

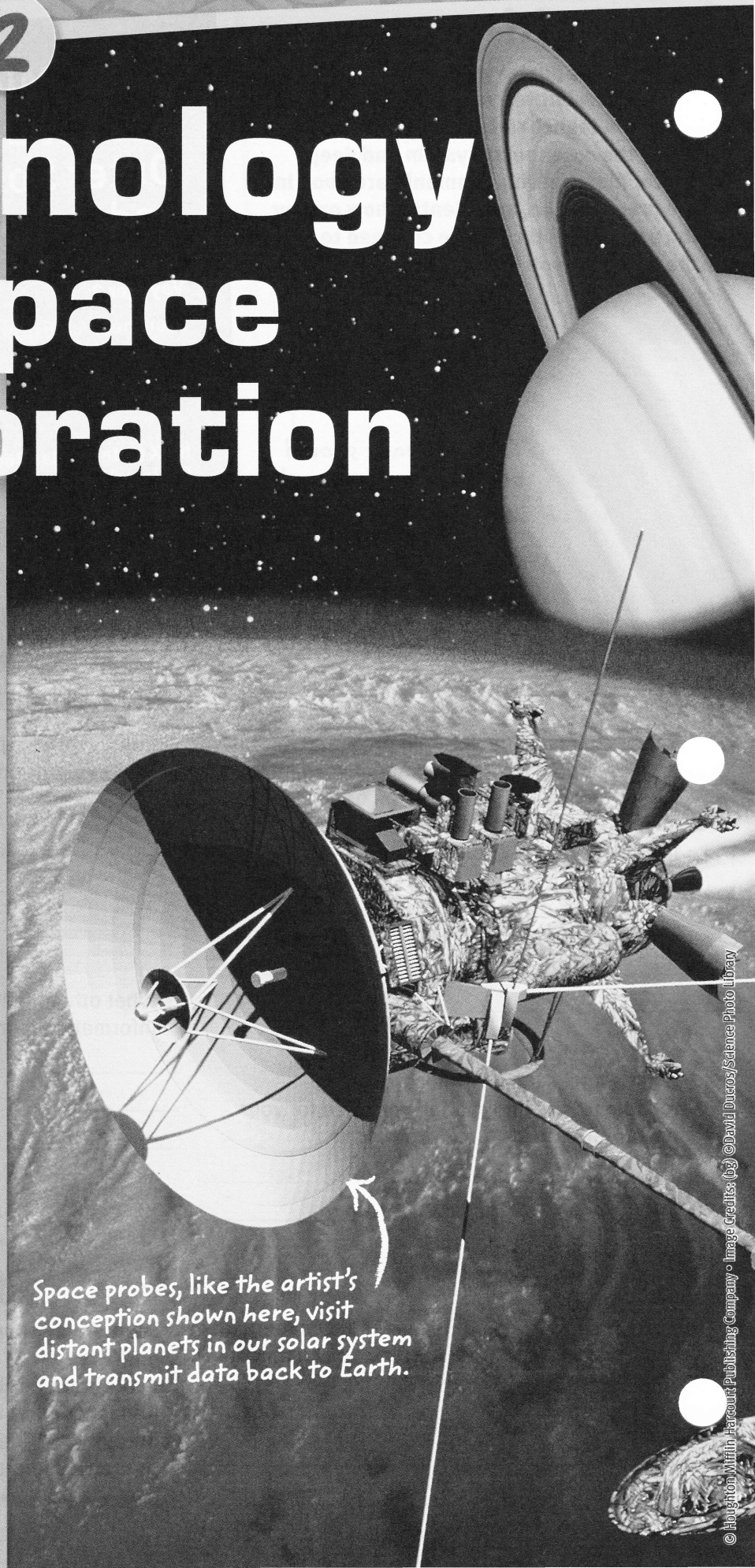


Technology for Space Exploration

ESSENTIAL QUESTION

*How do we
explore space?*

By the end of this lesson, you should be able to analyze the role of technology in the exploration of space.



Space probes, like the artist's conception shown here, visit distant planets in our solar system and transmit data back to Earth.

TEKS 6.11C describe the history and future of space exploration, including the types of equipment and transportation needed for space travel



Lesson Labs

Quick Labs

- Analyzing Satellite Images
- Design a Spacecraft

S.T.E.M. Lab

- Build a Rocket



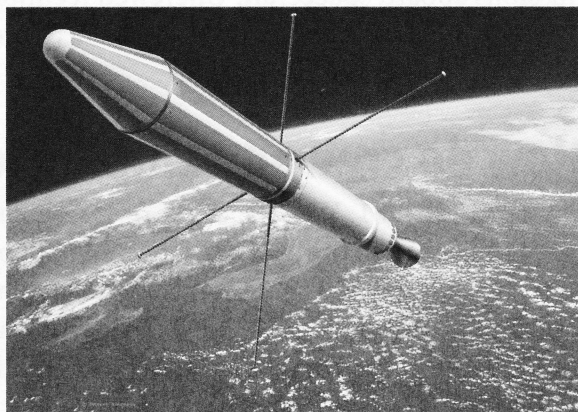
Engage Your Brain

1 Predict Check T or F to show whether you think each statement is true or false.

T F

- | | | |
|--------------------------|--------------------------|--|
| <input type="checkbox"/> | <input type="checkbox"/> | Astronauts can travel to distant planets in the solar system. |
| <input type="checkbox"/> | <input type="checkbox"/> | The space shuttle orbits the moon. |
| <input type="checkbox"/> | <input type="checkbox"/> | Artificial satellites in space can help you find locations on Earth. |
| <input type="checkbox"/> | <input type="checkbox"/> | Rovers explore the surfaces of planets and moons. |

2 Describe Write your own caption to this photo.



Active Reading

3 Apply Use context clues to write your own definition for the words *analyze* and *transmit*.

Example sentence

Some spacecraft carry technology that can analyze soil and rock samples from objects in space.

analyze:

Example sentence

Satellites transmit data back to Earth.

transmit:

Vocabulary Terms

- | | |
|-----------------|------------------------|
| • space shuttle | • lander |
| • space station | • rover |
| • probe | • artificial satellite |
| • orbiter | |

4 Identify As you read, place a question mark next to any words that you don't understand. When you finish reading the lesson, go back and review the text that you marked. If the information is still confusing, consult a classmate or a teacher.

Beyond the Clouds

What are two types of technology that people use to explore space?

Both crewed and uncrewed technologies are used to explore space. Crewed technologies, such as spacecraft, have astronauts on board. Astronauts are people who pilot spacecraft or complete missions aboard spacecraft. Uncrewed technologies carry scientific instruments that collect data. These data are sent back to Earth, where scientists analyze them.

How do crewed vehicles reach space?

On April 12, 1961, Yuri Gagarin (YOOR-ee guh·GAR-in) became the first human to orbit Earth. Since then, people have continued to travel into space. The first vehicles to take humans into space had very little room for the crew. The space shuttle was developed later and allowed people more time to live and work in space. All of the vehicles used large rockets to reach space.

With Rockets

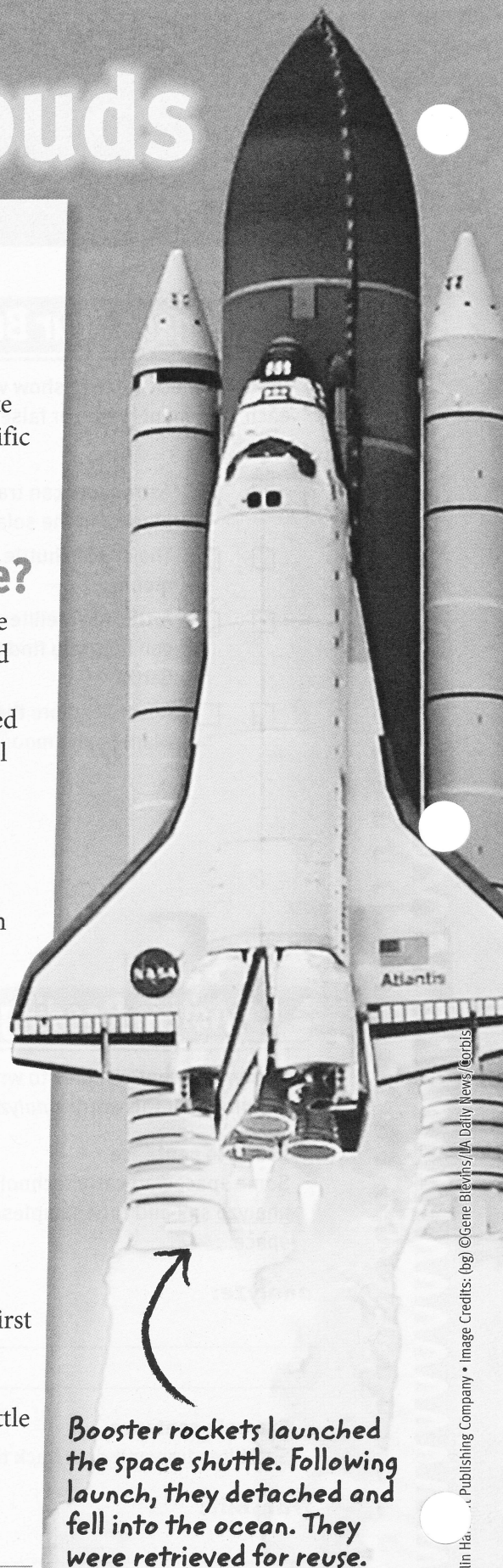
To travel away from Earth, large rockets must overcome Earth's gravitational attraction. A *rocket* is a machine that uses gas, often from burning fuel, to escape Earth's gravitational pull. Rockets launch both crewed and uncrewed vehicles into space. During early space missions, the capsules that contained the crews separated from the rockets. The rockets themselves burned up. The capsules "splashed down" in the ocean and were recovered. But, they were not reused.

With Space Shuttles

A **space shuttle** is a reusable spacecraft that launches using rocket boosters and liquid fuel, and glides to a landing on Earth like an airplane. The U.S. space shuttle program carried astronauts and supplies back and forth into orbit around Earth. *Columbia*, the first shuttle in a fleet of six, was launched by NASA in 1981. Between 1981 and 2011, more than 100 shuttle missions were completed. Two white, reusable solid rocket boosters (SRBs) helped the shuttle reach orbit. These booster rockets separated from the shuttle.



Active Reading 5 Explain What is the purpose of SRBs?



Booster rockets launched the space shuttle. Following launch, they detached and fell into the ocean. They were retrieved for reuse.

What are some technologies that allow people to live in space?

Astronauts have traveled to the moon. Yet, no human has traveled to more distant objects in the solar system. This is because there are many technological challenges. For example, enough fuel is needed for a long return voyage. Other challenges include having enough air, food, and water for a long journey. In addition, the spacecraft must be insulated from the intense cold of space. They must also be protected from harmful radiation from the sun.

Spacesuits protect astronauts when they work outside a spacecraft. But astronauts still face challenges inside a spacecraft. In space, everything seems weightless. Simple tasks like eating and drinking become difficult. The human body also experiences problems in a weightless environment. Bones and muscles weaken. So, astronauts must exercise daily to strengthen their bodies.

People can live and work in space on space stations. A **space station** is a long-term crewed spacecraft on which scientific research can be carried out. Currently, the *International Space Station* (ISS) is the only space station in Earth orbit.

Active Reading

- 6 List** What are challenges humans face when traveling in space?

Visualize It!

- 7 Identify** What are some technologies humans use to survive outside in space?

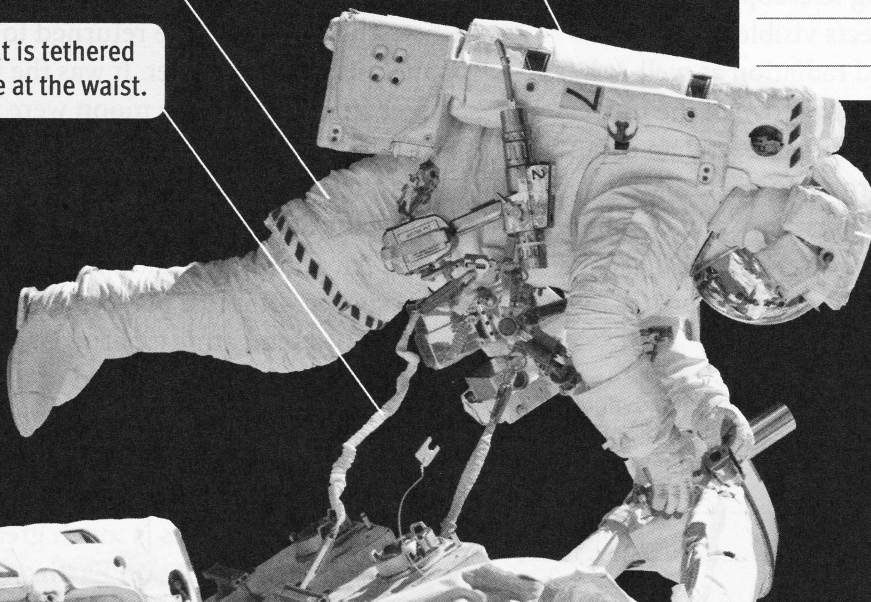
Spacesuits protect astronauts from extreme temperatures and from micrometeoroid strikes in space. They provide oxygen to astronauts and remove excess carbon dioxide.

Pressurized suits protect the astronaut from the vacuum of space.

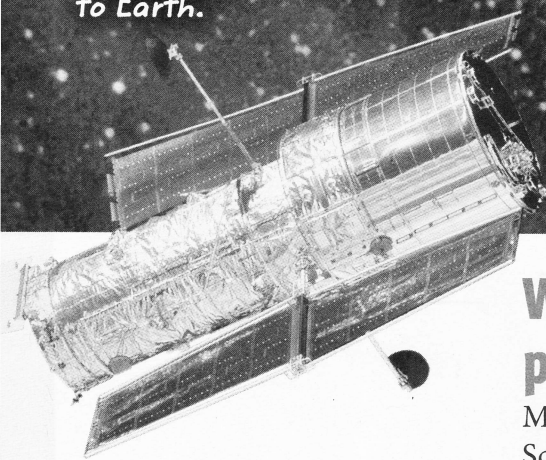
A life support pack supplies oxygen and removes carbon dioxide.

The astronaut is tethered to the shuttle at the waist.

The helmet contains communication gear and a protective visor.



The Hubble Space Telescope took this amazing image of Supernova SN1987A in the Large Magellanic Cloud and transmitted the image back to Earth.



Looking Up


What uncrewed technologies do people use to explore space?

Most objects in space are too far away for astronauts to visit. Scientists and engineers have developed uncrewed technologies to gather information about those objects. These technologies include space telescopes, probes, orbiters, landers, and rovers.

Telescopes in Space

Earth's atmosphere blocks some types of light. It also distorts light that passes through it. This makes it difficult to obtain clear images of objects in deep space. So, some telescopes are placed in Earth orbit to obtain clearer images. Computers in the telescopes gather data and transmit them back to Earth. For example, the Hubble Space Telescope is a reflecting telescope that was placed in orbit in 1990. It detects visible light, and ultraviolet and infrared radiation as well. It has greatly expanded our knowledge of the universe.

Other space telescopes collect data using different types of electromagnetic radiation. The *Chandra X-Ray Observatory* and *Compton Gamma-Ray Observatory* were placed in space because Earth's atmosphere blocks most x-rays and gamma rays.

 **Active Reading 8 Relate** What is one advantage of placing a telescope in space?

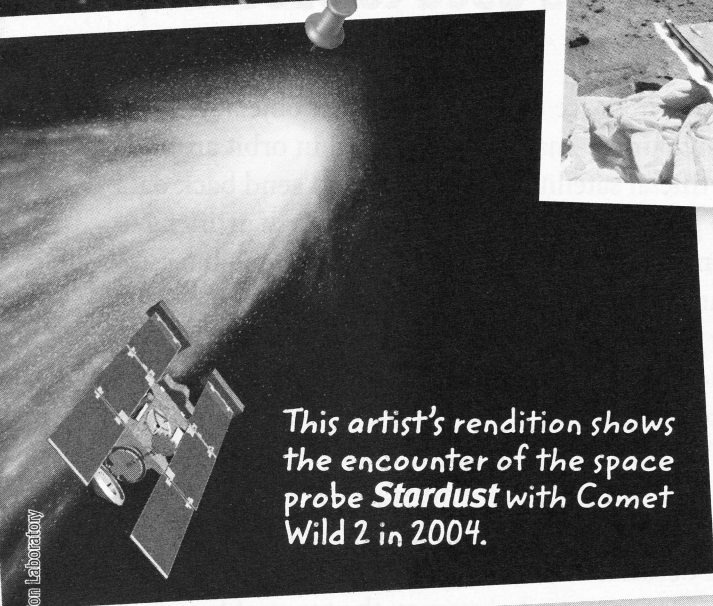
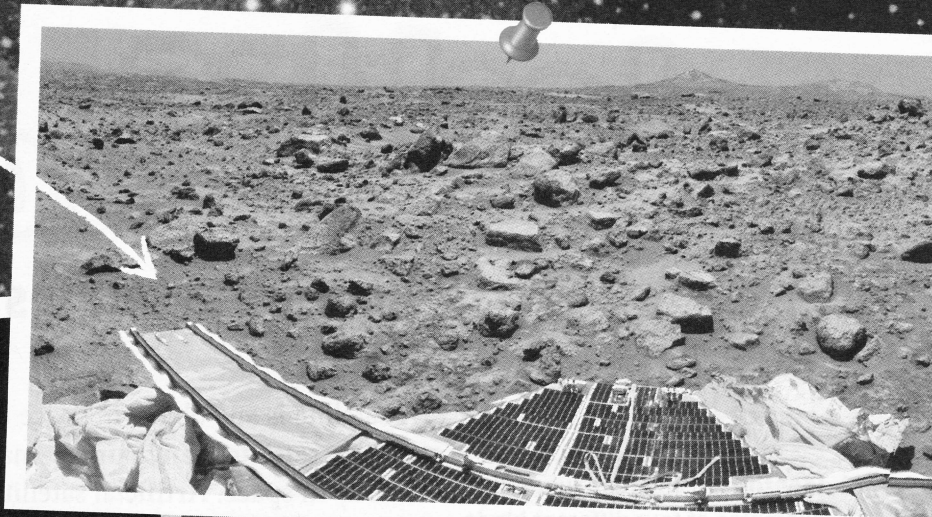
Space Probes

A space **probe** is an uncrewed vehicle that carries scientific instruments to distant objects in space. Probes carry a variety of data-collecting instruments. Computers on board handle data, which are sent back to Earth.

Some probes can collect and return materials to Earth. In 2004, NASA's *Stardust* probe collected dust samples as it flew by a comet. The particles were returned to Earth for analysis two years later. It was the first time samples from beyond the moon were brought back to Earth!

Probes have been especially useful for studying the atmospheres of the gas giant planets. An atmospheric entry probe is dropped from a spacecraft into a planet's atmosphere. These probes send atmospheric data back to the spacecraft for a short period of time before they are crushed in the planet's atmosphere. Remember, the gas giant planets do not have solid surfaces on which to land. The pressure within their atmospheres is much greater than the atmospheric pressure on Earth.

The **Mars Pathfinder** lander touched down on Mars in 1997. It found evidence that water once flowed on the surface of the planet.



This artist's rendition shows the encounter of the space probe **Stardust** with Comet Wild 2 in 2004.

Visualize It!

10 Compare How are probes and landers alike? How are they different?

Orbiters

An **orbiter** is an uncrewed spacecraft that is designed to enter into orbit around another object in space. As an orbiter approaches its target, rocket engines are fired to slow down the spacecraft so it can go into orbit. Controllers on Earth can place a spacecraft into orbit around a distant planet or its moons.

Orbiters can study a planet for long periods of time. Cameras and other equipment on board are used to monitor atmospheric or surface changes. Instruments are also used to make measurements of temperature and to determine the altitudes of surface features. Orbiters can photograph an entire planet's surface. The data allow scientists to create detailed maps of bodies in the solar system.

Active Reading 9 Describe What information can scientists obtain from orbiters?

Landers and Rovers

Orbiters allow astronomers to create detailed maps of planets. They do not touch down on a planet or moon, however. That task is accomplished by landers that are controlled by scientists on Earth. A **lander** is a craft designed to land on the surface of a body in space. Landers have been placed successfully on the moon, on Venus, on Mars, and on Saturn's moon Titan. Some, such as the *Mars Pathfinder*, have sent data for years. The images taken by a lander are more detailed than those taken by an orbiter.

In addition, a lander may carry a rover. A **rover** is a small vehicle that comes out of the lander. It explores the surface of a planet or moon beyond the landing site. Both landers and rovers may have mechanical arms for gathering rock, dust, and soil samples.

One of the most successful space missions was the Mars Exploration Rover mission. During this mission, twin rovers landed on Mars in 2004. The rovers, *Spirit* and *Opportunity*, took amazing photos of the surface of Mars. They also found evidence of water below the Martian surface.

Looking Down

How are satellites used to observe Earth?



Active Reading

- 11 Identify** As you read, underline examples of four different kinds of satellites.

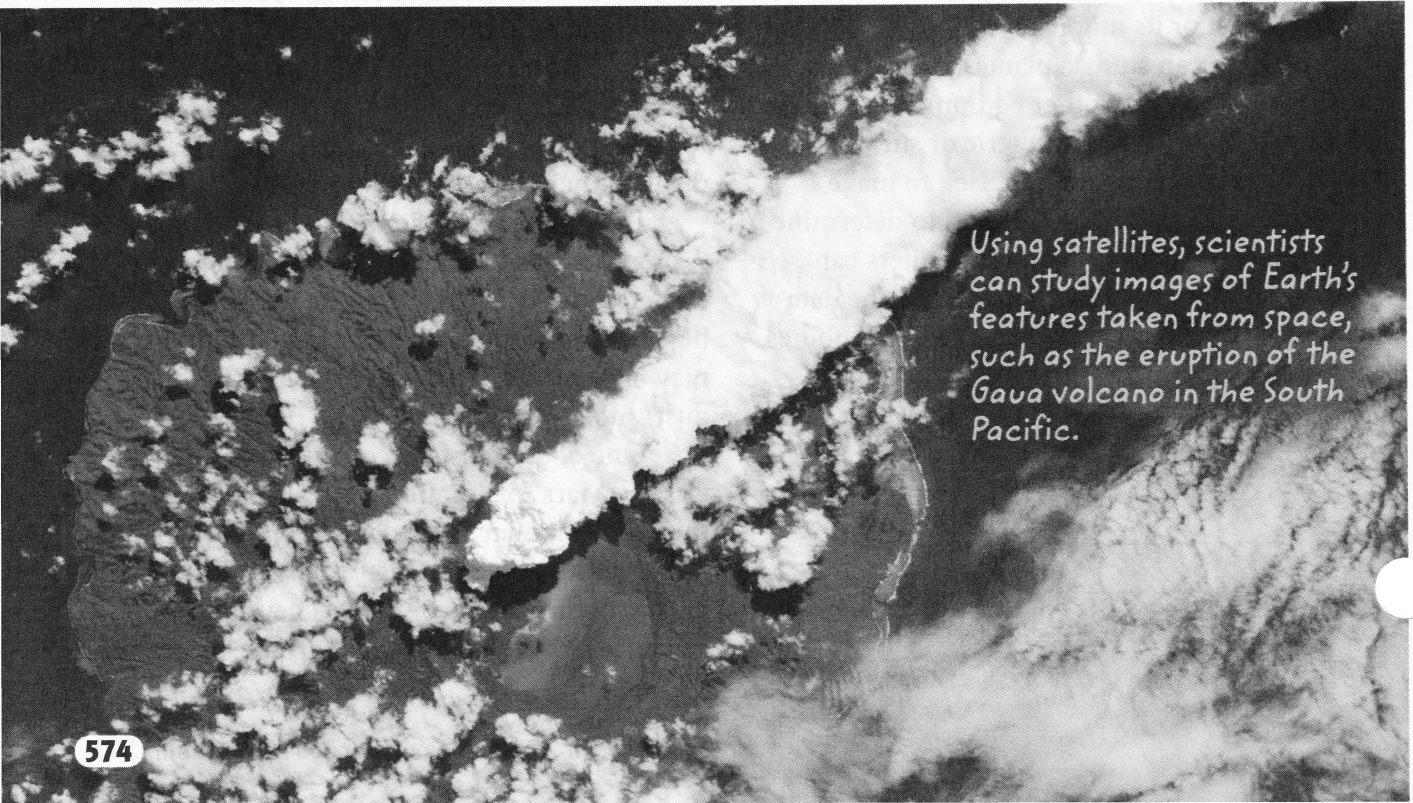
Inquiry

- 12 Apply** List two different features on Earth's surface, which are not given as an example here, that might be studied from space.

A satellite is any object in space that orbits another object. An **artificial satellite** is any human-made object placed in orbit around a body in space. Artificial satellites orbit Earth and send back data about our planet to ground stations. Some examples of artificial satellites include remote-sensing satellites, navigation satellites, weather satellites, and communications satellites.

Have you ever seen images of a large tropical storm on a weather report? These images are sent to Earth from weather satellites. They help scientists track storms and issue advance weather warnings. Weather satellites also monitor environmental conditions, such as changes in ocean temperatures. Remote-sensing satellites help scientists study Earth from space. They are used to map the ocean floor, identify sources of pollution, determine the size of ice caps, and even map the types of forests around the world. Astronauts in the *International Space Station* have photographed volcanoes during different stages of eruption.

The Global Positioning System (GPS) includes navigation satellites that can help pinpoint a user's exact location on Earth. Scientists use GPS to track wildlife. People use it to find locations on electronic maps. Communications satellites transmit television and telephone signals over long distances.



Using satellites, scientists can study images of Earth's features taken from space, such as the eruption of the Gaea volcano in the South Pacific.

Why It Matters

Exploring the Ocean

NEW
FRONTIERS

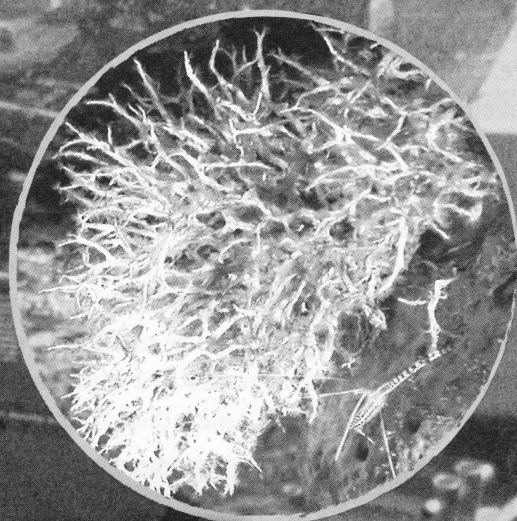
They may not seem related, but deep-sea exploration and space exploration have something in common. Both use advanced technologies to observe locations that are difficult or dangerous for humans to explore.

Ocean Submersibles

Both marine scientists and space scientists investigate areas most humans will never visit. Ocean submersibles can be crewed or uncrewed.

Black Smokers

Hydrothermal vents are on the ocean floor where humans cannot withstand the high pressure.



Tube Worms

In the 1970s, scientists aboard a submersible discovered giant tube worms living near an ocean vent. Similarly, NASA scientists examine the extreme conditions of Mars and other planets for any signs of life.

Extend

- 13 Identify** List two similarities between deep-sea exploration and space exploration.
- 14 Research and Record** List some features of an ocean submersible, for example, *Alvin*. How is the submersible's structure similar to that of spacecraft?

Inquiry

- 15 Recommend** Support more funding for deep-sea exploration by doing one of the following:
- write a letter
 - design an ad for a science magazine
 - write a script for a radio commercial

Space Trips

What are some goals of crewed space exploration?

Spacecraft have explored distant parts of our solar system. Because of technological limitations, these missions have been uncrewed. No human has traveled beyond the moon. But people may soon travel back to the moon. They may even go beyond the moon. NASA's plans for crewed space exploration include missions to the moon, to near-Earth asteroids, and to Mars.

To Explore Cis-Lunar Space

Cis-lunar space is the region of space between Earth's atmosphere and the moon's orbit. Crewed missions into cis-lunar space can add to our knowledge about the effects of long-term space exploration on the human body. NASA is developing plans for a facility in this space. It would be placed where the gravitational forces of Earth and the moon balance each other out. At such a place, a space facility can "park" for long periods of time. Places in cis-lunar space can be staging posts for crewed and uncrewed missions to Mars and other places that are even farther away. Large spacecraft and exploration equipment could also be assembled there.

To Explore the Moon

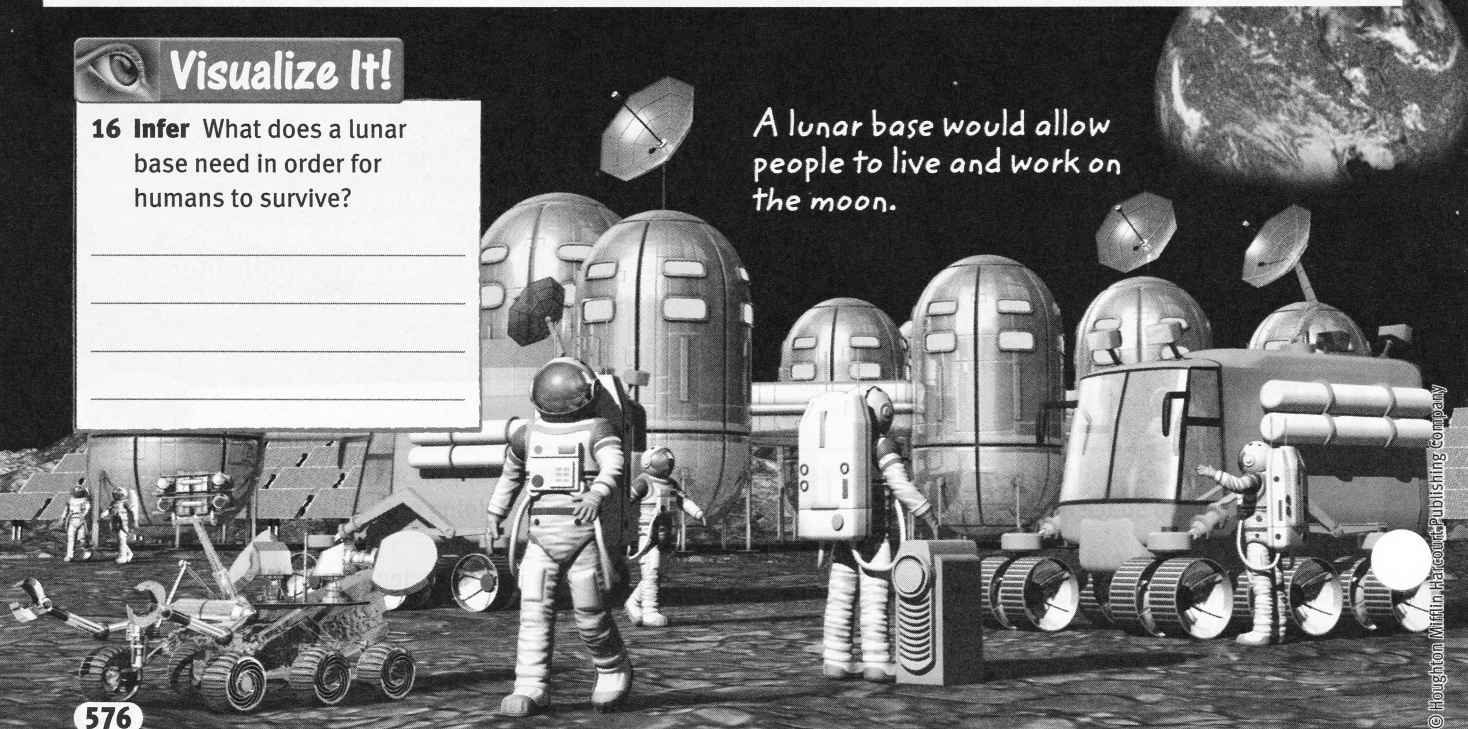
Several countries are developing plans to set up a crewed research base on the moon. A lunar base would allow astronauts to live and work for long periods of time on the moon's surface.

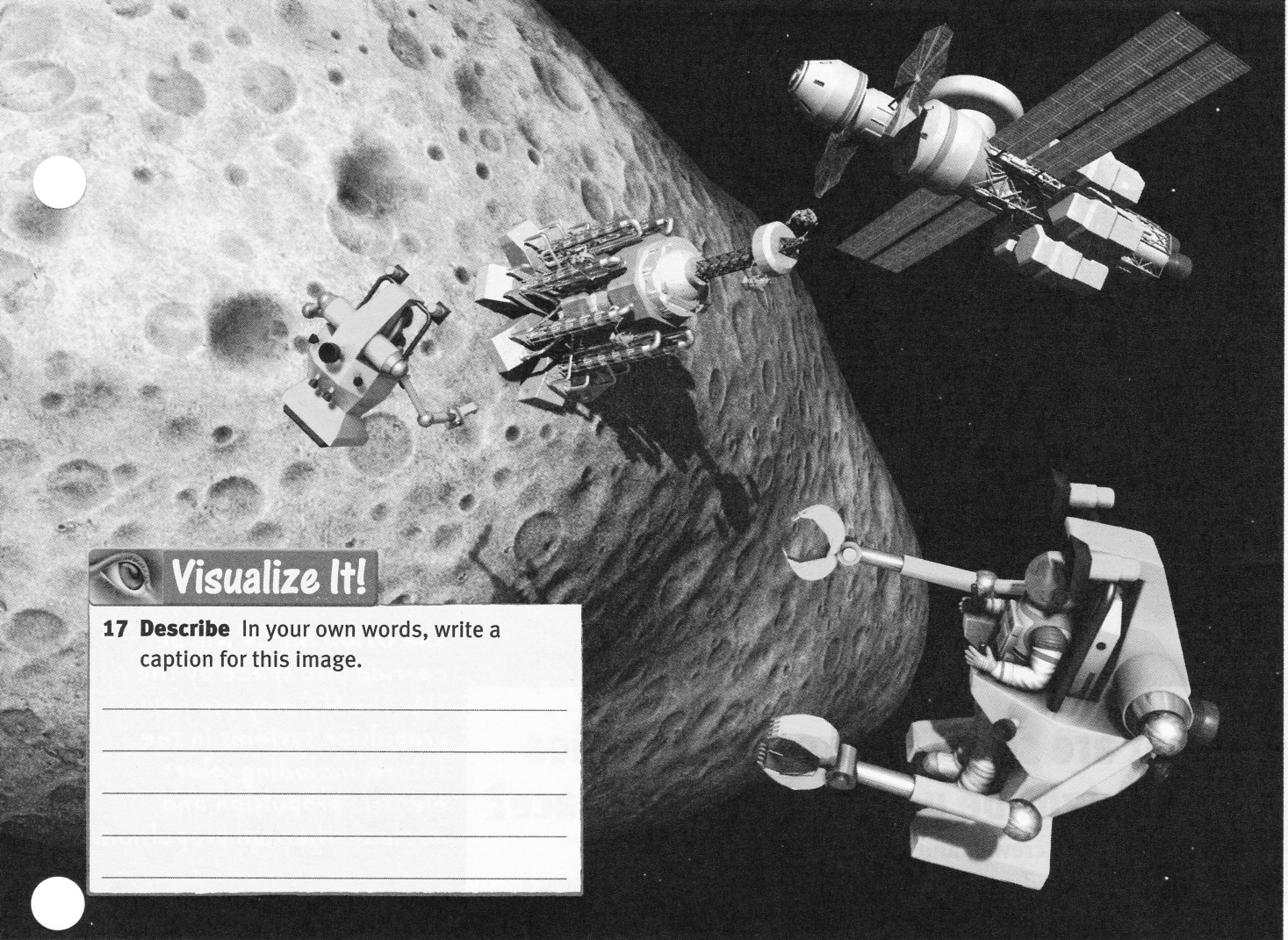
Scientists are eager to return to the moon for several reasons. Data about lunar soil gathered by rovers and crewed space missions indicate that the soil can unlock information about early Earth. Lunar soil also contains valuable resources, such as oxygen, water, silicon, aluminum, and titanium. These resources can be used to produce rocket propellant, drinking water, and the construction materials needed for a lunar base.

Visualize It!

16 Infer What does a lunar base need in order for humans to survive?

A lunar base would allow people to live and work on the moon.





Visualize It!

17 Describe In your own words, write a caption for this image.

To Explore Near-Earth Asteroids

Asteroids are small, rocky bodies in space. They are debris that is left over from the period during which the solar system formed. Therefore, asteroids that orbit near Earth, or *near-Earth asteroids*, provide clues about the early history of the solar system. They may also provide information about our own planet. Many asteroids struck ancient Earth. They may have been responsible for bringing the ingredients of life to our planet.

Scientists also want to explore near-Earth asteroids for safety reasons. They can test ways of deflecting near-Earth asteroids. This would prevent possible collisions of asteroids with Earth. In addition, near-Earth asteroids may contain minerals that can be mined.

Crewed missions to asteroids will be tricky. Asteroids have little or no gravity, different rates of rotation, and can be structurally unstable. So, they are going to be challenging places to explore.

To Explore Mars and Its Moons

NASA's biggest plans for crewed missions involve Mars and its moons. The red planet is one of the main goals of all crewed missions. Missions in cis-lunar space and on the surface of the moon will provide scientists and engineers with data they can use to plan a trip to Mars. Once on Mars, astronauts would search for water. They would also search for signs of life or for signs of the remains of ancient life. They would study the surface and the atmosphere.

Astronauts would have many challenges. For example, they would have to deal with the fine, red Martian dust and changing temperatures. However, they may be able to rely on Mars for water and other resources they need.



Active Reading 18 Identify What would astronauts look for on Mars?

Tools in Space




What are some future technologies that might be used to explore space?

To support both crewed and uncrewed missions, new transportation and equipment must be developed. NASA, space agencies of other countries, and private companies are improving existing technologies and developing new ones. These technologies include launch vehicles and capsules, deep-space habitats, space-exploration vehicles, destination systems, and robotic systems.

The Orion MPCV will be carried into space by the SLS. The SLS may use new propulsion systems in the future, including solar-electric propulsion and nuclear-thermal propulsion.

Launch Vehicles and Capsules

The Space Launch System (SLS) is a new type of launch vehicle planned by NASA. It will replace the space shuttle and carry the *Orion MPCV*. The *Orion MPCV* is a capsule. It can take a crew of two to four astronauts to places in cis-lunar space. At first, the SLS will use liquid hydrogen and liquid oxygen propulsion systems and solid rocket boosters. Later propulsion systems may use solar panels to collect energy from the sun. The collected energy would be converted into electricity to power thrusters. Nuclear power can also be used to power electric thrusters.

 **Active Reading 19 Identify** What new launch vehicle is planned to transport humans into space?

Places to Live

To stay on the moon or Mars for long periods of time, humans will need a safe place to live. The systems that are made for humans to live on the moon or Mars are called *deep-space habitats*. Deep-space habitats must have reliable life-support systems that give astronauts clean air and water. Habitats must protect humans from radiation and extreme temperatures. Resources are likely to be limited. Therefore, habitats must have ways to reduce both the use and waste of resources. Materials that are reusable, recyclable, or that can be repurposed for other uses would be used. These habitats must be able to meet the needs of crews in space for long periods of time. Therefore, they need to have medical technologies. They must also have ways of growing and storing food.

Space-Exploration Vehicles

Astronauts will need vehicles to travel from place to place on the surface of a planet or moon. New space-exploration vehicles will have pressurized cabins that can be adjusted for both high and low gravity. On crewed missions, astronauts in spacesuits may exit pressurized cabins through ports. Some vehicles may be able to hover over the surface of a planet or moon. They may also anchor to a near-Earth asteroid or a Martian moon. Other space-exploration vehicles may have robotic arms to collect soil or rocks.

Destination Systems

Destination systems include technologies that make it possible for astronauts to remain far away from the resources on Earth. For example, landers would take crews and cargo to and from a destination site, such as on the moon or Mars. At the destination, equipment would be needed to extract resources from the surface, to generate power, and to explore the surface. Destination systems would also include equipment to construct and maintain exploration vehicles.

Robots and Robotic Systems

Robotic systems and robots have already been used to explore space. They are also part of future space-exploration plans. Robots can withstand the harsh conditions in space better than humans can. They can work with astronauts. Robots can be programmed to do dangerous tasks. They can also do repetitive tasks, which allows astronauts to do more complex work.

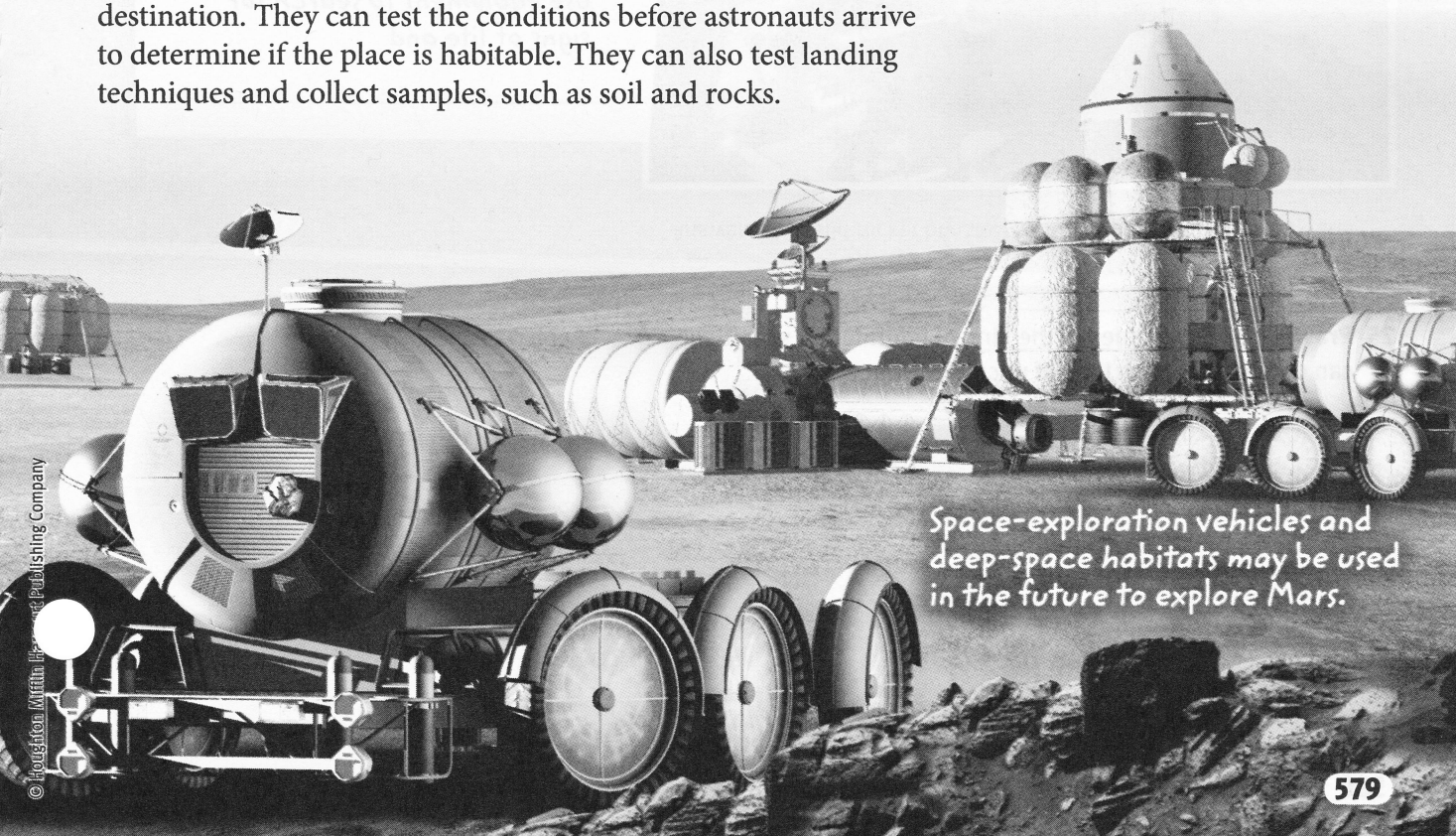
Robotic systems can be used to image and map the destination. They can test the conditions before astronauts arrive to determine if the place is habitable. They can also test landing techniques and collect samples, such as soil and rocks.

Think Outside the Book

20 Research Future space exploration will involve using new types of transportation, including propulsion systems. Research these systems to find out the advantages and disadvantages of each. Create a poster that shows each type of system and its advantages and disadvantages.

Visualize It!

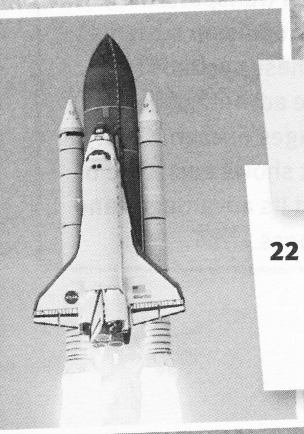
21 Identify What are some types of equipment that are shown below?



Space-exploration vehicles and deep-space habitats may be used in the future to explore Mars.

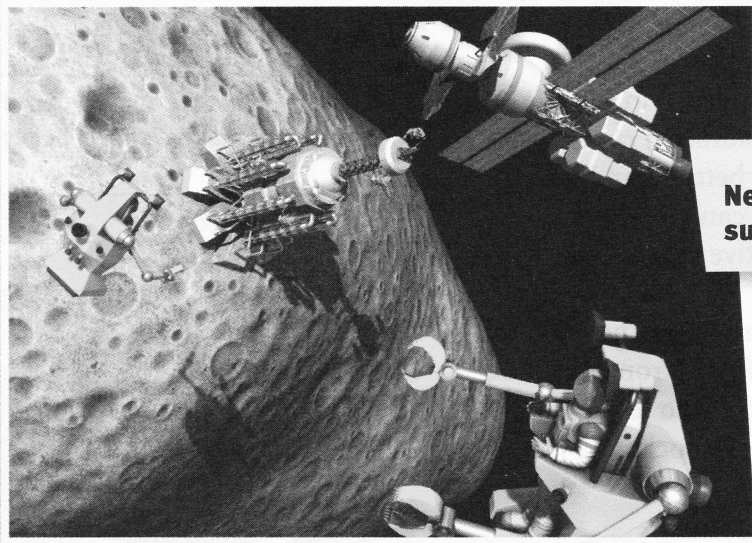
Visual Summary

To complete this summary, fill in the blanks with the correct word or phrase. Then, use the key below to check your answers. You can use this page to review the main concepts of the lesson.



Humans use crewed technology to travel to and from space.

22 To escape from Earth's gravity, the space shuttle used liquid fuel and _____

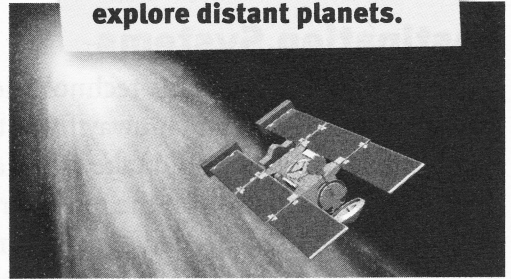


New equipment and transportation will support future space exploration.

24 On Mars, astronauts would use equipment to search for signs of life and _____

Technology for Space Exploration

Uncrewed spacecraft can explore distant planets.



23 To obtain clearer images, space telescopes orbit above _____

Answers: 22 solid rocket boosters; 23 Earth's atmosphere; 24 water

25 Provide Give examples of the kind of information scientists can obtain from each type of uncrewed spacecraft.

Lesson Review

Vocabulary

Circle the term that best completes the following sentences.

- 1 A *rocket* / *space shuttle* is a reusable crewed spacecraft.
- 2 A(n) *lander* / *orbiter* is a kind of artificial satellite.
- 3 A(n) *orbiter* / *rover* often has mechanical arms to gather rock samples.
- 4 A(n) *orbiter* / *probe* is more suited to the long-term study of a planet or moon.
- 5 A *rocket* / *space shuttle* had detachable capsules that contained the crew.

Key Concepts

- 6 **List** Give an example of how weather satellites are used to observe Earth.

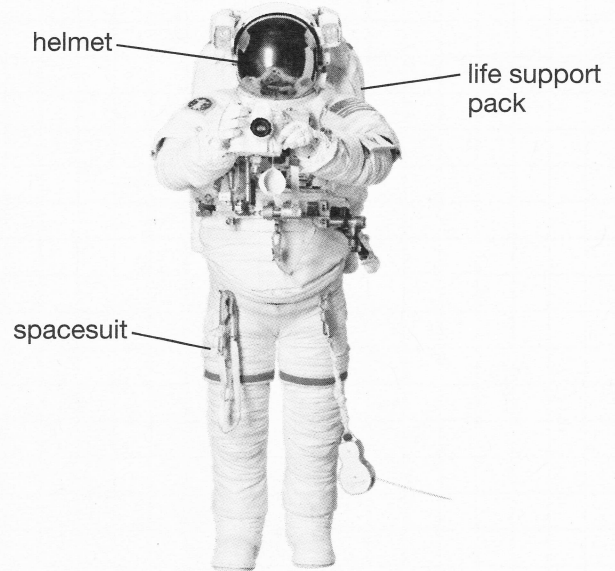
- 7 **Explain** Why is most space exploration accomplished with spacecraft that do not have crews on board?

- 8 **Summarize** What are four future goals of crewed space travel?

- 9 **Explain** What is one advantage of using an orbiter to study objects in space?

Critical Thinking

Use the diagram to answer the following questions.



- 10 **Identify** Which spacesuit feature provides oxygen to an astronaut?

- 11 **Infer** How is the spacesuit designed to protect the astronaut outside of a spacecraft?

- 12 **Infer** Why do you think it's important to map a planet's surface before a spacecraft, such as a lander, takes astronauts there?

- 13 **Analyze** Why will astronauts need equipment to extract resources at future bases in space if they stay for a long time?