

Directed Reading

Section: Structure of the Sun

1. From what did people once believe the sun's energy comes?

2. About how long ago did scientists discover that the sun's energy is quite different from fire?

THE SUN'S ENERGY

_____ 3. What does the sun look like to the unaided eye?

- a. a dazzling, brilliant ball that has no distinct features
- b. a bright disc with ridges and valleys
- c. a dazzling ball with seas and dark areas
- d. a softly glowing sphere with flaming edges

_____ 4. Why do astronomers use special filters to look at the sun?

- a. The sun seems only one color otherwise.
- b. No telescope can view the sun otherwise.
- c. The sun's brightness can damage your eyes.
- d. They view the sun only at night.

_____ 5. What do scientists use to break up the sun's light into a spectrum?

- a. a spectrometer
- b. a spectrograph
- c. a spectra-reader
- d. a light graphometer

_____ 6. What causes dark lines to form in the spectra of stars?

- a. Gases in the stars' interiors emit specific wavelengths of light.
- b. Gases in the stars' outer layers absorb specific wavelengths of light.
- c. Magnetic currents in the stars' outer layers distort wavelengths of light.
- d. Gases in the stars' outer layers emit specific wavelengths of light.

_____ 7. What factors determine which gases produce visible spectral lines?

- a. the size of the star
- b. the elements in a star
- c. the type of spectrograph that is used
- d. the temperature of a star's outer layers

Directed Reading *continued*

- _____ **8.** What important factor can be determined by studying the spectrum a star?
- a.** the amounts of elements that are not contained in the star
 - b.** the rate at which gases are released into a star's atmosphere
 - c.** the numbers of gases that are present in a star's atmosphere
 - d.** the amounts of elements that are present in a star's atmosphere
- _____ **9.** How can scientists deduce the temperature, density, and pressure of a gas in a star's surface?
- a.** by studying the spectrum of the star
 - b.** by studying the spectrum of nearby stars
 - c.** by studying the brightness of the star
 - d.** by calculating the size of the star
- _____ **10.** To identify the elements in a star's atmosphere, scientists
- a.** match the spectral lines of starlight against the spectra from known stars.
 - b.** match the spectral lines of starlight to those of Earth's elements.
 - c.** match the spectral lines of starlight against the spectra of gases in Earth's atmosphere.
 - d.** match the spectral lines of starlight to one another.
- _____ **11.** Why does matching the spectral lines of starlight to those of Earth's elements enable scientists to identify the elements in a star's atmosphere?
- a.** Groups of elements have the same spectral lines.
 - b.** Individual elements may have the same spectral lines.
 - c.** Each element has a unique pattern of spectral lines.
 - d.** Each group of elements has unique spectral lines.
- _____ **12.** What element makes up about 75% of the sun's mass?
- a.** helium
 - b.** iron
 - c.** hydrogen
 - d.** radium
- _____ **13.** How much of the sun's total mass is composed of hydrogen and helium?
- a.** about 75%
 - b.** about 85%
 - c.** about 90%
 - d.** about 99%

Directed Reading *continued*

- _____ **14.** The sun's spectrum reveals that it contains
- a.** almost nothing besides hydrogen.
 - b.** almost all chemical elements.
 - c.** only hydrogen and helium.
 - d.** hydrogen, helium, oxygen, and carbon.
- _____ **15.** What atomic process combines nuclei of small atoms to form more-massive nuclei?
- a.** nuclear fission
 - b.** nuclear fusion
 - c.** nuclear half-life
 - d.** nuclear decay
- _____ **16.** Nuclei of which atoms are the primary fuel for the sun?
- a.** hydrogen
 - b.** helium
 - c.** protons
 - d.** electrons

17. What is the common makeup of a hydrogen atom?

18. What happens inside the sun to the electrons in hydrogen atoms?

19. How many steps occur in nuclear fusion inside the sun?

20. Describe the first step of nuclear fusion.

21. What happens to the charge of one hydrogen proton?

22. What is a particle that is emitted by one proton?

23. What is the result of the first step of fusion?

24. Describe the second step of nuclear fusion.

Directed Reading *continued*

25. Describe the third step of nuclear fusion.

26. What is released in the fusion of two two-proton-one-neutron nuclei?

27. What particles are fused together to form a helium nucleus?

28. How often is energy released during nuclear fusion?

29. When hydrogen fusion occurs in the sun, what is always one of the final products?

30. How does the mass of a helium nucleus compare with the mass of the hydrogen nuclei that fused to form it?

31. What is converted into energy during the series of fusion reactions that form helium nuclei inside the sun?

32. What causes the sun to shine and gives the sun its high temperature?

MASS CHANGING INTO ENERGY

_____ **33.** In 1905, Albert Einstein proposed that a

- a.** small amount of matter yields a large amount of energy.
- b.** large amount of matter was equal to a large amount of energy.
- c.** large amount of matter yields a small amount of energy.
- d.** small amount of matter was equal to a small amount of energy.

Directed Reading *continued*

_____ **34.** At the time of Einstein's 1905 proposal, what two factors were unknown?

- a. nuclear fission and electrons
- b. energy and an atom's nucleus
- c. energy and matter
- d. nuclear fusion and the nucleus of the atom

_____ **35.** Einstein's proposal was

- a. part of his special theory of relativity.
- b. part of his general theory of physics.
- c. his basic theory about the makeup of atoms.
- d. part of his special theory of energy.

_____ **36.** What equation is part of Einstein's theory?

- a. $E=mc$
- b. $E^2=mc$
- c. $E=mc^2$
- d. $E=m^2c$

_____ **37.** In the equation $E = mc^2$, "E" represents

- a. mass, or the amount of matter.
- b. a constant.
- c. matter.
- d. energy produced.

_____ **38.** In the equation $E=mc^2$, "m" represents

- a. the total mass in the universe.
- b. the mass of one ounce of lead.
- c. mass, or the amount of matter that is changed.
- d. the amount of matter that remains.

_____ **39.** In the equation $E=mc^2$, "c" represents

- a. energy.
- b. matter.
- c. the diameter of the sun.
- d. the speed of light.

_____ **40.** What is the speed of light?

- a. 300,000 km/hr
- b. 300,000 km/s
- c. 300,000 m/hr
- d. 300,000 m/s

41. What can Einstein's equation be used to calculate?

Directed Reading *continued*

42. How much hydrogen is changed into helium in the sun every second?

43. What subatomic particle is given off during fusion?

44. How long does it take neutrinos that escape from the sun to reach Earth?

45. What does the study of neutrinos indicate?

THE SUN'S INTERIOR

In the space provided, write the letter of the temperature that matches the part of the sun.

_____ **46.** core

a. 3,800°C

_____ **47.** chromosphere

b. 6,000°C

_____ **48.** sunspot

c. 4,000°C to 50,000°C

_____ **49.** radiative zone

d. 1,000,000°C

_____ **50.** corona

e. 2,000,000° C

f. 2,000,000° C to 7,000,000°C

_____ **51.** photosphere

g. 15,000,000°C

_____ **52.** convective zone

_____ **53.** What has revealed what the invisible layers of the sun may be like?

- a.** the solar wind
- b.** neutrinos
- c.** computer models
- d.** the sun's corona

_____ **54.** In recent years, more detail has been learned about what is happening inside the sun by careful studies of

- a.** motions in the sun's corona.
- b.** motions on the sun's surface.
- c.** movement of sunspots.
- d.** changes in energy from the sun.

Directed Reading *continued*

_____ **55.** What is the size of the sun's core?

- a. 25% of 1,390 km
- b. 25% of 13,900 km
- c. 25% of 139,000 km
- d. 25% of 1,390,000 km

56. What is the sun's core made up of?

57. How does the mass of the sun compare with the mass of Earth?

58. What effect does the sun's large mass have on the density of the sun's core?

59. Compare the nuclei of atoms on Earth and in the sun's core.

60. What factors in the sun's core force nuclei close enough to fuse?

61. What is the most common nuclear reaction inside the sun?

62. What zone in the sun's interior surrounds the core, and what is its temperature?

63. In the radiative zone, in what form does energy move outward?

64. What zone surrounds the radiative zone, and what is its temperature?

65. Describe how energy produced in the sun's core moves through the convective zone. Compare the movement to an example on Earth.

Directed Reading *continued*

66. What causes the movement of gases in the convective zone?

THE SUN'S ATMOSPHERE

_____ **67.** To what does the word atmosphere refer, when applied to the sun?

- a. the sheath of air surrounding the sun
- b. all of the gases that make up the sun
- c. the uppermost region of solar gases
- d. the regions of gases above the sun's core

_____ **68.** What are the three layers of the sun's atmosphere?

- a. ionosphere, troposphere, stratosphere
- b. photosphere, chromosphere, convection zone
- c. photosphere, chromosphere, corona
- d. core, corona, photosphere

_____ **69.** What is the innermost layer of the solar atmosphere called?

- a. photosphere
- b. chromosphere
- c. corona
- d. solar wind

70. What is the sun's photosphere?

71. Why are we able to see the photosphere from Earth?

72. What are sunspots?

73. What layer lies above the photosphere? How did this layer get its name?

Directed Reading *continued*

74. How do gases move in the chromosphere?

75. Describe the upward movement of gas in the chromosphere.

76. How do spacecraft study the sun?

77. What is the outermost layer of the sun's atmosphere called?

78. Describe the size and temperature of the corona.

79. How can the corona stop most subatomic particles from escaping into space, even though it is not very dense?

80. Under what condition may the corona be visible during the day?

Skills Worksheet

Directed Reading

Section: Solar Activity

1. How do the gases that make up the sun's interior and atmosphere behave?

2. What causes the continuous rising and sinking of the sun's gases?

3. What else keeps the sun's gases in motion?

4. Why don't all locations on the sun rotate at the same speed?

5. On average, how long does it take the sun to rotate once?

SUNSPOTS

_____ 6. What do the movements of gases in the sun's convective zone and the movements caused by the sun's rotation produce?

- a. solar wind
- b. convection currents
- c. charged ions
- d. magnetic fields

_____ 7. Why are some regions of the photosphere so much cooler than others?

- a. The sun's surface temperatures vary wildly.
- b. Less energy is being transferred to the regions.
- c. Changes in the magnetic fields reduce heat.
- d. More energy is being transferred to the regions.

Directed Reading *continued*

- _____ **8.** How much cooler are the cool regions than the surrounding photosphere?
- a.** up to 3,000,000°C
 - b.** up to 300,000°C
 - c.** up to 30,000°C
 - d.** up to 3,000°C

9. What is a sunspot?

10. What is granulation?

11. How might the diameter of a large sunspot compare to the size of Earth?

THE SUNSPOT CYCLE

- _____ **12.** What did sunspots first reveal about the sun?
- a.** The sun rotates.
 - b.** The sun is not made of fire.
 - c.** The sun is fueled by nuclear fusion.
 - d.** The sun has a core.

- _____ **13.** Later, astronomers learned that the numbers and positions of sunspots vary in a cycle that lasts about
- a.** 75 years.
 - b.** 50 years.
 - c.** 27 years.
 - d.** 11 years.

- _____ **14.** A sunspot cycle begins when
- a.** there is a sudden increase in the number of sunspots all across the sun.
 - b.** the number of sunspots is very high but begins to decrease.
 - c.** the number of sunspots is very low but begins to increase.
 - d.** the location of sunspots on the sun suddenly changes.

Directed Reading *continued*

_____ **15.** Where do groups of sunspots initially appear?

- a. at the sun's poles
- b. at the sun's equator
- c. all across the sun's surface
- d. about midway between the sun's equator and poles

_____ **16.** Over the next few years after they appear, the number of sunspots

- a. increases until they reach a peak of 10 to 20 sunspots.
- b. increases until they reach a peak of more than 100 sunspots.
- c. decreases steadily until there are no sunspots at all.
- d. stabilizes between 40 and 50 sunspots.

17. What happens after the number of sunspots reaches its peak?

18. At what point does the sunspot cycle end and begin again?

SOLAR EJECTIONS

_____ **19.** The solar-activity cycle is caused by

- a. the alignment of solar system planets.
- b. the changing solar magnetic field.
- c. the rate at which fusion occurs in the solar core.
- d. the changing pattern of currents in the convective layer.

_____ **20.** The solar-activity cycle is characterized by

- a. decreases in solar surface events.
- b. increases in solar surface events.
- c. increases and decreases in sunspot activity.
- d. increases and decreases in various types of solar activities.

_____ **21.** What are events in which the sun emits atomic particles called?

- a. solar cycles
- b. solar eruptions
- c. solar ejections
- d. solar events

Directed Reading *continued*

- _____ **22.** One form of atmospheric disturbance on the sun is called a prominence, which can be described as
- a.** whirlpools in the photosphere.
 - b.** huge clouds of glowing gases.
 - c.** rivers of gas that look like streams.
 - d.** dark regions in the photosphere.
- _____ **23.** What shape do prominences take?
- a.** huge arches that reach high above the sun's surface
 - b.** huge circular storms on the sun's surface
 - c.** massive waves that cross the sun's surface
 - d.** giant masses of gas that resemble mountains
- _____ **24.** How does each solar prominence get its shape?
- a.** It follows curved lines of magnetic force from a region of one magnetic polarity to a field of the same polarity.
 - b.** It erupts from the sun's surface but is pulled back down by the sun's gravity, forming a curve.
 - c.** It follows the curved shape of the sun's surface.
 - d.** It follows curved lines of magnetic force from a region of one magnetic polarity to a field of the opposite polarity.
- _____ **25.** What are the most violent of all solar disturbances?
- a.** prominences
 - b.** sunspots
 - c.** solar flares
 - d.** coronal mass ejections
- _____ **26.** A solar flare is a
- a.** sudden outward eruption of electrically charged particles, such as electrons and protons.
 - b.** brief outward eruption of atomic particles, such as protons and neutrinos.
 - c.** gradual increase in the stream of charged particles that make up the solar wind.
 - d.** huge, arched prominence that breaks its magnetic field and streams outward.
- _____ **27.** Although the trigger for a solar flare is unknown, scientists know that
- a.** solar flares occur on a regular cycle that lasts about two years.
 - b.** solar flares release the energy stored in the strong magnetic fields of sunspots.
 - c.** solar flares are closely associated with the alignment of the planets in the solar system.
 - d.** solar flares are so powerful that they can be seen clearly in daytime.

Directed Reading *continued*

_____ **28.** What can be formed by the release of energy in a solar flare?

- a. prominences
- b. coronal streams
- c. coronal loops
- d. waves in the solar wind

_____ **29.** How long do most solar flares last?

- a. Few eruptions last more than an hour.
- b. Most eruptions last for two or three hours.
- c. Few eruptions last more than a minute.
- d. Most eruptions last for a week.

_____ **30.** A coronal mass ejection is

- a. a part of the corona that is thrown off from the sun.
- b. a part of a coronal loop that does not curve back to the sun.
- c. a prominence that breaks away from its magnetic field.
- d. another name for a certain type of solar flare.

_____ **31.** What is the space around Earth that contains a magnetic field?

- a. the magnetometer
- b. the magnetic corona
- c. the magnetosphere
- d. the magnet band

32. What are geomagnetic storms? What are they caused by?

33. With what frequency do geomagnetic storms occur?

AURORAS

_____ **34.** What are auroras?

- a. halos of light around stars and the moon
- b. long arches of gas on the sun's surface
- c. electromagnetic sparks in the sun's atmosphere
- d. bands of light in the sky

Directed Reading *continued*

- _____ **35.** How are auroras caused?
- a.** They are caused by the interaction of solar wind and Earth's magnetosphere.
 - b.** They are caused by the interaction of solar wind and Earth's atmosphere.
 - c.** The solar wind bends around Earth.
 - d.** The solar wind changes as it gets farther from the sun.
- _____ **36.** Where on Earth are auroras usually seen?
- a.** near Earth's equator
 - b.** everywhere in Earth's atmosphere
 - c.** close to Earth's magnetic poles
 - d.** only in Earth's northern hemisphere
- _____ **37.** Why are auroras usually seen close to Earth's magnetic poles?
- a.** Electrically charged particles reach only Earth's magnetic poles.
 - b.** Electrically charged particles are guided toward the poles by the planet's rotation.
 - c.** Electrically charged particles are guided toward Earth's magnetic poles by Earth's magnetosphere.
 - d.** Electrically charged particles are more easily seen through the thin air near the poles.
- _____ **38.** How does the solar wind produce the colorful sheets of light?
- a.** Electrically charged particles heat up in Earth's atmosphere and begin to glow.
 - b.** Electrically charged particles strike the atoms and gas molecules in the upper atmosphere.
 - c.** Electrically charged particles enter the magnetosphere and begin to glow.
 - d.** Electrically charged particles explode once they are in contact with the atoms and gases of the atmosphere.
- _____ **39.** What are auroras near the north pole called?
- a.** aurora borealis (northern lights)
 - b.** aurora australis (southern lights)
 - c.** aurora borealis (northern lights)
 - d.** aurora australis (southern lights)
- _____ **40.** What are auroras near the south pole called?
- a.** aurora borealis (northern lights)
 - b.** aurora australis (southern lights)
 - c.** aurora borealis (northern lights)
 - d.** aurora australis (southern lights)

Directed Reading *continued*

41. How far above Earth's surface do auroras normally occur?

42. When are auroras most frequent?

43. How often are auroras visible across the northern contiguous United States?

44. Where in the United States are auroras visible almost every clear, dark night?

45. In addition to Earth, where else have auroras been recorded?
