

#### AIM 4: What are galaxies?

##### HW

- Read “Galaxies of Stars” p239-242
- Do all questions on Part A&B-1 on p242&243

##### Review Unit

- Do all Chapter Review Questions p244-248

A galaxy is a huge cluster of stars and other matter in space.

- Galaxies are separated into groups with large, relatively empty spaces between them.
- The Sun is located in The Milky Way galaxy in a spiral arm well away from the center. There are about 100 billion stars in the Milky Way.



A star is a self-luminous celestial body made of gases.

- The Sun contains 99% of the mass in the solar system therefore gravity is great and if no outward pressure were present the Sun would collapse. Fortunately a nuclear reaction called fusion (the burning of hydrogen to form helium) creates enough energy to prevent this from happening.
- Once a star is born from interstellar clouds it burns hydrogen to form helium in a process called nuclear fusion.
- Once all the hydrogen is consumed the star collapses and starts burning helium to form carbon, it is now called a red giant.
- Once all the helium is consumed only carbon remains and it is now called a white dwarf or the final stage of stars.

The luminosity and temperature of stars is illustrated by a graph in the reference table “Luminosity and Temperature of Stars”. The main sequence is an area containing "middle aged" stars like the Sun

##### The Doppler shift

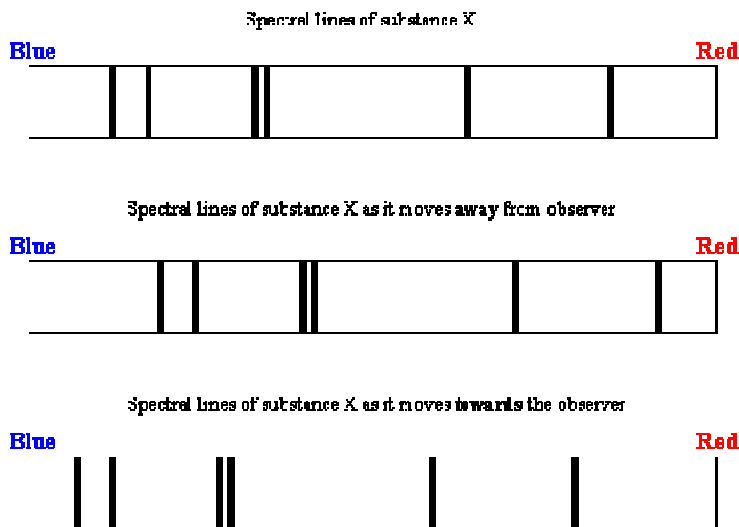
###### Blueshift

- The radiation emitted by an object moving toward an observer is squeezed and its wavelength decreases or shifts towards blue wavelength.

###### redshift

- The radiation emitted by an object moving away an observer is stretched and its wavelength increases or shifts towards red wavelength.

Ex: Spectral lines are like “signatures” of elements. Each element is identified by its spectral lines.



Galaxies show a redshift therefore they are moving away from each other. The universe is expanding.

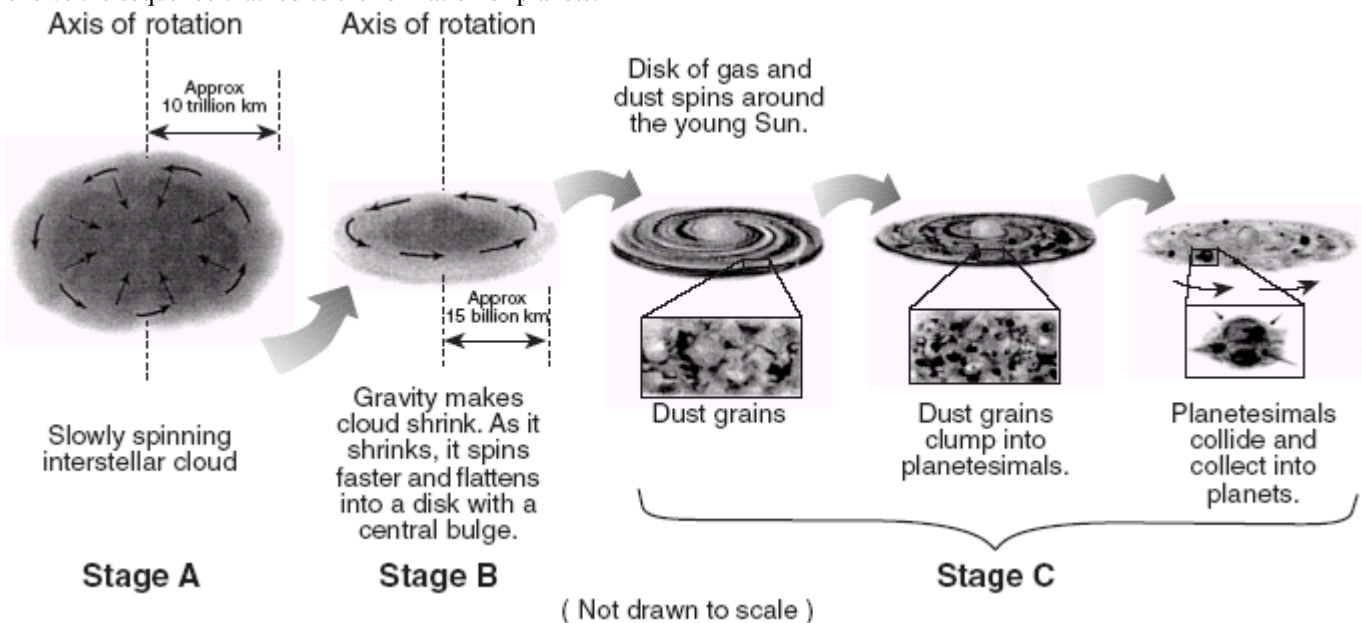
**TEST YOUR UNDERSTANDING**

8/07

6 Astronomers viewing light from distant galaxies observe a shift of spectral lines toward the red end of the visible spectrum. This shift provides evidence that

- (1) orbital velocities of stars are decreasing
- (2) Earth’s atmosphere is warming
- (3) the Sun is cooling
- (4) the universe is expanding

Base your answers to questions 42 and 43 on the diagram below, which shows an inferred sequence in which our solar system formed from a giant interstellar cloud of gas and debris. Stage A shows the collapse of the gas cloud, stage B shows its flattening, and stage C shows the sequence that led to the formation of planets.



42 From stage B to stage C, the young Sun was created

- (1) when gravity caused the center of the cloud to contract
- (2) when gravity caused heavy dust particles to split apart
- (3) by outgassing from the spinning interstellar cloud
- (4) by outgassing from Earth’s interior

43 After the young Sun formed, the disk of gas and dust

- (1) became spherical in shape
- (2) formed a central bulge
- (3) became larger in diameter
- (4) eventually formed into planets

6/07

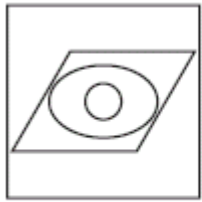
2 When viewed from Earth, the light from very distant galaxies shows a red shift. This is evidence that these distant galaxies are

- (1) revolving around the Sun
- (2) revolving around the Milky Way
- (3) moving away from Earth
- (4) moving toward Earth

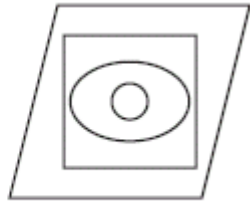
25 The symbols below are used to represent different regions of space.

Universe = □ Earth = ○ Galaxy = ▱ Solar system = ⊙

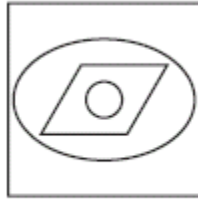
Which diagram shows the correct relationship between these four regions? [If one symbol is within another symbol, that means it is part of, or included in, that symbol.]



(1)



(3)



(2)



(4)

1/07

6 Which list shows stars in order of increasing temperature?

- (1) Barnard's Star, Polaris, Sirius, Rigel      (2) Aldebaran, the Sun, Rigel, Procyon B  
(3) Rigel, Polaris, Aldebaran, Barnard's Star      (4) Procyon B, Alpha Centauri, Polaris, Betelgeuse

12 Most scientists believe the Milky Way Galaxy is

- (1) spherical in shape      (2) 4.6 billion years old  
(3) composed of stars revolving around Earth      (4) one of billions of galaxies in the universe

8/06

Base your answers to questions 51 through 53 on the passage below and on your knowledge of Earth science.

### 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 end 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 will 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.

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

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

53 Explain why a red giant star, similar to *Aldebaran*, has a greater luminosity than the Sun.

Base your answers to questions 80 through 82 on the passage below and on your knowledge of Earth science.

### Asteroids

Most known asteroids are found orbiting the Sun approximately halfway between the orbits of Mars and Jupiter, in a vast ring known as the Asteroid Belt. Occasionally, though, an asteroid leaves this orbit belt and moves into a more eccentric orbit that brings it into the inner solar system. This sudden change may be caused by an impact with another asteroid or by the gravitational pull of Jupiter or Mars. The closest known near-Earth collision was in 1994, when asteroid 1994 XL1 came within the Moon's orbit at a distance of 100,000 kilometers from Earth. Earth had missed hitting this asteroid by a mere 52 minutes. This asteroid was only about 15 hours away from Earth when it was first noticed. Only 30 feet in diameter, 1994 XL1 was 100,000 times fainter than an object that could be seen with the naked eye. Each year other asteroids are spotted coming close to Earth. Evidence on Earth indicates that some asteroids have come close enough to be drawn into Earth by gravitational attraction. A 110-mile-wide crater discovered by oil geologists under the Yucatan Peninsula and the Gulf of Mexico is one such piece of evidence. This crater is closely linked to the extinction of the dinosaurs. Some scientists estimate that a 10-mile-wide asteroid caused this crater.

80 Approximately how many million kilometers from the Sun is the Asteroid Belt?

81 State *one* probable reason why asteroid 1994 XL1 was so close to Earth before being spotted by astronomers.

82 Some scientists believe an asteroid impact on Earth caused the extinction of the last of the dinosaurs. How many million years ago did this asteroid impact occur?

6/06

6 Compared to other groups of stars, the group that has relatively low luminosities and relatively low temperatures is the

- (1) Red Dwarfs      (2) White Dwarfs      (3) Red Giants      (4) Blue Supergiants

7 Which sequence correctly lists the relative sizes from smallest to largest?

- (1) our solar system, universe, Milky Way Galaxy      (2) our solar system, Milky Way Galaxy, universe  
(3) Milky Way Galaxy, our solar system, universe      (4) Milky Way Galaxy, universe, our solar system

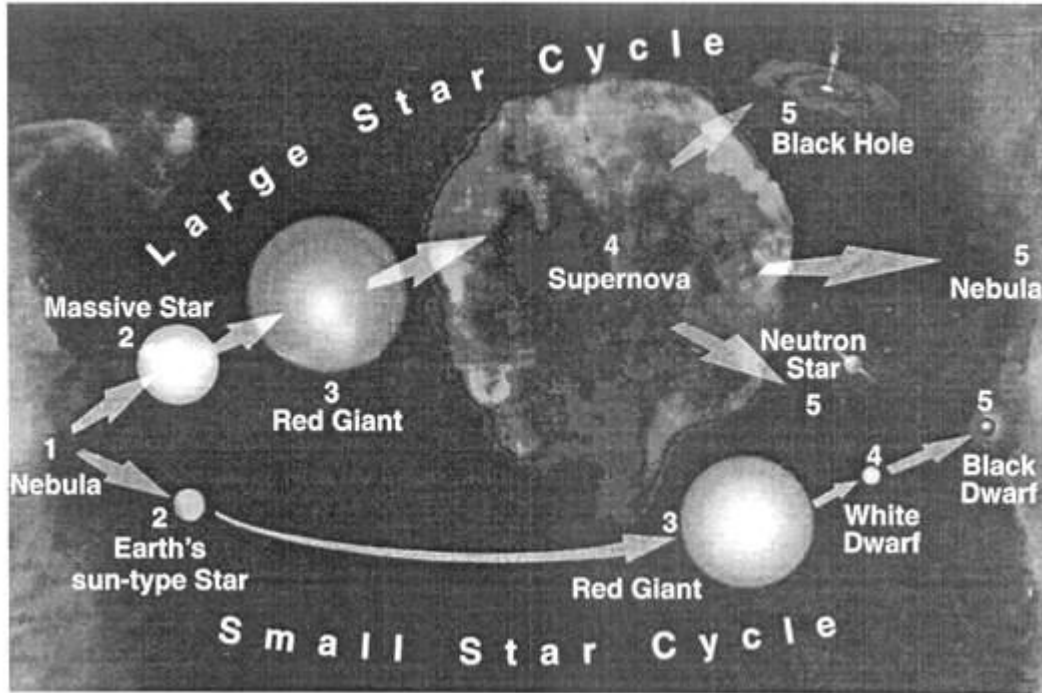
1/06

8 Compared to the surface temperature and luminosity of massive stars in the Main Sequence, the smaller stars in the Main Sequence are

- (1) hotter and less luminous      (2) hotter and more luminous      (3) cooler and less luminous      (4) cooler and more luminous

6/04  
 Base your answers to questions 36 through 38 on the diagram below, which shows two possible sequences in the life cycle of stars, beginning with their formation from nebular gas clouds in space.

The Life Cycles of Stars



- 36 According to the diagram, the life-cycle path followed by a star is determined by the star's initial  
 (1) mass and size (2) temperature and origin (3) luminosity and color (4) luminosity and structure
- 37 Stars like Earth's Sun most likely formed directly from a (1) nebula (2) supernova (3) red giant (4) black dwarf
- 38 According to the diagram, a star like Earth's Sun will eventually  
 (1) explode in a supernova (2) become a black hole (3) change into a white dwarf (4) become a neutron star
- 56 Using the "Luminosity and Temperature of Stars" graph in the *Earth Science Reference Tables*, list the five stars below in order of *decreasing* relative luminosity.
- 1/04  
 Which celestial feature is largest in actual size? (1) the Moon (3) the Sun (2) Jupiter (4) the Milky Way
- 8/03  
 6 Which star color indicates the hottest star surface temperature? (1) blue (2) white (3) yellow (4) red
- 6/03  
 2 The redshift of light from distant galaxies provides evidence that the universe is  
 (1) shrinking, only (2) expanding, only (3) shrinking and expanding in a cyclic pattern (4) remaining the same size

Base your answers to questions 58 through 60 on the information, data table, and diagram below and on your knowledge of Earth science.

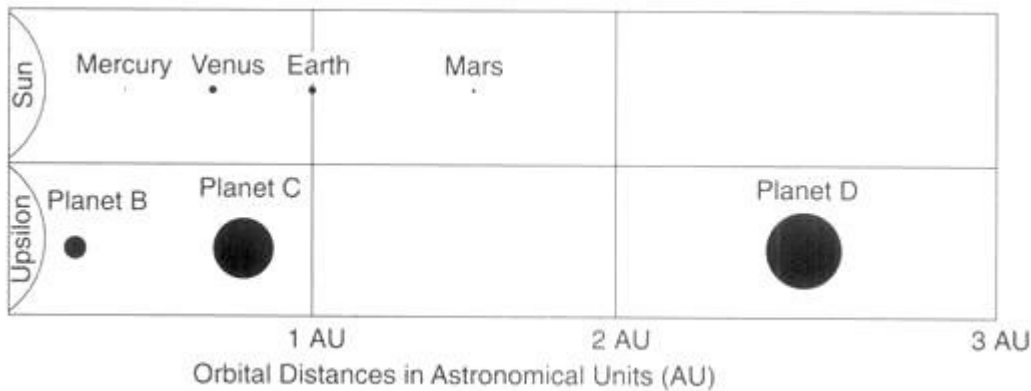
Astronomers have discovered strong evidence for the existence of three large extrasolar (outside our solar system) planets that orbit Upsilon Andromedae, a star located 44 light years from Earth. The three planets are called planet B, planet C, and planet D. Some of the information gathered about these three new planets is shown in the table below. The period of revolution for planet C has been deliberately left blank.

**Characteristics of Planets B, C, and D Orbiting Star Upsilon Andromedae**

Planet	Mass	Distance from Upsilon Andromedae	Period of Revolution
B	$\frac{3}{4}$ of the mass of Jupiter	0.06 AU	4.6 Earth days
C	2 times the mass of Jupiter	0.83 AU	
D	4 times the mass of Jupiter	2.50 AU	3.5 to 4.0 Earth years

[1 AU = average distance of Earth from the Sun]

The diagram below compares a part of our solar system to the Upsilon Andromedae planetary system. Planet distances from their respective star and the relative size of each planet are drawn to scale. [The scale for planet distances is not the same scale used for planet size.]



58 Planet D's diameter is 10 times greater than Earth's diameter. What planet in our solar system has a diameter closest in size to the diameter of planet D?

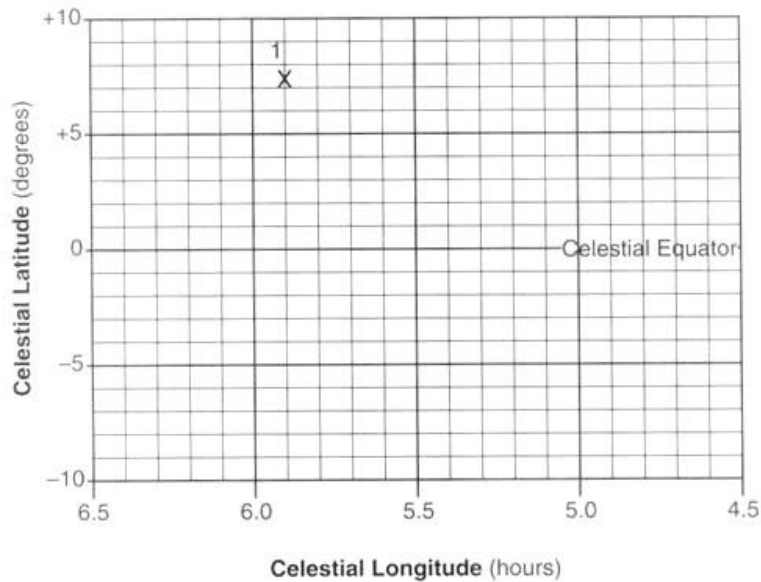
59 As planet B travels in its orbit, describe the change in orbital velocity of planet B as the distance between Upsilon Andromedae and planet B decreases.

60 If our solar system had a planet located at the same distance from the Sun as planet C is from Upsilon Andromedae, what would be its approximate period of revolution?

Base your answers to questions 69 through 72 on your knowledge of Earth science and on the table below, which lists the seven brightest stars, numbered 1 through 7, in the constellation Orion. This constellation can be seen in the winter sky by an observer in New York State. The table shows the celestial coordinates for the seven numbered stars of Orion.

Location of the Seven Brightest Stars in Orion		
Star Number	Celestial Longitude (measured in hours)	Celestial Latitude (measured in degrees)
1	5.9	+7.4
2	5.4	+6.3
3	5.2	-8.2
4	5.8	-9.7
5	5.7	-1.9
6	5.6	-1.2
7	5.5	-0.3

69 On the grid provided below, graph the data shown in the table by following the steps below.



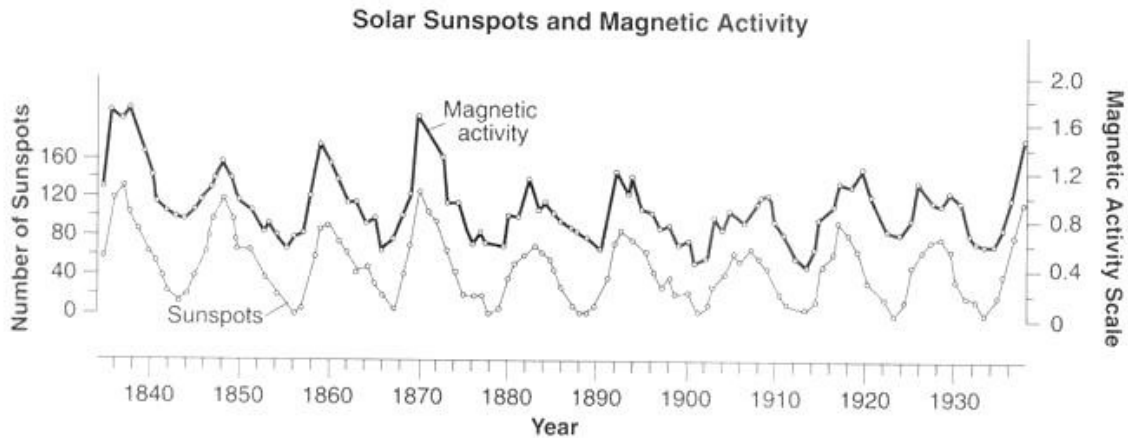
- Mark with an X, the position of each of the seven stars. Write the number of the plotted star beside each X. The first star has been plotted for you.
- Show the apparent shape of Orion by connecting the Xs in the following order: 5-1-2-7-3-4-5-6-7

70 Star 1 plotted on the grid is the star Betelgeuse. Star 3 plotted on the grid is the star Rigel. How do the temperature and luminosity of Betelgeuse compare to the temperature and luminosity of Rigel?

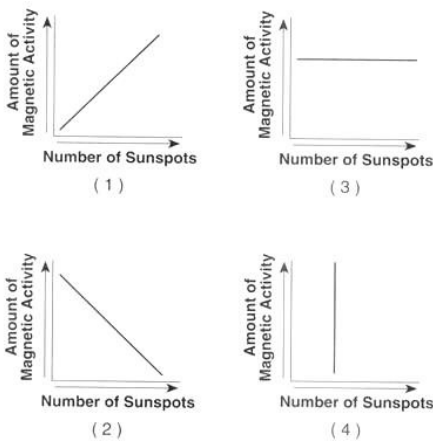
71 The seven stars of the constellation Orion that were plotted are located within our galaxy. Name the galaxy in which the plotted stars of Orion are located.

72 State one reason why an observer in New York State can never observe the constellation Orion at midnight during July but can observe the constellation Orion at mid- night during January.

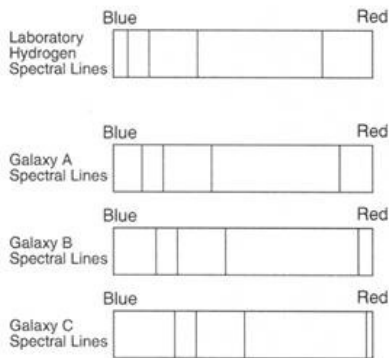
Base your answers to questions 37 and 38 on the graph below, which shows changes in the Sun's magnetic activity and changes in the number of sunspots over a period of approximately 100 years. Sunspots are dark, cooler areas within the Sun's photosphere that can be seen from Earth.



- 37 The graph indicates that years having the greatest number of sunspots occur  
 (1) randomly and unpredictably (2) precisely at the beginning of each decade  
 (3) in a cyclic pattern, repeating approximately every 6 years (4) in a cyclic pattern, repeating approximately every 11 years
- 38 Which graph best represents the relationship between the number of sunspots and the amount of magnetic activity in the Sun?



19 In the diagram below, the spectral lines of hydrogen gas from three galaxies, A, B, and C, are compared to the spectral lines of hydrogen gas observed in a laboratory.



- What is the best inference that can be made concerning the movement of galaxies A, B, and C?
- (1) Galaxy A is moving away from Earth, but galaxies B and C are moving toward Earth.
  - (2) Galaxy B is moving away from Earth, but galaxies A and C are moving toward Earth.
  - (3) Galaxies A, B, and C are all moving toward Earth.
  - (4) Galaxies A, B, and C are all moving away from Earth.

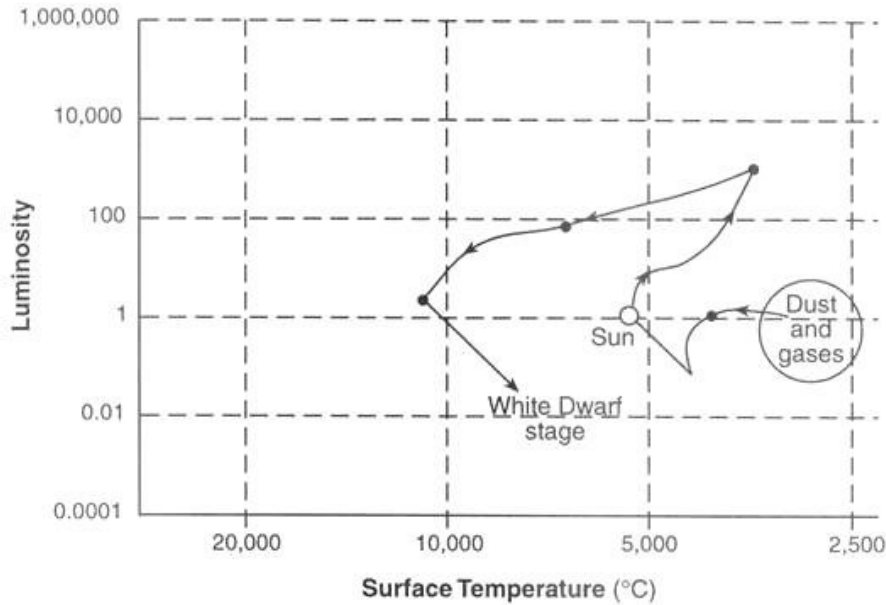
6/02

6 The Milky Way galaxy is best described as

- (1) a type of solar system
- (2) a constellation visible to everyone on Earth
- (3) a region in space between the orbits of Mars and Jupiter
- (4) a spiral-shaped formation composed of billions of stars

Base your answers to questions 61 and 62 on the graph below and on the "Luminosity and Temperature of Stars" graph in the Earth Science Reference Tables. The graph below shows the inferred stages of development of the Sun, showing luminosity and surface temperature at various stages.

**Inferred Stages of Development**



61 Describe the changes in luminosity of the Sun that will occur from its current Main Sequence stage to its final White Dwarf stage.

62 Which star shown on the "Luminosity and Temperature of Stars" graph in the Earth Science Reference Tables is currently at the Sun's final predicted stage of development?

1/02

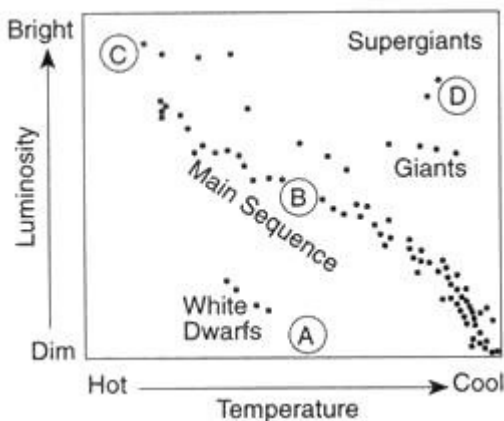
8 Which star is cooler and many times brighter than Earth's Sun? (1) Barnard's Star (2) Betelgeuse (3) Rigel (4) Sirius

6/01

2 The Sun's position in space is best described as the approximate center of

- (1) a constellation
- (2) the universe
- (3) the Milky Way galaxy
- (4) our solar system

5 The graph below represents the brightness and temperature of stars visible from Earth.



Which location on the graph best represents a star with average brightness and temperature? (1) A (2) B (3) C (4) D

34 In a Doppler red shift, the observed wavelengths of light from distant celestial objects appear closer to the red end of the spectrum than light from similar nearby celestial objects. The explanation for the red shift is that the universe is presently

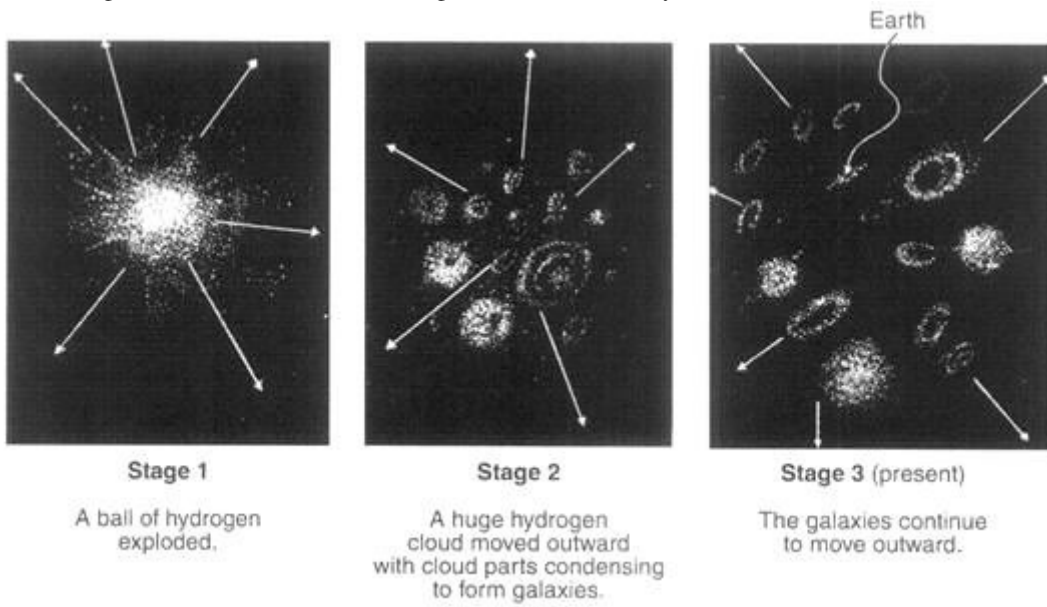
- (1) contracting, only
- (2) expanding, only
- (3) remaining constant in size
- (4) alternating between contracting and expanding

8/01

5 Which planet is approximately thirty times farther from the Sun than Earth is?

- (1) Jupiter (2) Saturn (3) Uranus (4) Neptune

44 The diagram below illustrates three stages of a current theory of the formation of the universe



A major piece of scientific evidence supporting this theory is the fact that wavelengths of light from galaxies moving away from Earth in stage 3 are observed to be

- (1) shorter than normal (a red shift) (2) shorter than normal (a blue shift)  
(3) longer than normal (a red shift) (4) longer than normal (a blue shift)