Exam

Name_____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) The farthest bright galaxies that modern telescopes are capable of seeing are up to   1) _____
    A) 1 billion light years away.
    B) 10 million light years away.
    C) 1 trillion light years away.
    D) 10 billion light years away.
    E) 1 million light years away.

2) Suppose we imagine the Sun to be about the size of a grapefruit. How big an area would the orbits   2) _____
of the eight planets of the Solar System cover?
    A) the size of a small city
    B) the size of a typical campus building
    C) the size of a typical campus
    D) the size of a western state (e.g., Colorado)
    E) the size of a typical dorm room

3) Earth is made mostly of metals and rocks. Where did this material come from?   3) _____
    A) It was made by our Sun.
    B) It was produced by nuclear fusion in stars.
    C) It was made by nuclear fission of uranium and other radioactive materials.
    D) It was produced in the Big Bang.
    E) It was created by chemical reactions in interstellar space.

4) What is *nuclear fusion*?   4) _____
    A) a process that only occurs in bombs
    B) the process of splitting nuclei to produce energy
    C) the process of turning matter into pure energy
    D) an explosion caused by putting together two volatile chemicals
    E) the process of combining lightweight nuclei to make heavier nuclei

5) Which of the following statements does *not* use the term *light-year* in an appropriate way?   5) _____
    A) It's about 4 light-years from here to Alpha Centauri.
    B) The Milky Way Galaxy is about 100,000 light-years in diameter.
    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) It will take me light-years to complete this homework assignment.

6) Light takes approximately one second to travel from the Earth to the Moon. This means that the   6) _____
Moon is approximately
    A) 1 light year from the Earth.
    B) twice the distance from the Earth to the Sun.
    C) 1 astronomical unit from the Earth.
    D) 300,000 kilometers from the Earth.
    E) 3,000 kilometers from the Earth.

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

    A) 9.46 trillion km
    B) 100 million km
    C) 1.08 billion km
    D) 300,000 km
    E) 18 million km

7) _____

8) Suppose we look at a photograph of many galaxies. Assuming that all galaxies formed at the same time after the Big Bang, which galaxy appears to us as the youngest?

    A) the galaxy that is furthest from us
    B) the galaxy that appears bluest to us
    C) the galaxy that is closest to us
    D) the galaxy that appears largest to us
    E) All galaxies would appear to have the same age.

8) _____

9) Suppose we imagine the Sun to be about the size of a grapefruit (about 10 cm across). Which of the following describes the size and distance of Earth on the same scale?

    A) Earth is the size of a golf ball about 15 meters away from the Sun.
    B) Earth is the size of a golf ball about 1 meter away from the Sun.
    C) Earth is the size of a point about 15 meters away from the Sun.
    D) Earth is the size of a point about 1 meter away from the Sun.
    E) Earth is the size of a marble about 25 miles away from the Sun.

9) _____

10) Which of the following correctly describes the concept of *galactic recycling*?

    A) Life is continuously being spread from star to star in the Milky Way.
    B) In the formation of a star, no matter is wasted as all excess material ends up recycled into planets.
    C) New galaxies are continuously being formed out of gas ejected from a previous generation of galaxies.
    D) Stars near the center of the Milky Way are continually recycled to the outskirts of the disk by their orbital motion.
    E) New stars are continuously being formed in the Milky Way out of gas that has been ejected from a previous generation of stars.

10) _____

11) What is the Sun mainly made of?

    A) hydrogen and oxygen
    B) nearly equal portions of all the elements
    C) hydrogen and helium
    D) oxygen and carbon
    E) carbon and nitrogen

11) _____

12) Which of the following is smallest?

    A) 1 AU   B) size of a typical star
    C) size of a typical planet   D) 1 light-second

12) _____

13) Which of the following is largest?

    A) size of Pluto's orbit
    B) 1 light-year
    C) distance to the nearest star (other than our Sun)
    D) size of a typical galaxy

13) _____

14) On the 1-to-10-billion scale, about how far is it to the nearest stars besides the Sun?   14) _____
   A) 4,400 kilometers
   B) 10,000 kilometers
   C) 400 kilometers
   D) 4 kilometers
   E) 1,000 kilometers

15) Suppose we imagine the Sun to be about the size of a grapefruit (about 10 cm across). How far   15) _____
   away are the nearest stars (the three stars of Alpha Centauri)?
   A) the length of a football field
   B) 2,500 miles
   C) 25,000 miles
   D) 250 miles
   E) 2.5 miles

16) If we use 1 millimeter to represent 1 light-year, how large in diameter is the Milky Way Galaxy?   16) _____
   A) 100 meters
   B) 100 millimeters
   C) 100 kilometers
   D) 1 million millimeters
   E) 1 kilometer

17) Which of the following best describes the Milky Way Galaxy?   17) _____
   A) a spiral galaxy with a disk about 100,000 light-years in diameter and containing about 100,000
      stars
   B) a spiral galaxy with a disk about 100,000 light-years in diameter and containing between 100
      billion and 1 trillion stars
   C) a spherically shaped collection of about 1 million stars that is about 100 light-years in
      diameter
   D) a spiral galaxy with a disk about a billion kilometers in diameter and containing between 100
      million and 1 billion stars
   E) a spherically shaped collection of stars including our solar system and about a dozen other
      solar systems, stretching about 4 light-years in diameter

18) How many galaxies are there in the observable universe?   18) _____
   A) about as many as the number of stars we see in the sky with our naked eyes
   B) roughly (within a factor of 10) the same as the number of stars in our galaxy
   C) about as many as the number of grains of sand on all the beaches on Earth
   D) infinity
   E) roughly a thousand times more than the number of stars in our galaxy

19) On the scale of the cosmic calendar, in which the history of the universe is compressed to 1 year,   19) _____
   how long has human civilization (*i.e.*, since ancient Egypt) existed?
   A) about a month
   B) less than a millionth of a second
   C) about half the year
   D) a few seconds
   E) a few hours

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

20) _____

    A) in late October
    B) in late September
    C) in late August
    D) in late December
    E) in late November

21) On a 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?

21) _____

    A) 1 week ago
    B) December 30
    C) 1 second ago
    D) December 25
    E) 1 day ago

22) Approximately how fast is a person located at the Earth's equator traveling due to the rotation of the Earth?

22) _____

    A) 1,700 km/hr
    B) 17 km/hr
    C) 17,000 km/hr
    D) 170 km/hr
    E) not moving at all

23) How long does it take our solar system to complete one orbit around the Milky Way Galaxy?

23) _____

    A) 100 million years
    B) 230 million years
    C) 10 thousand years
    D) 230 thousand years
    E) 1 million years

24) Which of the following statements about the Milky Way Galaxy is *not* true?

24) _____

    A) The galaxy is about 100,000 light-years in diameter.
    B) It contains between 100 billion and 1 trillion stars.
    C) Our solar system is located very close to the center of the Milky Way Galaxy.
    D) One rotation of the galaxy takes about 200 million years.

25) Which of the following correctly lists speeds from slowest to fastest? 25) _____
    A) Earth's speed of revolution about the Sun, Earth's speed of rotation on its axis, the speed of
       our solar system orbiting the center of the Milky Way Galaxy, typical speeds of stars in the
       local solar neighborhood relative to us, the speeds of very distant galaxies relative to us
    B) Earth's speed of rotation on its axis, typical speeds of stars in the local solar neighborhood
       relative to us, Earth's speed of revolution 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) the speed of our solar system orbiting the center of the Milky Way Galaxy, Earth's speed of
       revolution about the Sun, Earth's speed of rotation on its axis, the speeds of very distant
       galaxies relative to us, typical speeds of stars in the local solar neighborhood relative to us
    D) Earth's speed of revolution about the Sun, typical speeds of stars in the local solar
       neighborhood relative to us, Earth's speed of rotation on its axis, the speed of our solar system
       orbiting the center of the Milky Way Galaxy, the speeds of very distant galaxies relative to us
    E) the speeds of very distant galaxies relative to us, typical speeds of stars in the local solar
       neighborhood relative to us, Earth's speed of rotation on its axis, Earth's speed of revolution
       about the Sun, the speed of our solar system orbiting the center of the Milky Way Galaxy

26) Most of the mass in the Milky Way Galaxy is located 26) _____
    A) within the disk.
    B) in the halo (above/below the disk).
    C) in the central bulge of the galaxy.
    D) in the gas and dust.
    E) in the stars in the spiral arms.

27) The distribution of the mass of the Milky Way Galaxy is determined by 27) _____
    A) counting the number of stars.
    B) weighing various parts of the Milky Way.
    C) studying the rotation of the galaxy.
    D) studying how stars are distributed in the Milky Way.
    E) determining the amount of gas and dust.

28) From the fact that virtually every galaxy is moving away from us and more distant galaxies are 28) _____
   moving away from us at a faster rate than closer ones, we conclude that
    A) we are located at the center of the universe.
    B) the Milky Way Galaxy is expanding.
    C) the universe is expanding.
    D) the universe is shrinking.
    E) the farthest galaxies will eventually be moving faster than the speed of light.

29) By studying distant galaxies in the 1920s, Hubble made the following important discovery that led 29) _____
   us to conclude that the universe is expanding.
    A) All galaxies outside the Local Group are moving away from us, and all are moving away at
       nearly the same speed.
    B) All galaxies contain billions of stars, and all galaxies have spiral shapes.
    C) All galaxies outside the Local Group are orbiting the Local Group.
    D) All galaxies outside the Local Group are moving away from us, and the farther away they are,
       the faster they're going.
    E) All galaxies were born at the same time, and all will die at the same time.

30) 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 conclude?

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

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

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

    D) It depends: If you lived in a raisin near the left side 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 right side of the cake.

31) How many seconds are in one year? (Calculate this, do not look it up.)   31) _____

    A) about 86 thousand (86,000, or 8.6×10^5)

    B) about 3,600 (3.6×10^3)

    C) about 380 million (380,000,000, or 3.8×10^8)

    D) about 30 million (30,000,000, or 3×10^7)

32) The speed of light is about 300,000 km/s (3×10^5 km/s). How far does light travel in 30 seconds?   32) _____

    A) 9 million km (9,000,000, or 9×10^6 km)   B) 300 thousand km (300,000, or 3×10^5 km)

    C) 10 thousand km (10,000, or 10^6 km)   D) 900 thousand km (900,000, or 9×10^5 km)

33) One light-minute is the distance light travels in one minute. The speed of light is about 300,000 km/s (3×10^5 km/s). How far is one light-minute?   33) _____

    A) 18 million km (18,000,000, or 1.8×10^7 km)

    B) 9.46 trillion km (9,460,000,000,000, or 9.46×10^{12} km)

    C) 300 thousand km (300,000, or 3×10^5 km)

    D) 1.08 billion km (1,080,000,000, or 1.08×10^9 km)

34) One light-minute is the distance light travels in one minute. The speed of light is about 300,000 km/s (3×10^5 km/s). How far is 5 light-minutes?   34) _____

    A) 5.4 billion km (5,400,000,000, or 5.4×10^9 km)

    B) 47.3 trillion km (47,300,000,000,000, or 4.73×10^{13} km)

    C) 90 million km (90,000,000, or 9×10^7 km)

    D) 1.5 million km (1,500,000, or 1.5×10^6 km)

35) One light-hour is the distance light travels in one hour. The speed of light is about 300,000 km/s (3×10^5 km/s). How far is 1 light-hour?   35) _____

    A) 300 thousand km (300,000, or 3×10^5 km)

    B) 1.08 billion km (1,080,000,000, or 1.08×10^9 km)

    C) 9.46 trillion km (9,460,000,000,000, or 9.46×10^{12} km)

    D) 18 million km (18,000,000, or 1.8×10^7 km)

36) The planet Neptune is, on average, about 4.5 billion km from the sun. How long does it take light from the sun to reach Neptune? (Recall that the speed of light is about 300,000 km/s)   36) _____

    A) about 4 minutes   B) about 4 days

    C) about 4 hours   D) about 4 seconds

37) One light-year is the distance light travels in one year. The speed of light is about 300,000 km/s $(3 \times 10^5$ km/s). How far is 1 light-year?

    A) 300 thousand km (300,000, or 3×10^5 km)

    B) 9.46 trillion km (9,460,000,000,000, or 9.46×10^{12} km)

    C) 1.08 billion km (1,080,000,000, or 1.08×10^9 km)

    D) 18 million km (18,000,000, or 1.8×10^7 km)

37) _____

38) What is the diameter of the galaxy, in km?

    A) about 1 billion trillion km (10^{21} km)   B) about 100,000 km (10^5 km)

    C) about 10 trillion km (10^{13} km)   D) about 1 million trillion km (10^{18} km)

38) _____

39) If the entire galaxy (with a diameter of 100,000 light years) were represented by a circle with a diameter of 4,400 km (similar to the width of the continental United States), then how far apart would be the Sun and its nearest stellar neighbor, Proxima Centauri (which is 4.2 light years away)?

    A) about 200 meters (about 2 football fields)

    B) about 0.2 meters (about the length of an adult's forearm)

    C) about 20 meters (about the size of a large classroom)

    D) about 2 meters (about 2 long footsteps)

39) _____

40) The Earth has a radius of about 6,000 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) 1/2 of a second (0.5 s)   B) 1/ 6000 of a second (0.00015 s)

    C) 1/50 of a second (0.02s)   D) 1/300,000 of a second (0.0000033 s)

40) _____

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

    A) 100,000 light-years   B) 170,000 light-years

    C) 54,000 light-years   D) 85,000 light-years

41) _____

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

    A) 10^{18} km   B) 8.5×10^{17} km   C) 1.7×10^{18} km   D) 5.4×10^{17} km

42) _____

43) Stars nearby to our sun have an average relative speed of about 70,000 km/hour. How fast is that in km/s?

    A) about 3000 km/s   B) about 1200 km/s

    C) about 4.2 million km/s   D) about 20 km/s

43) _____

TRUE/FALSE. Write 'T' if the statement is true and 'F' if the statement is false.

44) Our solar system is located in the center of the Milky Way Galaxy.

44) _____

45) The solar system contains about 100 billion stars.

45) _____

46) A typical supercluster contains no more than about 10,000 stars.

46) _____

47) One light year is about 10 trillion kilometers.

47) _____

48) In the grapefruit model of the solar system, it would take a few minutes to walk from the Sun to Pluto.   48) _____

49) The observable universe is the same size today as it was a few billion years ago.   49) _____

50) The Milky Way is moving further away from most other galaxies in the universe.   50) _____

51) No galaxies existed before the Big Bang.   51) _____

52) *Voyager 2* should reach the nearest stars (besides the Sun) in about 500 years.   52) _____

53) Earth is always precisely 1 AU from the Sun.   53) _____

54) The solar system is a member of a galaxy containing approximately 100 billion stars.   54) _____

55) Compared to its size, the Sun is very far away from all other stars.   55) _____

56) Compared to its size, the Milky Way is very far away from all other galaxies.   56) _____

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

57) *Light Travel Time*: Because of the finite speed of light, we see more distant objects as they were in the past. For example, we see the star Alpha Centauri as it was 4.4 years ago, and the Andromeda Galaxy as it was 2.5 million years ago. Astronomers are often asked how we know that these objects still exist when we look at them in the night sky. How would you try to answer this question?

58) *The Observable Universe*: How does the age of the universe (estimated at 14 billion years) introduce the concept of the "observable universe?" Suppose you feel, as do many astronomers, that the universe is much larger than the observable universe. Do you think there is any way to obtain direct evidence for this larger universe?

59) *A Life Calendar*: Make a "life calendar" for hypothetical person. Assume that this person lived 80 years and represent the 80 year period as a single calendar year in which he or she was born on January 1st and died on December 31st. Estimate the calendar dates on which this person reached various life milestones. For example, when did he or she take their first step? Speak their first word? Start elementary school? Finish high school? When did he or she retire? Does your life calendar for this *particular* person give any insight into human lives in *general*?

60) *Stellar and galactic crowding*: The comparison of objects' sizes to the distance between them gives a sense of their relative density, i.e., how "crowded" they are. A typical human is about 1 meter across the shoulders. Compare the relative density of people in the case where they are standing on average 1 meter apart compared to a situation where they are on average 10 meters apart (hint: describe the separation in units of person-size). Now, compare the "crowding" of stars to that of galaxies. A typical star has a diameter of about 1 million km, while the average space between stars is about 5 light-years. A typical spiral galaxy in a cluster (such as the Milky Way) is 100,000 light-years across, and has another spiral galaxy within about 10 million light years.

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

61) The speed of light is 300,000 km/s. How far is a light-year? Be sure to show all work clearly on your calculation.   61) _____

62) Briefly explain what we mean by the statement "The farther away we look in distance, the further back we look in time."

62) _____

63) Starting from the Big Bang, briefly explain how our solar system came to contain the chemical elements necessary to make Earth and living organisms.

63) _____

64) Briefly explain why an expanding universe implies a beginning (called a Big Bang).

64) _____

65) Consider the following statement, and explain whether or not it is sensible: NASA hopes to build a new telescope that will allow us to see 100 million light-years into the past.

65) _____

66) Consider the following statement, and explain whether or not it is sensible: NASA hopes to build a new telescope that will allow us to see some galaxies as they appeared 8 billion years ago.

66) _____

67) Consider the following statement, and explain whether or not it is sensible: The universe is between 10 and 16 billion light-years old.

67) _____

68) Consider the following statement, and explain whether or not it is sensible: It will take me light-years to complete this homework assignment.

68) _____

69) Consider the following statement, and explain whether or not it is sensible: Someday we may build spaceships capable of traveling at a speed of 1 light-second per hour.

69) _____

70) Briefly explain how the Sun generates energy.

70) _____

71) Imagine that you could drive your car in space. Assume that you can drive at a constant speed of 100 kilometers per hour. Suppose you started driving from the Sun. How long would it take, in years, to reach Earth?

71) _____

72) Explain why it is so difficult to see planets around other stars.

72) _____

73) Based on the idea of "spaceship Earth," write one or two paragraphs explaining why it is not the case that we are "just sitting here."

73) _____

74) Consider the following statement, and explain whether or not it is sensible: Earth is always precisely 1 AU from the Sun.

74) _____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

75) Light travels at 300,000 km/sec. About how far does light travel in 10 years?
    A) about 30,000 kilometers
    B) about 10 light-years
    C) about 10 trillion kilometers
    D) about 3,000,000 kilometers
    E) about 30 million seconds

75) _____

76) In a ten-billion to one scale model, the Sun and the Earth are about the size of   76) _____
    A) a basketball and a grape.   B) a grapefruit and a grape.
    C) a grapefruit and a grain of sand.   D) a grape and a grain of sand.

77) Jupiter is about 5 AU from the Sun. In a ten billion to one scale model, Jupiter is   77) _____
    A) about 15 meters from the Sun.   B) about a kilometer from the Sun.
    C) less than one meter from the Sun.   D) about 75 meters from the Sun.

78) Our textbook discusses the cosmic calendar, a model of the history of the universe scaled to a single   78) _____
    year. The length of time represented by one month on this cosmic calendar is therefore
    A) about one billion years.
    B) about 1000 years.
    C) about ten billion years.
    D) about one million years.
    E) about ten million years.

79) Place the following items in order of actual physical size, from smallest to largest.   79) _____
    A) star, planet, solar system, galaxy
    B) star, planet, galaxy, solar system
    C) planet, star, galaxy, solar system
    D) planets and stars are about the same size, solar system, galaxy
    E) planet, star, solar system, galaxy

80) Rank the following 4 items by how long it takes for light to reach us from these objects, from   80) _____
    shortest to longest.
    A) the Andromeda Galaxy, the center of the Milky Way, Pluto, Sun
    B) Sun, Pluto, the Andromeda Galaxy, center of the Milky Way
    C) Sun, Pluto, center of the Milky Way, the Andromeda Galaxy
    D) Pluto, Sun, the Andromeda Galaxy, center of the Milky Way
    E) Pluto, Sun, center of Milky Way, the Andromeda Galaxy

81) Rank the following 3 items from nearest to farthest. Hint: the Orion Nebula is a cloud of gas in   81) _____
    which young stars are being born within the Milky Way, about 1,500 light-years away.
    A) Alpha Centauri, Orion Nebula, star in the center of the Milky Way
    B) star in the center of the Milky Way, Orion Nebula, Alpha Centauri
    C) star in the center of the Milky Way, Alpha Centauri, Orion Nebula

82) One of the most fundamental discoveries about the universe has been that it is expanding. "The   82) _____
    universe is expanding" means
    A) our estimate for the size of the universe has increased over the last century.
    B) distances between most galaxies are getting larger.
    C) galaxies are growing with time.
    D) the cosmological horizon is growing with time.

83) One of the main reasons the Hubble Space Telescope was built and launched was to measure how   83) _____
    fast the universe is expanding. If the expansion turns out to be faster than we thought, our estimate
    for the age of the universe will be
    A) unaffected.
    B) older (more time between now and the Big Bang).
    C) younger (less time between now and the Big Bang).

84) Wendy measures a recession velocity for two distant galaxies, well outside our Local Group of galaxies. Galaxy A has a recession velocity of 35,000 km/s and Galaxy B has a recession velocity of 70,000 km/s. What can she say about the distances to those galaxies?

    A) She can't say anything about the distances to Galaxy A or B.
    B) Galaxy B is twice as far as Galaxy A.
    C) Galaxy A is twice as far as Galaxy B.
    D) Galaxy A is four times as far as Galaxy B.
    E) Galaxy B is four times as far as Galaxy A.

84) _____

85) You have taken a picture of a galaxy 1 billion light years away. That picture shows

    A) a galaxy that is 13 billion years old.
    B) a galaxy that is 1 billion light years old.
    C) a galaxy that is 1 billion years old.
    D) a galaxy as it was 1 billion years ago.

85) _____

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

    A) about 65 million years ago
    B) about 10 billion years ago
    C) about 20 billion years ago
    D) about 4.5 billion years ago
    E) about 14 billion years ago

86) _____

87) How do scientists estimate how old the universe is?

    A) They measure the abundances of radioactive elements in meteorites, and use their half-lives to calculate the age.
    B) They make a guess; no one really knows how old the universe is.
    C) They measure the speeds and distances of galaxies, and calculate the time it took for them to travel that distance.
    D) They measure how fast the Sun is losing energy, and how much energy it has to lose.
    E) They look up the answer in a book.

87) _____

88) Which statement correctly locates the formation of the Earth and the appearance of the first humans on the cosmic calendar, which compresses the 14-billion year history of the universe into one "year," where "now" is exactly midnight, Dec 31?

    A) Earth forms in early September, life begins in November, and humans appear on Dec 15.
    B) Earth forms in January, life begins in April, and humans appear in early December.
    C) Earth forms in early September, life begins in late September, humans appear a few hours before midnight, Dec 31.
    D) Earth forms in January, life begins in September, and humans appear in October.

88) _____

89) Which object has aged the most since it emitted the light we see today?

    A) the Sun
    B) Pluto
    C) a star near the center of the Milky Way
    D) a star in the Andromeda Galaxy

89) _____

90) Which of the following is *not* a general difference between a planet and a star?

    A) All planets are made of rock, and all stars are made of gas.
    B) Planets are dimmer than stars.
    C) Planets are smaller than stars.
    D) Planets orbit stars, while stars orbit the center of the galaxy.

90) _____

91) Our solar system consists of _____.   91) _____
     A) the Sun and several nearby stars, as well as the planets and other objects that orbit these stars
     B) the Sun and the planets, and nothing else
     C) a few hundred billion stars, bound together by gravity
     D) the Sun and all the objects that orbit it

92) A typical galaxy is a _____.   92) _____
     A) system consisting of one or a few stars orbited by planets, moons, and smaller objects
     B) relatively small, icy object orbiting a star
     C) large, glowing ball of gas powered by nuclear energy
     D) collection of a few hundred million to a trillion or more stars, bound together by gravity
     E) nearby object orbiting a planet

93) Which of the following best describes what we mean by the *universe*?   93) _____
     A) a vast collection of stars that number as many as the grains of sand on all the beaches on Earth
     B) all the galaxies in all the superclusters
     C) The universe is another name for our Milky Way Galaxy.
     D) the sum total of all matter and energy

94) What do astronomers mean by the *Big Bang*?   94) _____
     A) the explosion of a massive star at the end of its life
     B) the event that marked the beginning of the expansion of the universe
     C) a gigantic explosion that blew all the galaxies in the universe to smithereens
     D) the event that marked the birth of our solar system

95) What do we mean when we say that the universe is *expanding*?   95) _____
     A) Within galaxies, average distances between star systems are increasing with time.
     B) Average distances between galaxies are increasing with time.
     C) Everything in the universe is gradually growing in size.
     D) The statement is not meant to be literal; rather, it means that our knowledge of the universe is
        growing.

96) Based on observations of the universal expansion, the age of the universe is about _____. 96) _____
     A) 14 trillion years   B) 14 billion years
     C) 14 million years   D) 14,000 years

97) A television advertisement claiming that a product is light-years ahead of its time does not make 97) _____
     sense because _____.
     A) a light-year is an astronomically large unit, so a product could not possibly be so advanced
     B) light-years can only be used to talk about light
     C) it doesn't specify the number of light-years
     D) it uses "light-years" to talk about time, but a light-year is a unit of distance

98) The term *observable universe* refers to _____.   98) _____
     A) the portion of the universe that can be seen by the naked eye
     B) the portion of the universe that is not hidden from view by, for example, being below the
        horizon
     C) that portion of the universe that we can see *in principle*, given the current age of the universe
     D) that portion of the universe that we have so far photographed through telescopes

12

99) On a scale in which the distance from Earth to the Sun is about 15 meters, the distance from Earth to the Moon is _____.

    A) about 30 meters   B) about 1 meter

    C) about 5 meters   D) small enough to fit within your hand

99) _____

100) 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) about the distance across the state of Delaware

    B) about the distance across 50 football fields

    C) about the distance across the United States

    D) 100 meters

100) _____

101) The number of stars in the Milky Way Galaxy is approximately _____.

    A) a few hundred thousand   B) a few hundred billion

    C) a few hundred million   D) a few hundred

101) _____

102) 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 average distance between any planet and the Sun

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

102) _____

103) What is the ecliptic plane?

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

    C) the plane of Earth's equator   D) the plane of the Milky Way Galaxy

103) _____

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

    A) one week

    B) one day

    C) one year

    D) one month

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

104) _____

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

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

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

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

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

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

105) _____

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

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

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

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

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

106) _____

107) How are galaxies important to our existence? 107) _____
    A) Without galaxies, there could not have been a Big Bang.
    B) Without galaxies, the universe could not be expanding.
    C) Galaxies recycle material from one generation of stars to the next, and without this recycling we could not exist.
    D) Deep in their centers, galaxies created the elements from which we are made.

108) When we look at an object that is 1,000 light-years away, we see it _____. 108) _____
    A) looking just the same as our ancestors would have seen it 1,000 years ago
    B) as it is right now, but it appears 1,000 times dimmer
    C) as it was 1,000 light-years ago
    D) as it was 1,000 years ago

109) Suppose we look at two distant galaxies: Galaxy 1 is twice as far away as Galaxy 2. In that case, _____. 109) _____
    A) we are seeing Galaxy 1 as it looked at a *later* time in the history of the universe than Galaxy 2
    B) Galaxy 1 must be twice as big as Galaxy 2
    C) we are seeing Galaxy 1 as it looked at an *earlier* time in the history of the universe than Galaxy 2
    D) Galaxy 2 must be twice as old as Galaxy 1

110) 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? 110) _____
    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 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.
    D) 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.

111) 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? 111) _____
    A) several years   B) several days
    C) several weeks   D) several thousand years

112) The total number of stars in the observable universe is about _____. 112) _____
    A) the same as the number of grains of sand on all the beaches on Earth
    B) 100 billion
    C) the same as the number of grains of sand in a school sandbox
    D) the same as the number of atoms that make up the Earth

113) Where is our solar system located within the Milky Way Galaxy? 113) _____
    A) very near the center of the galaxy
    B) in the halo of the galaxy
    C) roughly halfway between the center and the edge of the visible disk of the galaxy
    D) at the far edge of the galaxy's visible disk

114) If we imagine the history of the universe compressed into one year, dinosaurs became extinct _____.   114) _____
    A) about 3 weeks ago   B) about 6 months ago
    C) about an hour ago   D) yesterday morning

115) Relative to the age of the universe, how old is our solar system?   115) _____
    A) It is about 1% as old as the universe.
    B) It is about one-third the age of the universe.
    C) It is between about 5% and 10% as old as the universe.
    D) It is nearly the same age as the universe.

116) How do the speeds at which we are moving with Earth's rotation and orbit compare to the speeds   116) _____
    of more familiar objects?
    A) Earth's rotation carries most people around the axis at about the speed at which the Space
        Shuttle orbits Earth, and Earth's orbit carries us around the Sun at nearly the speed of light.
    B) 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.
    C) 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 Shuttle orbits Earth.
    D) 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.

117) Why do the patterns of the stars in our sky look the same from year to year?   117) _____
    A) 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
    B) because the stars in the constellations are so far away
    C) because the stars in the constellations move so slowly-typically about the speed of a
        snail-that their motions are not noticeable
    D) because the stars in the constellations are not moving

118) Astronomers infer that the universe is expanding because distant galaxies all appear to _____.   118) _____
    A) rotate rapidly
    B) be made mostly of dark matter
    C) be growing in size
    D) be moving away from us, with more distant ones moving faster

119) Which statement about motion in the universe is *not* true?   119) _____
    A) The mysterious *dark matter* is the fastest-moving material in the universe.
    B) Your speed of rotation around Earth's axis is faster if you live near the equator than if you live
        near the North Pole.
    C) Except for a few nearby galaxies, all other galaxies are moving away from us.
    D) Some stars in the Milky Way Galaxy are moving toward us and others are moving away from
        us.

1) D
2) C
3) B
4) E
5) E
6) E
7) C
8) A
9) C
10) E
11) C
12) C
13) D
14) A
15) B
16) A
17) B
18) B
19) D
20) D
21) C
22) A
23) B
24) C
25) B
26) B
27) C
28) C
29) D
30) B
31) D
32) A
33) A
34) C
35) B
36) C
37) B
38) A
39) A
40) C
41) B
42) C
43) D
44) FALSE
45) FALSE
46) FALSE
47) TRUE
48) TRUE
49) FALSE
50) TRUE

51) TRUE
52) FALSE
53) FALSE
54) TRUE
55) TRUE
56) FALSE
57) Will vary.
58) Will vary.
59) Will vary.
60) Students should reference the ratio of distance to size (or vice versa), to show that compared to their size, stars are much, much further apart than galaxies.
61) 1 light-year
= (speed of light) × (1 yr)
$$= \left[300{,}000\frac{km}{s}\right] \times \left[1 \text{ yr} \times \frac{km}{s} \times \frac{365}{1 \text{ yr}} \times \frac{24 \text{ hr}}{1 \text{ day}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{60 \text{ s}}{1 \text{ min}}\right]$$
= 9,460,000,000,000 km
62) It means that when we look at a distant object, we see it as it was some time in the past, rather than as it is now. This is because the light we see has taken time to travel from the object to us.
63) The Big Bang produced hydrogen and helium. Over time, stars have converted about 2 percent of this material into heavier elements, including all the elements of which we and Earth are made. Stars expel this material through winds and explosions, and the galaxy recycles it into new generations of stars. When a new star system forms, it therefore contains the ingredients needed to make planets and living organisms.
64) The fact that the universe is expanding means the average distance between galaxies is growing, which implies that this average distance was smaller in the past. Extrapolating back in time, there must have been a time when the distance between galaxies (or their precursors) was zero, which must be the beginning of the universe.
65) Not sensible: uses light-years as a time.
66) Sensible: By looking to a distance of 8 billion light-years, we can see objects as they looked 8 billion years ago.
67) This statement does not make sense because it uses the term *light-year* as a time, rather than as a distance.
68) This statement does not make sense because it uses the term *light-year* as a time, rather than as a distance.
69) This statement is fine. A light-second is 300,000 kilometers, so it simply says that we'll someday build spaceships that can travel at a speed of 300,000 km/hr.
70) The Sun generates energy through nuclear fusion in its core, converting hydrogen into helium. This process releases energy because a small amount of the mass of the hydrogen is converted to energy.
71) $t = \dfrac{149.6 \text{ million km}}{100 \text{ km/hr}} = 1.5$ million hours = 171 years

It would take about 171 years to drive from the Sun to Earth.
72) Planets are very faint compared to the stars they orbit. Moreover, they are very close to their parent star compared to the distance between stars. On the 1-to-10 billion scale, where the Sun is the size of a grapefruit and Earth is a pinhead about 15 meters way, the nearest star is several thousand kilometers away. Together, this makes it extremely difficult to distinguish the faint light of a planet from the star it orbits. (Nevertheless, many planets in sizes ranging from Earth-size to larger-than-Jupiter have been *indirectly* detected orbiting nearby stars, and a few massive Jupiter-like planets have been *directly* imaged, as well.)

73) Far from just sitting still, we on Earth are moving relative to the Sun, planets, stars, and even other galaxies. The rotation of Earth causes the most noticeable changes in the sky. This motion around Earth's axis causes the Sun and stars to appear to rise and set, producing what we call a "day." The revolution of Earth about the Sun produces the monthly changes of the constellations, the seasonal weather changes due to Earth's tilt, and the parallax of some stars. The precession of Earth's axis, a very slow movement that has a period of 26,000 years, causes the movement of the North Star, and the changing position of the equinoxes and solstices.

The motion of the Sun relative to the stars in the local solar neighborhood is at an extremely fast speed, although barely noticeable. Over time, this movement causes the patterns of the stars in the sky to change. The rotation of the galaxy means that the entire solar system is also orbiting the center of the Milky Way. This also produces motions of stars and clouds of gas. The expansion of the universe, the fact that the space between most galaxies is increasing with time, means that almost all galaxies outside the Local Group are moving away from us, with the more distant ones moving away faster. All of these motions, although not felt by us on Earth, are observed by watching the sky and prove that we are not "just sitting here."

74) Not sensible: One AU is the average distance between Earth and the Sun.
75) B
76) C
77) D
78) A
79) E
80) C
81) A
82) B
83) C
84) B
85) D
86) E
87) C
88) C
89) D
90) A
91) D
92) D
93) D
94) B
95) B
96) B
97) D
98) C
99) D
100) C
101) B
102) B
103) A
104) C
105) A
106) C
107) C
108) D
109) C
110) A

111) D
112) A
113) C
114) D
115) B
116) C
117) B
118) D
119) A