Section 3

The Inner Planets

Objectives

After this lesson, students will be able to

J.3.3.1 Describe the characteristics that the inner planets have in common.

J.3.3.2 Identify the main characteristics that distinguish each of the inner planets.

Target Reading Skill

Using Prior Knowledge Explain that using prior knowledge helps students connect what they already know to what they are about to read.

Answers

Possible answers include the following:

What You Know

1. Most of Earth is covered with water.
2. Mercury is closest to the sun.
3. Venus is very hot.
4. Mars is called the "red planet."

What You Learned

1. Earth is unique in our solar system for having liquid water at its surface.
2. Mercury has a greater temperature range than any of the other planets.
3. A day on Venus is longer than its year.
4. The reddish tinge on Mars is caused by the breakdown of iron-rich rocks.

All in One Teaching Resources

- Transparency J25

Preteach

Build Background Knowledge L2

The Blue Planet

Show students a colored drawing of the solar system with the names of the planets covered. Ask: **Which planet is Earth?** *(The third planet from the sun)* **How do you know?** *(Possible answer: The third planet appears blue, and Earth has liquid water on its surface, which makes it look blue from space.)*

Section 3

The Inner Planets

Reading Preview

Key Concepts

- What characteristics do the inner planets have in common?
- What are the main characteristics that distinguish each of the inner planets?

Key Terms

- terrestrial planets
- greenhouse effect

Target Reading Skill

Using Prior Knowledge Look at the section headings and visuals to see what this section is about. Then write what you know about the inner planets in a graphic organizer like the one below. As you read, write what you learn.

What You Know

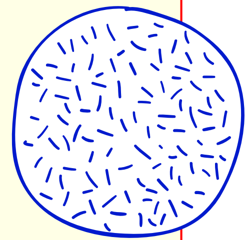
1. Most of Earth is covered with water.
2.

What You Learned

1.
2.

Lab zone Discover Activity

How Does Mars Look From Earth?



1. Work in pairs. On a sheet of paper, draw a circle 20 cm across to represent Mars. Draw about 100 small lines, each about 1 cm long, at random places inside the circle.
2. Have your partner look at your drawing of Mars from the other side of the room. Your partner should draw what he or she sees.
3. Compare your original drawing with what your partner drew. Then look at your own drawing from across the room.

Think It Over

Observing Did your partner draw any connecting lines that were not actually on your drawing? What can you conclude about the accuracy of descriptions of other planets based on observations from Earth?

Where could you find a planet whose atmosphere has almost entirely leaked away into space? How about a planet whose surface is hot enough to melt lead? And how about a planet with volcanoes higher than any on Earth? Finally, where could you find a planet with oceans of water brimming with fish and other life? These are descriptions of the four planets closest to the sun, known as the inner planets.

Earth and the three other inner planets—Mercury, Venus, and Mars—are more similar to each other than they are to the five outer planets. **The four inner planets are small and dense and have rocky surfaces.** The inner planets are often called the **terrestrial planets,** from the Latin word *terra,* which means "Earth." Figure 10 summarizes data about the inner planets.

Earth

As you can see in Figure 11, Earth has three main layers—a crust, a mantle, and a core. The crust includes the solid, rocky surface. Under the crust is the mantle, a layer of hot molten rock. When volcanoes erupt, this hot material rises to the surface. Earth has a dense core made of mainly iron and nickel. The outer core is liquid, but the inner core is solid.

Lab zone Discover Activity

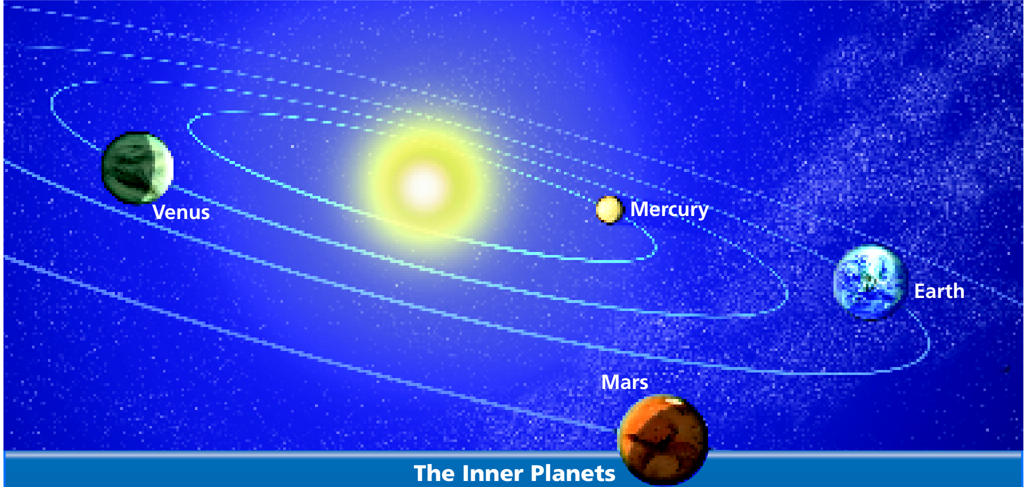
Skills Focus observing L1

Materials white paper, compass, ruler

Time 10 minutes

Tips Tell students to make the small lines dark enough to be seen from a distance. To minimize confusion, suggest that they label the drawings as *Original* and *Copied From a Distance.*

Think It Over The partner may see and draw patterns and lines that are not in the original drawing. The view from across the room is not an accurate representation of what the original drawing looked like.



The Inner Planets

Planet	Diameter (kilometers)	Period of Rotation (Earth days)	Average Distance From Sun (kilometers)	Period of Revolution (Earth years)	Number of Moons
Mercury	4,879	59	58,000,000	0.24	0
Venus	12,104	243	108,000,000	0.62	0
Earth	12,756	1	150,000,000	1	1
Mars	6,794	1.03	228,000,000	1.9	2

FIGURE 10
The inner planets take up only a small part of the solar system. Note that sizes and distances are not drawn to scale.

Water **Earth is unique in our solar system in having liquid water at its surface.** In fact, most of Earth's surface, about 70 percent, is covered with water. Perhaps our planet should be called "Water" instead of "Earth"! Earth has a suitable temperature range for water to exist as a liquid, gas, or solid. Water is also important in shaping Earth's surface, wearing it down and changing its appearance over time.

Atmosphere Earth has enough gravity to hold on to most gases. These gases make up Earth's atmosphere, which extends more than 100 kilometers above its surface. Other planets in the solar system have atmospheres too, but only Earth has an atmosphere that is rich in oxygen. The oxygen you need to live makes up about 20 percent of Earth's atmosphere. Nearly all the rest is nitrogen, with small amounts of other gases such as argon and carbon dioxide. The atmosphere also includes varying amounts of water in the form of a gas. Water in a gaseous form is called water vapor.

Reading Checkpoint **What two gases make up most of Earth's atmosphere?**

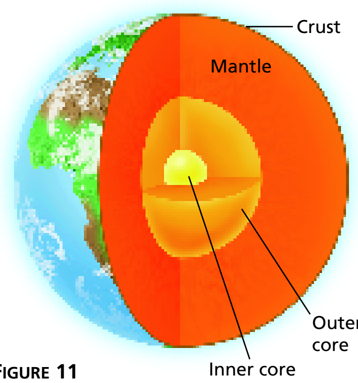


FIGURE 11
Earth's Layers
Earth has a solid, rocky surface.
Interpreting Diagrams *What are Earth's three main layers?*

Instruct

Earth

Teach Key Concepts L1

Comparing Other Inner Planets to Earth

Focus Have students examine Figure 10, which shows characteristics of the inner planets.

Teach Ask: **Which planet is most similar in size to Earth?** *(Venus)* **How many times does Mercury revolve around the sun during one Earth year?** *(About four)*

Apply Challenge students to make a generalization about a planet's distance from the sun and its period of revolution. *(The farther a planet is from the sun, the longer it takes to complete one period of revolution.)* **learning modality: visual**

All in One **Teaching Resources**
- Transparencies J26, J29

Independent Practice L2

All in One **Teaching Resources**
- Guided Reading and Study Worksheet: *The Inner Planets*

Student Edition on Audio CD

Differentiated Instruction

Gifted and Talented L3

Creating a Diagram Have students use a computer graphics program to create a scale diagram showing Earth's layers. Have students label the diagram and add pertinent information, such as the depth of each layer, gathered from independent research. **learning modality: visual**

Special Needs L1

Identifying Earth's Layers Place a hard-boiled egg on a paper towel spread on your desk. Use a knife to slice the shelled egg crosswise. Ask students to identify what each part of the egg represents. *(Shell—crust; white—mantle; yolk—core)* **learning modality: visual**

Monitor Progress L1

Drawing Have students draw a cross-section of Earth and its atmosphere and label the crust, the mantle, the outer core, the inner core, and the atmosphere. Have students save their drawings in their portfolios.

Portfolio

Answers

Figure 11 Crust, mantle, and core

Reading Checkpoint Nitrogen and oxygen

Mercury

Teach Key Concepts

L1

Mercury's Characteristics

Focus Show students images of Mercury and Earth's moon.

Teach Ask students to describe the features shared by the moon and Mercury. *(Heavily cratered surface, little atmosphere, no liquid water, little erosion)* Ask: **What difference do you see between the surface of Earth's moon and that of Mercury?** *(Mercury's surface has no maria.)*

Apply Tell students that in some ways, Mercury has more features in common with Earth's moon than with Earth and the other inner planets. **learning modality: visual**

Lab zone Build Inquiry

L2

Observing Mercury

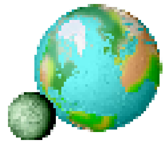
Materials coin, desk lamp, ruler

Time 20 minutes

Focus Have students write inferences regarding why scientists have a difficult time making observations of Mercury. After completing this activity, have students revise their inferences.

Teach Pair students. Have one student hold a coin about 10 cm in front of a dim desk lamp. The head side of the coin should face away from the bulb. Challenge the other student to determine the date on the coin. Caution the student not to look directly at the light bulb.

Apply Ask: **What do you observe about the coin?** *(The brightness of the bulb makes it impossible to see the date.)* **How is this similar to problems encountered by scientists who want to observe features on Mercury?** *(The brightness of the sun makes it hard to see Mercury's surface features.)* **learning modality: visual**



Size of Mercury compared to Earth

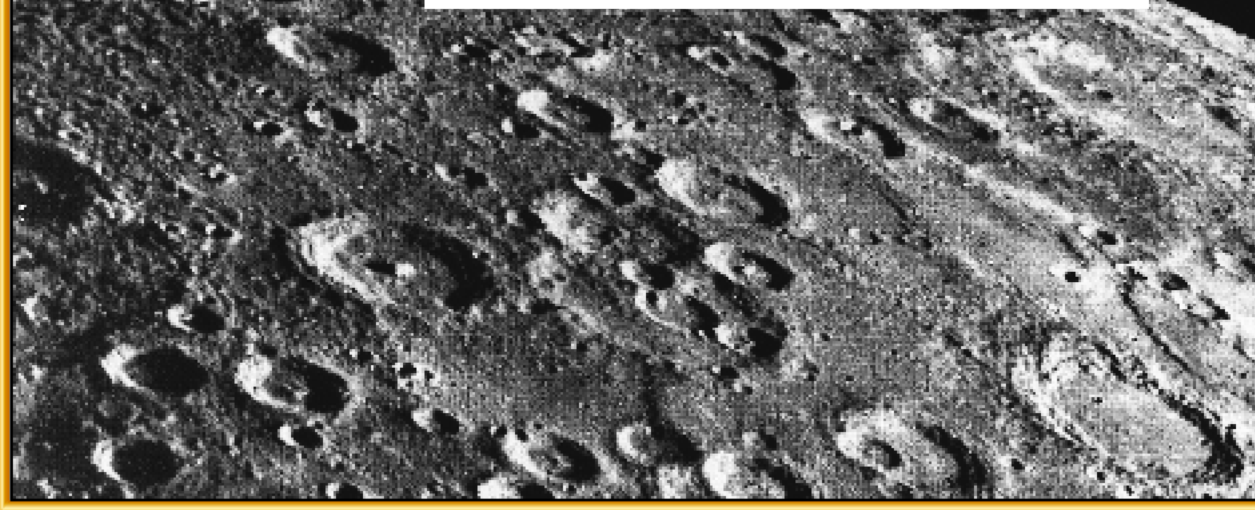


FIGURE 12
Mercury
This image of Mercury was produced by combining a series of smaller images made by the *Mariner 10* space probe.
Interpreting Photographs *How is Mercury's surface different from Earth's?*

Mercury

Mercury is the smallest terrestrial planet and the planet closest to the sun. Mercury is not much larger than Earth's moon and has no moons of its own. The interior of Mercury is probably made up mainly of the dense metal iron.

Exploring Mercury Because Mercury is so close to the sun, it is hard to see from Earth. Much of what astronomers know about Mercury's surface came from a single probe, *Mariner 10*. It flew by Mercury three times in 1974 and 1975. Two new missions to Mercury are planned. The first of these, called *MESSENGER*, is scheduled to go into orbit around Mercury in 2009.

Mariner 10's photographs show that Mercury has many flat plains and craters on its surface. The large number of craters shows that Mercury's surface has changed little for billions of years. Many of Mercury's craters have been named for artists, writers, and musicians, such as the composers Bach and Mozart.

Mercury's Atmosphere Mercury has virtually no atmosphere. Mercury's high daytime temperatures cause gas particles to move very fast. Because Mercury's mass is small, its gravity is weak. Fast-moving gas particles can easily escape into space. However, astronomers have detected small amounts of sodium and other gases around Mercury.

Mercury is a planet of extremes, with a greater temperature range than any other planet in the solar system. It is so close to the sun that during the day, the side facing the sun reaches temperatures of 430°C. Because Mercury has almost no atmosphere, at night its heat escapes into space. Then its temperature drops below −170°C.

Reading Checkpoint **Compare daytime and nighttime temperatures on Mercury.**

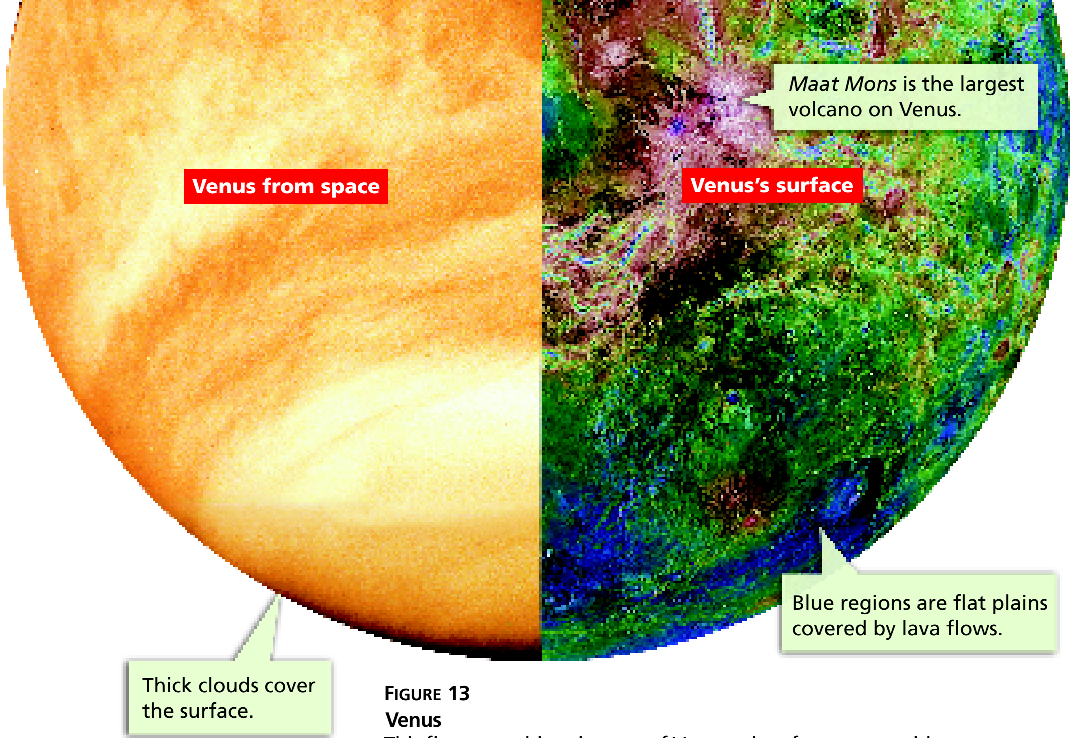


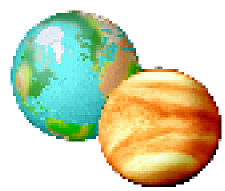
Figure 13
Venus
This figure combines images of Venus taken from space with a camera (left) and radar (right). The camera image shows Venus's thick atmosphere. Radar is able to penetrate Venus's clouds to reveal the surface. Both images are false color.

Venus

You can sometimes see Venus in the west just after sunset. When Venus is visible in that part of the sky, it is known as the "evening star," though of course it really isn't a star at all. At other times, Venus rises before the sun in the morning. Then it is known as the "morning star."

Venus is so similar in size and mass to Earth that it is sometimes called "Earth's twin." **Venus's density and internal structure are similar to Earth's. But, in other ways, Venus and Earth are very different.**

Venus's Rotation Venus takes about 7.5 Earth months to revolve around the sun. It takes about 8 months for Venus to rotate once on its axis. Thus, Venus rotates so slowly that its day is longer than its year! Oddly, Venus rotates from east to west, the opposite direction from most other planets and moons. Astronomers hypothesize that this unusual rotation was caused by a very large object that struck Venus billions of years ago. Such a collision could have caused Venus to change its direction of rotation. Another hypothesis is that Venus's thick atmosphere could have somehow altered its rotation.



Size of Venus compared to Earth

Go Online SCI LINKS NSTA
For: Links on the planets
Visit: www.SciLinks.org
Web Code: scn-0633

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For: Links on the planets
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Download a worksheet that will guide students' review of Internet resources on the planets.

Venus

Teach Key Concepts L2

Venus's Rotation

Focus Remind students that most planets, including Earth, rotate from west to east.

Teach Place a globe on a table and spin it so that it turns from west to east. Place a second globe on the table and spin it very slowly so that it turns from east to west. Ask: **Which globe represented Earth?** *(The first; Earth rotates from west to east.)* **What did the other globe represent?** *(Venus; it rotates very slowly from east to west.)*

Apply Ask students to compare and contrast Earth and Venus. *(They are similar in density and internal structure. They have different atmospheres and rotations.)*
learning modality: visual

Help Students Read L1

Visualizing Have students close their books and listen while you read the paragraph about Venus's rotation. Ask them to describe how they visualize what caused this unusual rotation. Then ask students to work in pairs and discuss how they visualized the process.

Differentiated Instruction

Less Proficient Readers L1

Comparing and Contrasting Inner Planets Suggest that students use Venn diagrams to compare and contrast each inner planet with Earth. Demonstrate how to use a Venn diagram to compare and contrast two subjects. First, have volunteers read aloud the information about Earth and Venus in the section. Then draw a Venn diagram on the chalkboard. As students name similarities between Venus and Earth, write these in the overlapping portion of the diagram. Then have students name differences and record these in the outer portions of the circles. Instruct students to complete additional Venn diagrams for the remaining inner planets and Earth. **learning modality: visual**

Monitor Progress L2

Writing Have students write paragraphs describing how sunrise on Venus differs from sunrise on Earth.

Answers

Figure 12 Mercury's surface is heavily cratered and barren.

Reading Checkpoint Temperatures on Mercury vary from 430°C on the sunlit side to below –170°C at night.

Use Visuals: Figure 14 L2

Radar Images

Focus Tell students that radar images are formed when radio waves are bounced off a surface.

Teach Have students infer why scientists used radar to obtain images of volcanoes on Venus. *(They could not see the volcanoes because the thick atmosphere of Venus blocked the view.)* Explain that radar images sometimes exaggerate the heights of objects such as volcanoes. Ask: **Why might astronomers want to use an exaggerated scale when examining an image?** *(Possible answer: Astronomers increase the scale of an image so that they can examine details more clearly.)*

Apply Inform students that the colors in the figure are generated by the computer-imaging process. The actual volcano colors vary; they appear more like those of volcanoes on Earth. **learning modality: visual**

Lab zone Build Inquiry L3

Interpreting the Greenhouse Effect

Materials photograph of a greenhouse

Time 20 minutes

Focus Show students a photograph of a greenhouse with plants growing inside. Explain that a greenhouse lets in sunlight and prevents convection from carrying away heat. The plants stay warm inside.

Teach Place students in pairs and have them create flowcharts or sketches that compare the path of light and heat energy in a greenhouse with the path of light and heat energy on Venus.

Apply Have students discuss possible environmental problems caused by changes in Earth's greenhouse effect. **learning modality: logical/mathematical**

Lab zone Try This Activity

Greenhouse Effect

How can you measure the effect of a closed container on temperature?

1. Carefully place a thermometer into each of two glass jars. Cover one jar with cellophane. Place both jars either in direct sunlight or under a strong light source.
2. Observe the temperature of both thermometers when you start. Check the temperatures every 5 minutes for a total of 20 minutes. Record your results in a data table.

Inferring Compare how the temperature changed in the uncovered jar and the covered jar. What do you think is the reason for any difference in the temperatures of the two jars? Which jar is a better model of Venus's atmosphere?

Venus's Atmosphere Venus's atmosphere is so thick that it is always cloudy there. From Earth or space, astronomers can see only a smooth cloud cover over Venus. The clouds are made mostly of droplets of sulfuric acid.

If you could stand on Venus's surface, you would quickly be crushed by the weight of its atmosphere. The pressure of Venus's atmosphere is 90 times greater than the pressure of Earth's atmosphere. You couldn't breathe on Venus because its atmosphere is mostly carbon dioxide.

Because Venus is closer to the sun than Earth is, it receives more solar energy than Earth does. Much of this radiation is reflected by Venus's atmosphere. However, some radiation reaches the surface and is later given off as heat. The carbon dioxide in Venus's atmosphere traps heat so well that Venus has the hottest surface of any planet. At 460°C, its average surface temperature is hot enough to melt lead. This trapping of heat by the atmosphere is called the **greenhouse effect.**

Exploring Venus Many space probes have visited Venus. The first probe to land on the surface and send back data, *Venera 7*, landed in 1970. It survived for only a few minutes because of the high temperature and pressure. Later probes were more durable and sent images and data back to Earth.

The *Magellan* probe reached Venus in 1990, carrying radar instruments. Radar works through clouds, so *Magellan* was able to map nearly the entire surface. The *Magellan* data confirmed that Venus is covered with rock. Venus's surface has many volcanoes and broad plains formed by lava flows.

Reading Checkpoint **What are Venus's clouds made of?**

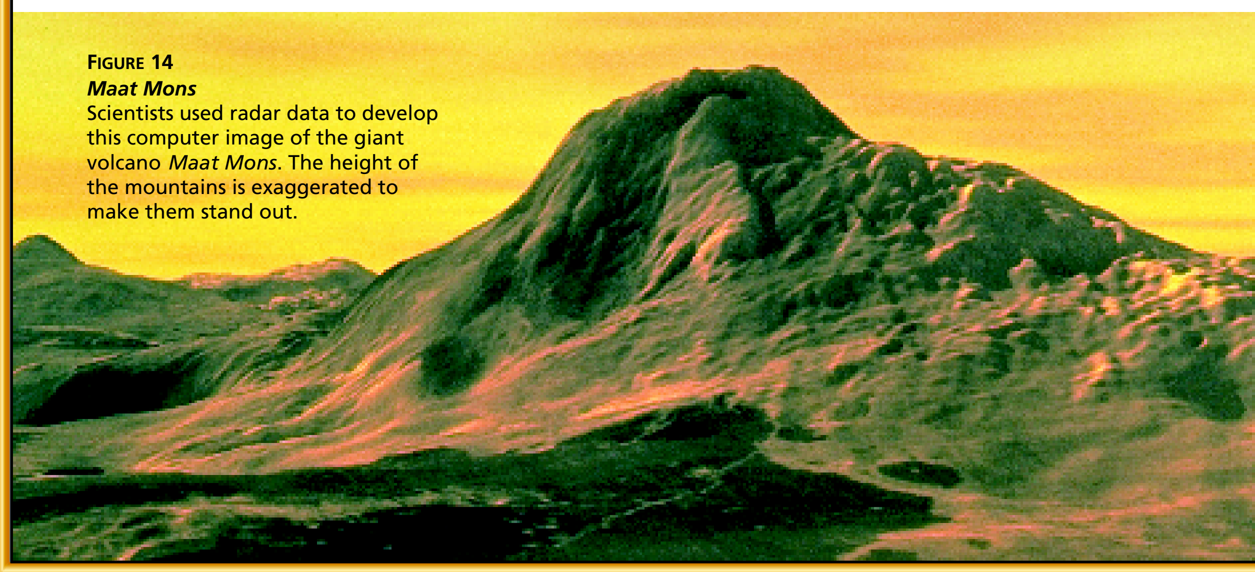


FIGURE 14
Maat Mons
Scientists used radar data to develop this computer image of the giant volcano *Maat Mons*. The height of the mountains is exaggerated to make them stand out.

Lab zone Try This Activity

Skills Focus inferring L2

Materials plastic wrap, two glass jars, two thermometers

Time 20 minutes

Tips Place jars and thermometers in a position so that thermometers can be read without touching the jars or disturbing them in any way.

Expected Outcome The temperature in the covered jar should rise faster.

Extend Have students infer normal working of Earth's atmosphere. That is, how a similar greenhouse effect keeps Earth warm. **learning modality: kinesthetic**

Mars

Mars is called the "red planet." When you see it in the sky, it has a slightly reddish tinge. This reddish color is due to the breakdown of iron-rich rocks, which creates a rusty dust that covers much of Mars's surface.

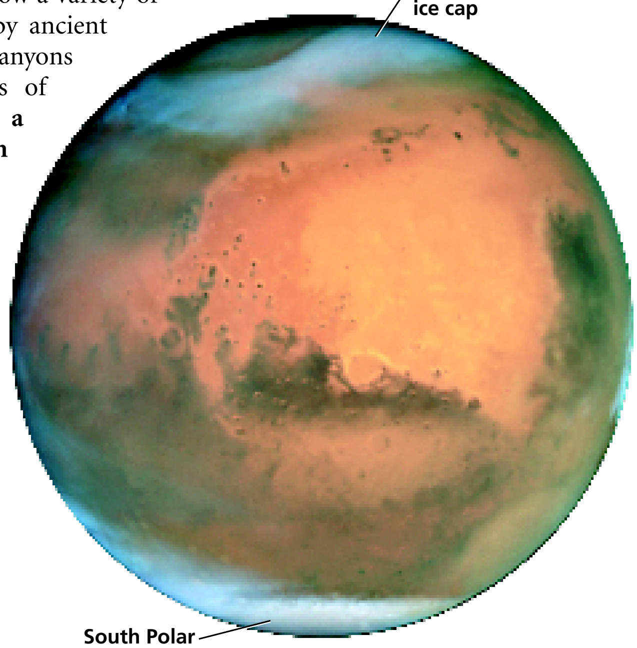
Mars's Atmosphere The atmosphere of Mars is more than 95 percent carbon dioxide. It is similar in composition to Venus's atmosphere, but much thinner. You could walk around on Mars, but you would have to wear an airtight suit and carry your own oxygen, like a scuba diver. Mars has few clouds, and they are very thin compared to clouds on Earth. Mars's transparent atmosphere allows people on Earth to view its surface with a telescope. Temperatures on the surface range from −140°C to 20°C.

Water on Mars In 1877, an Italian astronomer named Giovanni Schiaparelli (sky ah puh REL ee) announced that he had seen long, straight lines on Mars. He called them *canale*, or channels. In the 1890s and early 1900s, Percival Lowell, an American astronomer, convinced many people that these lines were canals that had been built by intelligent Martians to carry water. Astronomers now know that Lowell was mistaken. There are no canals on Mars.

Images of Mars taken from space do show a variety of features that look as if they were made by ancient streams, lakes, or floods. There are huge canyons and features that look like the remains of ancient coastlines. **Scientists think that a large amount of liquid water flowed on Mars's surface in the distant past.** Scientists infer that Mars must have been much warmer and had a thicker atmosphere at that time.

At present, liquid water cannot exist for long on Mars's surface. Mars's atmosphere is so thin that any liquid water would quickly turn into a gas. So where is Mars's water now? Some of it is located in the planet's two polar ice caps, which contain frozen water and carbon dioxide. A small amount also exists as water vapor in Mars's atmosphere. Some water vapor has probably escaped into space. But scientists think that a large amount of water may still be frozen underground.

FIGURE 15
Mars
Because of its thin atmosphere and its distance from the sun, Mars is quite cold. Mars has ice caps at both poles. **Inferring** *Why is it easy to see Mars's surface from space?*



Mars

Teach Key Concepts L1

Exploring Mars

Focus Explain to students that people on Earth can view the surface of Mars with a telescope.

Teach Ask: **What does Mars have in common with the other inner planets?** *(It has seasons, volcanoes, and polar caps like Earth. It may have had liquid water in the past. The composition of its atmosphere is similar to that of Venus. It is barren like Mercury.)* Ask: **What distinguishes Mars from the other inner planets?** *(Unlike Venus and Earth, Mars has a very thin atmosphere. Mars has two moons.)*

Apply Ask: **What challenges might astronauts face if they went to Mars?** *(Possible answer: Lack of oxygen in the atmosphere, distance from Earth, extreme temperatures, lack of liquid water)* **learning modality: verbal**

Address Misconceptions

Science or Science Fiction?

Focus Students' ideas about the features and history of Mars may be partly based on science-fiction stories, television shows, and movies.

Teach Have each student prepare a Fact/Fiction sheet to distinguish scientific findings about Mars from science fiction.

Apply Have students share their sheets with partners and discuss whether they agree on what is fact and what is fiction. **learning modality: verbal**

Differentiated Instruction

Gifted and Talented L3

Musical Planets The English composer Gustav Holst, who lived from 1874 to 1934, composed a group of pieces for orchestra entitled *The Planets*. The seven pieces describe musically the planets Mercury, Venus, Mars, Jupiter, Saturn, Uranus, and Neptune. Have interested students listen to one of the pieces. Ask each to write a brief paragraph describing how Holst used music to represent the planet. Encourage students to use descriptive terms, such as *eerie* and *brash*. **learning modality: verbal**

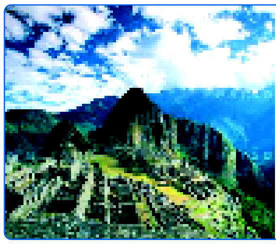
Monitor Progress L2

Oral Presentation Have students work in groups of four. Assign each member of the group an inner planet. Have each student read the information about the assigned planet in the text and then teach the other members of the group what he or she has learned.

Answers

Figure 15 Mars has a thin, transparent atmosphere.

Reading Checkpoint Mostly droplets of sulfuric acid



Discovery Channel School Video Field Trip

The Solar System

Show the Video Field Trip to let students experience exploring the inner planets. Discussion questions: **Name the inner planets of our solar system.** *(Mercury, Venus, Earth, and Mars)* **Describe one unique characteristic of each inner planet.** *(Possible answers: Mercury—closest planet to sun, on Mercury there are only one and one-half days per year; Venus—covered with thick, swirling clouds; brightest planet in Earth's sky; Venus's year is shorter than its day; its rotation is in opposite direction from that of other planets; Earth—has life, liquid water, protective atmosphere; Mars—red planet; has water as ice on surface near poles)*

Lab zone Build Inquiry

L2

Modeling Channels

Materials sand, rectangular baking pans, large beaker, bucket for sand disposal

Time 15 minutes

Focus Remind students that water changes geologic features through the process of erosion.

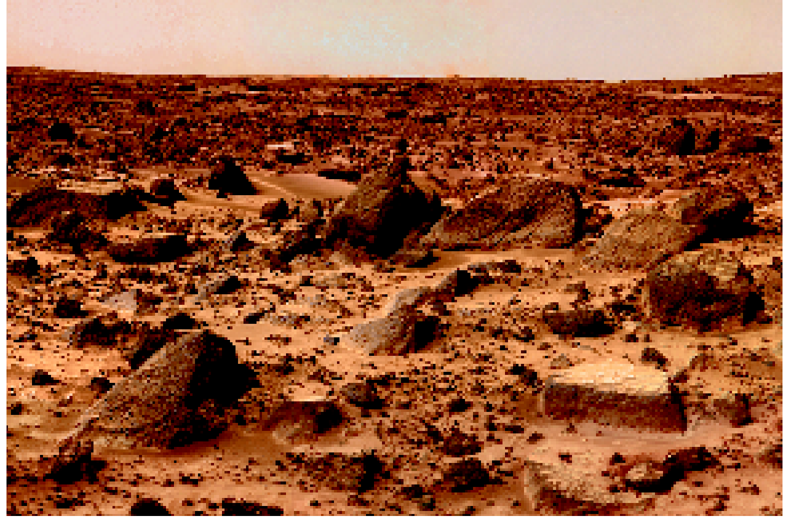
Teach Place large buckets in strategic locations around the room for sand disposal. Warn students to keep the sand out of the sinks. Have pairs of students build slopes with moist sand in one end of a rectangular metal baking pan. The sand should slope from just below the rim on one end to about the middle of the pan. Have students pour a slow, steady stream of water onto the top of the slope and observe what happens as the water runs down the slope. Have students continue pouring until there is about 1 cm of water in the pan.

Apply Ask: **How did the flowing water change the surface of the sand?** *(It formed channels.)* Ask students to infer why scientists believe water once flowed on Mars. *(Channels on Mars look similar to channels formed by flowing water on Earth.)* **learning modality: kinesthetic**

Discovery Channel School

The Solar System

- Video Preview
- ▶ Video Field Trip
- Video Assessment



Lab zone Try This Activity

Remote Control

How hard is it to explore another planet by remote control?

1. Tape a piece of paper over the front of a pair of goggles. Have your partner put them on.
2. Walk behind your partner and direct him or her to another part of the room. **CAUTION:** *Do not give directions that would cause your partner to walk into a wall or a corner, trip on an obstacle, or bump into anything.*
3. Trade places and repeat Steps 1 and 2.

Drawing Conclusions Which verbal directions worked best? How quickly could you move? How is this activity similar to the way engineers have moved rovers on Mars? How fast do you think such a rover could move?

Seasons on Mars Because Mars has a tilted axis, it has seasons just as Earth does. During the Martian winter, an ice cap grows larger as a layer of frozen carbon dioxide covers it. Because the northern and southern hemispheres have opposite seasons, one ice cap grows while the other one shrinks.

As the seasons change on the dusty surface of Mars, windstorms arise and blow the dust around. Since the dust is blown off some regions, these regions look darker. A hundred years ago, some people thought these regions looked darker because plants were growing there. Astronomers now realize that the darker color is often just the result of windstorms.

Exploring Mars Many space probes have visited Mars. The first ones seemed to show that Mars is barren and covered with craters like the moon. In 2004, two new probes landed on Mars's surface. NASA's *Spirit* and *Opportunity* rovers explored opposite sides of the planet. They examined a variety of rocks and soil samples. At both locations, the rovers found strong evidence that liquid water was once present. The European Space Agency's *Mars Express* probe orbited overhead, finding clear evidence of frozen water (ice). However, the *Mars Express* lander failed.

Volcanoes on Mars Some regions of Mars have giant volcanoes. Astronomers see signs that lava flowed from the volcanoes in the past, but the volcanoes are no longer active. *Olympus Mons* on Mars is the largest volcano in the solar system. It covers a region as large as the state of Missouri and is nearly three times as tall as Mount Everest, the tallest mountain on Earth!

Lab zone Try This Activity

Skills Focus drawing conclusions L2

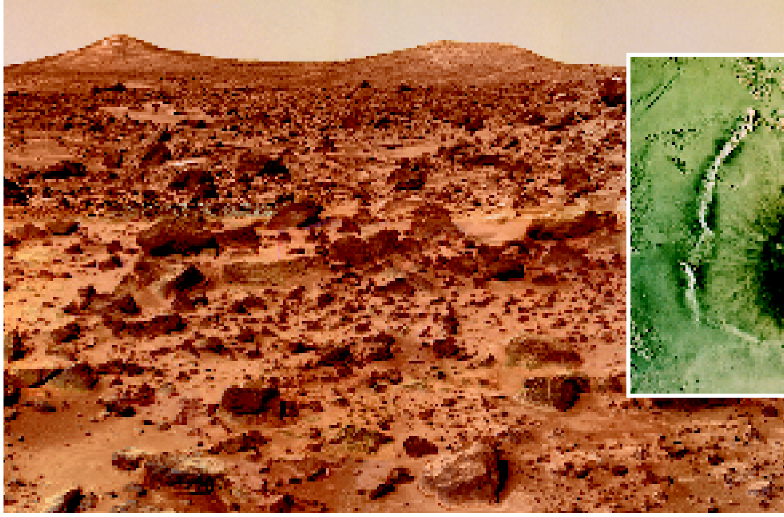
Materials paper, goggles, tape

Time 15 minutes

Tips Perform this activity in a large, open area with no obstacles.

Expected Outcome Clear simple directions worked best. Students could not move quickly. In a similar way, rovers must be given simple directions, and they move slowly.

Extend Have students infer difficulties that NASA encountered when trying to get rovers to perform tasks on Mars. **learning modality: kinesthetic**



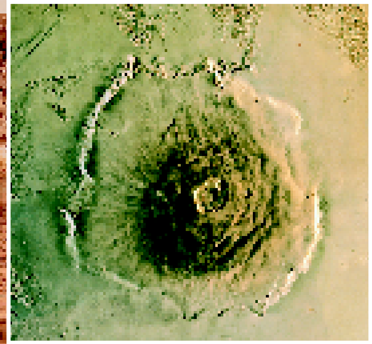


FIGURE 16
Mars's Surface
As the large photo shows, the surface of Mars is rugged and rocky. Mars has many large volcanoes. The volcano *Olympus Mons* (inset) rises about 27 km from the surface. It is the largest volcano in the solar system.

Mars's Moons Mars has two very small moons. Phobos, the larger moon, is only 27 kilometers in diameter, about the distance a car can travel on the highway in 20 minutes. Deimos is even smaller, only 15 kilometers in diameter. Like Earth's moon, Phobos and Deimos are covered with craters. Phobos, which is much closer to Mars than Deimos is, is slowly spiraling down toward Mars. Astronomers predict that Phobos will smash into Mars in about 40 million years.

Reading Checkpoint **How many moons does Mars have? What are their names?**

Section 3 Assessment

Target Reading Skill Using Prior Knowledge Review your graphic organizer about the inner planets and revise it based on what you just learned in the section.

Reviewing Key Concepts

1. a. **Listing** List the four inner planets in order of size, from smallest to largest.
   b. **Comparing and Contrasting** How are the four inner planets similar to one another?
2. a. **Describing** Describe an important characteristic of each inner planet.
   b. **Comparing and Contrasting** Compare the atmospheres of the four inner planets.
   c. **Relating Cause and Effect** Venus is much farther from the sun than Mercury is. Yet average temperatures on Venus's surface are much higher than those on Mercury. Explain why.

Writing in Science

Travel Brochure Select one of the inner planets other than Earth. Design a travel brochure for your selected planet, including basic facts and descriptions of places of interest. Also include a few sketches or photos to go along with your text.

Monitor Progress L2

Answer

Reading Checkpoint Two; Phobos and Deimos

Assess

Reviewing Key Concepts

1. a. Mercury, Mars, Venus, Earth **b.** They are all small and rocky.
2. a. Possible answers: Mercury—heavily cratered surface; Venus—thick atmosphere; Earth—liquid water at surface; Mars—has largest volcano in the solar system
b. Mercury: almost no atmosphere; Venus: thick atmosphere made mostly of carbon dioxide; Earth: atmosphere made mostly of nitrogen and oxygen; Mars: thin atmosphere made mostly of carbon dioxide **c.** Venus's thick atmosphere traps heat as a result of the greenhouse effect.

Reteach L1

Tell students to imagine they are scientists studying Mercury, Venus, and Mars. Ask: **Which planets' surfaces would be easy to see? Which would be hard to see?** Have them explain their answers. *(Mercury's surface would be hard to see because it is close to the sun. Venus's surface would be hard to see because the planet's atmosphere is thick. Mars's surface would be easy to see because this planet's atmosphere is thin.)*

Performance Assessment L2

Skills Check Have students create models of the four inner planets using art supplies and classroom items. Models should include some distinguishing characteristics of each planet.

All in One Teaching Resources

- Section Summary: *The Inner Planets*
- Review and Reinforce: *The Inner Planets*
- Enrich: *The Inner Planets*

Lab zone Chapter Project

Keep Students on Track Students should now design a model that shows the relative diameters of the planets. If students have trouble finding a scale that works, suggest 1 cm = 10,000 km. At this scale, Mercury would be about the size of a pea and the sun would be about the size of an easy chair.

Writing in Science

Writing Mode Persuasion

Scoring Rubric

4 Exceeds criteria, includes complete descriptions, basic facts, and photos; brochure is colorful and entertaining
3 Meets all criteria but does not go beyond requirements
2 Includes only brief descriptions
1 Is inaccurate or incomplete

Science and Society

Space Exploration—Is It Worth the Cost?

Key Concept

Space exploration is expensive and poses risks and danger to human explorers.

Build Background Knowledge

Recalling Space Exploration Missions

Help students recall that many successful probes have been sent to planets and moons in our solar system. Ask: **How many of the planets in our solar system have been photographed up close or visited by space probes from Earth?** *(All except Pluto)* **What have we learned about them that couldn't be learned with Earth-based observations?** *(Surface features, existence of minor moons, existence of rings, properties such as magnetic fields, composition of rocks, and so on)* Remind students that some missions included astronauts. Ask: **Have any of the moons or planets in the solar system been explored by astronauts?** *(Yes; Earth's moon)* **Why did astronauts go to the moon?** *(The moon landing was part of the "space race." Some responses may also include that the landings were missions of discovery.)*

Introduce the Panel Discussion

Ask: **What value is there in exploring space?** *(To learn about the universe and solar system and how they formed; to learn new ideas in science and technology that can be applied on Earth)* **If there is value in exploring space, is there any real value in sending people to explore space?** *(Accept all answers. Possible answers: No; uncrewed probes can learn everything we need to know. Yes; crewmembers can respond better than machines to unusual situations or make immediate decisions in response to unplanned occurrences.)*

Facilitate the Panel Discussion

- Have students complete the first two steps under "You Decide" as a way to prepare themselves for taking part in the discussion.
- After the discussion, have students complete step three, using what they learned in the discussion to find solutions to the problem.

Science and Society

Space Exploration—Is It Worth the Cost?

Imagine that your spacecraft has just landed on the moon or on Mars. You've spent years planning for this moment. Canyons, craters, plains, and distant mountains stretch out before you. Perhaps a group of scientists has already begun construction of a permanent outpost. You check your spacesuit and prepare to step out onto the rocky surface.

Is such a trip likely? Would it be worthwhile? How much is space flight really worth to human society? Scientists and public officials have already started to debate such questions. Space exploration can help us learn more about the universe. But exploration can be risky and expensive. Sending people into space costs billions of dollars and risks the lives of astronauts. How can we balance the costs and benefits of space exploration?

▼ **Moon Landing**
A rocket is preparing to dock with a lander on the moon's surface in this imaginative artwork.

The Issues

Should Humans Travel Into Space?

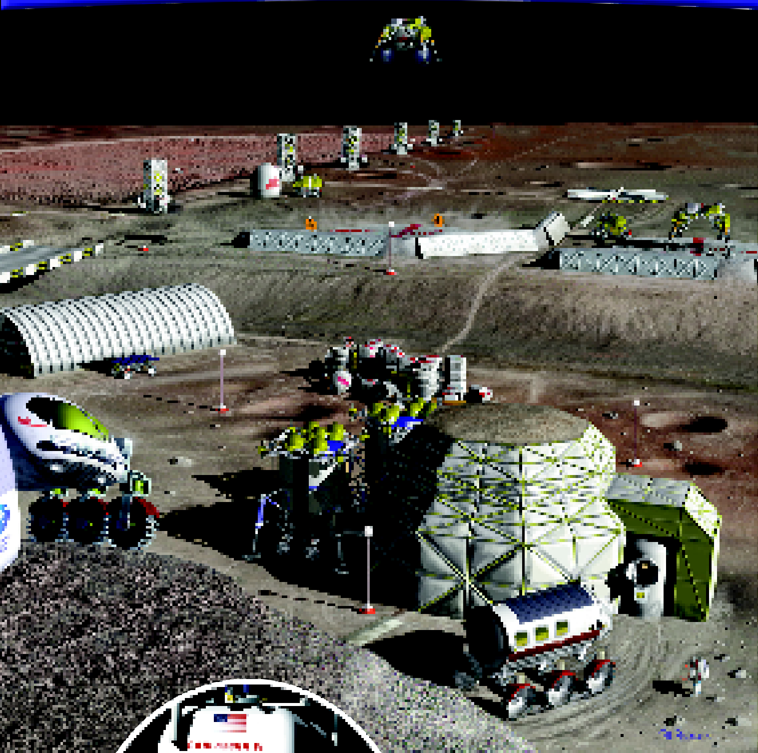
Many Americans think that Neil Armstrong's walk on the moon in 1969 was one of the great moments in history. Learning how to keep people alive in space has led to improvements in everyday life. Safer equipment for firefighters, easier ways to package frozen food, and effective heart monitors have all come from space program research.

What Are the Alternatives?

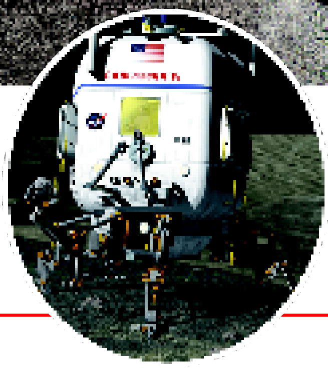
Space exploration can involve a project to establish a colony on the moon or Mars. It also can involve a more limited use of scientific instruments near Earth, such as the Hubble Space Telescope. Instead of sending people, we could send space probes like *Cassini* to other planets.

Background

NASA has included a detailed justification of space exploration on the Web site. NASA argues that the basic knowledge about the universe gained through space exploration gives us a better understanding of Earth. Space exploration has also allowed application in satellite communication. Many technological breakthroughs have come as a result of the space program. The space program supports many jobs and is thus good for the economy. The exploration of space serves as an inspiration to humans to explore the unknown and push back boundaries. Additional information is available at **www.nasa.gov.**



◀ **Lunar Outpost**
A mining operation on the moon is shown in this imaginative artwork. Such a facility may someday harvest oxygen from the moon's soil.



◀ **Lunar Module**
This artwork shows a futuristic vehicle that may one day be used to explore the moon and Mars. The vehicle serves as a combination lander, rover, and habitat for astronauts.

Is Human Space Exploration Worth the Cost?

Scientists who favor human travel into space say that only people can collect certain kinds of information. They argue that the technologies developed for human space exploration will have many applications on Earth. But no one knows if research in space really provides information more quickly than research that can be done on Earth. Many critics of human space exploration think that other needs are more important. One United States senator said, "Every time you put money into the space station, there is a dime that won't be available for our children's education or for medical research."

You Decide

1. Identify the Problem
In your own words, list the various costs and benefits of space exploration.

2. Analyze the Options
Make a chart of three different approaches to space exploration: sending humans to the moon or another planet, doing only Earth-based research, and one other option. What are the benefits and drawbacks of each of these approaches?

3. Find a Solution
Imagine that you are a member of Congress who has to vote on a new budget. There is a fixed amount of money to spend, so you have to decide which needs are most important. Make a list of your top ten priorities. Explain your decisions.

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Students can research this issue online.

You Decide

1. Costs may include the monetary expense as well as the possible cost in human lives. The benefits may include the knowledge gained, the spinoff technology, and the jobs that result from building and launching spacecraft.

2. Option charts should include three approaches. Possible answer for human exploration approach: People can interpret situations in different ways and extend their research; for example, if a test indicates that certain chemicals on a planet's surface might have been produced by a life form, a human explorer can devise further testing to reach more exact conclusions. Possible answer for Earth-based approach: Better ways to refine instruments are found every day. Possible answer for other option approach: Unpiloted probes could be designed that would be able to make the types of analyses and decisions that currently only the human brain can make.

3. Students may set priorities for Congress's budget in many different ways. Many may put financing education or researching diseases near the top of the list and space exploration near the bottom.

Extend

Ask students to come up with several questions concerning space exploration that they could ask their family or community members in order to gain other insights into the space program and its potential benefits. For example, students may not realize how inspiring Neil Armstrong's first steps on the moon were unless they talk to someone who witnessed the moon landing on television in 1969.