5. Sample answer: The Viking missions sent images of dry water channels on the surface of Mars. *Venera* 9 recorded information about the surface and atmosphere of Venus. *Galileo* discovered that two of Jupiter's moons have magnetic fields.
6. Venus and Mars have surface features that are similar to Earth's. In addition, the high levels of CO_2 in Venus's atmosphere produce a severe greenhouse effect. This may help us understand the greenhouse effect on Earth. The atmosphere of Titan may be similar to Earth's early atmosphere. Studying Titan's atmosphere may provide clues about how life developed on Earth.
7. 299,793 km/s × 60 s/min = 17,987,580 km/min
   17,987,580 km/min × 60 min/h = 1,079,254,800 km/h
   1,079,254,800 km/h × 12 h = 12,951,057,600 km
8. Answers may vary. Students should note that the conditions on Mars and Europa are extreme and that the danger and expense of sending humans there is great. These places are also too distant to be seen clearly by a telescope on Earth's surface or in orbit around Earth.
9. Sample answer: The Discovery program seeks to produce results quickly and inexpensively. The disadvantages may be that missions may fail because of cost-cutting. Also, probes in the Discovery program may not gather as much data as larger probes do.
10. *Deep Space* 1 accelerates by expelling very small charged particles at a high speed. The probe reacts by moving forward.

SECTION: PEOPLE IN SPACE

1. Sample answer: NASA has completed more than 100 successful space shuttle missions. The International Space Station is being built with the help of many nations.
2. C
3. Answers may vary. Students should note that Cold War tensions greatly accelerated the space programs of the United States and the Soviet Union.
4. Answers may vary. Students can describe any of the space-age spinoffs that are described in the text or in Table 1.
5. Answers may vary. Space stations will serve as refueling, construction, and research stations.
6. Answers may vary. The United States was mainly focused on space shuttle development, while the Soviet Union was focused on space station development.
7. 2 million kg × 0.80 = 1.6 million kg
8. Answers may vary. After the Apollo program, the United States focused on developing a reusable space shuttle.
9. Answers may vary. Accept any well-supported answer. Students may describe the technology that has come from the space program to support increasing NASA funding. Students may also support a position to decrease funding based on the expense of the space program and the tragedies that have occurred.

Chapter Review

1. Sample answer: A geostationary orbit is about 36,000 km above the Earth's surface. In order to maintain GEO, satellites must orbit at a speed that exactly matches the speed of Earth's rotation. LEO is less than 1,500 km above the Earth's surface. To remain in LEO, satellites must travel much faster than the Earth rotates.
2. Sample answer: A space probe is a vehicle that carries scientific instruments to planets or other bodies in space. Space probes do not carry people. A space station is a long-term orbiting platform with scientific research labs and living quarters for astronauts.
3. Sample answer: An artificial satellite is any human-made object placed in orbit around a body in space. A moon is a natural satellite of a planet.

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4. thrust
5. oxygen
6. C
7. C
8. D
9. B
10. A
11. C
12. C
13. D
14. D
15. C
16. Answers may vary. Sample answer: Newton's third law of motion states that for every action, there is an equal reaction in the opposite direction. As the gases escape through the rocket nozzle, the rocket reacts by moving in the opposite direction.
17. Answers may vary. One disadvantage of LEO is that a satellite cannot maintain constant communication with a ground station.
18. Answers may vary. One reason the United States developed the space shuttle was to have a reusable space vehicle that would be less expensive than the Apollo rockets.
19. Answers may vary.
20. An answer to this exercise can be found at the end of the Teacher Edition.
21. Speed is a measure of how fast an object travels. Velocity is the speed and direction an object travels.
22. Rockets must carry oxygen with them because there is no oxygen in outer space. Without oxygen, rocket fuel cannot burn.
23. Answers may vary. Students should note that space research has helped develop many areas of human knowledge, including medicine, physics, engineering, biology, geology, and astronomy. The space program is also a challenge to human courage and can promote international cooperation and peace. Students may also mention space-age spinoffs. Finally, space probes enable us to study the atmospheres and surfaces of other bodies in the solar system. Scientists use these data to understand changes in Earth's environment.
24. no
25. 60 s/min×60 min/h 3 24 h/day× 3days= 25 200s
    259,200 s× 3 11 km/s= 5 2,851,200 km
26. 11 km/s – 8 km/s 5 × km/s
    A rocket traveling in orbital velocity would need to travel 3 km/s faster to reach escape velocity.
27. If a planet's velocity was 9 km/s, the planet's mass would be less than the mass of Earth.

Reinforcement

RONNIE ROCKET

rocket; fuel; oxygen; combustion; pressure; bottom; thrust; third; gravity; escape

PROBING SPACE

Earth's moon: *Luna* 9, U.S.S.R.; *Clementine*, U.S.; Sample answer: Craters of the moon may contain water left by comet impacts. Venus: *Venera* 9, U.S.S.R.; *Magellan*, U.S.; Sample answers: Venus has a very high surface temperature and atmospheric pressure; in many ways, the geology of Venus is similar to Earth's. Mars: *Viking* 2, U.S.; *Pathfinder*, U.S.; Sample answers: There is no hard evidence of life on Mars; images of dry water channels suggest that massive floods once flowed across the surface of Mars. Jupiter: *Pioneer* 10, U.S.; *Voyager* 2, U.S.; *Galileo*, U.S.; Sample answer: Jupiter's moon Europa may have an ocean of water under its icy surface.

Critical Thinking

1. a. A probe travels to other bodies in space. A satellite remains in Earth's orbit.
   b. A satellite requires orbital velocity to reach Earth's orbit. A probe requires escape velocity to break away from Earth's gravitational pull.
2. satellite in LEO: movement of dolphins and close up views of weather patterns; satellite in GEO: triggers leading to severe weather conditions and images of pollution patterns in a specific location; probe: rock samples of other moons and planets and images from distant planets
3. Answers may vary. Sample answer: My spacecraft would be a satellite in LEO

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