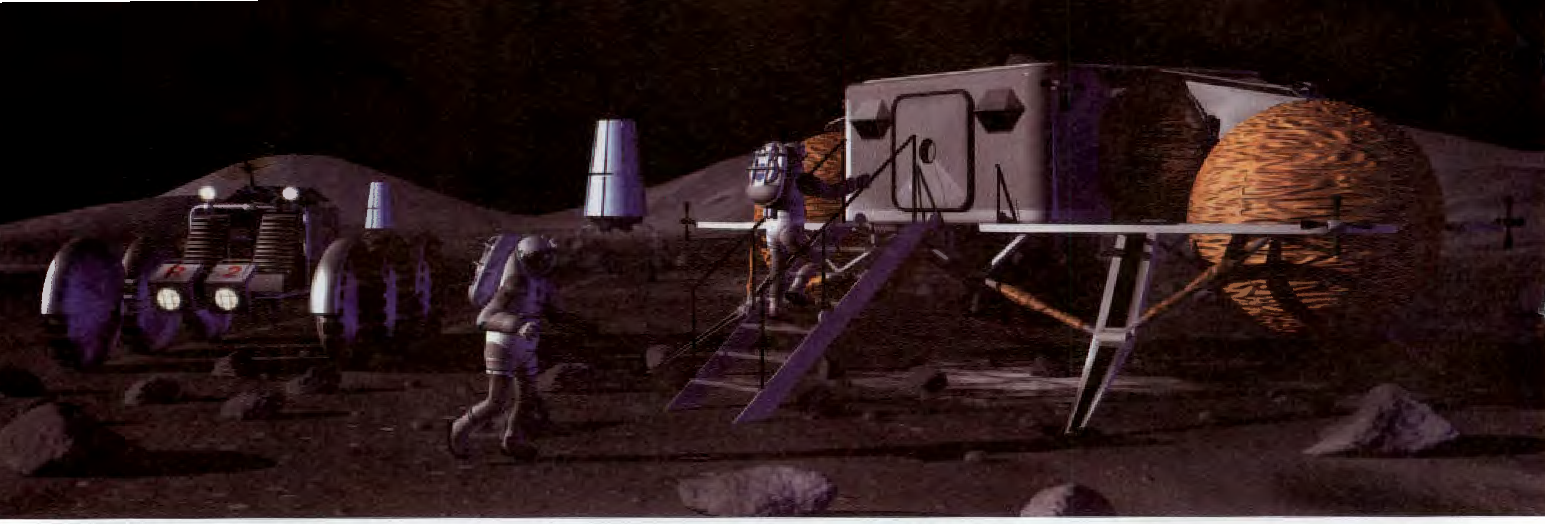


FIGURE 9
Lunar Base
A possible future base on the moon is shown in this painting.
Predicting *How might a lunar base be useful for the future human exploration of Mars?*

New Missions to the Moon The Apollo missions were a tremendous achievement. They yielded fascinating information and memorable images. Yet, the cost of those missions was high, and there were few immediate benefits beyond the knowledge gained about the moon. NASA moved on to other projects. For decades, the moon was largely ignored.

Recently, however, interest in the moon has revived. In 2003, the European Space Agency launched an unpiloted spacecraft to orbit the moon. Its main purpose was to collect data for a detailed map of the moon. Private businesses have funded similar research spacecraft.

Soon, humans may walk again on the moon. In 2004, the United States announced a plan to establish a permanent colony of people on the moon. From such a base, missions could be launched to carry people to Mars.

Section 2 Assessment

S 8.4.d, E-LA: 8.2.0

Target Reading Skill **Relate Cause and Effect** Create a cause-and-effect graphic organizer that shows the causes of the space race. Use your graphic organizer to answer Question 1.

Reviewing Key Concepts

1. a. **Summarizing** What was the "space race"?
   b. **Identifying** What event began the space race?
   c. **Relating Cause and Effect** What role did competition play in the space race? Who were the competitors?
2. a. **Identifying** What was the Apollo program?
   b. **Sequencing** Place these events in the correct sequence: first humans on the moon, *Sputnik I*, first American in space, John Glenn orbits Earth, NASA formed, Yuri Gagarin orbits Earth.
   c. **Drawing Conclusions** Was the Apollo program successful in meeting President Kennedy's challenge?

Lab zone At-Home Activity

Landmarks in Space Flight
Interview someone who remembers the early space programs. Prepare your questions in advance, such as: What did you think when you heard that *Sputnik* was in orbit? How did you feel when the first Americans went into space? Did you watch any of the space flights on TV? You may want to record your interview and then write it out later.

Section 3

Exploring Space Today

CALIFORNIA Standards Focus

S 8.4.d Framework Various types of exploratory missions have yielded much information about the reflectivity, structure, and composition of the Moon and the planets. Those missions have included spacecraft flying by and orbiting those bodies, the soft landing of spacecraft fitted with instruments, and, of course, the visits of astronauts to the Moon.

- What are the roles of space shuttles and space stations?
- What features do space probes have in common?

Key Terms

- space shuttle
- space station
- space probe
- rover

Lab zone **Standards Warm-Up**

What Do You Need to Survive in Space?

1. Make a list of everything that would be essential to your well-being if you were placed in a spacecraft in orbit around Earth.
2. Cross out everything on the list that you wouldn't be able to find while in orbit.
3. For each of the items you crossed out, suggest a way you could provide yourself with that essential item while in space.

Think It Over

Drawing Conclusions Is there anything necessary to your well-being that you wouldn't have to take with you into space? How hard would it be to provide everything you need for a journey into space?

Can you imagine living in space? When you're in orbit, you feel weightless, so there is no up or down. Astronaut Janet Kavandi knows how it feels. She spent eleven days aboard the Russian space station *Mir*. As she floated inside the central cabin, she could look into modules that extended outward in every direction.

"It was very amusing to look into one module and see people standing on the wall, working on an experiment. In the adjacent module, someone might be jogging on a treadmill on the ceiling. Beneath your feet, you might see someone having a meal. Above your head, you'd hear the thumping of a body coming toward you, and you'd have to move aside to let him pass."

Janet Kavandi aboard the space shuttle ▶

FIGURE 10
The Space Shuttle
The Space Shuttle *Discovery* is launched into space by liquid–fuel powered engines as well as by a pair of reusable solid-fuel booster rockets.
Inferring What is one advantage of a reusable space vehicle?

Working in Space

After the great success of the moon landings, the question for space exploration was, "What comes next?" Scientists and public officials decided that one goal should be to build space shuttles and space stations where astronauts can live and work.

Space Shuttles Before 1983, spacecraft could be used only once. In contrast, a space shuttle is like an airplane—it can fly, land, and then fly again. A **space shuttle** is a spacecraft that can carry a crew into orbit, return to Earth, and then be reused for the same purpose. A space shuttle includes large rockets that launch it into orbit and then fall away. At the end of a mission, a shuttle returns to Earth by landing like an airplane. **NASA has used space shuttles to perform many important tasks. These include taking satellites into orbit, repairing damaged satellites, and carrying astronauts and equipment to and from space stations.**

During a shuttle mission, astronauts live in a pressurized crew cabin at the front of the shuttle. There, they can wear regular clothes and breathe without an oxygen tank. Behind the crew cabin is a large, open area called the payload bay. The payload bay is like the trailer end of a large truck that carries supplies to stores and factories. A shuttle payload bay might carry a satellite to be released into orbit or a scientific laboratory in which astronauts can perform experiments.

NASA has built six shuttles. Tragically, two—*Challenger* and *Columbia*—were destroyed during flights. After the *Columbia* disaster in 2003, there was much debate about whether to continue the shuttle program. One reason to keep flying space shuttles is to deliver astronauts and supplies to the International Space Station. NASA currently plans to retire the shuttle by 2010 and replace it with a new reusable spacecraft.

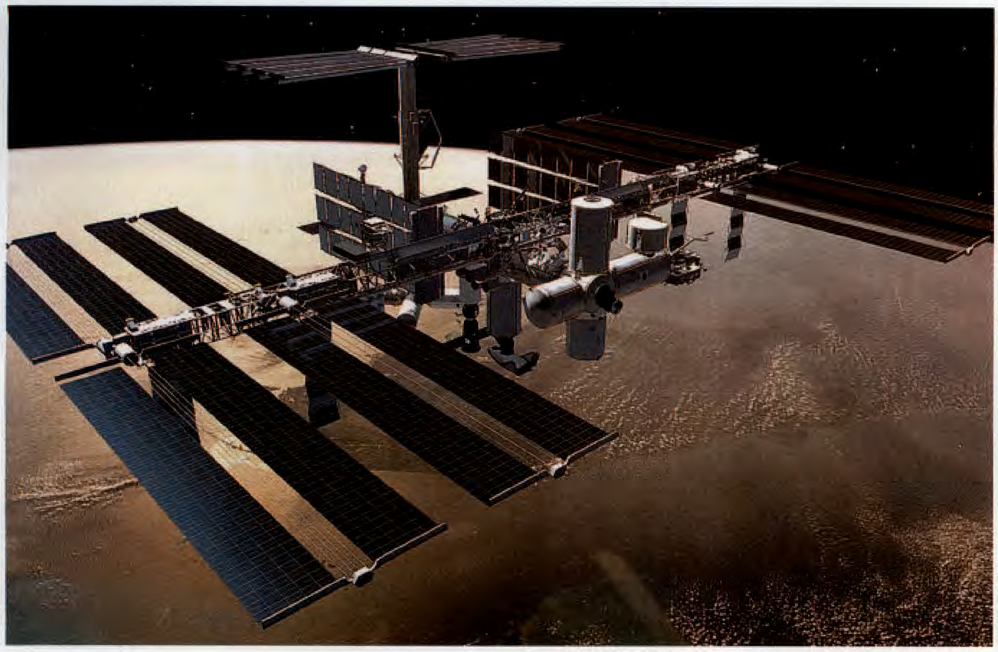


FIGURE 11
International Space Station
The International Space Station is a cooperative project involving 16 countries, including the United States, Russia, Japan, and Canada. This is an artist's view of how the station will look when completed.

Space Stations A space station is a large artificial satellite on which people can live and work for long periods. **A space station provides a place where long-term observations and experiments can be carried out in space.** In the 1970s and 1980s, both the United States and the Soviet Union placed space stations in orbit. The Soviet space station *Mir* stayed in orbit for 15 years before it fell to Earth in 2001. Astronauts from many countries, including Janet Kavandi and other Americans, spent time aboard *Mir.*

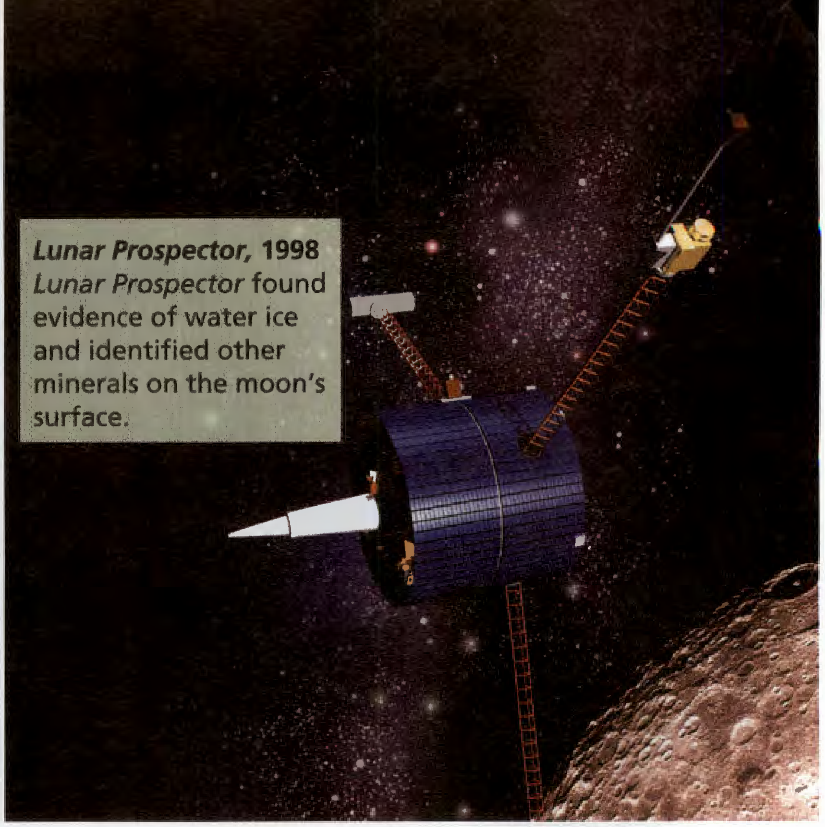
In the 1980s, the United States and 15 other countries began planning the construction of the International Space Station. The first module, or section, of the station was placed into orbit in 1998. Since then, many other modules have been added. On board, astronauts and scientists from many countries are already carrying out experiments in various fields of science. They are also learning more about how humans adapt to space. Figure 11 shows how the space station will look when completed. It will be longer than a football field, and the living space will be about as large as the inside of the largest passenger jet.

The International Space Station has large batteries to guarantee that it always has power. Its main source of power, though, is its eight large arrays of solar panels. Together, the solar panels contain more than 250,000 solar cells, each capable of converting sunlight into electricity. At full power, the solar panels produce enough electricity to power about 55 houses on Earth.

Reading Checkpoint **What is a space station?**

Video Field Trip
Discovery Channel School
Exploring Space

***Galileo*, 1995**
Galileo provided detailed images and data about Jupiter and its moons.



***Lunar Prospector*, 1998**
Lunar Prospector found evidence of water ice and identified other minerals on the moon's surface.

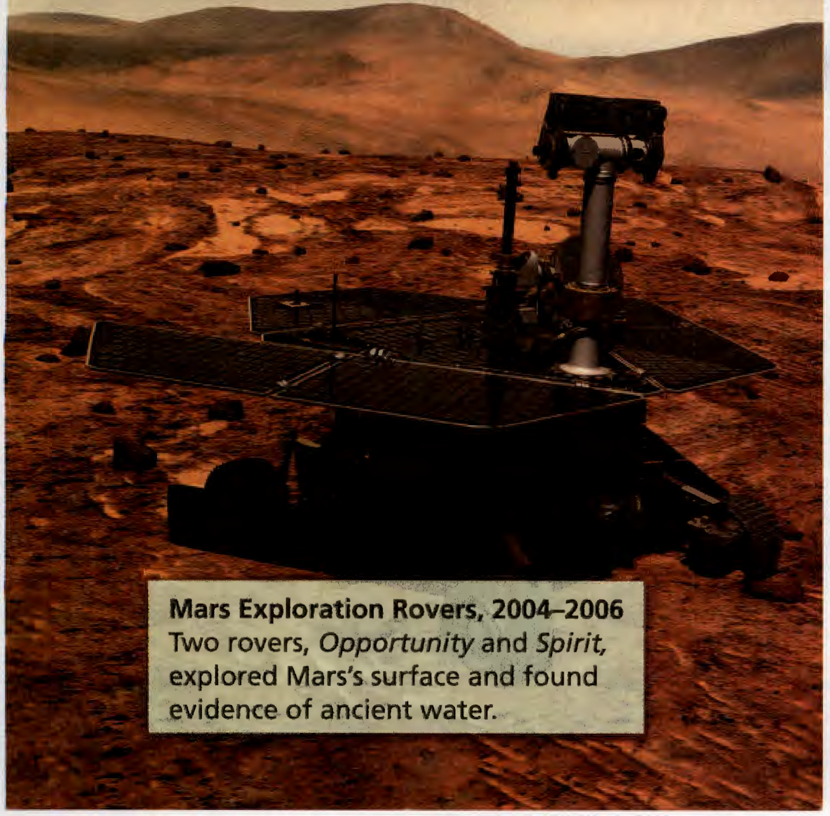
FIGURE 12
Space Probes
These are artist's views of the *Galileo, Lunar Prospector, Mars Exploration Rover,* and *Cassini* space probes.
Comparing and Contrasting *What advantage does a rover have compared to a probe that remains in orbit?*

Space Probes

Since space exploration began in the 1950s, only 24 people have traveled as far as the moon—and no one has traveled farther. Yet, during this period space scientists have gathered great amounts of information about other parts of the solar system. This data was collected by space probes. A **space probe** is a spacecraft that carries scientific instruments that can collect data, but has no human crew.

How Do Probes Work? Each space probe is designed for a specific mission. Some probes are designed to land on a certain planet. Other probes collect information about a planet from orbit. Still other probes are designed to fly by and collect data about more than one planet or moon. Thus, each probe is unique. Still, all probes have some features in common. **Each space probe has a power system to produce electricity, a communication system to send and receive signals, and scientific instruments to collect data and perform experiments.**

The scientific instruments that a probe contains depend on the probe's mission. Some probes are equipped to photograph and analyze the atmosphere of a planet. Other probes are equipped to land on a planet and analyze the materials on its surface. Some probes have small robots called **rovers** that move around on the surface. A rover typically has instruments that collect and analyze soil and rock samples.



Mars Exploration Rovers, 2004–2006 Two rovers, *Opportunity* and *Spirit,* explored Mars's surface and found evidence of ancient water.

***Cassini*, 2004–2008** *Cassini* is exploring Saturn's moons. It launched a smaller probe, *Huygens,* to explore Titan, Saturn's largest moon.

Exploring With Space Probes Probes have now visited or passed near to all of the planets. They have also explored many moons, asteroids, and comets. The information gathered by probes has given scientists tremendous new insights about the environments on the different planets. These probes have helped to solve many of the mysteries of the solar system.

Reading Checkpoint **What is a rover?**

Section 3 Assessment

S 8.4.d, E-LA: Reading 8.1.0, Writing 8.2.0

Vocabulary Skill **High-Use Academic Words** In a complete sentence, identify the main *source* of power of the International Space Station.

Reviewing Key Concepts

1. a. **Describing** What is the space shuttle? What is its main advantage?
   b. **Defining** What is a space station?
   c. **Comparing and Contrasting** What are the roles of space shuttles and space stations in the space program?
2. a. **Summarizing** What is a space probe?
   b. **Listing** List three features that are common to all space probes.
   c. **Making Judgments** What do you think are some advantages and disadvantages of a space probe compared to a piloted spacecraft?

Writing in Science

News Report As a newspaper reporter, you are covering the launch of a new space probe. Write a brief news story, including details on the probe's mission and how the probe works. What planet will it explore? What question will it try to answer?

Section 4

• Tech & Design •

Using Space Science on Earth

CALIFORNIA Standards Focus

S 8.7.c Students know substances can be classified by their properties, including their melting temperature, density, hardness, and thermal and electrical conductivity.

- How are the conditions in space different from those on Earth?
- How has space technology benefited modern society?
- What are some uses of satellites orbiting Earth?

Key Terms

- vacuum
- microgravity
- space spinoff
- remote sensing
- geostationary orbit

Lab zone Standards Warm-Up

Which Tool Would Be More Useful in Space?

1. Observe your teacher using two types of drills.
2. Pick up each drill and examine how it works.
3. Repeat Step 2 for a space pen and a regular pen.

Think It Over

Drawing Conclusions What is the main difference between the two drills? The pens? Which drill would be more useful to have while constructing the International Space Station? Why? How would a space pen be useful in space?

You've probably used a joystick to play a video game. A joystick is a great way to control images on a screen. It's easy to use because it is designed to fit the hand just right. Joystick controllers have many uses besides video games. They're so well engineered that people with disabilities can use them to operate a wheelchair.

The joystick was invented for controlling airplanes. It was later improved by NASA for the space program. Apollo astronauts used a joystick to operate a lunar rover on the moon. From the surface of the moon to video games on Earth—it's not such a stretch. Many materials and devices have made a similar transition from use in space to everyday use by people on Earth.

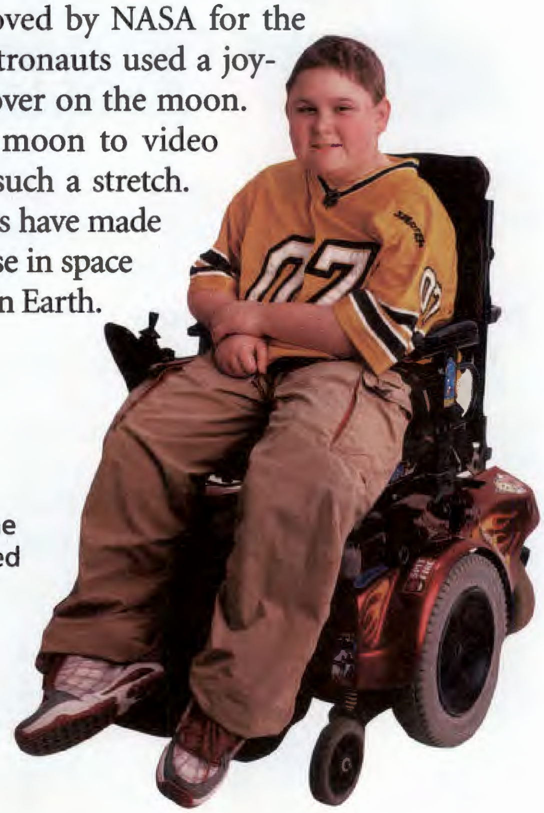


FIGURE 13
Joystick Controls
The joysticks used for some wheelchairs were improved for the space program.

The Challenges of Space

Astronauts who travel into space face conditions that are quite different from those on Earth. **Conditions in space that differ from those on Earth include near vacuum, extreme temperatures, and microgravity.** Many types of engineers and scientists have worked together to respond to the challenges of space.

Vacuum Space is nearly a vacuum. A **vacuum** is a place that is empty of all matter. Except for a few stray atoms and molecules, most of space is empty. Since there is no air in space, there is no oxygen for astronauts to breathe. To protect astronauts, spacecraft must be airtight.

Because there is no air in space, there is nothing to hold the sun's heat. In direct sunlight, the surface of a spacecraft heats up to high temperatures. But in shadow, temperatures fall to very low levels. Spacecraft must be well insulated to protect astronauts against the extreme temperatures outside.

Microgravity Astronauts in orbit experience a feeling of weightlessness, or **microgravity**. Their mass is the same as it was on Earth, but on a scale their weight would register as zero. Although they are in microgravity, they are still under the influence of Earth's gravity. In fact, Earth's gravity is holding them in orbit. Astronauts in orbit feel weightless because they are falling through space with their spacecraft. They don't fall to Earth because their inertia keeps them moving forward.

Space engineers must create systems and devices that are capable of working in microgravity. For example, drink containers must be designed so that their contents do not simply float away. Long periods in microgravity can cause health problems. Scientists are trying to discover how to reduce the effects of microgravity on people.

Reading Checkpoint What is microgravity?

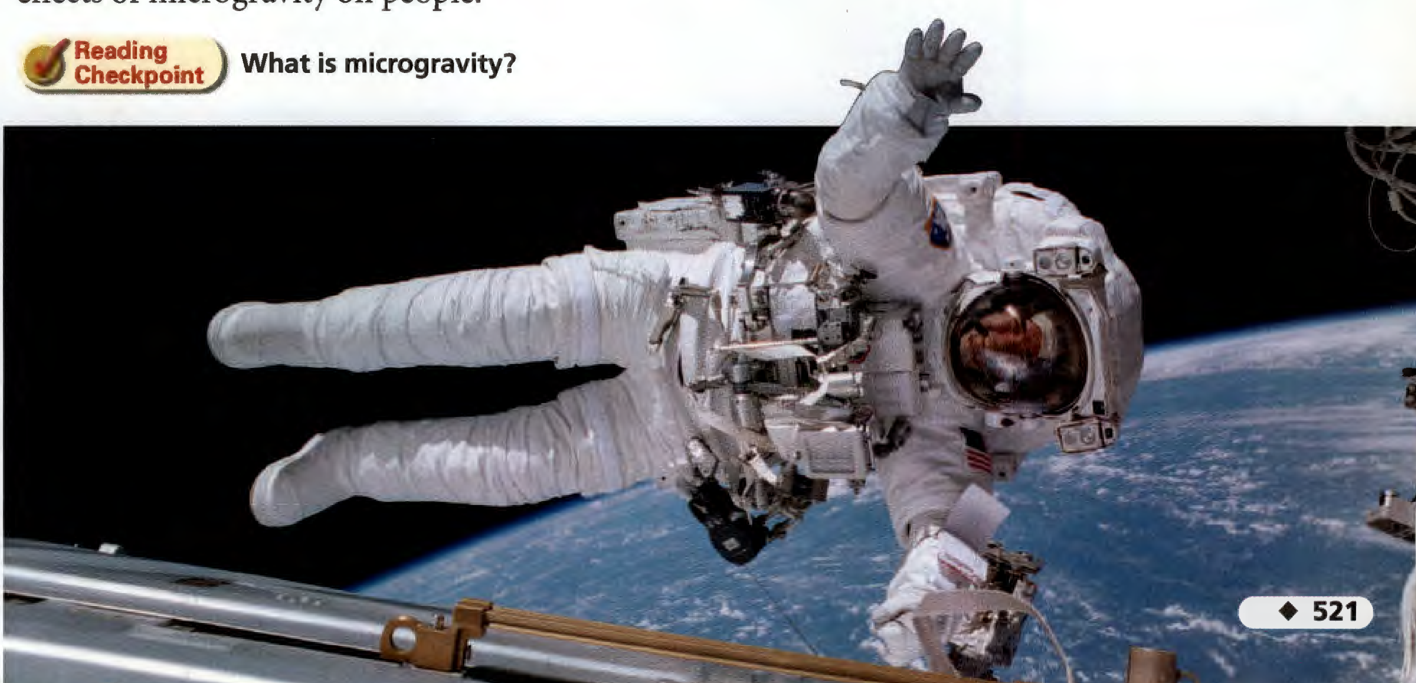


FIGURE 14
Microgravity
This astronaut appears to be floating in space, but he is actually falling through space at the same rate as the nearby spacecraft.
Inferring *Why doesn't the astronaut fall directly down toward Earth?*

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Space Spinoffs

The scientists and engineers who have worked on the space program have developed thousands of new materials and devices for use in space. Many of these items have proved useful on Earth as well. An item that has uses on Earth but was originally developed for use in space is called a **space spinoff**. Often such spinoffs are modified somewhat for use on Earth.

The space program has developed thousands of products that affect many aspects of modern society, including consumer products, new materials, medical devices, and communications satellites. Figure 15 shows a few familiar examples.

Consumer Products Space spinoffs include many devices that are used in consumer products. The joystick controller is one example. The bar codes on every product you buy at a grocery store are another space spinoff. Similar bar codes were developed by NASA to keep an accurate inventory of the many parts used in spacecraft.

Cordless power tools were also originally developed for astronauts. There's no place to "plug in" a tool when repairing a satellite in space. Cordless, rechargeable tools met the need for work in space. Now they're very popular here on Earth. Other examples of consumer product spinoffs from the space program include scratch-resistant lenses, freeze-dried foods, shock-absorbing helmets, and smoke detectors.

FIGURE 15
Spinoffs From the Space Program
Many technologies that were developed for the space program have proved useful on Earth as well. A few of these technologies are shown here.
Applying Concepts *What advantage is there to fog-free vision in space? On Earth?*

▲ Miniature parts developed for space have been adapted for use on Earth. Artificial limbs have been made with controls as small as coins.

▼ A metal alloy of nickel and titanium used in dental braces was originally developed for space equipment such as antennas.

New Materials A variety of materials were first developed by chemists and engineers for use in spacecraft. These materials have specific physical properties—such as low density, high strength, or low thermal conductivity—that make them useful for certain products in space or on Earth. For example, flexible metal eyeglass frames are made with metals that "remember" their former shapes when bent. The composite materials used in modern tennis rackets were developed to make spacecraft components lightweight yet strong. Some athletic shoes contain a shock-absorbing material developed for moon boots.

Highly efficient insulating materials were developed to protect spacecraft against radiation and the extreme temperatures of space. These insulating materials are now being used in houses, cars, and trucks. Fire-resistant material developed for spacesuits is used in fireproof clothing and firefighter's suits.

Medical Devices Medical science has benefited greatly from the technology of the space program. Medical spinoffs include devices that use lasers to clean clogged arteries and pacemakers for hearts. These pacemakers use longer-life batteries originally developed for space power systems. Most hospitals use computer-aided imaging techniques developed for use on the moon during the Apollo program.

Reading Checkpoint Why did NASA develop cordless power tools?

▼ Fire-resistant material developed for spacesuits is used in fireproof clothing such as suits worn by race-car drivers and firefighters.

◀ Many bicyclists use a lightweight, aerodynamic helmet with cooling vents that was developed with NASA's help.

◀ The design of the Apollo helmet, which gave the astronauts fog-free sight, has been adapted for use in ski goggles.

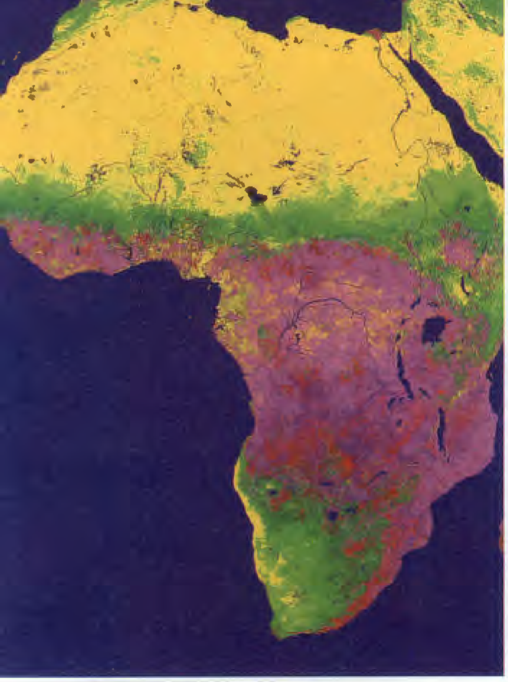


FIGURE 16
Remote Sensing
This satellite image shows patterns of vegetation in Africa. It is a false-color image, meaning that the colors have been adjusted to make certain features more obvious.
Inferring *What do you think the yellow areas in the image represent?*

Satellites

When a World Cup soccer final is played, almost everyone around the world can watch! Today, hundreds of satellites are in orbit around Earth, relaying television signals from one part of the planet to another. Satellites also relay telephone signals and computer data. **Satellites are used for communications and for collecting weather data and other scientific data.**

Observation satellites are used for many purposes, including tracking weather systems, mapping Earth's surface, and observing changes in Earth's environment. Observation satellites collect data using **remote sensing,** which is the collection of information about Earth and other objects in space without being in direct contact. Modern computers take the data collected by satellites and produce images for various purposes. For example, Figure 16 shows vegetation patterns in Africa. Satellite data might also be used to analyze the amount of rainfall over a wide area, or they might be used to discover where oil deposits lie underground.

Satellites are placed in different orbits depending on their purpose. Most communications satellites are placed in a geostationary orbit. In a **geostationary orbit,** a satellite orbits Earth above the equator at the same rate as Earth rotates and thus stays over the same place on Earth all the time. Read the *Technology and Society* feature on pages 526–527 to learn more about communications satellites.

Reading Checkpoint What is remote sensing?

Section 4 Assessment

S 8.7.c, E-LA: Reading 8.1.0

Vocabulary Skill High-Use Academic Words

In a complete sentence, identify two ways that new *technology* was developed for use in space.

Reviewing Key Concepts

1. a. **Listing** Name three ways that conditions in space are different from conditions on Earth.
   b. **Relating Cause and Effect** How have engineers designed spacecraft to operate in the special conditions of space?
2. a. **Defining** What is a space spinoff?
   b. **Summarizing** How has medical science benefited from the space program?
   c. **Comparing and Contrasting** Choose one space spinoff and compare how it is used in space and on Earth.
3. a. **Listing** Name three uses of satellites that affect everyday life.
   b. **Inferring** What advantage would there be to placing a satellite in geostationary orbit?
   c. **Designing Experiments** How could a scientist use satellites to determine whether a rain forest was becoming smaller over time?

Lab zone At-Home Activity

Spinoffs at Home Look back at the various space spinoffs discussed in the chapter. Then, with a family member, make a list of space spinoffs in your home.

Lab zone **Consumer Lab**

Space Spinoffs

S 8.7.c, 8.9.c

Problem

Which blanket protects better against heat loss?

Skills Focus

graphing, drawing conclusions

Materials

- 1 foil blanket piece
- 1 cloth blanket piece
- 3 thermometers
- 1 beaker, 600 mL
- ice
- 3 identical small test tubes
- hot water
- 3 identical large test tubes
- cotton balls
- cellophane tape or rubber bands
- tap water

Procedure

1. On a separate sheet of paper, copy the data table below to record your observations.
2. Wrap the outside of one small test tube with the foil blanket piece. Wrap a second small test tube with the cloth blanket piece. Use tape or rubber bands to secure the blankets. Leave the third small test tube unwrapped.
3. Fill each of the three small test tubes half full with hot water. Be sure to use the same volume of water in each test tube. Insert a thermometer into each small test tube. Use cotton to "seal" the top of the small test tube and to hold the thermometer in place. Then, insert each small test tube into a large test tube.

Data Table			
Time (minutes)	Temperature (°C)		
	Foil-Wrapped Thermometer	Cloth-Wrapped Thermometer	Unwrapped Thermometer
0			
1			

4. Put ice in the beaker and fill the beaker two-thirds of the way with water.
5. Put the large test tubes into the ice water. Do not let water enter the test tubes. Record the starting temperatures of all three thermometers.
6. Allow the test tubes to sit in the ice water bath for about 10 minutes. Every minute note the temperature of each thermometer and record the results in your data table.

Analyze and Conclude

1. **Graphing** Graph the temperature over time for each of the thermometers.
2. **Calculating** Calculate the difference between the starting and ending temperatures of each thermometer. Which thermometer was best protected against heat loss?
3. **Controlling Variables** What was the purpose of the third, unwrapped small test tube?
4. **Drawing Conclusions** Which type of blanket protects better against heat loss? Explain.
5. **Communicating** Write an advertisement for the blanket that proved to be the best insulator. In the ad, describe the test procedures you used to justify your claim. Also explain why this blanket would benefit consumers.

Design an Experiment

The activity you just completed tested how well different materials protected against the loss of heat. Design an experiment that would test how well the same blankets would protect against an increase in heat. Obtain your teacher's approval before conducting your experiment.

Technology and Society

• Tech & Design •

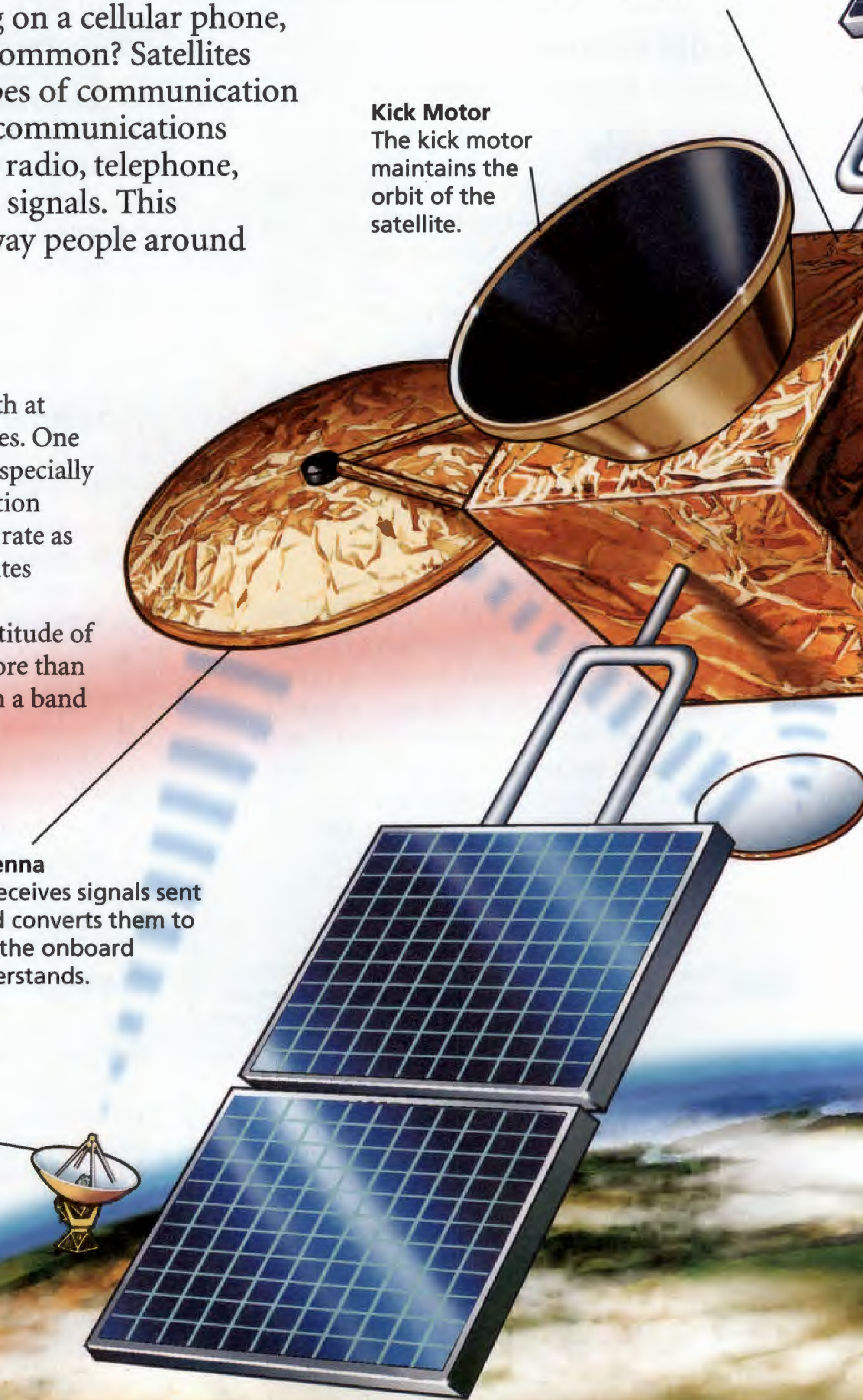
S 8.4.d Framework

Communications Satellites

What do watching TV, talking on a cellular phone, and sending e-mails have in common? Satellites orbiting Earth make these types of communication possible. Using microwaves, communications satellites receive and transmit radio, telephone, TV, computer data, and other signals. This technology has changed the way people around the globe communicate.

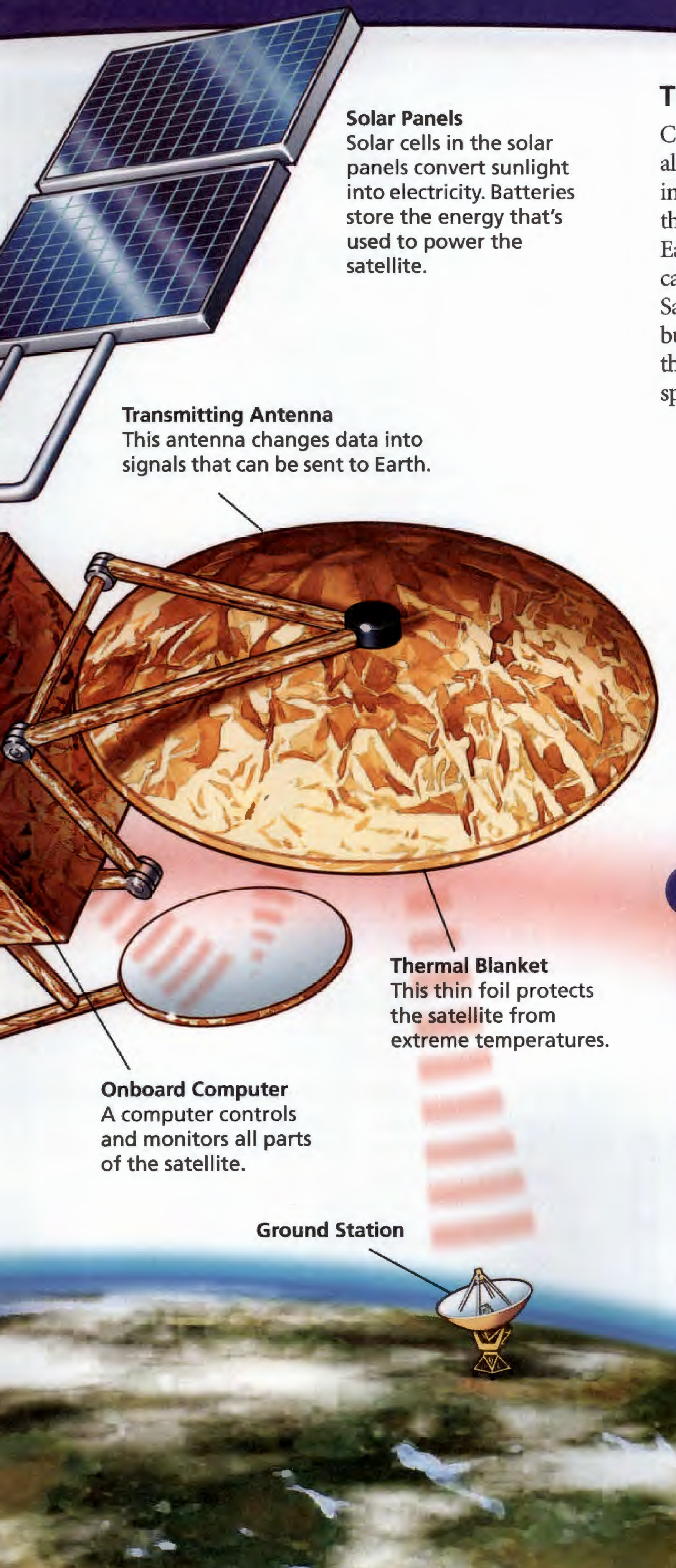
Orbiting Satellites

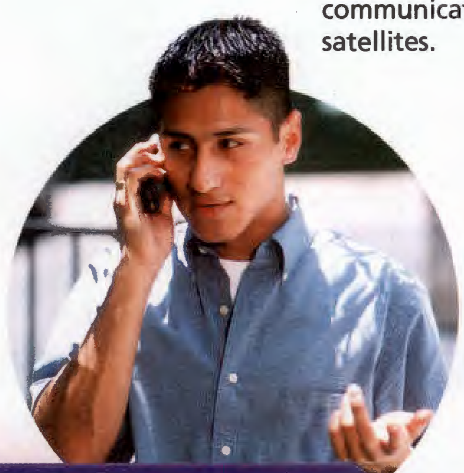
Communications satellites orbit Earth at different speeds and different altitudes. One type—geostationary satellites—are especially useful for long-distance communication because they orbit Earth at the same rate as Earth rotates. As a result, these satellites remain over fixed points on Earth. Geostationary satellites orbit at an altitude of about 35,880 km. Today there are more than 150 geostationary satellites located in a band around the Equator.



The Cost of Going Global

Communications satellites can relay signals, allowing the immediate exchange of information worldwide. Like all technology, though, there are trade-offs to using satellites. Earth's atmosphere can interfere with signals, causing problems such as static and time delays. Satellites cost hundreds of millions of dollars to build and even more to launch into space. When they are no longer useful, many burn up in space or become space junk.





Cellular phone signals are sent by communications satellites.

Weigh the Impact

1. Identify the Need
How have communications satellites changed people's lives?

2. Research
Research the uses of communications satellites over the last 20 years. List their influences on society.

3. Write
In several paragraphs, describe ways in which you and your family use this satellite technology in your daily lives.

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Chapter 13 Study Guide

The BIG Idea Scientists have learned much about the solar system through various types of space missions.

1 The Science of Rockets

Key Concepts — S 8.2.e

- Rocket technology originated in China hundreds of years ago and gradually spread to other parts of the world.
- A rocket moves forward when gases shooting out the back of the rocket push it in the opposite direction.
- The main advantage of a multistage rocket is that the total weight of the rocket is greatly reduced as the rocket rises.

Key Terms

rocket
thrust
velocity
orbital velocity
escape velocity

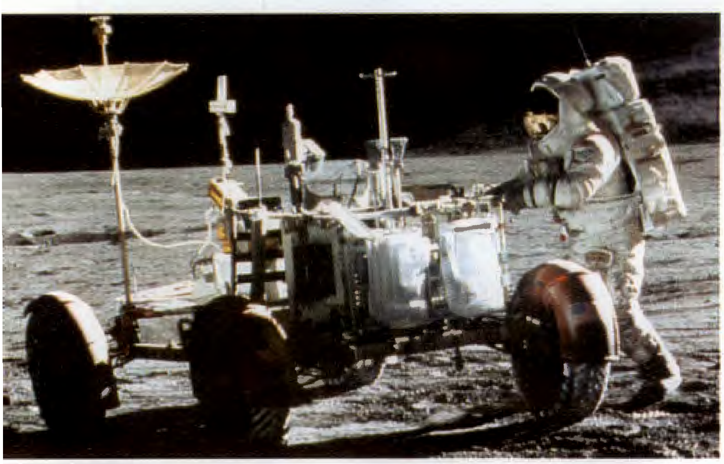
2 The Space Program

Key Concepts — S 8.4.d Framework

- The space race began in 1957 when the Soviets launched the satellite *Sputnik I* into orbit. The United States responded by speeding up its own space program.
- The American effort to land astronauts on the moon was named the Apollo program.

Key Term

satellite



3 Exploring Space Today

Key Concepts — S 8.4.d Framework

- NASA has used space shuttles to perform many important tasks. These include taking satellites into orbit, repairing damaged satellites, and carrying astronauts and equipment to and from space stations.
- A space station provides a place where long-term observations and experiments can be carried out in space.
- Each space probe has a power system to produce electricity, a communication system to send and receive signals, and scientific instruments to collect data and perform experiments.

Key Terms

space shuttle
space station
space probe
rover

4 Using Space Science on Earth

Key Concepts — S 8.7.c

- Conditions in space that differ from those on Earth include near vacuum, extreme temperatures, and microgravity.
- The space program has developed thousands of products that affect many aspects of modern society, including consumer products, new materials, medical devices, and communications satellites.
- Satellites are used for communications and for collecting weather data and other scientific data.

Key Terms

vacuum
microgravity
space spinoff
remote sensing
geostationary orbit

Review and Assessment

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Target Reading Skill

Relate Cause and Effect

The work of the many scientists who participated in the space program has resulted in many benefits to society. Create a cause-and-effect graphic organizer that shows at least three benefits of the space program.

Cause

Scientists develop new materials and products to meet the challenges of space.

Effects

Communications satellites are used in television, telephone, and computer networks on Earth.

Reviewing Key Terms

Choose the letter of the best answer.

1. A device that expels gas in one direction to move in the opposite direction is a
   a. rocket. **b.** space probe.
   c. space station. **d.** rover.
2. To fly beyond a planet's gravitational pull, a spacecraft must reach
   a. velocity.
   b. orbital velocity.
   c. escape velocity.
   d. geostationary orbit.
3. Any object that revolves around another object in space is called a
   a. vacuum. **b.** space station.
   c. satellite. **d.** rocket.
4. A spacecraft that can carry a crew into space, return to Earth, and then be reused for the same purpose is a
   a. rover.
   b. space shuttle.
   c. space station.
   d. space probe.
5. Acquiring information about Earth and other objects in space without being in direct contact with these worlds is called
   a. microgravity.
   b. spinoff.
   c. thrust.
   d. remote sensing.

Complete the following sentences so that your answers clearly explain the key terms.

6. In order to move, a rocket must generate **thrust,** which is __________ .
7. **Space probes,** which are __________ , are often used to gather data about distant planets.
8. Astronauts in orbit experience **microgravity,** which is __________ .
9. *Mir* is an example of a **space station,** which is __________ .
10. Observation satellites collect data using **remote sensing,** which is __________ .

Writing in Science

Descriptive Paragraph Imagine that you are a scientist planning the first human expedition to Mars. In a detailed paragraph, list some of the major challenges that such a mission would face and provide possible solutions. Think about the physical stresses of space travel and how the crew's basic needs will be met.

Video Assessment
Discovery Channel School
Exploring Space

Review and Assessment

Checking Concepts

11. What are three types of rocket fuels?

12. What did Neil Armstrong say when he first set foot on the moon?

13. Describe some tasks carried out by the crew of the space shuttle.

14. What is the purpose of a space station?

15. Name a space spinoff in each of the following categories: medical devices, materials, and consumer products.

Thinking Critically

16. **Applying Concepts** The diagram below shows a rocket lifting off. What does each of the arrows represent?

17. **Classifying** A jet airplane usually uses liquid fuel that is burned with oxygen from the atmosphere. A jet engine expels hot gases to the rear, and the airplane moves forward. Is a jet a type of rocket? Explain.

18. **Relating Cause and Effect** When the Soviet Union launched *Sputnik I* into orbit in 1957, educators in the United States decided to improve math and science education in U.S. schools. Why do you think educators made that decision?

19. **Making Judgments** Do you think that the benefits of the Apollo program outweighed the program's costs? Explain.

20. **Comparing and Contrasting** How is orbital velocity different from escape velocity?

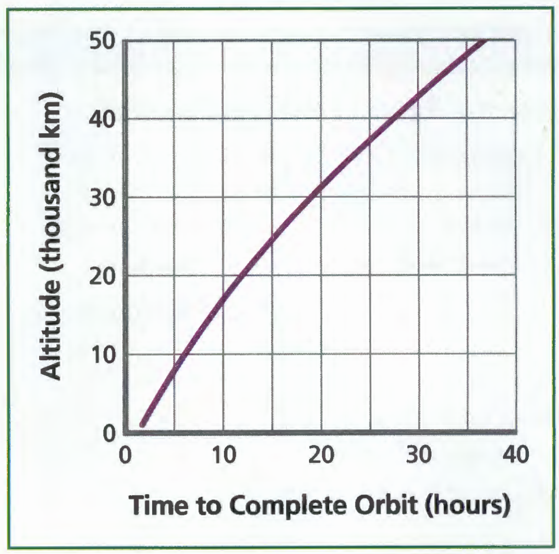
21. **Making Generalizations** How could the International Space Station help with further exploration of the solar system?

Applying Skills

Use the graph below to answer Questions 22–24.

The graph shows the amounts of time needed for satellites at different altitudes above Earth's surface to complete one orbit.

Satellite Orbits



22. **Interpreting Diagrams** How long will a satellite orbiting at an altitude of 50,000 km take to complete one orbit?

23. **Applying Concepts** A geostationary satellite orbits Earth once every 24 hours. At what altitude does such a satellite orbit?

24. **Making Generalizations** What is the relationship between satellite altitude and the time needed to complete one orbit?

Lab zone Standards Investigation

Performance Assessment Before testing your vehicle, list your design goals and criteria. Describe some of the challenges you faced. What could you change to improve your model?

CALIFORNIA Standards Practice

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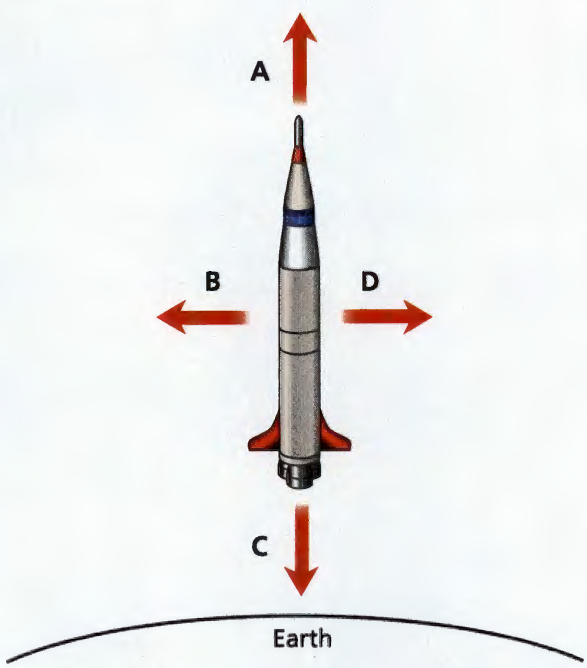
Choose the letter of the best answer.

1. Which of the following developments was most directly responsible for the creation of rockets that were capable to going to the moon?
A gunpowder
B explosives
C single-stage rockets
D multistage rockets
S 8.4.d Framework

2. What force must a rocket overcome to be launched into space?
A thrust
B gravity
C orbital velocity
D escape velocity
S 8.2.e, S 8.2.g

The diagram below shows a rocket and the direction of four forces. Use the diagram and your knowledge of rockets to answer Question 3.



3. Which of the lettered forces shown in the diagram represents an equal and opposite force to the thrust of the rocket?
A Force A
B Force B
C Force C
D Force D
S 8.2.e

4. Space shuttles have been used to perform all of the following tasks except
A placing satellites in orbit.
B landing on the moon.
C carrying astronauts and equipment to and from space stations.
D repairing damaged satellites.
S 8.4.d Framework

5. A satellite in geostationary orbit revolves around Earth once each
A hour.
B week.
C month.
D day.
S 8.4.d Framework

6. Spacecraft fitted with instruments but lacking a human crew are called
A space probes.
B space shuttles.
C space stations.
D space spinoffs.
S 8.4.d Framework

7. During the space race, the former Soviet Union was the first to accomplish all of the following except
A launching the first satellite into orbit.
B sending the first living creature into space.
C sending the first human into space.
D landing the first human on the moon.
S 8.4.d Framework

8. In order to collect soil and rock samples on Mars, scientists would probably use a
A space station.
B rover.
C vacuum.
D satellite in geostationary orbit.
S 8.4.d Framework

Apply the BIG Idea

9. Space probes have been used to explore all the planets, but not yet Pluto. Describe three types of information that a probe orbiting Pluto could gather about it.
S 8.4.d Framework, S 8.4.e