Stars

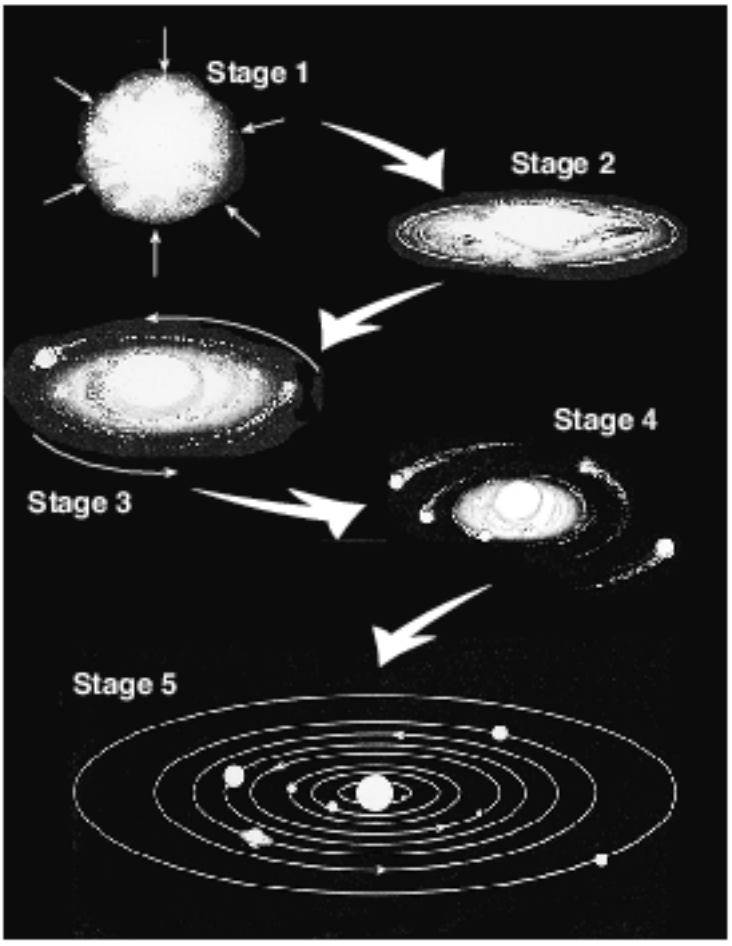
1 Which star type has a surface temperature of4000 K and a luminosity 1000 times greater than the Sun?

(1) dwarf
(3) giant
(2) main sequence
(4) supergiant

2 Which star is cooler and less luminous than the Sun?

(1) Proxima Centauri
(3) Rigel
(2) Pollux
(4) 40 Eridani B

Base your answers to questions 3 on the diagram below. The diagram represents the inferred stages in the formation of our solar system. Stage 1 shows a contracting gas cloud. The remaining stages show the gas cloud flattening into a spinning disk as planets formed around our Sun.

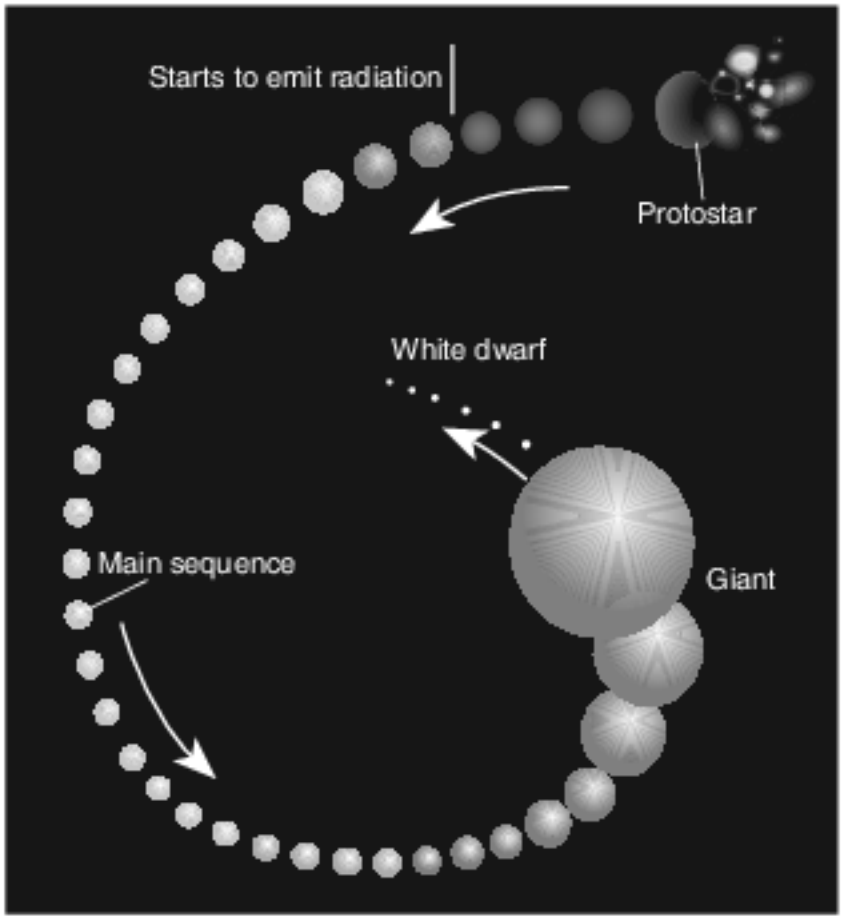


(Not drawn to scale)

3 Which force was mostly responsible for the contraction of the gas cloud?

(1) friction
(3) magnetism
(2) gravity
(4) inertia

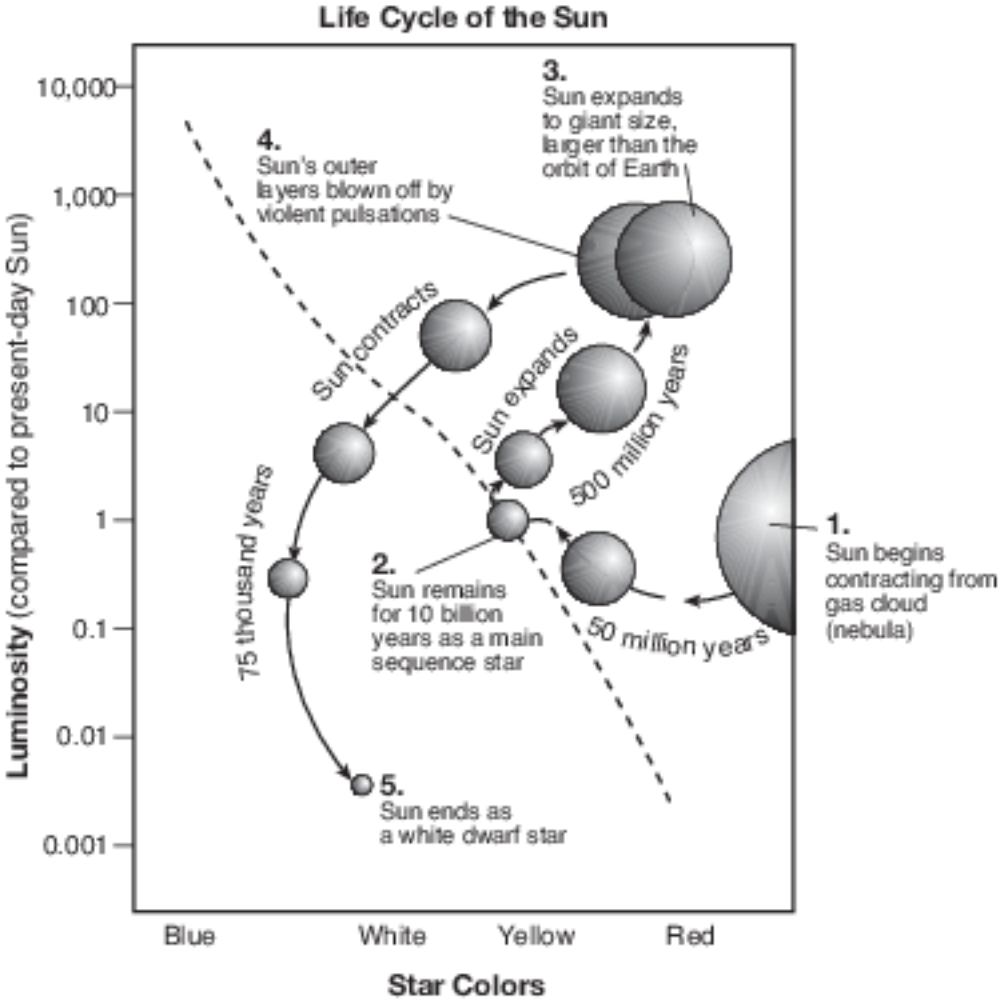
Base your answers to questions 4 on the diagram below, which shows the change in the size of a star such as our Sun as it evolves from a protostar to a white dwarf star.



4 During which stage of development does the star have a cool surface temperature and the greatest luminosity?

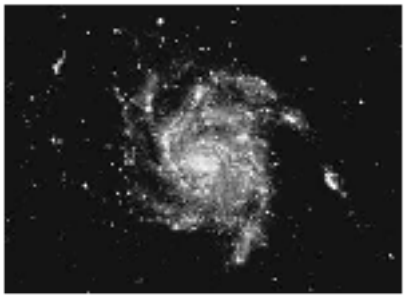
(1) protostar
(2) main sequence
(3) giant
(4) white dwarf

Base your answers to questions 5 on the diagram below and on your knowledge of Earth science. The diagram represents the inferred changes to the luminosity and color of the Sun throughout its life cycle. The diagonal dashed line represents the main sequence stars. The numbers 1 through 5 represent stages in the life cycle of the Sun.



5 The Sun is inferred to spend the greatest amount of time in its life cycle
(1) contracting from a gas cloud (nebula)
(2) as a main sequence star
(3) moving away from the main sequence and becoming a giant star
(4) changing from a giant star to a white dwarf star

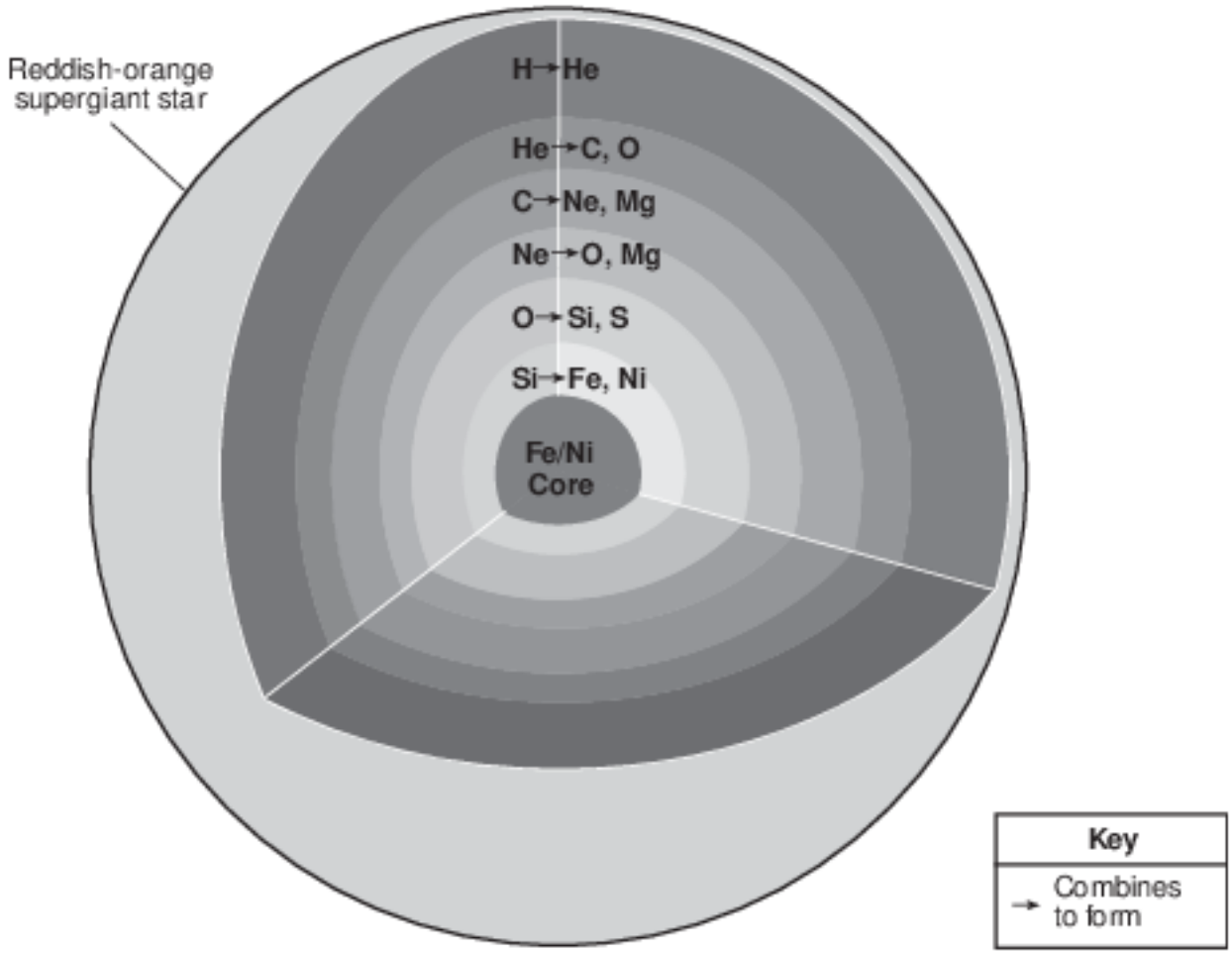
6 The photograph below shows a feature of the universe as seen through a telescope.



This feature is best identified as

(1) a galaxy
(2) a comet
(3) an asteroid
(4) a star

Base your answers to questions 7 on the cross-sectional model below and the table on the following page, and on your knowledge of Earth science. The model shows a reddish-orange supergiant star. The layers in the model indicate where new chemical elements are forming from existing elements as temperature and pressure conditions increase with depth within the star. In each layer, atomic nuclei of the existing chemical element combine to form the new elements shown to the right of the arrow. The table shows the chemical symbols and names of selected elements in the star.



(Not drawn to scale)

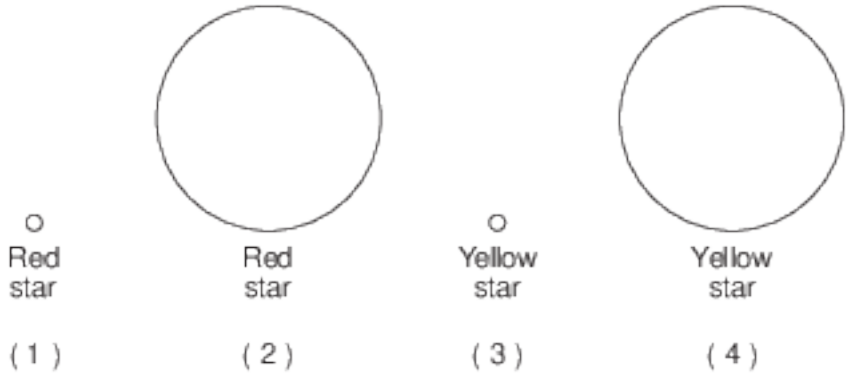
Elements in the Star

Chemical Symbol	Name
H	hydrogen
He	helium
C	carbon
O	oxygen
Ne	neon
Mg	magnesium
Si	silicon
S	sulfur
Fe	iron
Ni	nickel

7 Which process represented in the model is occurring in each layer of this star to produce the new chemical elements?
(1) contact metamorphism
(2) internal crystallization
(3) nuclear fusion
(4) radioactive decay

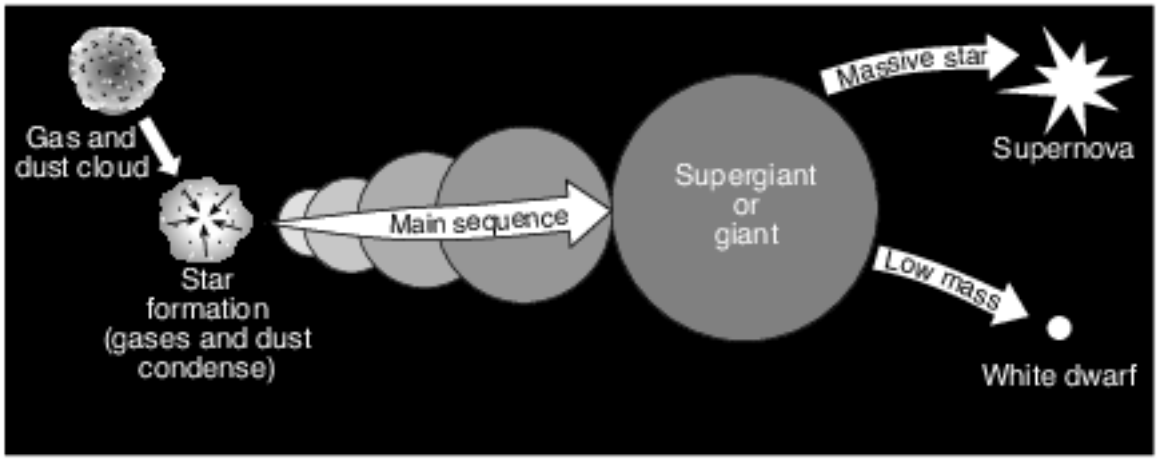
8 The diagram below represents a model of the size of the Sun and indicates the color of the Sun.

Which diagram best represents the relative size and indicates the color of Polaris compared to the Sun?



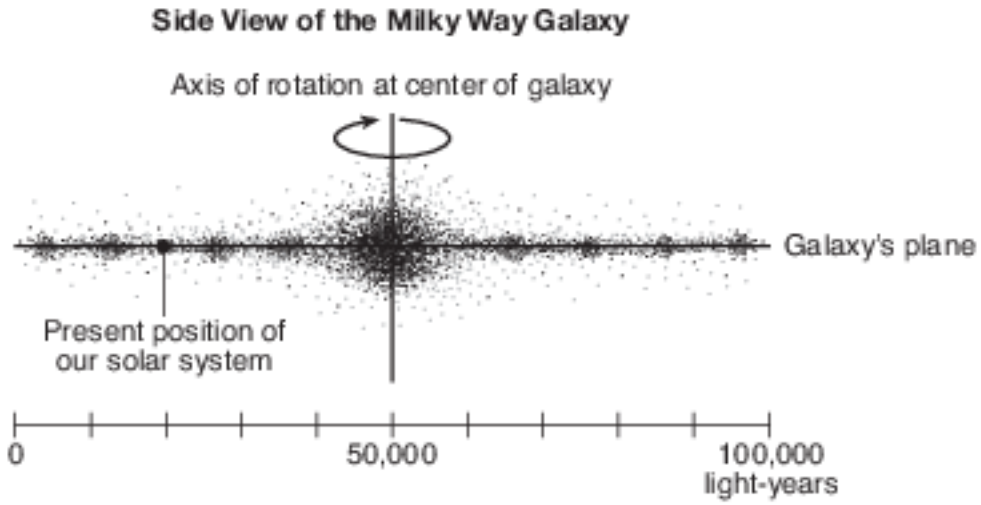
(1) 1
(2) 2
(3) 3
(4) 4

Base your answers to questions 9 on the diagram below and on your knowledge of Earth science. The diagram represents the inferred origin and evolution of most stars.



9 What causes the gas and dust cloud to condense and become a star?
(1) density
(2) friction
(3) gravity
(4) outgassing

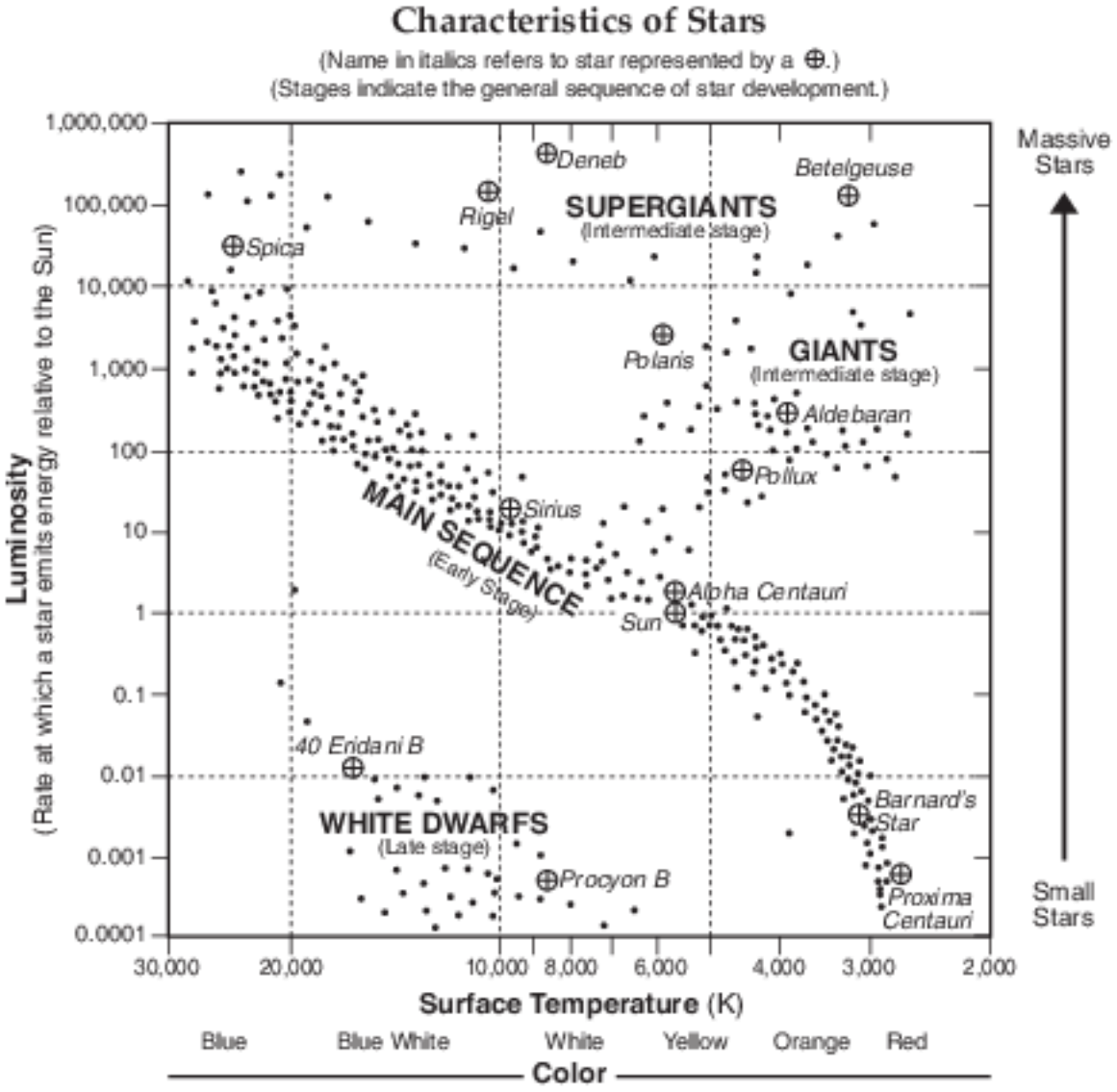
Base your answers to questions 10 on the diagram below and on your knowledge of Earth science. The diagram represents the present position of our solar system in a side view of the Milky Way Galaxy. The distance across the Milky Way Galaxy is measured in light-years.



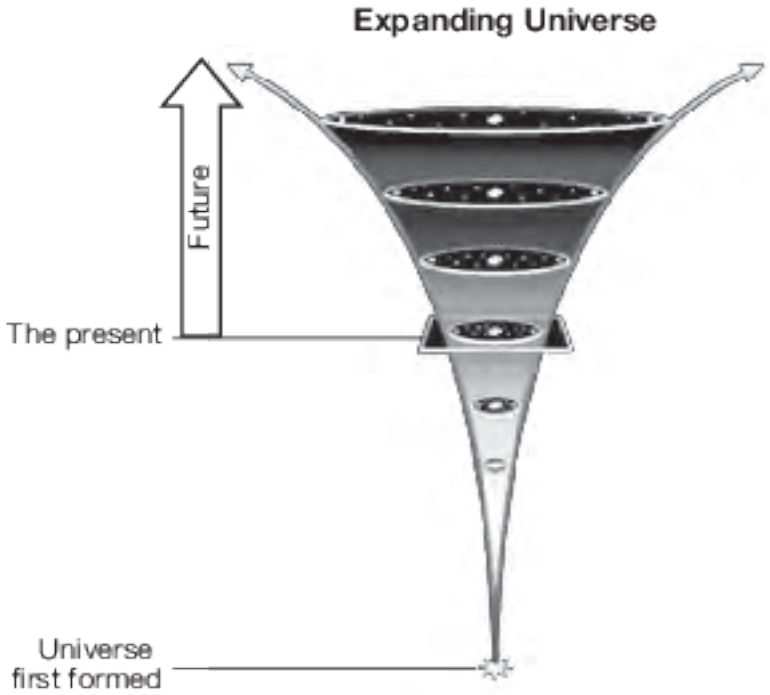
10 What is the distance, in light-years, from the center of the Milky Way Galaxy to our solar system? [1]
light-years

Base your answers to questions 11 on the Characteristics of Stars graph in image provided and on your knowledge of Earth science.

11 The star Canopus has a surface temperature of 7400 K and a luminosity (relative to the Sun) of 1413. In your answer booklet, use an X to plot the position of Canopus on the graph, based on its surface temperature and luminosity. [1]



Base your answers to questions 12 on the diagram below and on your knowledge of Earth science. The diagram represents a model of the expanding universe.



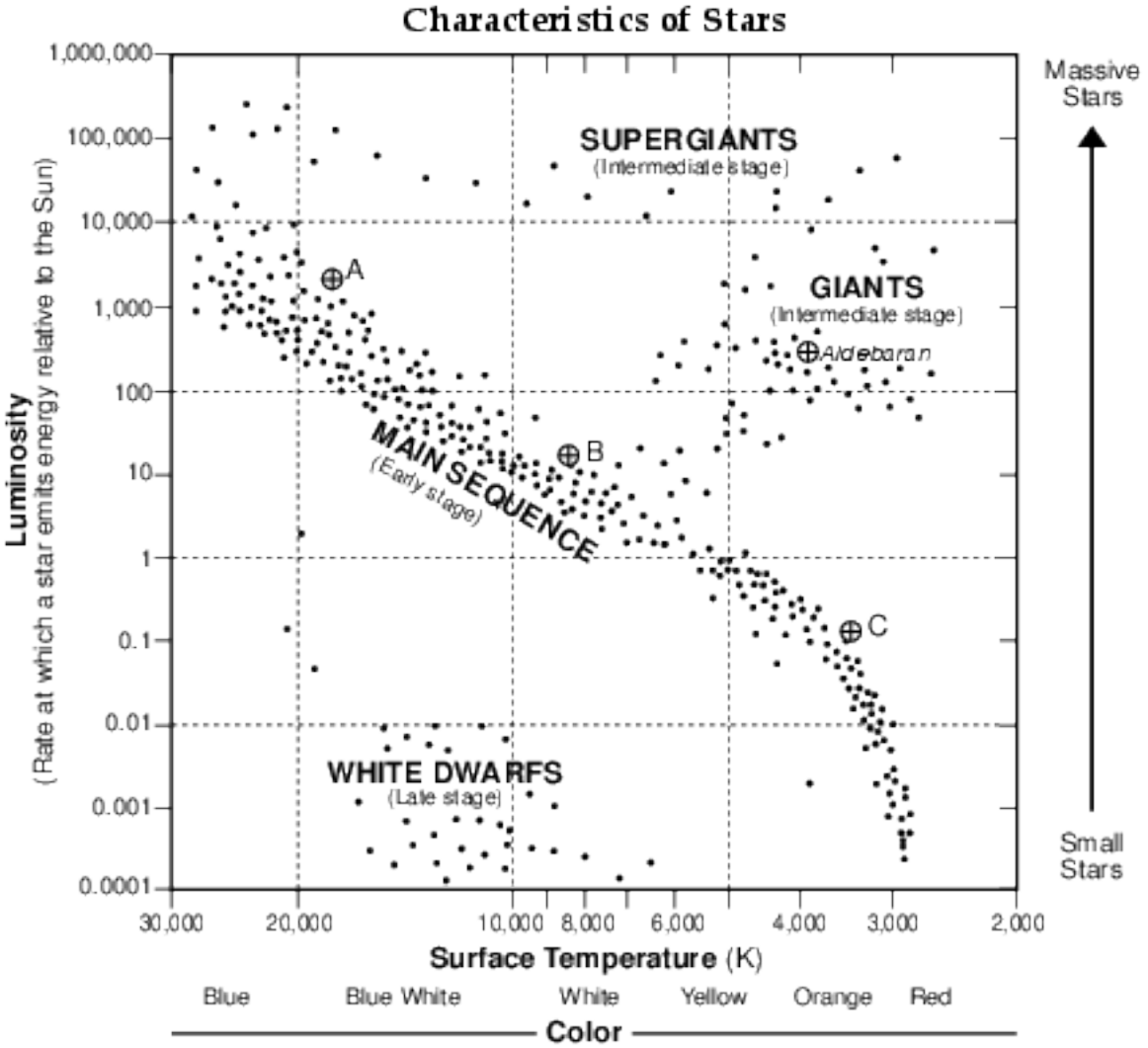
12 Identify the nuclear process that combines lighter elements into heavier elements to produce the energy radiated by stars. [1]

Base your answers to questions 13 on the passage and the Characteristics of Stars graph below, and your knowledge of Earth science. Letters A, B, and C represent main sequence stars on the graph. The giant star Aldebaran is also shown.

Globular Star Clusters

Globular star clusters appear as small, hazy spots among the other stars. These clusters are groups of hundreds of thousands of stars held together by gravity. Individual stars within a cluster can be seen by using powerful telescopes, allowing scientists to determine their luminosities and temperatures.

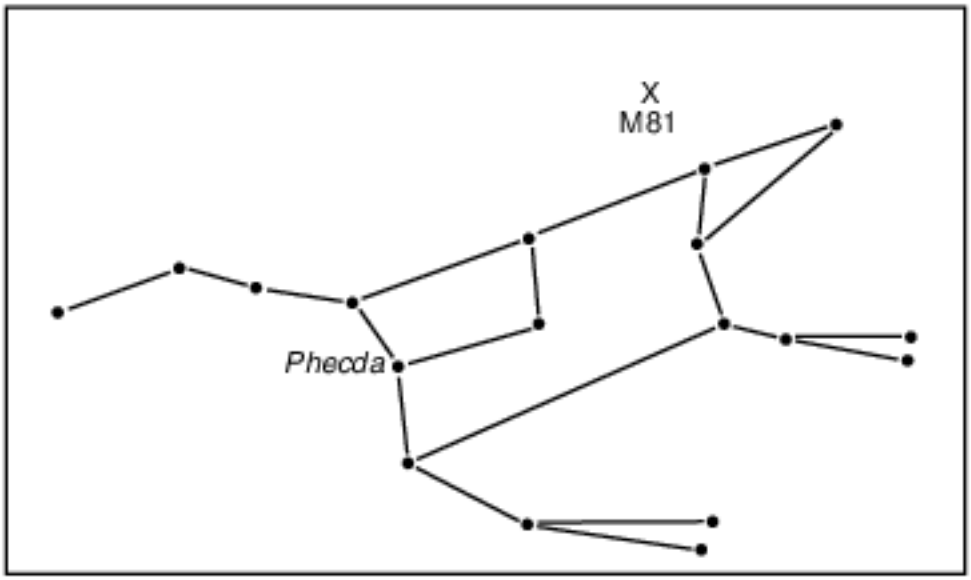
All of the stars in a given cluster formed at the same time. In young clusters, most of the stars are classified as main sequence stars. As the stars in a cluster age, they eventually use up their core hydrogen and expand, changing from main sequence stars to giants. The most massive main sequence stars become supergiants. The less massive a star is in the cluster, the longer it remains a main sequence star. Over time, the number of main sequence stars in a cluster decreases.



13 Compared to the relative amount of time that star A remains in the main sequence, state how the relative amount of time that star C remains in the main sequence is different. Explain why this amount of time is different. [1]
Relative time for star C:
Explanation:

Base your answers to questions 14 on the diagram and photograph below and on your knowledge of Earth science. The diagram represents the constellation Ursa Major. One star, Phecda, has been labeled. Letter X represents the location of the Messier 81 galaxy (M81), which can be observed near Ursa Major. The photograph shows the Messier 81 galaxy as viewed through a telescope.

Ursa Major



Messier 81 Galaxy

14 Phecda has a surface temperature of approximately 9500 K and a luminosity of 63. Identify the name of the star found on the Characteristics of Stars chart in the 2011 Edition Reference Tables for Physical Setting/ Earth Science that has a surface temperature and luminosity closest to Phecda. [1]

Base your answers to questions 15 on the information and data table below and on your knowledge of Earth science. The table shows data for the six planets in the Kepler-11 star system.

Kepler-11 is one of many star systems discovered by space satellites. Scientists find this system unusual because of its small size and its six planets, identified by letters b through g, that orbit relatively close to its central star. The central star, Kepler-11, has a surface temperature of 5663 K and a luminosity of 1.0.

Planet	**Mean Distance from Star** (million km)	**Period of Revolution** (days)	**Eccentricity of Orbit**	**Equatorial Diameter** (km)	**Density** (g/cm^3)
Kepler-11b	13.7	10.3	0.045	45,869	1.70
Kepler-11c	16.0	13.0	0.026	73,151	0.66
Kepler-11d	23.2	22.7	0.004	79,528	1.28
Kepler-11e	29.1	32.0	0.012	106,780	0.58
Kepler-11f	37.5	46.7	0.013	63,456	0.69
Kepler-11g	69.7	118.4	0.150	84,847	1.20

15 Identify the star located on the Characteristics of Stars graph on the Physical Setting/Earth Science Reference Tables that has the most similar surface temperature and luminosity as the Kepler-11 star. [1]

Answer Keys

1 3

2 1

3 2

4 3

5 2

6 1

7 3

8 4

9 3

10 Allow 1 credit for any value from 25,000 light-years to 35,000 light-years.

11 Allow 1 credit if the center of the X is placed within or touches the box shown below.

- Note: Allow credit if a symbol other than an X is used.
- It is recommended that an overlay of the same scale as the student answer booklet be used to ensure reliability in rating.
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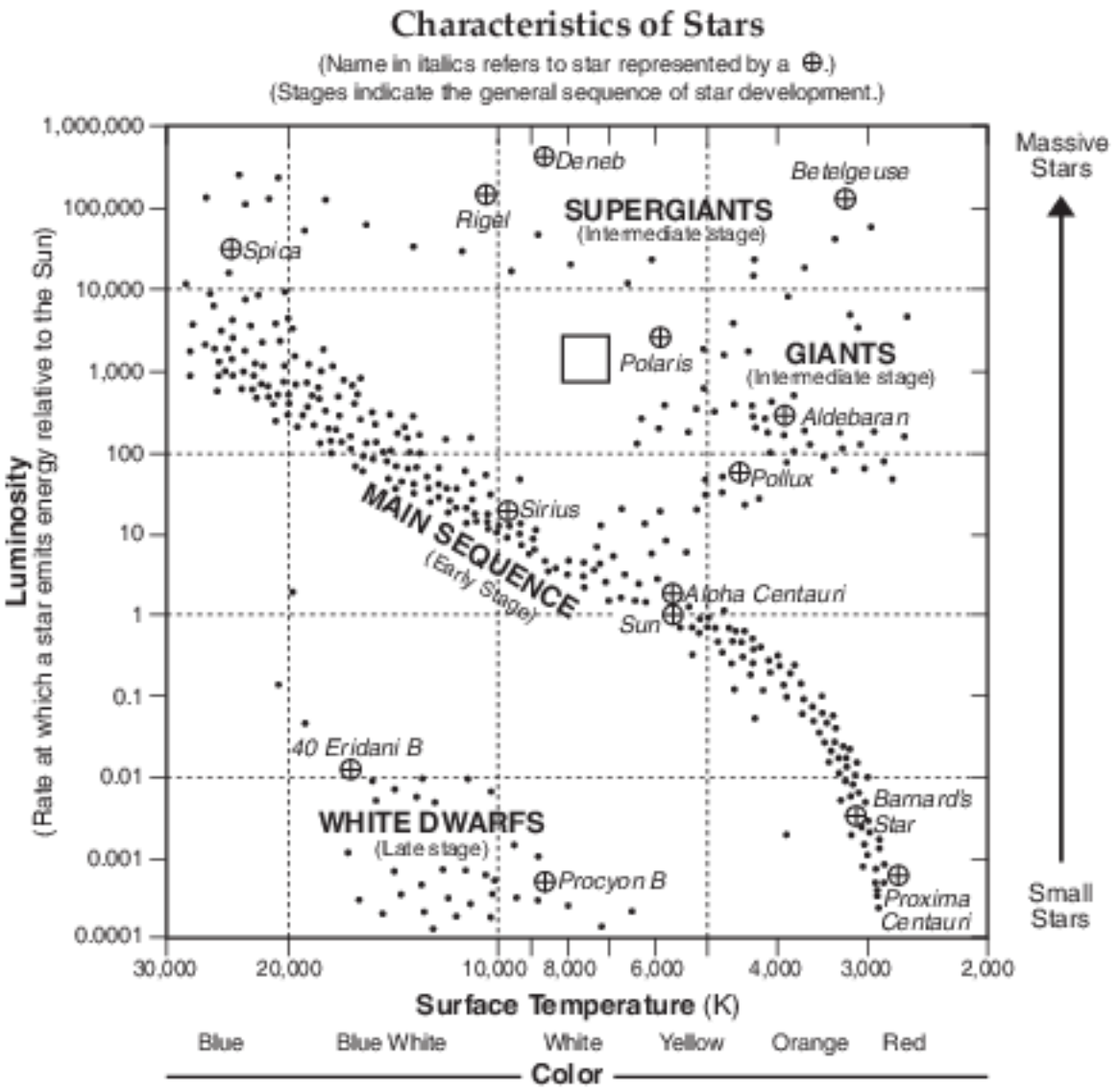

12 Allow 1 credit for fusion or nuclear fusion.

13 Allow 1 credit if both responses are correct. Acceptable responses include, but are not limited to:

- Relative time for star C:
- — stays in main sequence longer
- — greater amount of time/more time
- — Star A leaves the main sequence sooner.
- Explanation:
- — Star C is less massive/smaller.
- — It is cooler.
- — Star C uses up its core hydrogen more slowly.
- — Star A is more massive/larger.
- — The less massive a star is in the cluster, the longer it remains a main sequence star.

14 Allow 1 credit for Sirius.

15 Allow 1 credit for the Sun.