Get Ready for Unit 3

The Study of the Universe

Answers for page 94

Multiple Choice

1. d

2. b

3. e

4. a

5. c

6. b

7. a

8. d

Answers for page 95

Written Answer

9. Six types of celestial objects found in the solar system are planets, the Sun, moons, comets, asteroids, and meteoroids.

10. A star is a large celestial body that is composed of very hot gases and that emits light and heat.

11. Earth is the third planet from the Sun. It is in the right location to have the temperature range that allows water to exist in three states.

12. A star is single object. Galaxies are composed of billions of stars, planets, moons, and dust.

13. During a solar eclipse, the new Moon passes in front of the Sun. During a lunar eclipse, the Moon passes into Earth's shadow.

14. Although meteors are commonly called "shooting stars" or "falling stars," meteors are not stars. They are small fragments of rock and metal that cause a streak of light as they enter Earth's atmosphere.

15. Answers may vary. Students may point out that robotic instruments or special materials designed to help astronauts perform tasks in space or to protect astronauts can be adapted for life on Earth. Satellite technology is used for communication and navigation.

16. The diagram shows a constellation.

Section 7.1 Review

Ancient Astronomy

Answers for page 96

Multiple Choice

1. a

2. c

3. e

4. d

5. e

6. e

7. b

8. e

Answers for page 97

Written Answer

9. The Sun sets every night and rises every morning. The Moon goes through the same phases every month. The stars sweep across the night sky with the changing seasons and return with exact timing to the same position in the sky every year.

10. The days are organized into a schedule of larger units of time, such as weeks, months, seasons, or years.

11. The earliest astronomers who kept detailed records of the sky lived in Mesopotamia, in the region between the Tigris and Euphrates Rivers, in what is now Iraq.

12. The period of one revolution of Earth around the Sun determines the length of a year on Earth.

13. Earth revolves around the Sun in 365.24 days. Every four years, an extra day is added in February to account for the accumulation of the quarter days. The year in which this happens is called a leap year.

14. Early clocks were simply pillars and sticks in the ground. As the Sun moved across

the sky, the position and length of the shadow cast by the stick or pillar changed. The shape and size of the shadow indicated a specific time of day.

15. The ancient Egyptians thought that Earth was flat and supported by mountains at four different places. The ancient Inuit also thought that Earth was flat, stationary, and at the centre of the universe. The ancient Chinese believed that Earth was a square surrounded by one huge ocean. Originally, the ancient Greeks thought that Earth floated in the ocean like a piece of wood floats on water.

16. Observer 1 sees the sky in the semi-circle above. Observer 2 sees the sky in the semi-circle above. They can both see the area of the sky where the two semi-circles overlap, but observer 1 cannot see the sky below horizon 1, and observer 2 cannot see the sky below horizon 2.

Section 7.2 Review

The Constellations

Answers for page 98

Multiple Choice

1. a

2. d

3. b

4. a

5. a

6. d

7. a

8. d

Answers for page 99

Written Answer

9. A constellation is a group of stars that seem to form a distinctive pattern in the sky.

10. Ursa Major, Orion, and Libra can be seen from Ontario.

11. Although the stars are far apart in space, they appear to be close together and at exactly the same distance from Earth because they lie in the same line of sight. These seemingly unrelated stars appear to form a distinctive pattern (a W shape) when viewed from Earth.

12. A light-year is 9.5×10^{12} km.

13. Apparent magnitude is the brightness of a star as seen from Earth.

14. An imaginary line drawn through these two stars points toward Polaris, the North Star.

15. Earth's rotational axis points to Polaris, so Polaris does not move during the night as the other stars move. Once you have located Polaris, you know which direction is north.

From there, you can determine which directions are east, south, and west.

16. As you move northward, constellations along the southern horizon slip below the horizon so that you cannot see them. As you move southward, constellations that were formerly unseen rise above the southern horizon.

Section 7.3 Review

Movements of Earth and the Moon

Answers for page 100

Multiple Choice

1. d

2. b

3. a

4. b

5. a

6. e

7. c

8. a

Answers for page 101

Written Answer

9. The seasons are the result of the tilt of Earth's axis and Earth's revolution around the Sun. Tides are the result of the gravitational attraction between the Moon and Earth. Tides change regularly as the Moon orbits Earth.

10. A circle has one centre point and a radius that define the size and shape of the circle. An ellipse has two points, called focal points, that give the ellipse the shape of a stretched circle, or an oval.

11. Earth's axis is tilted 23.5° from the flat plane of Earth's orbit. Therefore, at different times of the year, different parts of the planet's surface are exposed to different intensities of sunlight. In the summer months, the northern hemisphere is tilted toward the Sun. In the winter months, the northern hemisphere is tilted away from the Sun. When the northern hemisphere is tilted toward the Sun, Ontario receives more direct sunlight, which causes temperatures to be warmer than when the northern hemisphere is pointed away from the Sun (in the winter months).

12. Temperature is most likely highest at or near 0° (the equator) because this area of Earth receives the most concentrated amount of sunlight.

13. Humans got their first look at the far side of the Moon in 1959, when the Union of Soviet Socialist Republics launched a spacecraft that passed behind the Moon and photographed the far side.

14. During a total lunar eclipse, the full Moon passes through the umbra portion of Earth's shadow, so Earth is between the Sun and the Moon.

15. On average, two lunar eclipses occur every year.

16. Tides in the Bay of Fundy can reach 16 m. These tides have a range in height that is great enough to harness tidal energy.

Section 7.4 Review

Meet Your Solar System

Answers for page 102

Multiple Choice

1. e

2. b

3. b

4. e

5. a

6. b

7. a

8. e

Answers for page 103

Written Answer

9. The Sun's gravitational pull keeps the objects in the solar system in orbit around the Sun.

10. Our solar system is composed of the Sun, the planets, their moons, and smaller objects such as comets, asteroids, and meteoroids.

11. The diagram illustrates retrograde motion.

12. When first proposed, the heliocentric model of the solar system had the planets orbiting the Sun in perfect circles. Kepler revised the model to have the planets orbiting the Sun in ellipses.

13. <HB09_ANS_U3_001a: VENN DIAGRAM THAT COMPARES AND CONTRASTS VENUS AND EARTH>

14. Retrograde motion is produced when Earth catches up with and passes an outer planet in its orbit. Earth is on an inside track and moves faster than the outer planets. Every time Earth catches up to an outer planet and moves between the outer planet and the Sun, the

outer planet appears to make a looping motion as observed from Earth, or to move backward for a time.

15. Astronomers use light-years to measure much greater distances, such as distances to galaxies and other stars.

16. Venus's atmosphere is very dense and is composed of sulfuric acid, carbon dioxide, and nitrogen, which form thick clouds and acid rain. Venus's atmosphere is not suitable for life as we know it. Earth's atmosphere is suitable for life as we know it.

Section 7.5 Review

Other Objects in the Solar System

Answers for page 104

Multiple Choice

1. a

2. a

3. c

4. b

5. c

6. d

7. e

8. c

Answers for page 105

Written Answer

9. A trans-Neptunian object is an object that orbits the Sun beyond the orbit of Neptune. Two examples of trans-Neptunian objects are Kuiper Belt objects and objects in the Oort Cloud.

10. The Kuiper Belt is a disc-shaped group of millions of small objects orbiting the Sun beyond the orbit of Neptune. Astronomers theorize that the Kuiper Belt is composed of fragments of material left over from the formation of the solar system.

11. a. Pluto is closest to the Sun. **b.** Eris and Buffy are larger than Pluto. **c.** Sedna takes the longest time to orbit the Sun.

12. The Oort Cloud is a spherical cloud of small icy fragments of debris that lies between 50 000 AU and 100 000 AU from the Sun, or about one quarter of the distance between the Sun and Proxima Centauri, the nearest star.

13. When a comet comes close to the Sun, the radiation from the Sun heats the comet, which releases gases and particles. The flow of solar radiation, known as the solar wind, pushes the gases and particles away from the comet, forming a tail.

14. Most comets originate in the Kuiper Belt or the Oort Cloud.

15. <HB09_ANS_U3_002a: SEQUENCE OF EVENTS GRAPHIC ORGANIZER THAT ILLUSTRATES HOW A METEOROID FORMS, BECOMES A METEOR, AND BECOMES A METEORITE >

16. Scientists speculate that some pieces of the object may be at the bottom of Lake Cheko, in Siberia. If the object hit water rather than land, that could explain why no remnants have been recovered.

Chapter 7 Review

The Night Sky

Answers for page 106

Multiple Choice

1. a

2. b

3. c

4. b

5. d

6. b

7. b

8. e

Answers for page 107

Written Answer

9. When the ancient Greek astronomer Hipparchus developed the scale around 130 B.C.E., he assigned the number 1 to the brightest star he could see and the numbers 2 through 6 for sequentially fainter stars.

10. A constellation is an officially recognized grouping of stars. An asterism is a smaller grouping of stars that forms a pattern within a constellation.

11. As a ship sailed out into the ocean, the ship slowly disappeared below the horizon. As people travelled farther north and farther south, the appearance of the stars changed. Earth's shadow appeared to be curved when viewed during an eclipse.

12. The path of Earth's orbit around the Sun is not a perfect circle. It is an ellipse.

13. A sundial has a raised edge and a flat area with hour markers. As Earth rotates, the shadow of the straight edge moves and aligns with the hour markers.

14. The Sun is about 400 times farther from Earth than the Moon is. As a result, the Sun and the Moon appear to be about the same size in the sky.

15. In 2006, the International Astronomical Union changed the definition of *planet*. Pluto was demoted because Pluto's orbit sometimes crosses Neptune's orbit.

16. <CATCH HB09_ANS_U03_015a; completed Venn comparing solar eclipse and lunar eclipse>

Answers for page 108

17. A star, such as Sirius, can be used to mark an event because it is seasonal and starts to appear in the night sky at the same time every year. In ancient times, Sirius coincidentally rose just before dawn at the same time every year before the annual flooding of the Nile River.

18. People in most cultures imagined that the patterns formed by the stars in the night sky represented people, animals, and objects that formed the bases of different myths or stories. They also used the constellations to mark annual events.

19. Distances in space are very large. Because light travels fast, using light-years allows scientists to reduce the size of the numbers used to describe the distances between celestial objects. This makes calculations and descriptions less complicated.

20. The brightest stars on this star map are Vega and Capella, as indicated by the size of the dots used to represent these stars.

21. The Moon is always half-illuminated by the Sun. But how much of the illumination you see depends on where the Moon is relative to Earth. The amount of illumination you see is classified as the phases of the Moon.

22. a. Saturn **b.** Mercury **c.** Mars **d.** Jupiter

23. A comet's dust tail is whitish because sunlight reflects off the dust particles released.

24. Asteroids are small, non-spherical objects that range in size from a tiny speck, like a grain of sand, to 500 km wide. Asteroids are believed to be debris left over from the formation of the solar system. Meteoroids are small pieces of rock that are moving through space and that have probably broken off from asteroids and planets.

Answers for page 109

25. <CATCH HB09_ANS_U3_003a: VENN DIAGRAM THAT COMPARES METEORS, METEORITES, AND METEOROIDS>

26. <CATCH HB09_ANS_U3_004a: NEW ART; SIMPLE ILLUSTRATION OF A COMET ORBITING THE SUN; REFERENCE IMAGE IS FROM ON SCIENCE 9, P. 299, FIGURE 7.28>

27. *Sample answer*:

Planetary Characteristics

Planet	Diameter (km)	Distance from Sun (AU)	Number of Known Moons	Length of a Year (Earth years)	Unique Feature
Mercury	4 880	0.39	0	0.24	Long, immense cracks caused by extreme heating and cooling of the surface
Venus	12 104	0.72	0	0.62	Thick atmosphere composed of sulfur, carbon dioxide, and nitrogen
Earth	12 756	1.00	1	1.00	Only planet that has water in three phases: vapour, ice, and liquid
Mars	6 792	1.52	2	1.88	Red, iron-rich rocks and the largest volcano in the solar system
Jupiter	142 980	5.20	61	11.86	Great Red Spot, an enormous storm the size of three Earths
Saturn	120 540	9.54	60	29.46	Prominent, elaborate ring system composed of ice and rock
Uranus	51 120	19.18	27	84.01	A methane-rich atmosphere that gives the planet a blue-green colour; its axis of rotation is turned on its side
Neptune	49 530	30.06	13	164.8	Similar in composition and size to Uranus, but it is a darker blue colour

28. <CATCH HB09_ANS_U3_005a: SIMPLE DIAGRAMS SHOWING THE LIT AREA OF THE MOON INCREASING FOR WAXING, DECREASING FOR WANING. THE GIBBOUS ILLUSTRATIONS SHOULD SHOW THE MOON WITH MORE THAN HALF OF THE CIRCLE LIT, WHEREAS THE WAXING AND WANING DIAGRAMS SHOULD SHOW LESS THAN HALF OF THE CIRCLE LIT. REFERENCE IMAGES FROM ON SCIENCE 9, P. 286, FIGURE 7.17>

29. <CATCH HB09_ANS_U3_006a: FLOW CHART EXPLAINING HOW TO USE THE BIG DIPPER TO DETERMINE WHICH DIRECTIONS ARE NORTH, SOUTH, EAST, AND WEST OF A LOCATION ON EARTH'S SURFACE>

30. North American Aboriginal cultures used the constellations as the basis for stories about their lives. For example, for several North American Aboriginal cultures, such as the Algonquin, Iroquois, and Narragansett, the bowl of the Big Dipper is a bear. The stars in the handle are hunters who are following the bear.

31. The northern hemisphere is experiencing summer, while the southern hemisphere is experiencing winter. The northern hemisphere is tilted toward the Sun and receives more direct sunlight. In the northern hemisphere, daylight lasts for 12 to 24 h, depending on the latitude. In the southern hemisphere, daylight lasts for 0 to 12 h, depending on the latitude. The amount of solar radiation that reaches Earth's surface determines the temperature of the region. The southern hemisphere receives less light and the northern hemisphere receives more light, so temperatures are higher in the northern hemisphere.

32. <CATCH HB09_ANS_U3_007a: SIMPLE DIAGRAM ILLUSTRATING HOW EARTH'S SHAPE CAN BE INFERRED FROM THE SHAPE OF EARTH'S SHADOW DURING A LUNAR ECLIPSE>

Section 8.1 Review

Exploring Space

Answers for page 110

Multiple Choice

1. d

2. e

3. a

4. d

5. a

6. d

7. c

8. e

Answers for page 111

9. c

10. a

11. e

12. a

13. c

14. b

15. e

16. c

Answers for page 112

Written Answer

17. Curiosity and the need to understand the world around them have driven people to explore. People also explore to obtain materials, such as minerals and food, and to find new places to live.

18. People need enough food and air for long trips, they must be protected from the extreme cold of space, and their spacecraft must be prevented from breaking down and leaving them stranded in space.

19. Electromagnetic radiation is radiation consisting of electromagnetic waves that travel at the speed of light. Examples of electromagnetic radiation are radio waves, microwaves, infrared waves, visible light, ultraviolet radiation, X rays, and gamma rays.

20. Non-optical telescopes detect non-visible radiation, such as radio waves, X rays, and gamma rays.

21. People can see electromagnetic radiation that has wavelengths between 10^{-6} m and 10^{-7} m. This portion of the electromagnetic spectrum is called *visible light*.

22. Telescopes in space are above Earth's atmosphere, so they can detect parts of the electromagnetic spectrum that do not reach Earth's surface. They can take long exposures of certain parts of the sky without being affected by daylight and bad weather. This allows the telescopes to detect faint astronomical objects that are not detectable from on the ground.

23. MOST's purpose is to study stars that are similar to the Sun, one star at a time, for about eight weeks per star.

24. An orbiter is an observatory that orbits a planet other than Earth and is equipped with digital cameras that provide high-resolution images of the planet.

Answers for page 113

25. An orbiter is a satellite that orbits a celestial body to gather data. A lander is a spacecraft that lands on a planet and gathers data from the planet's surface.

26. The data sent by the contractor to the engineers used the wrong system of measurements and, therefore, the wrong units (such as miles instead of kilometres). The difference in calculations that resulted caused the spacecraft to enter too low an orbit and burn up.

27. Global positioning technology can be used in farm equipment, such as tractors and combines. The GPS unit receives data from satellites that monitor the conditions in the farmer's fields. The unit provides the farmer with data about soil, moisture, and plant growth. The farmer can use that data to change the amount of water and fertilizer applied to specific parts of the field.

28. Remote sensing is the process of gathering data about Earth by using instruments mounted on satellites.

29. a. The ISS orbits 350 km higher than airplanes travel. **b.** GPS satellites orbit about 56 times higher than the altitude of the ISS (20 200 km ÷ 360 km = 56 times).

30. ENVISAT data have been used to study changes in Arctic sea ice; to monitor the heights of oceans, land surfaces, and major lakes and rivers; and to assess damage and risk of fires. In addition, teams racing to the North Magnetic Pole in 2005 used ENVISAT maps to show ice.

31. Canadian engineers developed robotic fixtures, such as Canadarm, Canadarm2, and Dextre. The Canadarm is used on NASA's space shuttles. The Canadarm2 and Dextre are used on the International Space Station. All three help with the construction of the International Space Station.

32. Some space junk is small fragments that have broken off telescopes, satellites, and spacecraft. Some countries have intentionally exploded satellites in space. Objects in orbit around Earth collide with other pieces of space junk and cause new fragments to break off. Old satellites and other equipment are left in space after they stop functioning.

Section 8.2 Review

Exploring the Sun

Answers for page 114

Multiple Choice

1. c

2. e

3. a

4. b

5. d

6. e

7. c

8. b

Answers for page 115

Written Answer

9. Stars and planets form together in a nebula, which is a vast cloud of gas and dust. Gravity pulls the gas and dust together to form a star. When the centre reaches a certain density and temperature, the core of the star begins nuclear fusion, and a star is born. As the gas and dust in the nebula spin around the new star, called a protostar, the dust and gases begin to contract. Tiny grains begin to form and expand into larger, rocky lumps called planetesimals. As the planetesimals grow, they may develop into full-fledged planets.

10. All the planets in the solar system revolve around the Sun in the same direction, and the orbits all lie in roughly the same plane. Astronomers have also discovered flattening dust clouds around young stars that are beyond our solar system.

11. Extrasolar planets are planets that orbit stars other than the Sun. Their presence supports the solar nebula theory because the theory indicates that planets are by-products of star formation, so planets should be fairly common. Astronomers have discovered over 300 extrasolar planets.

12. As a star-forming nebula collapses and contracts, the gas compresses. As a result of

the compression, the temperature of the protostar increases. When the temperature reaches around 10 000 000°C, nuclear fusion begins, and the star starts emitting light.

13. The Sun rotates faster at its equator than at its poles, which means that the Sun does not rotate as a solid body the way Earth does.

14. Auroras result when the high-energy, charged particles from the Sun are carried past Earth's magnetic field and interact with gases in Earth's upper atmosphere. These interactions generate electric currents that flow toward Earth's poles and produce coloured lights known as auroras.

15. The outer layers of the Sun transfer energy through convection.

16. a. 30 percent **b.** 70 percent

Section 8.3 Review

Exploring Other Stars

Answers for page 116

Multiple Choice

1. d

2. b

3. e

4. d

5. c

6. e

7. a

8. c

Answers for page 117

9. e

10. b

11. a

12. c

13. b

14. a

15. a

16. d

Answers for page 118

Written Answer

17. Luminosity is a star's total energy output per second, or its power in joules per second. Absolute magnitude is a measure of how bright a star would be if it were 32.6 light-years from Earth.

18. By comparing the magnitude, or brightness, of stars as if all the stars were the same distance from Earth, scientists are better able to compare the relative brightness of the stars to determine which stars give off the most light.

19. The temperature of the Sun's photosphere is about 6000°C. The Sun is yellow, so astronomers infer that yellow stars have a similar surface temperature. Bluish stars are much hotter. The surface temperature of a bluish star typically varies between 21 000°C and 35 000°C. On the other end of the scale, the temperatures of reddish stars are typically much cooler, about 3300°C.

20. Scientists use a spectroscope to analyze the light from the Sun and other stars. A spectroscope is an instrument that produces a pattern of colours, called a spectrum, and lines, called spectral lines, from a narrow beam of light. The pattern of spectral lines in a star's spectrum identifies the elements within the star's photosphere.

21. A binary star system is one in which two stars orbit each other.

22. a. Canopus is brightest. It is located highest on the luminosity and absolute magnitude scales. **b.** Proxima Centauri is the coolest. It is located in the lower right corner of the diagram; red stars are the coldest stars. **c.** Proxima Centauri, the Sun, and Vega are on the main sequence. When their characteristics are plotted on the graph, main-sequence stars form a band that runs diagonally through the middle of the H-R diagram.

23. A Hertzsprung–Russell diagram is a graph that shows the relationships between luminosity, absolute magnitude, temperature, colour, and size of stars.

24. About 90 percent of stars fall within the main sequence region.

Answers for page 119

25. a. Blue stars are the brightest. **b.** A white star is about seven times more massive than a red star.

26. It takes 100 billion years for a star to become a black dwarf. The universe is not old enough to contain any black dwarfs.

27. Low-mass stars consume their hydrogen fuel slowly, in as long as 100 billion years. Intermediate-mass stars consume their hydrogen fuel much faster, in about 10 billion years.

28. In the core of a massive star, fusion causes the formation of iron. Iron cannot release energy by fusing with other atoms, and the star's energy production stops. The inward

force of gravity overpowers the outward pressure of radiation in the star, and the core collapses violently. A shock wave travels through the star, and the outer portion of the star explodes in a supernova.

29. The initial mass of the star before it became a supernova determines whether the star will become a neutron star or a black hole.

30. After a massive star produces a supernova, the core of the star shrinks to about 20 km in diameter. At this size, the electrons and protons in the star's core are compressed together and form neutrons. The extremely dense mass of neutrons emits radiation and is known as a neutron star.

31. A pulsar is a type of neutron star that spins very rapidly and sends pulses of radiation into space, much like an extremely fast-sweeping searchlight.

32. A black hole is a tiny patch of space that has no volume but has mass and, therefore, has gravity.

Chapter 8 Review

Exploring Our Stellar Neighbourhood

Answers for page 120

Multiple Choice

1. b

2. a

3. b

4. e

5. c

6. b

7. e

8. a

Answers for page 121

Written Answer

9. Refracting telescopes use lenses to collect and focus light. Reflecting telescopes use curved mirrors to collect and focus light.

10. Non-optical telescopes can be used on cloudy days, and they can be used at night as well as during daylight.

11. Designing, testing, and constructing equipment is time-consuming and expensive. In addition, tragic accidents have cost the lives of human explorers during space travel.

12. Two ethical issues related to space exploration are mining of planets and ownership of planets. If a country visits another planet, does that country have the right to take materials from that planet? Does that country own that planet?

13. *Sample answer*: Many of the technologies developed by engineers for the space program have been adapted for uses on Earth. Satellite technologies have improved communications on Earth, and helped us better understand and predict weather. They also allow scientists to monitor dangerous conditions on Earth and avert disasters, such as fires, and prepare for disasters, such as hurricanes.

14. The lidar instrument uses laser technology. The laser shot quick pulses of light into the Martian atmosphere, and the light bounced off clouds and dust particles. The laser light then returned to an optical telescope in the instrument. By running the instrument four times a day, the science team was able to gather information on the movement, size, and composition of Martian clouds and dust particles above the weather station.

15. Solar energy powers the winds and ocean currents. It also drives all weather, from soft summer winds to gigantic hurricanes. Sunlight provides the energy required for photosynthesis. Photosynthesis is the process by which green plants provide all the vital oxygen in the atmosphere and all the food at the base of the food chain.

16. a. Object A is a protostar. It forms when gases and dust in a nebula are pulled together by the force of gravity. **b.** Object B is a planetesimal, and object C is a planet. A planetesimal increases in size as a result of collisions with other small objects to form a planet.

Answers for page 122

17. An extrasolar planet is a planet that orbits a star other than the Sun.

18. Astronomers cannot see extrasolar planets because they are very far away. From such a great distance, they appear very close to the star they orbit, and the bright light from the star prevents astronomers from seeing the planets themselves.

19. During nuclear fusion, hydrogen nuclei combine to form helium nuclei. A by-product of this reaction is energy.

20. When charged particles disturb the Sun's photosphere, areas of strong magnetic fields form. These areas are visible as dark spots.

21. During a solar flare, magnetic fields explosively eject intense streams of charged particles into space from the Sun's surface. When these particles collide with Earth's atmosphere, they can cause solar storms that interfere with electric signals and damage electronic equipment. They can also overload the electrical power network and cause power blackouts.

22. Absolute magnitude is a measure of how bright a star would be if it were 32.6 light-years from Earth. Apparent magnitude is the brightness of a star as seen from Earth, at the distance the star actually is from Earth.

23. A star that lies far above the main sequence on the H-R diagram is a cool, bright star, such as a red giant or a red supergiant.

24. Pluto's orbit is inclined quite a bit more to the plane of the solar system than the orbits of the planets. According to the solar nebula theory, the planets formed in a

spinning disk and their orbits are approximately in the plane of the solar system, so no, it seems unlikely that Pluto formed at the same time as the planets because its orbit is so different.

Answers for page 123

25. *Sample answer*: I think the Canadian government should work together will all nations that are active in space exploration and agree on how to proceed ethically with space exploration and the use of space resources.

26. <CATCH HB09_ANS_U3_008a: FLOWCHART THAT ILLUSTRATES HOW GAS AND DUST IN A NEBULA MAY BECOME A SOLAR SYSTEM LIKE EARTH'S>

27. <CATCH HB09_ANS_U3_009a: DIAGRAM THAT ILLUSTRATES WHAT HAPPENS TO SOLAR RADIATION THAT REACHES EARTH FROM THE SUN>
About 20 percent of the total incoming solar radiation is absorbed by Earth's atmosphere; about 30 percent is reflected by Earth's atmosphere, clouds, and surface and ocean features; and about 50 percent is absorbed by Earth's surface and ocean features. Earth's surface absorbs most of the visible light, and then emits longer-wavelength infrared radiation to the atmosphere. In turn, the atmosphere absorbs and emits infrared radiation.

28. <CATCH HB09_ANS_U3_010a: FLOWCHART THAT OUTLINES THE STAGES OF THE LIFE CYCLE OF A MASSIVE STAR FROM SOLAR NEBULA TO THE FINAL STAGES>

29. Telescopes that detect radio waves and visible light can be placed on Earth's surface. Telescopes to detect infrared radiation, ultraviolet radiation, X rays, and gamma rays are better placed in space.

30. *Sample answer*: In my opinion, there should be some sort of consortium among all space-travelling nations that says that space resources belong to planet Earth.

31. Elements heavier than hydrogen and helium are formed by nuclear fusion in the cores of massive stars. When these stars go supernova, the heavier elements are ejected into the universe. Some of these elements become parts of new stars and some form planets and other bodies. These elements form the crust of Earth, from which humans get all of the compounds and elements that make up our bodies.

32. A neutron star that is also a pulsar is in the centre of the Crab Nebula.

Section 9.1 Review

Galaxies

Answers for page 124

Multiple Choice

1. a

2. c

3. c

4. e

5. a

6. e

7. b

8. d

Answers for page 125

9. a

10. c

11. a

12. c

13. c

14. c

15. b

16. e

Answers for page 126

Written Answer

17. The Milky Way appears as a hazy white band extending from the southern horizon and across the sky overhead. The ancient Greeks gave the Milky Way its name. They imagined that the white band was milk, spilled by the goddess Hera while she was feeding her son Heracles.

18. A galaxy is a huge collection of stars, planets, gas, and dust held together by gravity.

19. William and Caroline Herschel were famous for building and selling fine telescopes. William Herschel is credited for discovering that the Milky Way is a gigantic system of stars rather than a series of clouds.

20. Galaxies are composed of a lot of dust, and radio waves can penetrate the dust whereas some other kinds of radiation cannot.

21. A spiral galaxy looks like a pinwheel when viewed from above. It has many long arms spiralling out from a central core. When viewed from the side, a spiral galaxy looks like a plate with a bulge in the middle.

22. An elliptical galaxy ranges in shape from a sphere to an ellipse. A spiral galaxy is shaped like a pinwheel with long arms spiralling out from a central core.

23. Elliptical galaxies are most common. Scientists think well over half of all galaxies are elliptical galaxies.

24. <CATCH HB09_ANS_U03_014a; completed Venn diagram illustrating the differences between open star clusters and globular star clusters>

Answers for page 127

25. The two types of star clusters are open clusters and globular clusters.

26. It is a globular cluster. Globular clusters are spherical structures that contain between 100 000 and 1 million stars.

27. Open clusters are located along the main band of the Milky Way, whereas globular clusters are located around the centre of the Milky Way.

28. The Milky Way galaxy is about 100 000 light-years in diameter.

29. Herschel pointed one of his best telescopes at the Milky Way and was able to make out numerous stars.

30. The Local Group is a small group of about 40 galaxies that includes the Milky Way galaxy and the Andromeda galaxy. The Local Group is about 10 million light-years in diameter.

31. Open clusters and globular clusters are groupings of stars within a galaxy. A supercluster is a grouping of galaxies.

32. Enormous clouds of gas and dust block the light from the stars in the centre.

Section 9.2 Review

The Universe

Answers for page 128

Multiple Choice

1. d

2. c

3. a

4. b

5. c

6. a

7. e

8. a

Answers for page 129

Written Answer

9. The Doppler effect is the apparent change in frequency of a light source due to its motion relative to an observer.

10. The object is moving toward the observer on the left because the spectrum is blueshifted toward that observer.

11. Scientists use the amount of redshift in the galaxy's spectrum to calculate the speed at which the galaxy is moving.

12. The Hubble constant is the rate at which the universe is expanding.

13. Time and space both began 14 billion years ago, when the universe began expanding with unimaginable violence from a hot and incredibly dense state to its present state.

14. Hubble's law and the cosmic microwave background radiation both provide evidence of the big bang.

15. Two American scientists, Wilson and Penzias, were looking for sources of "noise"

that could interfere with satellite communication. They accidentally discovered microwave noise that was produced by radiation left over from the big bang.

16. Conseil Européen pour la Recherche Nucléaire, or European Council for Nuclear Research, is an organization that conducts experiments to help scientists understand the big bang by using a Large Hadron Collider.

Section 9.3 Review

Unsolved Mysteries

Answers for page 130

Multiple Choice

1. d

2. c

3. a

4. e

5. a

6. b

7. a

8. b

Answers for page 131

Written Answer

9. The universe imagined by the ancient Greeks contained Earth, the Sun, the Moon, the planets, and all the stars. Over time, astronomers have included the Milky Way galaxy. Then, they expanded their view to include an unknown number of galaxies. Today, astronomers are piecing together the story of the universe—its evolution, age, and size.

10. The structure of the Andromeda galaxy is similar to the structure of the Milky Way. By examining the total amount of light that the stars in the Andromeda galaxy emit, astronomers have been able to estimate the total mass of this galaxy with a high degree of confidence. The mass of the Andromeda galaxy is about the same as the mass of the Milky Way galaxy.

11. Scientists know that dark matter must exist because of the effect the mass of dark matter has on surrounding matter. In order for the stars, planets, and galaxies in the universe to move at the speed calculated by scientists, the universe must contain 90 percent more mass than can be accounted for by visible matter.

12. Composition of the Universe

Component	Percent

Visible matter	4%
Dark matter	23%
Dark energy	76%

13. Dark matter does not emit electromagnetic radiation, so it cannot be detected. It seems to interact with visible matter only through its weak gravitational effects.

14. Astronomers have estimated the mass of the Milky Way to be about 200 billion solar masses. Yet the motion of small, nearby galaxies that are orbiting the Milky Way indicates that the mass of the Milky Way is at least 10 times larger than the estimated mass. Therefore, only 10 percent of the Milky Way is made of visible matter.

15. Scientists plotted the absolute magnitudes of Type Ia supernovae against the redshifts of the supernovae. The supernovae were fainter than the scientists predicted based on reliable, previous data. This evidence indicated that the rate at which the universe is expanding is increasing, rather than decreasing, as the big bang theory predicted. Scientists called the force behind the increase in the rate of expansion "dark energy."

16. Dark energy is a form of energy that makes up nearly three quarters of the universe and that has the effect of increasing the expansion of the universe.

Chapter 9 Review

The Mysterious Universe

Answers for page 132

Multiple Choice

1. c

2. d

3. e

4. a

5. c

6. b

7. e

8. c

Answers for page 133

Written Answer

9. William Herschel discovered the planet Uranus, coined the term *asteroid*, and observed that the Milky Way is a collection of stars rather than fuzzy white clouds.

10. The three types are spiral, elliptical, and irregular.

11. Open clusters contain 50 to 1000 stars and appear along the main band of the Milky Way. Globular clusters contain 100 000 to 1 000 000 stars. The stars in a globular cluster are arranged in a spherical shape. Globular clusters appear around the centre of the Milky Way.

12. The Milky Way galaxy is a spiral galaxy. It has a disk-like shape, with a central bulge of stars. Around the bulge, there is a sphere of globular clusters. The Milky Way has two major spiral arms and numerous minor arms that contain many open clusters.

13. The Local Group is part of a galaxy supercluster. It is composed of about 40 galaxies. Open clusters and globular clusters are not galaxies but are groups of stars within a galaxy.

14. Longer wavelengths are associated with the red end of the spectrum. Because the wavelength of light from an object moving away from an observer is lengthened toward the red end of the visible spectrum, astronomers say that the spectrum of the object is redshifted. Shorter wavelengths are associated with the blue end of the spectrum. Because the wavelength of light from an object moving toward an observer is shortened, toward the blue end of the visible spectrum, astronomers say that the spectrum of the object is blueshifted. Redshifted galaxies are moving away from the Milky Way galaxy. Blueshifted galaxies are moving toward the Milky Way galaxy.

15. Answers may vary but could include star-mapping technology that has been adapted to detect cancers in the human body; breathing equipment used by firefighters and divers; specialized materials that are chemical-resistant and fire-retardant; eye-controlled switches that can allow people confined to wheelchairs to control their environment; robot technology that is used in cancer treatment; insulating materials that help protect products and keep people warm; and the Light Duty Utility Arm.

16. Cosmic microwave background radiation is radiation left over from the big bang. Initially, the universe was very hot. It was filled with gamma rays—high-energy electromagnetic radiation that has very short wavelengths. As the universe expanded, the electromagnetic radiation lost energy and the wavelengths of the gamma rays became longer. As the wavelengths became longer, the radiation changed from gamma rays to visible light. As the universe continued to expand, the wavelengths of the radiation lengthened further and the energy became radiation characteristic of different parts of the electromagnetic spectrum. Today, the cosmic microwave background radiation that astronomers observe has a very short wavelength, only about 1.07 mm, which is in the microwave part of the electromagnetic spectrum.

Answers for page 134

17. COBE and WMAP

18. The mission of the James Webb Space Telescope will be to find the first galaxies that formed after the big bang.

19. Edwin Hubble was an American astronomer who photographed and recorded distant galaxies and studied their spectra.

20. The Hubble law is significant because it means that the universe is expanding.

21. a. Earth formed about 9 billion years after the big bang (14 billion years – 5 billion years = 9 billion years). **b.** Earth has existed for 36 percent of the length of time the universe has existed (5 billion years ÷ 14 billion years × 100 = 36%).

22. The WMAP satellite was launched in 2001, and the COBE satellite was launched in 1989. The technology improved significantly between 1989 and 2001, so WMAP was able to provide more detailed data.

23. a. With time, the energy of particles in the universe has decreased. **b.** With time, the temperature of the universe has decreased. **c.** As particle energy decreases, temperature decreases.

24. Answers may vary. Some students may argue that the gravitational evidence is strong enough to support the idea of "invisible" matter and energy. Other students may argue that although dark matter and dark energy may offer a possible explanation for the structure and movement of galaxies, scientists do not fully understand how matter, energy, and gravitational forces affect the large-scale universe. Therefore, the presence of dark matter and dark energy is only speculation; their existence has not been proven.

Answers for page 135

25. <CATCH HB09_ANS_U3_011a: VENN DIAGRAM COMPARING AND CONTRASTING THE THREE DIFFERENT TYPES OF GALAXIES>

26. *Sample answer*:
Features of Galaxies, Star Clusters, and Superclusters

Type of Structure	Description	Shape	Number of Stars/Galaxies
Spiral galaxy	A collection of stars, planets, gas, and dust	Look like pinwheels from above; from the side are flat with a central bulge	100 billion stars and many open clusters
Irregular galaxy	A collection of stars, planets, gas, and dust	Irregularly shaped	Vary in size from the smallest to the largest galaxies
Elliptical galaxy	A collection of stars, planets, gas, and dust	Spherical or elliptical	Hundreds of millions to over 1 trillion stars and many globular clusters
Open cluster	A small collection of stars that appear along the main plane of a galaxy, especially spiral galaxies	A dense core of stars surrounded by a more diffuse, irregularly shaped "shell" of stars	50 to 1000 stars
Globular cluster	A large but compact collection of stars that appear around the centre of a galaxy	Spherical	100 000 to several million stars
Supercluster	A large cluster of galaxies	Variable, from flattened disks to	4 to 25 clusters of galaxies, each of

		spheres	which may contain tens to thousands of galaxies

27. <CATCH HB09_ANS_U3_012a: TIMELINE ILLUSTRATING THE HISTORY OF THE UNIVERSE>

28. <CATCH HB09_ANS_U3_013a: SIMPLE ILLUSTRATION SHOWING WHERE DARK MATTER IS LOCATED IN THE MILKY WAY GALAXY>
I drew the picture to be similar to how astronomers think the dark matter surrounds the Andromeda galaxy. The Andromeda galaxy has a similar structure and mass to that of the Milky Way galaxy.

29. The raisins represent different galaxies. If you could observe from a single point within the loaf of rising dough, you would see all the raisins moving away from you. The outer part of the dough expands faster than the parts of the dough that are closest to the centre of the loaf. The situation is similar in the universe, with the galaxies at the farthest edges of the universe travelling faster than the galaxies nearer to the centre.

30. Immediately after the big bang, the universe expanded. Over time, the rate at which the expansion was happening slowed as the energy from the big bang dissipated. Evidence from the redshifts of supernovae indicates that the rate of expansion of the universe increased about 7 billion years ago and that the expansion is continuing to accelerate. Therefore, there must be a form of energy that works to overcome the effects of gravity and to cause the expansion of the universe to increase.

31. Galaxy B is moving toward the Milky Way. The spectrum of galaxy B is blueshifted, which means that the wavelengths of light in the spectrum appear to have been shortened, which happens when an object is moving toward the observer.

32. As the universe continues to expand, the cosmic microwave background radiation will continue to lose energy and the wavelengths will become longer. The CMB radiation will eventually become radio waves.

Unit 3 Review

The Study of the Universe

Answers for page 136

Written Answer

1. Detailed calendars allowed for organized agriculture, which led to the production of extra food. Producing extra food meant that other people in these societies could be freed up from farming to focus on specializing their skills in diverse areas such as woodworking, metallurgy, and other skills.

2. Tides are the rising and falling of ocean water that result from the pull of the Moon on the surface of Earth.

3. On a star map, stars that are brighter are larger than dimmer stars.

4. Trans-Neptunian objects would be located beyond point A on the diagram. Trans-Neptunian objects orbit the Sun beyond the orbit of Neptune, in the Kuiper Belt.

5. Once a protostar begins nuclear fusion, the core continues to heat up, which increases the pressure that pushes outward from the star's core. At the same time, the immense mass of the star causes gravitational force that pulls matter toward the core. When gravity and pressure are balanced, the result is a stable star, such as the Sun.

6. When the Sun has converted about 10 percent of its hydrogen to helium, the helium in the core will accumulate and also begin to undergo fusion. As the Sun continues to fuse hydrogen into helium, the helium core will grow larger. The region of hydrogen fusion, which lies around the helium core, will also grow larger. So, the Sun is getting larger.

7. Astronomers have observed that sunspots that form near the Sun's north and south poles take about 35 days to complete one rotation, and sunspots that form near the Sun's equator take about 27 days to complete one rotation. Based on these observations, astronomers infer that not only does the Sun rotate, but it rotates faster at its equator than at its poles.

8. Studying luminosity and absolute magnitude allows scientists to accurately classify stars and predict the sizes of stars, estimate their distance from Earth, and understand how they formed.

Answers for page 137

9. The inner layers of a star are very hot and radiate energy outward. The outer layers of the star are cooler, and some of the gases in the outer layers absorb some of the energy radiated by the inner layers. Different elements absorb different wavelengths of light. The

"missing" wavelengths of light are represented by spectral lines within an absorption spectrum. Those spectral lines are characteristic of specific elements in the star's outer layers.

10. In the core of a massive star, fusion causes the formation of iron. Iron cannot release energy by fusing with other atoms, and the star's energy production stops. The inward force of gravity overpowers the outward pressure of radiation in the star, and the core collapses violently. A shock waves travels through the star, and the outer portion of the star explodes in a supernova.

11. Answers may vary. Students should relate the increase to improvements in technology and consistency of monitoring rather than to an actual increase in the number of objects that cross Earth's orbit.

12. A star of magnitude 1 is 100 times brighter than a star of magnitude 5.

13. *Sample answer*: Yes, I think the mission would be worthwhile, but only if the astronauts understood the danger of the mission and were willing to participate. *Sample answer*: No, I do not think that the mission would be worthwhile. Human lives are worth far more than knowledge about the universe.

14. *Sample answer*:

Celestial Object	Size	Location	Moons	Composition
Planet	Various sizes, spherical, with radii from 2440 km to 71 490 km	Various distances from the Sun	Most have moons	Can be terrestrial or gas giant
Asteroid	Various sizes and shapes: from a tiny speck to radius of about 250 km; smaller than dwarf planets	Most found only in asteroid belt, between Mars and Jupiter	Most too small to have a moon, although at least one asteroid does (Ida)	Rocky, metallic
Dwarf planet	Larger than asteroids but smaller than planets	Some in asteroid belt but most are trans-Neptunian objects	Some have moons, e.g., Pluto has three known moons	Rocky, icy, and metallic

15. In order for the stars in the Andromeda galaxy to move at the speed calculated by scientists, the galaxy must contain 90 percent more mass than can be accounted for by visible matter. The "missing mass" is called dark matter.

16. Answers may vary but may include training additional astronauts, developing more robot technology, or engineering new telescopes or satellites.

Literacy Test Prep

The Story of Pluto

Answers for page 138

Multiple Choice

17. d

18. c

19. a

20. d

21. d

Written Answer

22. The staff of the Lowell Observatory named the former ninth planet Pluto after the Greek god of the Underworld. The astronomers assumed the object was cold and dark because it is so far away from the Sun. The Greek Underworld must also be cold and dark.

Literacy Test Prep

Quasars

Answers for page 139

Multiple Choice

23. b

24. c

25. d

26. b

27. a

Written Answer

28. Spectral analysis showed that quasars must be very distant—at the edges of the observable universe. But quasars are also very bright, so for astronomers to be able to detect quasars, the amount of energy they emit must be enormous.