***The Essential Cosmic Perspective, 9e* (Bennett et al.)**

**Chapter 1 A Modern View of the Universe**

Section 1.1

1) About where is our solar system located within the Milky Way Galaxy?

A) at the center of the galaxy

B) about 10 percent of the way from the center of the galaxy to the edge of the galactic disk

C) about halfway from the center of the galaxy to the edge of the galactic disk

D) near the far edge of the galactic disk

E) in the halo of the galaxy above the galactic disk

Answer: C

2) When we speak of the entire universe (as opposed to the *observable* universe), we mean \_\_\_\_\_\_\_\_.

A) all the stars and galaxies that we can see with telescopes

B) all material located within about 14 billion light-years of Earth

C) the sum total of all matter and energy

D) all the matter in galaxies, but not the spaces between the galaxies

Answer: C

3) Which of the following is the smallest distance?

A) Diameter of a typical planet

B) 1 light-second

C) 1 AU

D) Diameter of a typical star

Answer: A

4) Which of the following is the largest distance?

A) Diameter of a typical galaxy

B) Diameter of Pluto's orbit

C) Distance to the nearest star (other than our Sun)

D) 1 light-year

Answer: A

5) Which of the following statements does *not* use the term *light*-*year* in an appropriate way?

A) It's about 4 light-years from here to Alpha Centauri.

B) It will take me light-years to complete this homework assignment.

C) A light-year is about 10 trillion kilometers.

D) It will take the Voyager spacecraft about 20,000 years to travel just 1 light-year.

E) The Milky Way Galaxy is about 100,000 light-years in diameter.

Answer: B

6) One *light*-*minute* is the distance that light travels in one minute. How far is this, in kilometers? (Recall that the speed of light is 300,000 km/s.)

A) 300,000 km

B) 18 million km

C) 100 million km

D) 1.08 billion km

E) 9.46 trillion km

Answer: B

7) One light-year is approximately \_\_\_\_\_\_\_\_.

A) the distance from the Sun to Earth

B) the speed at which Earth orbits the Sun

C) 10 trillion kilometers

D) the same as one regular year

Answer: C

8) Light takes approximately one second to travel from Earth to the Moon. This means that the Moon is approximately \_\_\_\_\_\_\_\_.

A) 1 astronomical unit from Earth

B) 1 light-year from Earth

C) 3000 kilometers from Earth

D) 300,000 kilometers from Earth

E) near the top of Earth's atmosphere

Answer: D

9) Sunlight takes about 8.4 minutes to travel from the Sun to Earth. When NASA's *New Horizons* Spacecraft passed Pluto in 2015, it was about 32 AU from Earth. About how long did it take for transmitted images of Pluto to travel from the spacecraft to Earth?

A) One Plutonian year

B) 4-1/2 hours

C) 2-1/4 days

D) 3 weeks

E) They arrived almost instantaneously.

Answer: C

10) The *Voyager 2* Spacecraft is currently on its way out of our solar system at a speed of about 50,000 kilometers per hour. It will reach the distance of the nearest star system (beyond our solar system) in about \_\_\_\_\_\_\_\_ years.

A) 100

B) 1000

C) 10,000

D) 100,000

E) 1,000,000

Answer: D

11) Suppose we look at a photograph of many galaxies. Assuming that all galaxies formed at about the same time, which galaxy in the picture is the youngest?

A) The one that is farthest away

B) The one that is reddest in color

C) The one that is bluest in color

D) The one that is closest to us

E) The one that appears smallest in size

Answer: A

12) Suppose we imagine the Sun to be about the size of a grapefruit. Which of the following best describes the size and distance of Earth on the same scale?

A) Earth is the size of a tip of a ballpoint pen about 1 meter from the Sun.

B) Earth is the size of a golf ball about 1 meter from the Sun.

C) Earth is the size of a tip of a ballpoint pen about 15 meters from the Sun.

D) Earth is the size of a golf ball about 15 meters from the Sun.

E) Earth is the size of a marble about 25 miles from the Sun.

Answer: C

13) Suppose we imagine the Sun to be about the size of a grapefruit. How big an area would the orbits of the eight planets of the solar system cover?

A) The size of a typical dorm room

B) The size of a typical campus building

C) The size of a typical campus

D) The size of a small city

E) The size of a western state (e.g., Colorado)

Answer: C

14) Which of the following best describes the Milky Way Galaxy?

A) A spiral galaxy with a disk about 100,000 light**-**years in diameter

B) A spiral galaxy with a disk about 1 billion kilometers in diameter

C) A spiral galaxy with a disk about 1000 light**-**years in diameter

D) A spherically shaped galaxy that is about 4 light-years in diameter

E) A spherically shaped galaxy that is about 100,000 light**-**years in diameter

Answer: A

15) If we use 1 millimeter to represent 1 light**-**year, about how large in diameter is the Milky Way Galaxy?

A) 100 millimeters

B) 100 meters

C) 1 kilometer

D) 100 kilometers

E) 1 million millimeters

Answer: B

16) How long would it take to count all the stars in the Milky Way Galaxy at a rate of one star per second?

A) Several days

B) Several weeks

C) Several years

D) Several thousand years

E) Hundreds of thousands of years

Answer: D

17) About how many galaxies are there in the observable universe?

A) Roughly (within about a factor of 10) the same as the number of stars in our galaxy

B) A few dozen

C) A few thousand

D) About as many as the number of grains of sand on all the beaches on Earth

E) An infinite number

Answer: A

18) If you represented each star by a grain of sand, about how much sand would it take to represent all the stars in the observable universe?

A) All the sand in a typical playground sandlot

B) All the sand on Miami Beach

C) All the sand on the beaches of California

D) One cubic meter of sand

E) All the sand on all the beaches on Earth

Answer: E

19) The distance of Mars from the Sun is about 1.5 AU. How far is this in kilometers? (You do not need a calculator to answer this question. You do need to know what an AU is, within a factor of 1000.)

A) 1.5 150,000,000 km

B) 1.5 150,000 km

C) 150,000,000,000 / 1.5 km

D) 150,000,000 / 1.5 km

E) 1.5 150,000,000,000 km

Answer: A

20) One light-year is the distance light travels in one year. The speed of light is about 300,000 km/s (3 × 105 km/s). How far is 1 light-year?

A) 3 × 105 km

B) 1.8 × 107 km

C) 1.08 × 109 km

D) 9.46 × 1012 km

Answer: D

21) Light travels at a speed of 300,000 km/s. About how far is a light-year?

A) 10 million meters

B) 10 billion km

C) 300,000 km

D) 10 million km

E) 10 trillion km

Answer: E

22) Consider how the Moon moves through the Solar System and complete the following sentence. The Moon orbits *the Sun* \_\_\_\_\_\_\_\_.

A) once a month

B) once a year

C) once a day

Answer: B

23) Suppose you know the speed of a spacecraft in kilometers per second. How would you calculate its speed in kilometers per hour?

A) Multiply by 60 and then multiply by 60 again.

B) Divide by 60 and then divide by 60 again.

C) Multiply by 24.

D) Divide by 24.

Answer: B

24) How many seconds are in one year? (Calculate this, do not look it up.)

A) About 380 million (380,000,000, or 3.8 × 108)

B) About 30 million (30,000,000, or 3 × 107)

C) About 86 thousand (86,000, or 8.6 × 105)

D) About 3600 (3.6 × 103)

Answer: B

25) One light-hour is the distance light travels in one hour. The speed of light is about 300,000 km/s (3 × 105 km/s). If Jupiter is 0.72 light hours from the Sun, how far is this?

A) 216 thousand km (2.16 × 105 km)

B) 13 million km (1.3 × 107 km)

C) 778 million km (7.78 × 108 km)

D) 1.5 billion km (1.5 × 109 km)

Answer: C

26) The planet Mars is, on average, about 228 million km from the Sun. How long does it take light from the Sun to reach Mars? (Recall that the speed of light is about 300,000 km/s.)

A) About 8.4 minutes

B) About 12.7 minutes

C) About 1.52 light seconds

D) About 1.52 hours

Answer: B

27) The Earth has a radius of about 6000 km. How long would it take for an object traveling at the speed of light to circle the Earth? (Recall that the speed of light is 300,000 km/s.)

A) 1/300,000 of a second (0.0000033 s)

B) 1/6000 of a second (0.000017 s)

C) 1/8 of a second (0.0125 s)

D) 1/2 of a second (0.5 s)

Answer: C

Section 1.2

1) Suppose we look at two distant galaxies: Galaxy 1 is twice as far away as Galaxy 2. In that case \_\_\_\_\_\_\_\_.

A) we are seeing Galaxy 1 as it looked at an earlier time in the history of the universe than Galaxy 2

B) we can't say anything about these galaxies except for their distances

C) we are seeing Galaxy 1 as it looked at a later time in the history of the universe than Galaxy 2

Answer: A

2) Shortly after the Big Bang, the chemical composition of the universe was \_\_\_\_\_\_\_\_.

A) almost entirely hydrogen and helium

B) hydrogen only

C) about equal amounts of all the elements

D) about the same as it is today

Answer: A

3) About what percentage of the original hydrogen and helium of the universe had been converted into heavier elements by the time our solar system was born?

A) 20%

B) 10%

C) 50%

D) 2%

Answer: D

4) What is *nuclear fusion*?

A) An explosion caused by putting together two volatile chemicals

B) The process of splitting nuclei to produce energy

C) The process of turning matter into pure energy

D) The process of combining lightweight nuclei to make heavier nuclei

E) A process that only occurs in bombs

Answer: D

5) Earth is made mostly of metals and rocks. Where did most of the elements that make up these materials (carbon, silicon, iron, etc.) form?

A) They were produced by the Big Bang.

B) They were produced by chemical reactions in interstellar gas clouds.

C) They were produced by stars.

D) They were produced in our Sun.

E) They were produced by nuclear fission of uranium and other radioactive materials in space.

Answer: C

6) Why did Carl Sagan say that we are *star stuff*?

A) The composition of most stars (mostly hydrogen and helium) is about the same as the composition of our bodies.

B) Cosmic rays reaching Earth from distant astronomical sources may be one source of mutations that help evolution along.

C) Nearly every atom from which we are made once (before the solar system formed) was inside of a star.

D) Nearly every atom from which we are made was once inside our star, the Sun.

E) Sagan thought that all of us have the potential to be movie (or TV) stars like he was.

Answer: C

7) The Sun is made primarily of \_\_\_\_\_\_\_\_.

A) hydrogen and oxygen

B) hydrogen and helium

C) carbon and nitrogen

D) oxygen and carbon

E) nearly equal portions of all the elements

Answer: B

8) Our Sun formed \_\_\_\_\_\_\_\_ our galaxy formed.

A) before

B) at the same time that

C) billions of years after

D) within about 10 million years after

Answer: C

9) In what sense are galaxies cosmic recycling plants?

A) Every time one star dies, a new one of exactly the same size and mass is born.

B) As a galaxy rotates, its stars cycle around the galaxy center again and again, each time returning to exactly where they started.

C) New stars in galaxies form from gas that has been ejected by previous generations of stars.

D) New galaxies are continuously being formed from the remains of older galaxies.

Answer: C

10) On the scale of the cosmic calendar, in which the history of the universe is compressed to 1 year, when did the Sun and Earth form?

A) January

B) December

C) September

D) February

Answer: C

11) On the scale of the cosmic calendar, in which the history of the universe is compressed to 1 year, how long has human civilization (i.e., since ancient Egypt) existed?

A) About half the year

B) About a month

C) A few hours

D) A few seconds

E) Less than a millionth of a second

Answer: D

12) On the scale of the cosmic calendar, in which the history of the universe is compressed into 1 year, when did the dinosaurs become extinct?

A) In late December

B) In late November

C) In late October

D) In late September

E) In late August

Answer: A

13) On the scale of the cosmic calendar, in which the history of the universe is compressed into 1 year, when did Kepler and Galileo first discover that we live on a planet in a solar system?

A) 1 second ago

B) 1 day ago

C) 1 week ago

D) December 25

E) December 30

Answer: A

14) On the scale of the cosmic calendar, in which the history of the universe is compressed into 1 year, how long is the average human life span?

A) 0.2 millisecond

B) 0.2 second

C) 2 seconds

D) 2 minutes

E) 2 hours

Answer: B

15) Your textbook discusses the cosmic calendar, a model of the history of the universe scaled to a single year. The length of time represented by one month on this cosmic calendar is therefore closest to \_\_\_\_\_\_\_\_.

A) 1 billion years.

B) 1 1000 years.

C) 10 million years.

D) 10 billion years.

E) 1 million years.

Answer: A

16) What made most of the oxygen nuclei in the solar system?

A) Stars

B) Nothing makes elements—oxygen has always been present in the universe.

C) The Big Bang

D) Our Sun

E) High energy collisions of dust and cosmic rays

Answer: A

17) Astronomer Alan says the universe is expanding at one rate and Astronomer Wendy says it is expanding at a faster rate. All other things being equal, which astronomer would say that the universe is *older*?

A) Wendy

B) Alan

C) Neither

Answer: B

18) Astronomers have used observations from the Hubble Space Telescope to measure the rate at which the universe is expanding, and have estimated the age of the universe from that measured rate. Suppose the expansion turns out to be *faster* than current measurements indicate. In that case, our new estimate for the age of the universe would be \_\_\_\_\_\_\_\_.

A) Unaffected

B) Younger (less time between now and the Big Bang)

C) Older (more time between now and the Big Bang)

Answer: B

19) About how long does it take our solar system to complete one orbit around the center of the Milky Way Galaxy?

A) 10,000 years

B) 1 million years

C) 230 million years

D) 4-1/2 billion years

E) 14 billion years

Answer: C

20) What do astronomers mean when they say the universe is expanding?

A) Everything in the universe is gradually growing in size.

B) Average distances are increasing between most galaxies.

C) Average distances are increasing between most stars.

D) The universe is expanding from a single point.

Answer: B

21) How do scientists estimate the age of the universe?

A) They look up the answer in a book or they Google it.

B) They measure the abundances of radioactive elements in meteorites, and use their half-lives to calculate the age of the meteorites, which are the oldest solids in the solar system.

C) They measure the speeds and distances of galaxies, andcalculate the time it took for them to travel that distance (away from us).

D) They make a guess: no one really knows how old the universe is.

E) They measure how fast the Sun is losing energy, and how much energy it has left to lose.

Answer: C

22) According to astronomers, approximately how old is the universe?

A) 14 billion years

B) 14 trillion years

C) Infinite

D) 14 million years

Answer: A

23) According to current scientific estimates, when did the Big Bang occur?

A) About 4.5 billion years ago

B) About 20 billion years ago

C) About 65 million years ago

D) About 14 billion years ago

E) About 10 billion years ago

Answer: D

Section 1.3

1) Approximately how fast is a person located at the Earth's equator moving around Earth's axis due to the rotation of the Earth?

A) 17,000 km/hr

B) 1700 km/hr

C) 170 km/hr

D) 17 km/hr

E) Not moving at all

Answer: B

2) Earth's rotation causes a person at the North Pole to \_\_\_\_\_\_\_\_ relative to the center of the Earth.

A) move at a speed of about 1670 km/hr

B) spin in place once each year

C) remain completely stationary

D) spin in place once each day

Answer: D

3) The *ecliptic plane* is \_\_\_\_\_\_\_\_.

A) the plane of Earth's orbit around the Sun

B) the plane of the Moon's orbit around Earth

C) the plane of our solar system's orbit around the Milky Way Galaxy

D) a flat disk of material that lies between the Sun and Earth

E) the plane defined by Earth's equator

Answer: B

4) We say that Earth has an axis tilt of 23-1/2° because this is the angle between Earth's \_\_\_\_\_\_\_\_.

A) rotation axis and a line perpendicular (vertical) to the ecliptic plane

B) rotation axis and the star Polaris

C) equator and rotation axis

D) rotation axis and north pole

E) rotation axis and magnetic axis

Answer: A

5) Patterns of stars in constellations hardly change in appearance over times of even a few thousand years. Why?

A) Stars are fixed and never move.

B) Stars move, but they move very slowly—only a few kilometers in a thousand years.

C) Although most stars move through the sky, the brightest stars do not, and these are the ones that trace the patterns we see in the constellations.

D) The stars in our sky actually move rapidly relative to us—thousands of kilometers per hour—but are so far away that it takes a long time for this motion to make a noticeable change in the patterns in the sky.

E) Stars within a constellation move together as a group, which tends to hide their actual motion and prevent the pattern from changing.

Answer: D

6) Which of the following correctly lists the described speeds from slowest to fastest?

A) Earth's orbital speed about the Sun

Earth's speed of rotation on its axis

Earth's orbital speed about the Sun

typical speeds of stars in the local solar neighborhood relative to us

the speed of our solar system orbiting the center of the Milky Way Galaxy

the speeds of very distant galaxies relative to us

B) typical speeds of stars in the local solar neighborhood relative to us

Earth's speed of rotation on its axis

Earth's orbital speed about the Sun

the speed of our solar system orbiting the center of the Milky Way Galaxy

the speeds of very distant galaxies relative to us

C) Earth's speed of rotation on its axis

Earth's orbital speed about the Sun

the speed of our solar system orbiting the center of the Milky Way Galaxy

the speeds of very distant galaxies relative to us

typical speeds of stars in the local solar neighborhood relative to us

D) Earth's orbital speed about the Sun

the speeds of very distant galaxies relative to us

Earth's speed of rotation on its axis

typical speeds of stars in the local solar neighborhood relative to us

the speed of our solar system orbiting the center of the Milky Way Galaxy

E) typical speeds of stars in the local solar neighborhood relative to us

the speed of our solar system orbiting the center of the Milky Way Galaxy

Earth's orbital speed about the Sun

the speeds of very distant galaxies relative to us

Earth's speed of rotation on its axis

Answer: A

7) What evidence leads astronomers to conclude that most of the Milky Way's mass consists of a mysterious *dark matter*?

A) We observe many dark clouds of gas that block the light of stars behind them.

B) The galaxy's rotation indicates that it must contain much more matter than we can observe with our telescopes.

C) Observations indicate that most stars are dimmer than the Sun, so we say they are "dark."

D) Stars are separated from one another by vast distances, and therefore most places in the galaxy would be dark to our eyes.

Answer: B

8) Most of the mass in the Milky Way Galaxy is located \_\_\_\_\_\_\_\_.

A) in the halo (above/below the disk)

B) within the disk

C) in the stars in the spiral arms

D) in the gas and dust

E) in the central bulge of the galaxy

Answer: A

9) The amount and distribution of matter in the Milky Way Galaxy is determined by \_\_\_\_\_\_\_\_.

A) counting the number of stars in the galaxy

B) determining the amount of gas and dust in the galaxy

C) studying where stars are located in the Milky Way

D) studying the rotation of the galaxy

E) adding together the mass of the galaxy's stars and gas

Answer: D

10) What evidence leads astronomers to conclude that the universe contains a mysterious *dark energy?*

A) The expansion of the universe is accelerating with time.

B) The gravity of distant galaxies is stronger than that of galaxies nearby.

C) Studies of galactic motion indicate that there is more matter in the universe than we can account for with stars and gas.

D) Stars shine much more brightly than we would expect from nuclear fusion.

E) The existence of such dark energy is the only way to account for evil in the universe.

Answer: A

11) From the fact that virtually every galaxy is moving away from us and more distant galaxies are moving away from us at a faster rate than closer ones, we conclude that \_\_\_\_\_\_\_\_.

A) the Milky Way Galaxy is expanding

B) we are located at the center of the universe

C) even nearby galaxies will eventually be moving faster than the speed of light

D) the universe is expanding

E) the universe is shrinking

Answer: D

12) By studying distant galaxies in the 1920s, Hubble made the following important discovery that led us to conclude that the universe is expanding.

A) All galaxies contain billions of stars, and all galaxies have spiral shapes.

B) All galaxies were born at the same time, and all will die at the same time.

C) All galaxies outside the Local Group are moving away from us, and the farther away they are, the faster they're going.

D) All galaxies outside the Local Group are orbiting the Local Group.

E) Galaxies are in motion throughout the universe, with about equal numbers moving toward us and away from us.

Answer: C

13) Imagine that we put a raisin cake into the oven, with each raisin separated from the others by 1 cm. An hour later, we take it out and the distances between raisins are 3 cm. If you lived in one of the raisins and watched the other raisins as the cake expanded, which of the following would you observe?

A) All raisins would be moving away from you at the same speed.

B) More distant raisins would be moving away from you faster.

C) More distant raisins would be moving away from you more slowly.

D) It depends: If you lived in a raisin near the edge of the cake, you'd see other raisins moving away from you, but they'd be coming toward you if you lived in a raisin near the center of the cake.

E) The raisins would be expanding too, so you'd never notice any changes in the cake.

Answer: B

14) Recall the raisin cake model of the universe and its analogy to our expanding universe. Suppose you measure the recession velocity (the speed at which any object is moving away from us) of Galaxy A to be 2000 km/s and the recession velocity of Galaxy B to be 6000 km/s. What can you conclude about the relative distances of these two galaxies?

A) Galaxy A is 3 times as far from us as Galaxy B.

B) Galaxy B is 3 times as far from us as Galaxy A.

C) Galaxy A is 6 times as far from us as Galaxy B.

D) Galaxy B is 6 times as far from us as Galaxy A.

E) The relative distances cannot be determined from the information in this problem.

Answer: B

15) The reason that we observe more distant galaxies to be moving away from us at higher speeds than nearby galaxies is that \_\_\_\_\_\_\_\_.

A) the more distant galaxies were flung outward faster by the Big Bang

B) the more distant galaxies are smaller and less massive, so they can move faster

C) the nearby galaxies are slowed by our own galaxy's gravitational pull

D) there is more space to expand between us and the distant galaxies

Answer: D

16) We observe that most galaxies are moving away from us. If we could (somehow) communicate with an observer in a distant galaxy, what would that observer say about what it sees?

A) Most galaxies are moving away from me, except for yours.

B) Most galaxies are moving away from me, including yours.

C) Most galaxies are moving away from you, and about half are moving towards me.

Answer: B

17) The farthest galaxies visible in Hubble Space Telescope photos are about \_\_\_\_\_\_\_\_ light-years away.

A) 1 million

B) 12 million

C) 1 billion

D) 12 billion

E) 12 trillion

Answer: D

18) Our solar system is located about 27,000 light-years from the galactic center. About how far does our solar system travel in one orbit?

A) 54,000 light-years

B) 85,000 light-years

C) 100,000 light-years

D) 170,000 light-years

Answer: D

19) You observe two distant galaxies (well outside our Local Group of galaxies). You find that Galaxy W is moving away from us at a speed of 35,000 km/s and Galaxy X is moving away from us at a speed of 70,000 km/s. What can you say about the distances to those galaxies?

A) Galaxy W is four times as far as Galaxy X.

B) Galaxy W is twice as far as Galaxy X.

C) She can't say anything about the distances to Galaxy W or X.

D) Galaxy X is four times as far as Galaxy W.

E) Galaxy X is twice as far as Galaxy W.

Answer: B

Short Answer Questions

1) The speed of light is 300,000 km/s. How far is a light-year? Be sure to show all work clearly on your calculations.

Answer: 1 light-year

= (speed of light) × (1 yr)

=  × 

= 9,460,000,000,000 km

2) Earth's actual diameter is about 12,800 kilometers. What is Earth's diameter in a 1-to-10 billion scale model solar system? Show your work clearly.

Answer: Scaled radius of Earth = actual radius/1010

= 6,378 km/1010

= 6,378 × 105 cm/1010

= 6.378 × 108 cm/1010

= 6.378 × 10−2 cm

= 0.6 mm - This is about the size of the tip of a (fine tip) ballpoint pen.

Reading Quiz Questions

1) Which of the following is a general difference between a planet and a star?

A) Stars shine with energy released by nuclear fusion while planets shine primarily with light reflected from stars.

B) Stars are found in galaxies but planets are not part of galaxies.

C) Stars are made of gas and planets are made of rock.

D) Stars are stationary while planets orbit stars.

Answer: A

2) Our solar system consists of \_\_\_\_\_\_\_\_.

A) the Sun and all the objects that orbit it

B) the Sun and the planets, and nothing else

C) a few hundred billion stars, bound together by gravity

D) the Sun and several nearby stars, as well as the planets and other objects that orbit these stars

Answer: A

3) A typical galaxy is a \_\_\_\_\_\_\_\_.

A) collection of millions or billions of stars, bound together by gravity and orbiting a common center

B) large, glowing ball of gas powered by nuclear energy

C) nearby object orbiting a planet

D) relatively small, icy object orbiting a star

E) system consisting of one or a few stars orbited by planets, moons, and smaller objects

Answer: A

4) Which of the following best describes what we mean by the term universe?

A) The sum total of all matter and energy

B) A vast collection of stars that number as many as the grains of sand on all the beaches on Earth

C) All the galaxies in all the superclusters

D) Our Milky Way Galaxy

Answer: A

5) An astronomical unit (AU) is \_\_\_\_\_\_\_\_.

A) any very large unit, such as a light-year

B) the *average* distance between Earth and the Sun

C) the *current* distance between Earth and the Sun

D) the average distance between any planet and the Sun

Answer: B

6) A *light-year* is \_\_\_\_\_\_\_\_.

A) about 10 trillion kilometers

B) the time it takes light to reach the nearest star

C) the time it takes light to travel around the Sun

D) about 300,000 kilometers per second

Answer: A

7) A television advertisement claiming that a product is light-years ahead of its time does not make sense because \_\_\_\_\_\_\_\_.

A) it doesn't specify the number of light-years

B) it uses "light-years" to talk about time, but a light-year is a unit of distance

C) a light-year is an astronomically large unit, so a product could not possibly be so advanced

D) light-years can only be used to talk about light

Answer: B

8) The term *observable universe* refers to \_\_\_\_\_\_\_\_.

A) the portion of the universe that we have so far photographed through telescopes

B) the portion of the universe that can be seen by the naked eye

C) the portion of the universe that is not hidden from view by, for example, being below the horizon

D) the portion of the universe that we can see *in principle*, given the current age of the universe

Answer: D

9) On a scale where the distance from Earth to the Sun is about 15 meters, the distance from Earth to the Moon is \_\_\_\_\_\_\_\_.

A) small enough to fit within your hand

B) about 1 meter

C) about 5 meters

D) about 30 meters

Answer: A

10) On a scale where the Sun is about the size of a grapefruit and the Earth is about 15 meters away, how far away are the nearest stars besides the Sun?

A) 100 meters

B) About the distance across 50 football fields

C) About the distance across the state of Delaware

D) About the distance across the United States

Answer: D

11) The number of stars in the Milky Way Galaxy is approximately \_\_\_\_\_\_\_\_.

A) a few hundred

B) a few hundred thousand

C) a few hundred billion

D) a few hundred million

Answer: C

12) What do astronomers mean by the *Big Bang*?

A) The event that marked the beginning of the expansion of the universe

B) A gigantic explosion that blew all the galaxies in the universe to smithereens

C) The explosion of a massive star at the end of its life

D) The event that marked the birth of our solar system

Answer: A

13) What do we mean when we say that the universe is *expanding*?

A) Everything in the universe is gradually growing in size.

B) Within galaxies, average distances between star systems are increasing with time.

C) The statement is not meant to be literal; rather, it means that our knowledge of the universe is growing.

D) Average distances between galaxies are increasing with time.

Answer: D

14) Based on observations of the universal expansion, the age of the universe is about \_\_\_\_\_\_\_\_.

A) 14,000 years

B) 14 million years

C) 14 billion years

D) The universe is younger than this.

Answer: C

15) If the 14 billion year history of the universe were compressed to one year, and "now" is exactly midnight December 31, approximately how long ago were your grandparents born?

A) 0.15 second ago

B) 1 second ago

C) 1 minute ago

D) 1 hour ago

Answer: C

16) What is the *ecliptic plane*?

A) The plane of Earth's orbit around the Sun

B) The plane of Earth's equator

C) The plane of the Sun's equator

D) The plane of the Milky Way Galaxy

Answer: A

17) How long does it take the Earth to complete one orbit around the Sun?

A) One year

B) One day

C) One month

D) One week

E) The time it takes Earth to orbit the Sun changes significantly from one orbit to the next.

Answer: A

18) What is the "raisin cake analogy" to the expanding universe intended to explain?

A) That as a raisin cake expands, every raisin moves away from every other raisin, just as galaxies move away from each other in an expanding universe

B) That raisins, like galaxies, expand in size as the cake or universe expands

C) That from within the raisin cake, you would see other raisins moving away from you only if you were on the central raisin, just as you see galaxies moving away only if you are in the center of the universe

D) That the universe heats up as it expands, just as the raisin cake heats up as it bakes

Answer: A

Concept Quiz Questions

1) Which of the following has your "cosmic address" in the correct order?

A) You, Earth, solar system, Local Group, Local Supercluster, Milky Way Galaxy, universe

B) You, Earth, solar system, Milky Way Galaxy, Local Group, Local Supercluster, universe

C) You, Earth, Local Group, Local Supercluster, solar system, Milky Way Galaxy, universe

D) You, Earth, solar system, Local Group, Milky Way Galaxy, Local Supercluster, universe

E) You, Earth, Milky Way Galaxy, solar system, Local Group, Local Supercluster, universe

Answer: B

2) When we look at an object that is 1,000 light-years away we see it \_\_\_\_\_\_\_\_.

A) as it was 1,000 years ago

B) as it was 1,000 light-years ago

C) as it is right now, but it appears 1,000 times dimmer

D) looking just the same as our ancestors would have seen it 1,000 years ago

Answer: A

3) Suppose we look at two distant galaxies: Galaxy 1 is twice as far away as Galaxy 2. In that case \_\_\_\_\_\_\_\_.

A) Galaxy 1 must be twice as big as Galaxy 2

B) we are seeing Galaxy 1 as it looked at an *earlier* time in the history of the universe than Galaxy 2

C) we are seeing Galaxy 1 as it looked at a *later* time in the history of the universe than Galaxy 2

D) Galaxy 2 must be twice as old as Galaxy 1

Answer: B

4) Could we see a galaxy that is 20 billion light-years away? (Assume that we mean a "lookback time" of 20 billion years.)

A) No, because it would be beyond the bounds of our observable universe.

B) Yes, if we had a big enough telescope.

C) No, because a galaxy could not possibly be that far away.

D) Yes, we have already detected galaxies at that distance.

Answer: A

5) Suppose we make a scale model of our solar system, with the Sun the size of a grapefruit. Which of the following best describes what the planets would look like?

A) The planets are all much smaller than the Sun. Four planets are within about 20 meters of the Sun, while the rest planets are spread much farther apart.

B) The planets are all much smaller than the Sun and are spread out evenly over a distance about the length of a large classroom.

C) The planets are all much smaller than the Sun. Four planets are located within a few centimeters of the Sun, and four planets are located at distances ranging up to about a meter.

D) The planets range in size from about the size of a marble to the size of a baseball. They are spread out over a region about the size of a football field.

Answer: A

6) If you could count stars at a rate of about one per second, how long would it take to count all the stars in the Milky Way Galaxy?

A) Several days

B) Several weeks

C) Several years

D) Several thousand years

Answer: D

7) The total number of stars in the observable universe is about \_\_\_\_\_\_\_\_.

A) 100 billion

B) the same as the number of grains of sand in a school sandbox

C) the same as the number of grains of sand on all the beaches on Earth

D) the same as the number of atoms that make up the Earth

Answer: C

8) Using the ideas discussed in your text, in what sense are we "star stuff"?

A) The overall chemical composition of our bodies is about the same as that of stars.

B) Movie stars and other people are all made of the same stuff, so we all have the potential to be famous.

C) Nearly every atom from which we are made was once inside of a star.

D) We could not survive without light from our star, the Sun.

Answer: C

9) How are galaxies important to our existence?

A) Without galaxies, there could not have been a Big Bang.

B) Without galaxies, the universe could not be expanding.

C) Deep in their centers, galaxies created the elements from which we are made.

D) Galaxies recycle material from one generation of stars to the next, and without this recycling we could not exist.

Answer: D

10) If we imagine the history of the universe compressed into one year, with the present as the stroke of midnight at the very end of that year, dinosaurs became extinct \_\_\_\_\_\_\_\_.

A) about 6 months ago

B) about 3 weeks ago

C) yesterday morning

D) about an hour ago

Answer: C

11) Relative to the age of the universe, how old is our solar system?

A) It is about 1% as old as the universe.

B) It is between about 5% and 10% as old as the universe.

C) It is about one-third the age of the universe.

D) It is nearly the same age as the universe.

Answer: C

12) How do the speeds at which we are moving with Earth's rotation and orbit compare to the speeds of more familiar objects?

A) Earth's rotation carries most people around the axis faster than a commercial jet travels, and Earth's orbit carries us around the Sun faster than the Space Station orbits Earth.

B) Earth's rotation carries most people around the axis at about the speed of a commercial jet, and Earth's orbit carries us around the Sun at about the speed of a military jet.

C) Earth's rotation carries most people around the axis at about the speed of a car on the freeway, and Earth's orbit carries us around the Sun at about the speed of a commercial jet.

D) Earth's rotation carries most people around the axis at about the speed at which the Space Station orbits Earth, and Earth's orbit carries us around the Sun at nearly the speed of light.

Answer: A

13) Why do the patterns of the stars in our sky look the same from year to year?

A) Because the stars in the constellations are so far away.

B) Because the stars in the constellations are not moving.

C) Because the stars in the constellations all move at the same speeds and in the same directions, so they don't change their relative positions.

D) Because the stars in the constellations move so slowly — typically about the speed of a snail — that their motions are not noticeable.

Answer: A

14) Where is our solar system located within the Milky Way Galaxy?

A) Very near the center of the galaxy

B) At the far edge of the galaxy's visible disk

C) Roughly halfway between the center and the edge of the visible disk of the galaxy

D) In the halo of the galaxy

Answer: C

15) Consider a raisin cake expanding uniformly in an oven. Viewed from one of the raisins, you would see \_\_\_\_\_\_\_\_.

A) all other raisins moving away from you, with more distant raisins moving faster

B) all other raisins moving away from you, with more distant raisins moving slower

C) all other raisins moving away from you at the same speed

D) all raisins, including your own, growing in size as the cake expands

Answer: A

16) Astronomers infer that the universe is expanding because distant galaxies all appear to \_\_\_\_\_\_\_\_.

A) be growing in size

B) be moving away from us, with more distant ones moving faster

C) be made mostly of dark matter

D) rotate rapidly

Answer: B

17) Which statement about motion in the universe is *not* true?

A) The mysterious *dark matter* is the fastest-moving material in the universe.

B) Some stars in the Milky Way Galaxy are moving toward us and others are moving away from us.

C) Except for a few nearby galaxies, all other galaxies are moving away from us.

D) Your speed of rotation around Earth's axis is faster if you live near the equator than if you live near the North Pole.

Answer: A

Visual Quiz Questions

1) Each box in this figure represents a different level of structure in our universe. Each box is labeled with one of the numbers 1–5. Which box represents the Milky Way Galaxy?



A) 1

B) 2

C) 3

D) 4

E) 5

Answer: C

2) What does this photograph show?



A) It is a picture of our own Milky Way Galaxy.

B) It is a picture of the Andromeda galaxy, located about 2.5 million light-years away.

C) It is a picture of a cloud of gas known as the Orion Nebula.

D) It is a picture of our own solar system.

E) It is a picture of a young star in the process of being born.

Answer: B

3) This painting represents the Sun and planets (and two dwarf planets) of our solar system. What is *not* to scale in this painting?



A) The sizes of the planets are not correctly scaled compared to each other or the Sun.

B) The distances between the planets are not shown to scale.

C) The Sun is too big compare to the planets.

D) Everything is correctly scaled, but the planets are shown in the wrong order from the Sun.

E) Neither distances nor sizes are correctly scaled.

Answer: B

4) What is the significance of this photograph?



A) It shows the first person ever to land on Mars.

B) It shows a person standing on the most distant world ever visited by a human being.

C) It shows the first person ever to go into space.

D) It was taken Jan. 1, 2000, to commemorate the turn of the millennium.

Answer: B

5) Suppose we made a scale model of our Milky Way Galaxy in which the disk of the galaxy is the size of a football field. Which (if any) diagram represents the Sun on the same scale?

A)



B)



C)



D) The Sun on this scale would be about two feet in diameter and too big to show on the screen.

E) The Sun on this scale would be microscopic and too small to see on the screen.

Answer: E

6) These photos show two different astronomical objects. Which object is bigger, and by about how much?



A) Object 2 is more than a trillion times as large as Object 1.

B) Object 2 is approximately 1,000 times as large as Object 1.

C) Object 2 is about 10 times as large as Object 1.

D) Object 1 is about 10 times as large as Object 2.

E) Both objects are about the same size.

Answer: A



7) This diagram represents Earth's rotation and orbit. What do we call the flat blue plane shown in this diagram?

A) The solar plane

B) The ecliptic plane

C) Earth's axis

D) The galactic plane

E) An astronomical unit

Answer: B

8) Notice that Earth's axis is shown with an arrowhead in this diagram. What does the arrow point to?

A) The Sun

B) The ecliptic plane

C) The center of the Milky Way Galaxy

D) Polaris, the North Star

E) The Northern lights

Answer: D

9) These diagrams show a raisin cake before it is put in the oven and again one hour later after it has expanded during baking. Suppose you lived in Raisin 3 (the raisin labeled "3"). What would you have noticed about Raisin 2 during baking?



A) Raisin 2 is moving away from you at a speed of 4 cm/hr.

B) Raisin 2 always stays in the same place but gets bigger in size.

C) Raisin 2 is moving away from you at a speed of 2 cm/hr.

D) Raisin 2 is moving away from you at a speed of 6 cm/hr.

E) Raisin 2 is moving toward you at a speed of 2 cm/hr.

Answer: C

10) Nearly all of the objects that you can see in this photograph are \_\_\_\_\_\_\_\_.



A) planets

B) stars

C) galaxies

D) astronomical units

Answer: C

End-of-Chapter Questions

**Visual Skills Check**

*Use the following questions to check your understanding of some of the many types of visual information used in astronomy.*



*The figure above shows the sizes of Earth and the Moon to scale; the scale used is 1 cm = 4000 km. Using what you've learned about astronomical scale in this chapter, answer the following questions. (Hint: If you are unsure of the answers, you can calculate them using the given data.)*

*Earth—Sun distance = 150,000,000 km*

*Diameter of Sun = 1,400,000 km*

*Earth—Moon distance = 384,000 km*

*Diameter of Earth = 12,800 km*

1) If you wanted to show the *distance* between Earth and the Moon on the same scale, about how far apart would you need to place the two photos?

A) 10 centimeters (about the width of your hand)

B) 1 meter (about the length of your arm)

C) 100 meters (about the length of a football field)

D) 1 kilometer (a little more than a half mile)

Answer: B

2) Suppose you wanted to show the Sun on the same scale. About how big would it need to be?

A) 3.5 centimeters in diameter (the size of a golf ball)

B) 35 centimeters in diameter (a little bigger than a basketball)

C) 3.5 meters in diameter (about 11-1/2 feet across)

D) 3.5 kilometers in diameter (the size of a small town)

Answer: C

3) About how far away from Earth would the Sun be located on this scale?

A) 3.75 meters (about 12 feet)

B) 37.5 meters (about the height of a 12-story building)

C) 375 meters (about the length of four football fields)

D) 37.5 kilometers (the size of a large city)

Answer: C

4) Could you use the same scale to represent the distances to nearby stars? Why or why not?

Answer: No. The nearest stars would not fit on Earth using this scale. The total distance to the nearest star would wrap around the Earth about 2.5 times!

Chapter Review Questions

1) Briefly describe the major levels of structure (such as planet, star, galaxy) in the universe.

2) Define *astronomical unit* and *light-year*.

3) Explain the statement *The farther away we look in distance, the further back we look in time.*

4) What do we mean by the *observable universe*? Is it the same thing as the entire universe?

5) Using techniques described in the chapter, put the following into perspective: the size of our solar system; the distance to nearby stars; the size and number of stars in the Milky Way Galaxy; the number of stars in the observable universe.

6) What do we mean when we say that the universe is *expanding*, and how does expansion lead to the idea of the *Big Bang* and our current estimate of the age of the universe?

7) In what sense are we "star stuff"?

8) Use the cosmic calendar to describe how the human race fits into the scale of time.

9) Briefly explain Earth's daily rotation and annual orbit, defining the terms *ecliptic plane* and *axis tilt.*

10) Briefly describe our solar system's location and motion within the Milky Way Galaxy.

11) Why do scientists suspect that most of our galaxy's mass consists of *dark matter*? Briefly describe the mystery of dark matter and *dark energy*.

12) What key observations lead us to conclude that the universe is expanding? Use the raisin cake model to explain how these observations imply expansion.

**Does It Make Sense?**

*Decide whether or not each of the following statements makes sense (or is clearly true or false). Explain clearly; not all of these have definitive answers, so your explanation is more important than your chosen answer.*

**Example:** I walked east from our base camp at the North Pole.

**Solution:** The statement does not make sense because east has no meaning at the North Pole–all directions are south from the North Pole.

13) Our solar system is bigger than some galaxies.

14) The universe is billions of light-years in age.

15) It will take me light-years to complete this homework assignment!

16) Someday we may build spaceships capable of traveling a light-year in only a decade.

17) Astronomers discovered a moon that does not orbit a planet.

18) NASA will soon launch a spaceship that will photograph our Milky Way Galaxy from beyond its halo.

19) The observable universe is larger today than it was a few billion years ago.

20) Photographs of distant galaxies show them as they were when they were much younger than they are today.

21) At a nearby park, I built a scale model of our solar system in which I used a basketball to represent Earth.

22) Because nearly all galaxies are moving away from us, we must be located near the center of the universe.

**Quick Quiz**

*Choose the best answer to each of the following. For additional practice, try the Chapter 1 Reading and Concept Quizzes in the Study Area at www.MasteringAstronomy.com.*

23) Which of the following correctly lists our "cosmic address" from small to large?

A) Earth, solar system, Milky Way Galaxy, Local Group, Local Supercluster, universe

B) Earth, solar system, Local Group, Local Supercluster, Milky Way Galaxy, universe

C) Earth, Milky Way Galaxy, solar system, Local Group, Local Supercluster, universe

Answer: No Correct Answer Was Provided.

24) An *astronomical unit* is \_\_\_\_\_\_\_\_.

A) any planet's average distance from the Sun

B) Earth's average distance from the Sun

C) any large astronomical distance

Answer: No Correct Answer Was Provided.

25) The star Betelgeuse is about 600 light-years away. If it explodes tonight, \_\_\_\_\_\_\_\_.

A) we'll know because it will be brighter than the full Moon in the sky

B) we'll know because debris from the explosion will rain down on us from space

C) we won't know about it until about 600 years from now

Answer: No Correct Answer Was Provided.

26) If we represent the solar system on a scale that allows us to walk from the Sun to Pluto in a few minutes, then \_\_\_\_\_\_\_\_.

A) the planets are the size of basketballs and the nearest stars are a few miles away

B) the planets are marble-size or smaller and the nearest stars are thousands of miles away

C) the planets are microscopic and the stars are light-years away

Answer: No Correct Answer Was Provided.

27) The total number of stars in the observable universe is roughly equivalent to \_\_\_\_\_\_\_\_.

A) the number of grains of sand on all the beaches on Earth

B) the number of grains of sand on Miami Beach

C) infinity

Answer: No Correct Answer Was Provided.

28) When we say the universe is *expanding*, we mean that \_\_\_\_\_\_\_\_.

A) everything in the universe is growing in size

B) the average distance between galaxies is growing with time

C) the universe is getting older

Answer: No Correct Answer Was Provided.

29) If stars existed but galaxies did not, \_\_\_\_\_\_\_\_.

A) we would probably still exist anyway

B) we would not exist because life on Earth depends on the light of galaxies

C) we would not exist because we are made of material that was recycled in galaxies

Answer: No Correct Answer Was Provided.

30) Could we see a galaxy that is 50 billion light-years away?

A) Yes, if we had a big enough telescope

B) No, because it would be beyond the bounds of our observable universe

C) No, because a galaxy could not possibly be that far away

Answer: No Correct Answer Was Provided.

31) The age of our solar system is about \_\_\_\_\_\_\_\_.

A) one-third of the age of the universe

B) three-fourths of the age of the universe

C) 2 billion years younger than the age of the universe

Answer: No Correct Answer Was Provided.

32) The fact that nearly all galaxies are moving away from us, with more distant ones moving faster, helped us to conclude that \_\_\_\_\_\_\_\_.

A) the universe is expanding

B) galaxies repel each other like magnets

C) our galaxy lies near the center of the universe

Answer: No Correct Answer Was Provided.

**Inclusive Astronomy**

*Use these questions to reflect on participation in science.*

33) *Group Discussion: What does a scientist look like?* The purpose of this exercise is to help you identify preconceptions that you or others may have about science and scientists.

**a.** Working independently, make a simple sketch of a professional scientist and write down five words that describe the scientist in your sketch. Then join with a group of two or three other students to share your sketches and word lists.

**b.** Make a list of all the words the group wrote down, then rank them in order of how often they were used.

**c.** Discuss any similarities, differences, or patterns you notice among the scientists described by the group members.

**d.** Discuss whether the group members feel they have much in common with professional scientists.

**e.** Discuss how feelings about what you have (or do not have) in common with scientists might affect your approach to scientific thinking.

**The Process of Science**

*These questions may be answered individually in short-essay form or discussed in groups, except where identified as group-only.*

34) *Earth as a Planet.* For most of human history, scholars assumed Earth was the center of the universe. Today, we know that Earth is just one planet orbiting the Sun, and the Sun is just one star in a vast universe. How did science make it possible for us to learn these facts about Earth?

35) *Thinking About Scale.* One key to success in science is finding a simple way to evaluate new ideas, and making a simple scale model is often helpful. Suppose someone tells you that the reason it is warmer during the day than at night is that the day side of Earth is closer to the Sun than the night side. Evaluate this idea by thinking about the size of Earth and its distance from the Sun in a scale model of the solar system.

36) *Looking for Evidence.* In this first chapter, we have discussed the scientific story of the universe but have not yet discussed most of the evidence that backs it up. Choose one idea presented in this chapter–such as the idea that there are billions of galaxies in the universe, or that the universe was born in the Big Bang, or that the galaxy contains more dark matter than ordinary matter–and briefly discuss the type of evidence you would want to see before accepting the idea. (*Hint*: It's okay to look ahead in the book to see the evidence presented in later chapters.)

37) *A Human Adventure.* Astronomical discoveries clearly are important to science, but are they also important to our personal lives? Defend your opinion.

38) *Infant Species.* In the last few tenths of a second before midnight on December 31 of the cosmic calendar, we have developed an incredible civilization and learned a great deal about the universe, but we also have developed technology through which we could destroy ourselves. The midnight bell is striking, and the choice for the future is ours. How far into the next cosmic year do you think our civilization will survive? Defend your opinion.

39) *Group Activity: Counting the Milky Way's Stars.* Work as a group to answer each part. *Note*: This activity works particularly well in groups of four students, with each student taking on one of the following roles: *scribe:* takes notes on the group's activities; *proposer:* suggests tentative explanations to the group; *skeptic:* points out weaknesses in proposed explanations; *moderator:* leads group discussion and makes sure everyone contributes.

**a.** Work together to estimate the number of stars in the Milky Way from just these two facts: (1) the number of stars within 12 light-years of the Sun, which you can count in Appendix F, and (2) the total volume of the Milky Way's disk (100,000 light-years in diameter and 1000 light-years thick), which is about 1 billion times the volume of the region of your star count.

**b.** Discuss how your value from part a compares to the value given in this chapter. Make a list of possible reasons why your technique may have underestimated or overestimated the actual number.

**Investigate Further**

40) *Alien Technology.* Some people believe that Earth is regularly visited by aliens who travel here from other star systems. For this to be true, how much more advanced than our own technology would the aliens' technology have to be? Write one to two paragraphs to give a sense of the technological difference. (*Hint*: The ideas of scale in this chapter can help you contrast the distance the aliens would have to travel with the distances we currently are capable of traveling.)

41) *Raisin Cake Universe.* Suppose that all the raisins in a cake are 1 centimeter apart before baking and 4 centimeters apart after baking.

**a.** Draw diagrams to represent the cake before and after baking.

**b.** Identify one raisin as the Local Raisin on your diagrams. Construct a table showing the distances and speeds of other raisins as seen from the Local Raisin.

**c.** Briefly explain how your expanding cake is similar to the expansion of the universe.

42) *The Hubble Extreme Deep Field.* The photo that opens this chapter is called the Hubble Extreme Deep Field. Find this photo on the Hubble Space Telescope website. Learn how it was taken, what it shows, and what we've learned from it. Write a short summary of your findings.

Answer: No Correct Answer Was Provided.

43) *The Cosmic Perspective.* Write a short essay describing how the ideas presented in this chapter affect your perspectives on your own life and on human civilization.

Answer: No Correct Answer Was Provided.

**Quantitative Problems**

*Be sure to show all calculations clearly and state your final answers in complete sentences.*

44) *Distances by Light.* Just as a light-year is the distance that light can travel in 1 year, we define a light-second as the distance that light can travel in 1 second, a light-minute as the distance that light can travel in 1 minute, and so on. Calculate the distance in both kilometers and miles represented by each of the following:

**a.** 1 light-second

**b.** 1 light-minute

**c.** 1 light-hour

**d.** 1 light-day

45) *Moonlight and Sunlight.* How long does it take light to travel from

**a.** the Moon to Earth?

**b.** the Sun to Earth?

46) *Saturn versus the Milky Way.* Photos of Saturn and photos of galaxies can look so similar that children often think the photos show similar objects. In reality, a galaxy is far larger than any planet. About how many times larger is the diameter of the Milky Way Galaxy than the diameter of Saturn's rings? (*Data*: Saturn's rings are about 270,000 km in diameter; the Milky Way is 100,000 light-years in diameter.)

47) *Driving Trips.* Imagine that you could drive your car at a constant speed of 100 km/hr (62 mi/hr), even across oceans and in space. How long would it take to drive

**a.** around Earth's equator? (Earth's circumference ≈ 40,000 km)

**b.** from the Sun to Earth?

**c.** from the Sun to Pluto? (Pluto distance ≈ 5.9 × 109 km)

**d.** to Alpha Centauri (4.4 light-years away)?

48) *Faster Trip.* Suppose you wanted to reach Alpha Centauri in 100 years.

**a.** How fast would you have to go, in km/hr?

**b.** How many times faster is the speed you found in part a than the speeds of our fastest current spacecraft (around 50,000 km/hr)?

49) *Galaxy Scale.* Consider the 1-to-1019 scale, on which the disk of the Milky Way Galaxy fits on a football field. On this scale, how far is it from the Sun to Alpha Centauri (real distance: 4.4 light-years)? How big is the Sun itself on this scale? Compare the Sun's size on this scale to the actual size of a typical atom (about 10—10 m in diameter).

50) *Age of the Universe*. Suppose we did not yet know the expansion rate of the universe, and two astronomers came up with two different measurements: Wendy measured an expansion rate for the universe that was 50% faster than the expansion rate Allan measured. Was the age of the universe that Allan inferred older or younger than the age that Wendy inferred? By how much? Explain. (*Hint*: Read the discussion of the raisin cake analogy carefully, and the answer should become clear.)