Name Date Period

Chapter 3 Free Response

1)

2)

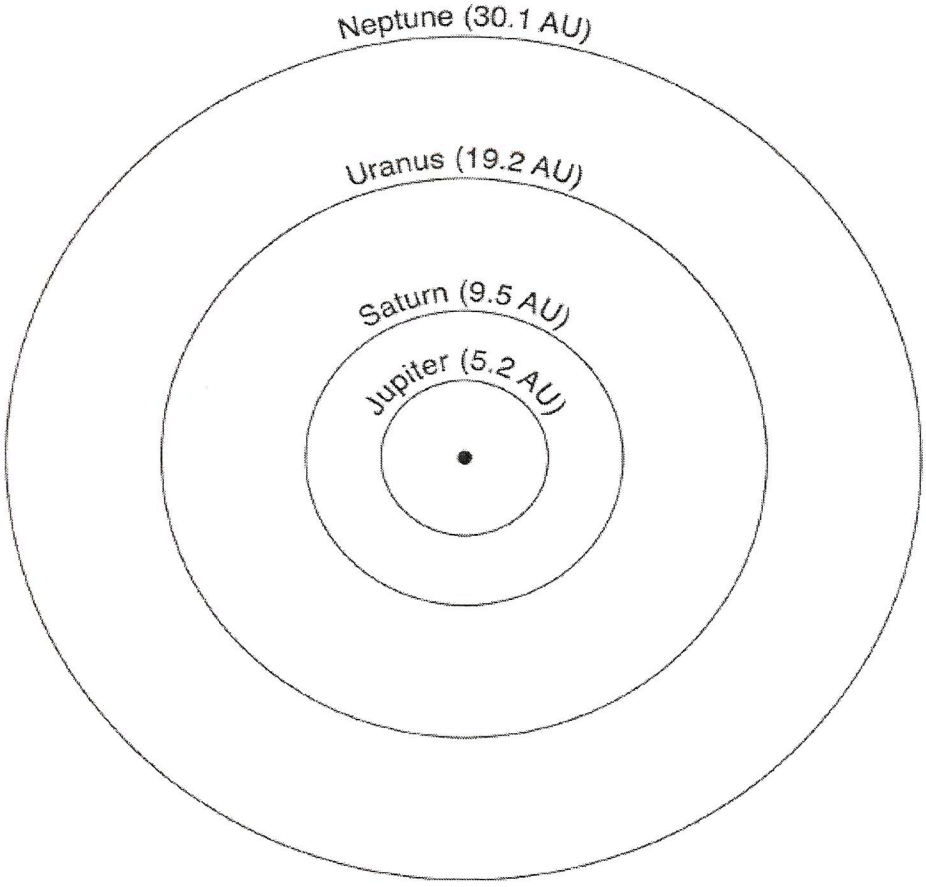
3)

4)

1 centimeter = 100,000 kilometers

5)

6)



7)

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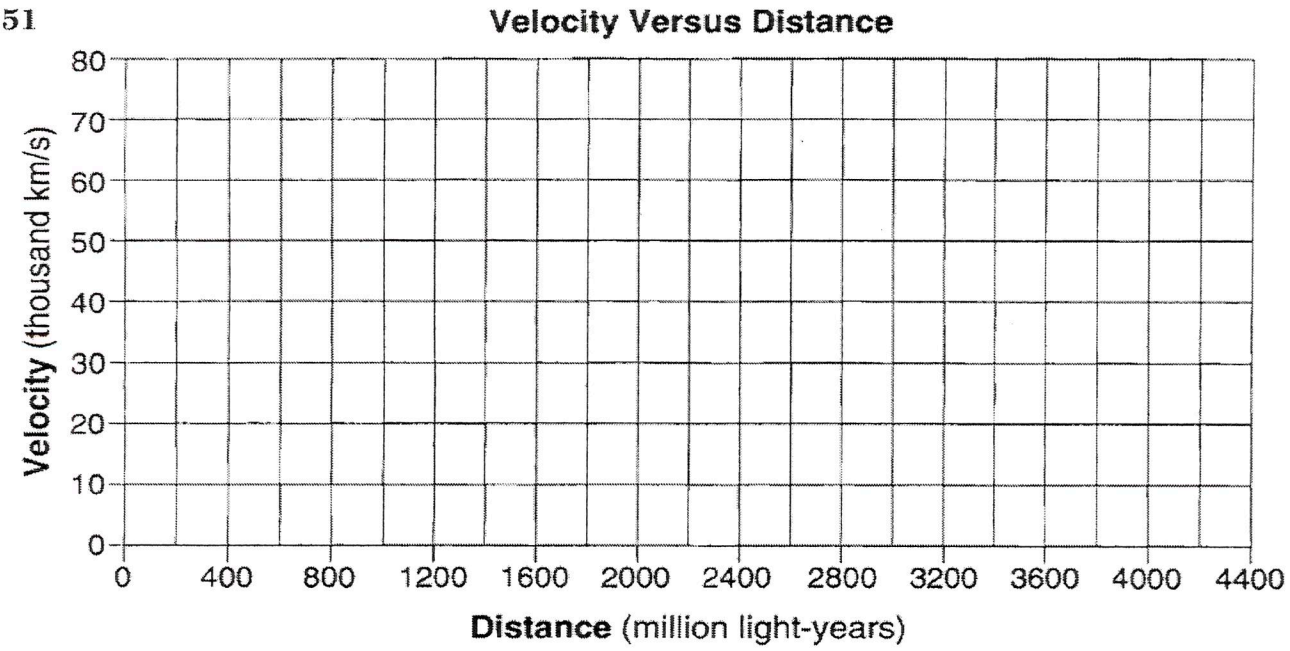
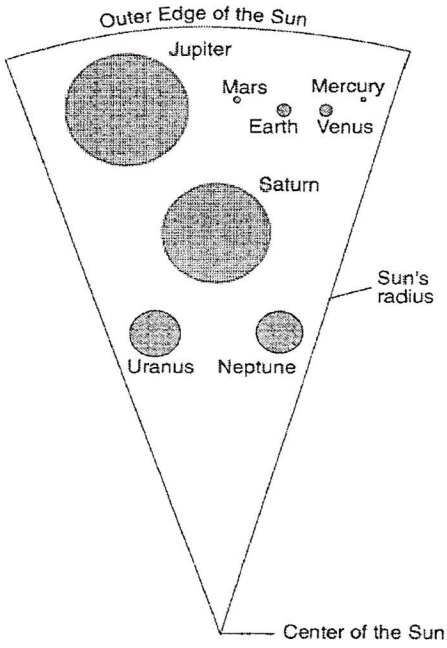


11) _____

12)

	Temperature		Luminosity	
Stars	Hotter	Cooler	Brighter	Dimmer
Procyon B				
Barnard's Star				
Rigel				



13) _____

14 and 15 on diagram

16) _____

17) _____

18) _____

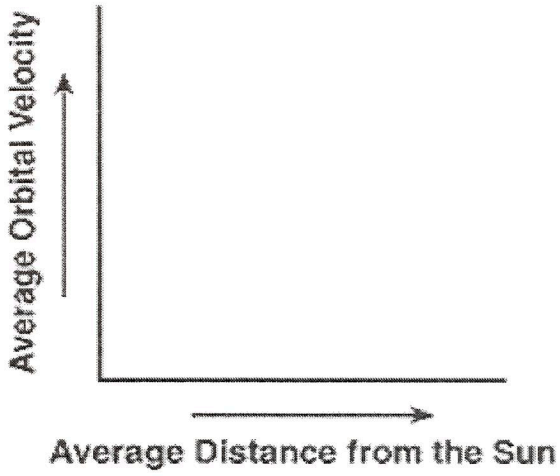
_____

19) _____

20) _____

21) _____

22)



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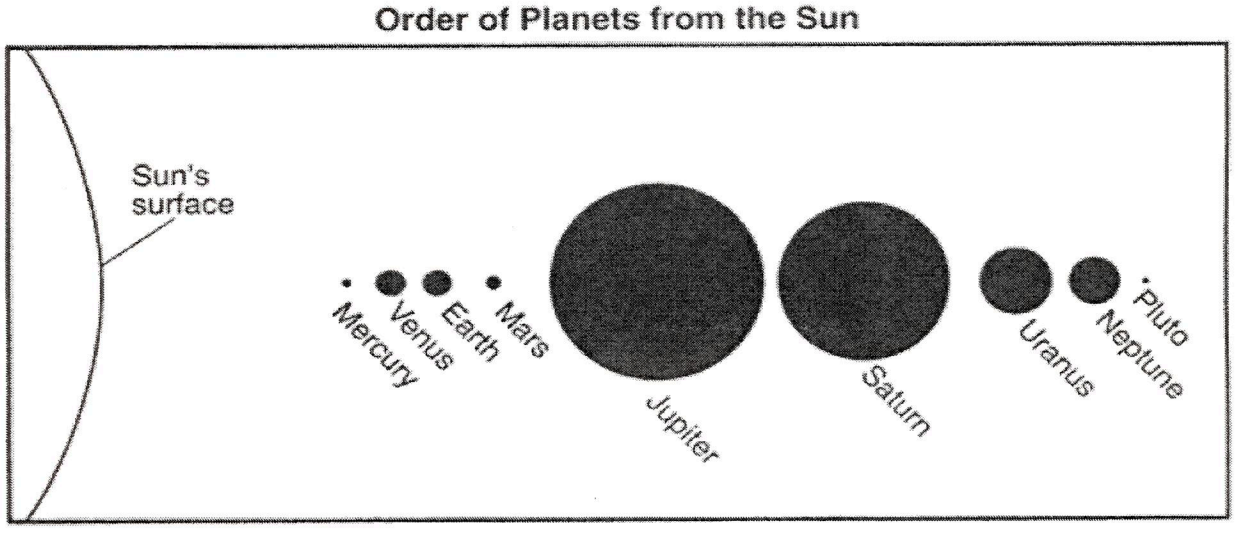


(Distances are not drawn to scale)

25) _____

Name

Chapter 3 Free Response

Base your answers to questions **1** through **5** on

the table below, which lists some information about *Barnard's Star.*

Barnard's Star

Distance from Sun	• 6.0 light-years* • currently moving toward the Sun (and Earth) and will get as close as 3.8 light-years in approximately 11,000 years
Characteristics of Barnard's Star	• less than 17 percent of the Sun's mass • approximately 20 percent of the Sun's diameter • age thought to be between 11 and 12 billion years old and may last another 40 billion years • no planets observed orbiting Barnard's Star

* A light-year is the distance light travels in one year.

1. If a planet with the same mass as Earth were discovered orbiting *Barnard's Star* at the same distance that Earth is orbiting the Sun, why would there be less gravitational attraction between this new planet and *Barnard's Star* than there is between Earth and the Sun?

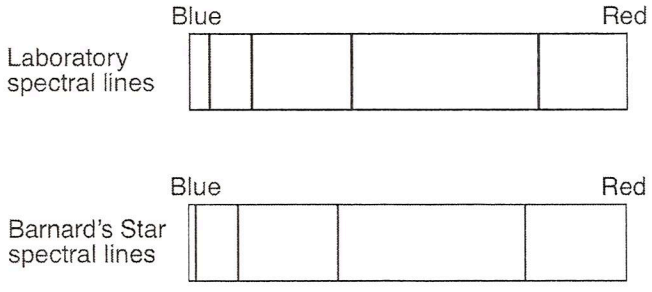
2. List *Barnard's Star*, the Sun, and the universe in order by age from oldest to youngest.

3. Compared to the surface temperature and luminosity of the Sun, describe the relative surface temperature and the relative luminosity of *Barnard's Star.*

4. The distance from point *A* to point *S* on the line below represents the equatorial diameter of the Sun. On this line, place a point labeled *B* at the correct scale distance from point *A* to represent the equatorial diameter of *Barnard's Star.*

1 centimeter = 100,000 kilometers

5. The diagram below shows four spectral lines produced by glowing hydrogen gas in a laboratory and four spectral lines produced by hydrogen gas as seen in the light from *Barnard's Star.*



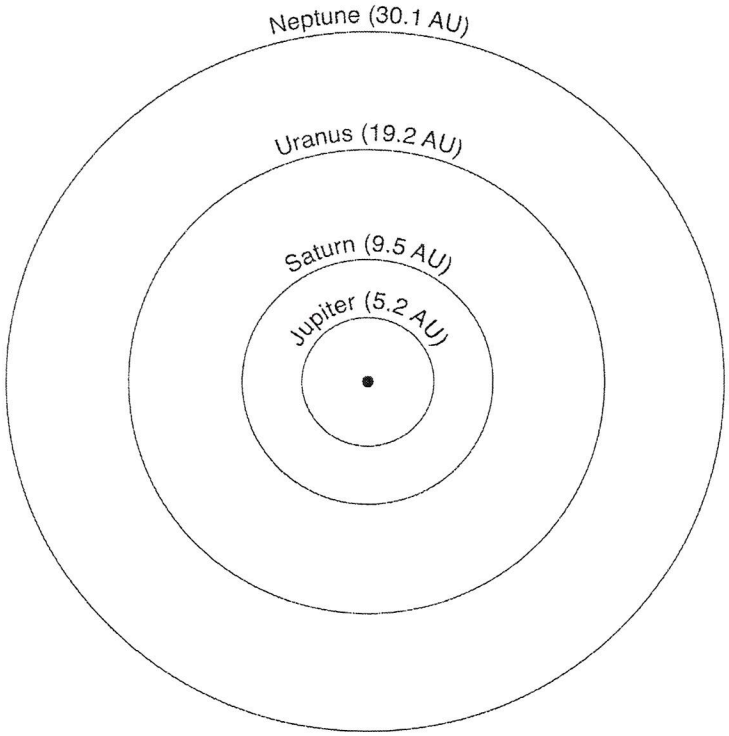
Explain why the positions of the spectral lines of *Barnard's Star* are all shifted toward the blue end of the spectrum.

6. Base your answer to the following question on the table below, which shows information about five large objects in the Kuiper Belt. The Kuiper Belt is located approximately 30 to 1000 astronomical units (AU) from the Sun. An astronomical unit is the average distance between Earth and the Sun, 149.6 million kilometers.

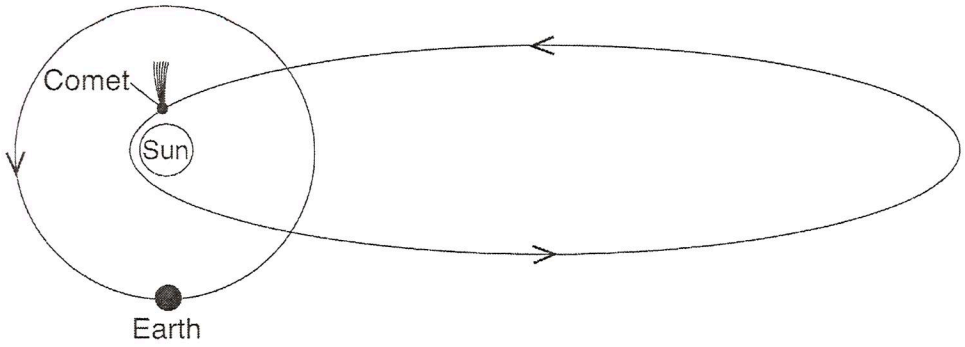
Kuiper Belt Data

	Orbit Characteristics			
Kuiper Belt Objects	**Closest Distance to the Sun** (AU)	**Farthest Distance from the Sun** (AU)	**Eccentricity**	**Approximate Equatorial Diameter** (km)
Varuna	40.47	45.13	0.053	900
Eris	37.77	97.56	0.442	2400
Quaoar	41.92	45.28	0.039	1260
Sedna	76.15	975.05	0.855	1500
Ixion	30.04	49.36	0.243	1065

The diagram shows the orbits of some of the planets in our solar system. The approximate average distances from the Sun, in astronomical units, are indicated. On the diagram, place an **X** to show the closest distance of Ixion to the Sun.



7. Base your answer to the following question on the diagram below, which shows Earth's orbit and the orbit of a comet within our solar system.



(Not drawn to scale)

Explain why the time required for one revolution of the comet is more than the time required for one revolution of Earth.

Base your answers to questions **8** through **10** on the data table below, which shows some galaxies, their distances from Earth, and the velocities at which they are moving away from Earth.

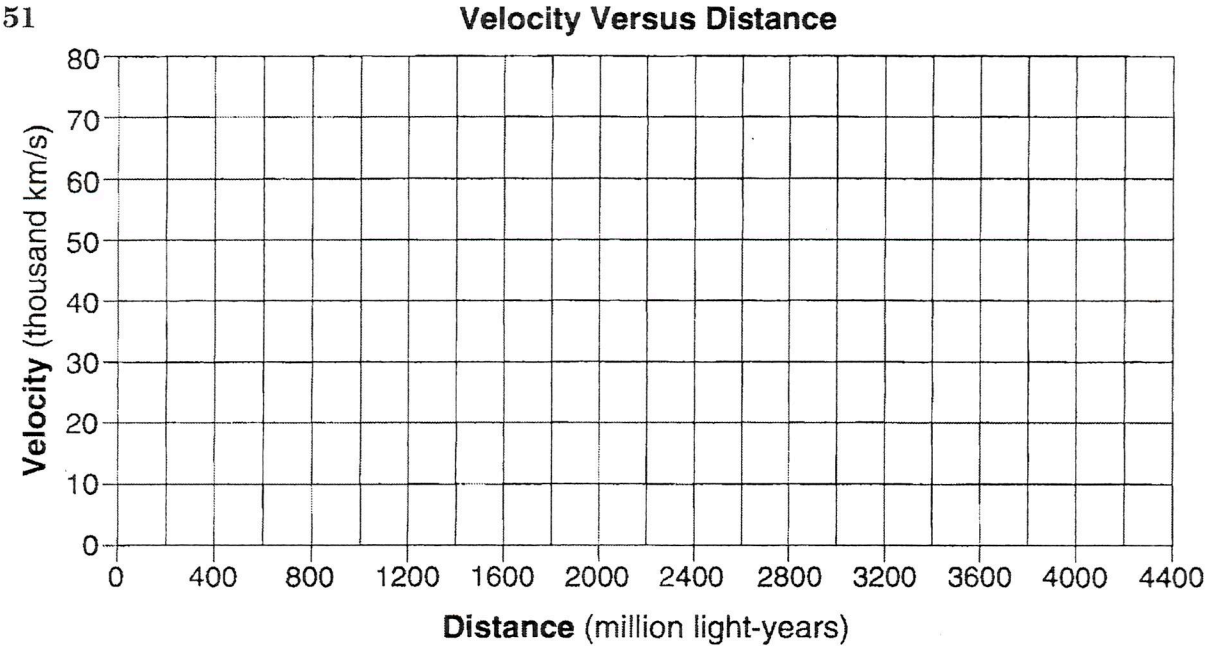
Name of Galaxy	**Distance** (million light-years)	**Velocity** (thousand km/s)
Virgo	70	1.2
Ursa Major 1	900	15
Leo	1100	19
Bootes	2300	40
Hydra	3600	61

One light-year = distance light travels in one year

8. Another galaxy is traveling away from Earth at a velocity of 70 thousand kilometers per second. Estimate that galaxy's distance from Earth in million light-years.

9. State the general relationship between a galaxy's distance from Earth and the velocity at which the galaxy is moving away from Earth.

10. On the grid below, use an **X** to plot the distance and velocity for each galaxy from the data table to show the relationship between each galaxy's distance from Earth and the velocity at which it is moving away from Earth. Connect the **X**s with a smooth line.



Base your answers to questions **11** and **12** on on the passage below and on your knowledge of stars and galaxies.

Stars

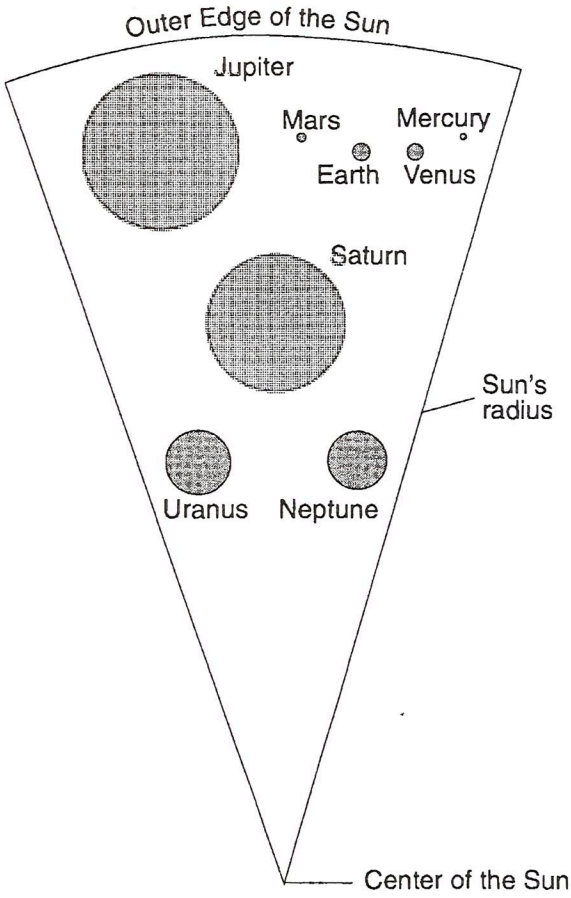
Stars can be classified according to their properties, such as diameter, mass, luminosity, and temperature. Some stars are so large that the orbits of the planets in our solar system would easily fit inside them. Stars are grouped together in galaxies covering vast distances. Galaxies contain from 100 billion to over 300 billion stars. Astronomers have discovered billions of galaxies in the universe.

11. The star *Betelgeuse* is farther from Earth than the star *Aldebaran.* Explain why *Betelgeuse* appears brighter or more luminous than *Aldebaran.*

12. Complete the table by placing an **X** in the boxes that indicate the temperature and luminosity of each star compared to our Sun.

	Temperature		Luminosity	
Stars	Hotter	Cooler	Brighter	Dimmer
Procyon B				
Barnard's Star				
Rigel				

Base your answers to questions **13** through **15** on the diagram in your answer booklet, which shows the relative diameter sizes of the planets compared to the radius of the Sun.

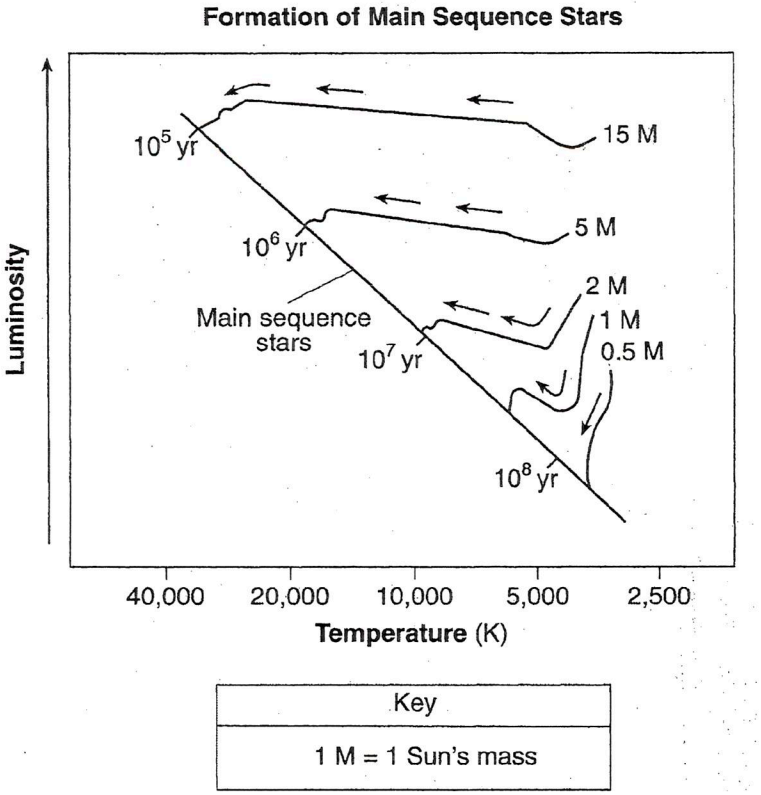


13. How many times larger is the diameter of the Sun than the diameter of Jupiter?

14. On the diagram above, place an **X** on the planet with the *lowest* density.

15. On the diagram above, circle only the terrestrial planets.

Base your answers to questions **16** through **18** on the graph below, which shows the early formation of main sequence stars of different masses (M). The arrows represent temperature and luminosity changes as each star becomes part of the main sequence. The time, needed for each star to develop into a main sequence star is shown on the main sequence line.

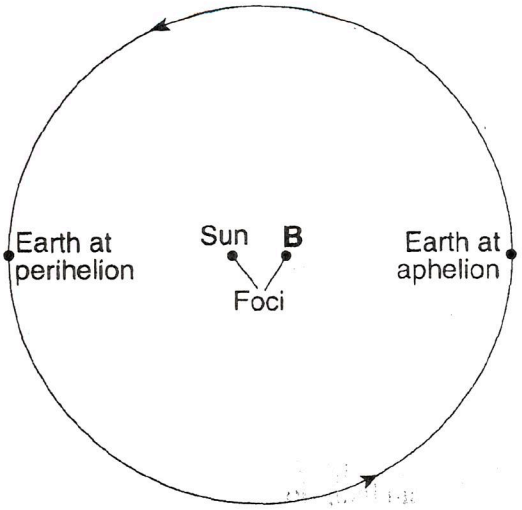


16. Identify the force that causes the accumulation of matter that forms the stars.

17. Describe the change in luminosity of a star that has an original mass of 0.5 M as it progresses to a main sequence star.

18. Describe the relationship between the original mass of a star and the length of time necessary for it to become a main sequence star.

Base your answers to questions **19** through **21** on on the diagram below, which represents a model of Earth's orbit. Earth is closest to the Sun at one point in its orbit (perihelion) and farthest from the Sun at another point in its orbit (aphelion). The Sun and point B represent the foci of this orbit.



(Not drawn to scale)

19. Describe how the shape of Earth's orbit would differ if the Sun and focus B were farther apart.

20. Describe the change that takes place in the gravitational attraction between Earth and the Sun as Earth moves from perihelion to aphelion and back to perihelion during one year.

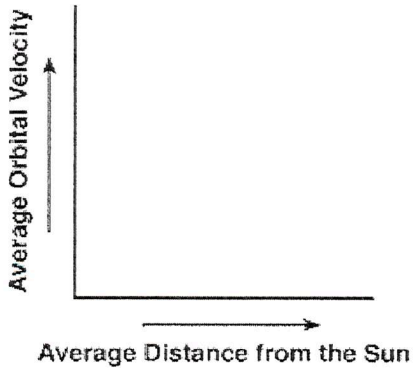
21. Explain why Earth's orbit is considered to be elliptical.

Base your answers to questions **22** and **23** on the data table below, which shows the average distance from the Sun, the average surface temperature, and the average orbital velocity for each planet in our solar system.

Data Table

Planet	**Average Distance from Sun** (millions of km)	**Average Surface Temperature** (°C)	**Average Orbital Velocity** (km/sec)
Mercury	58	167	47.9
Venus	108	457	35.0
Earth	150	14	29.8
Mars	228	–55	24.1
Jupiter	778	–153	13.1
Saturn	1427	–185	9.7
Uranus	2869	–214	6.8
Neptune	4496	–225	5.4

22. On the graph below, draw a line to indicate the general relationship between a planet's average distance from the Sun and its average orbital velocity.



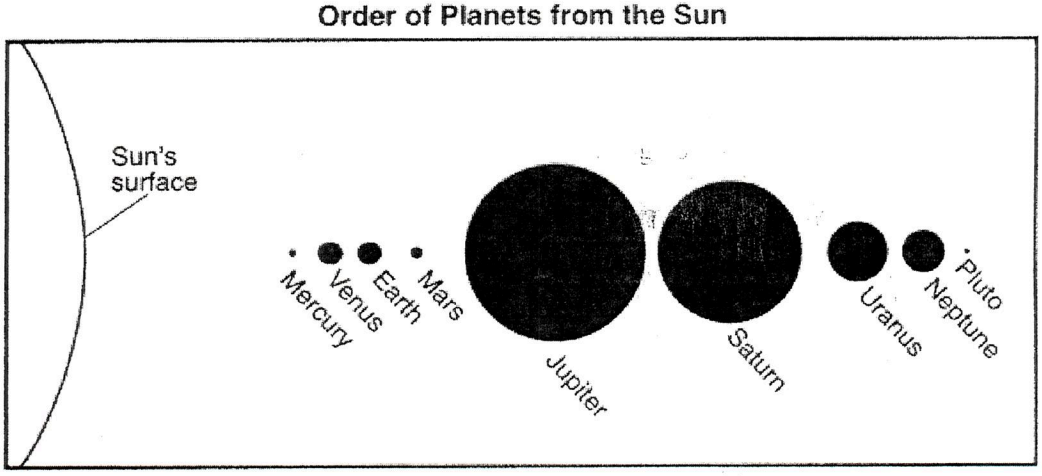
23. State the relationship between the average distance from the Sun and the average surface temperature of the Jovian planets.

Base your answers to questions **24** and **25** on the passage below.

The Future of the Sun

Hydrogen gas is the main source of fuel that powers the nuclear reactions that occur in the Sun. But just like many sources of fuel, the hydrogen is in limited supply. As the hydrogen gas is used up, scientists predict that the helium created as an product of earlier nuclear reactions will begin to fuel new nuclear reactions. When this happens, the Sun is expected to become a red giant star with a radius that would extend out past the orbit of Venus and possibly out as far as Earth's orbit. Earth probably not survive this change in the Sun's size. But no need to worry at this time. The Sun is not expected to expand to this size for a few billion years.

24. On the diagram of the planets and the Sun's surface, draw a vertical line to represent the inferred location of the Sun's surface when it becomes a red giant star.



(Distances are not drawn to scale)

25. Identify the nuclear reaction referred to in this passage that combines hydrogen gas to form helium and produces most of the Sun's energy.