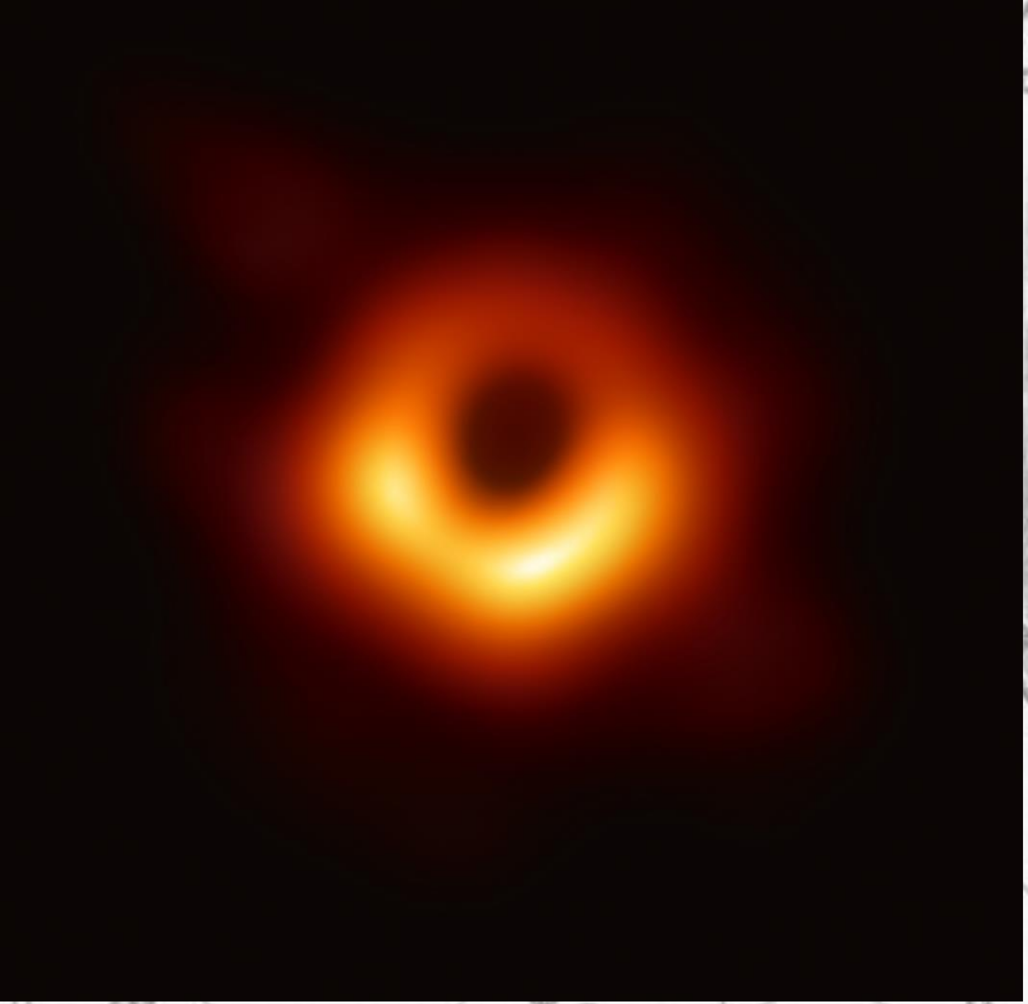
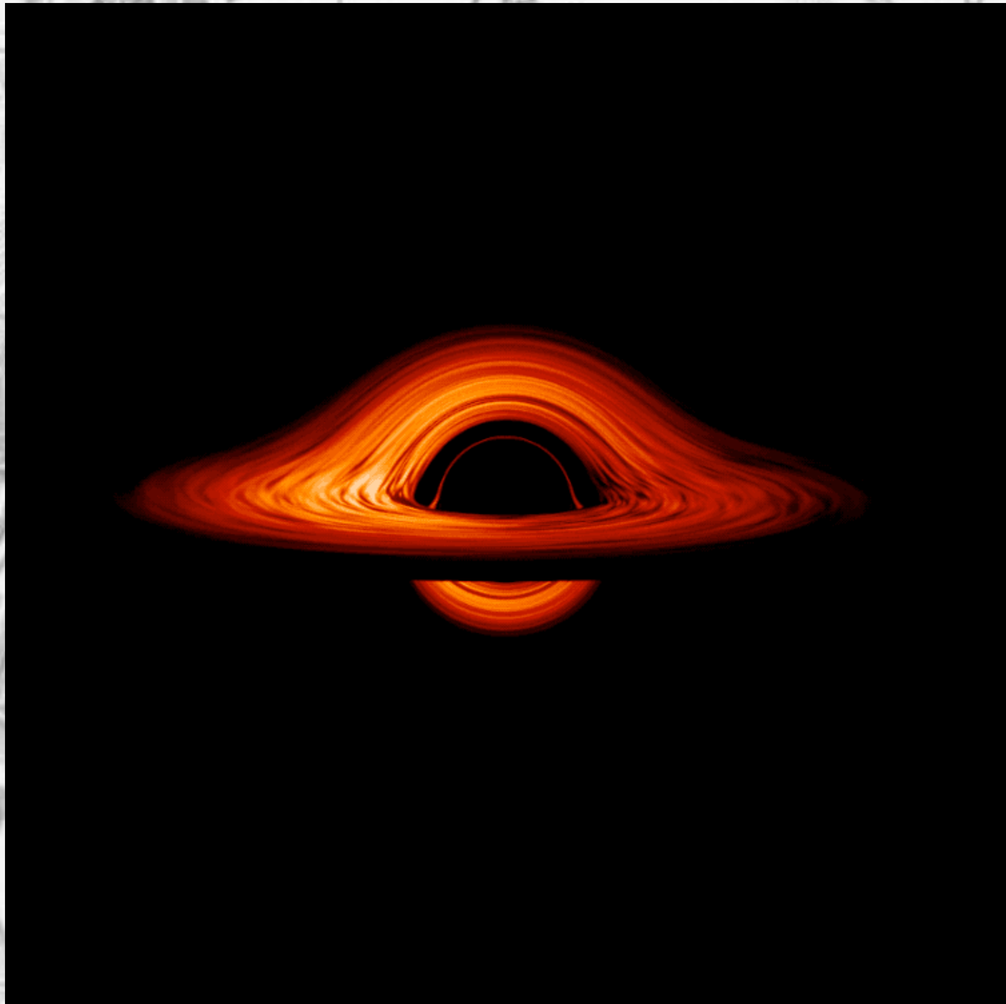


Phenomenon 1: A Black Hole

The first image of a black hole shows a bright ring with a dark, central spot. That ring is a bright disk of gas orbiting the supermassive behemoth in the galaxy M87.

- Event Horizon Telescope Collaboration



Science in Our World

Watch the video of a black hole. What questions do you have about black holes?

____

____

____

Phenomenon 2: How big are the stars in our galaxy?

[Star Comparison]

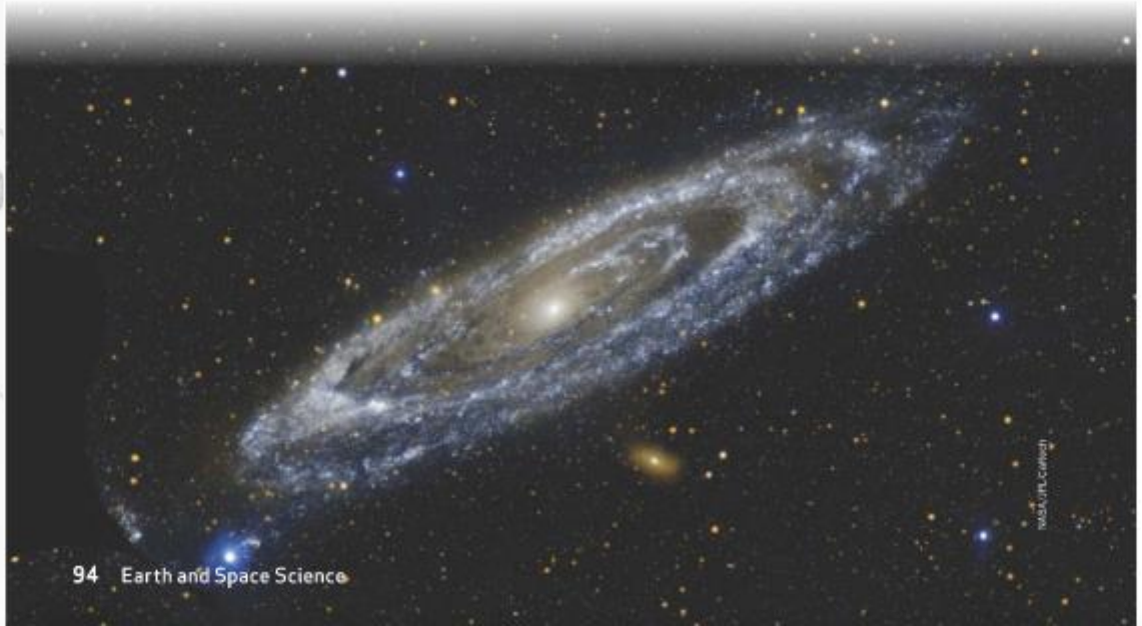
Stars

A **star** is a sphere of hot gases that gives off light and heat. The only star you can observe during the daytime is the Sun. The Sun is the closest star to Earth. Other stars are much farther away. Throughout the universe, stars are found in large groups called galaxies. Our Sun is near the edge of a galaxy with billions of other stars. You may know this galaxy as the Milky Way. Our galaxy's nearest neighbor is the Andromeda Galaxy.

Star Colors and Temperature

Stars are different colors. These colors occur because of the surface temperature of each star. Think about the flames of a bonfire. Different parts of the fire are different temperatures. Cooler areas are red. The hottest areas are orange-yellow. This same relationship between color and temperature applies to stars. The Sun's temperature makes it look yellow. Cooler stars are red or orange. Warmer stars are white or blue.

Like the Milky Way, the Andromeda Galaxy is shaped like a spiral. It is wider than our own Milky Way Galaxy.



Star Distances

The Sun is about 150 million km (93 million mi) from Earth. It takes about eight minutes for its light to reach Earth. Most stars are much farther away. The Sun appears to be the brightest star because it is the closest star to Earth. Other stars may be brighter but are much farther away. After the Sun, the next closest star to Earth is Proxima Centauri. This star is about 40 trillion km (24.8 trillion mi) away. Because stars are so far from Earth, writing their distance in kilometers or miles becomes awkward.

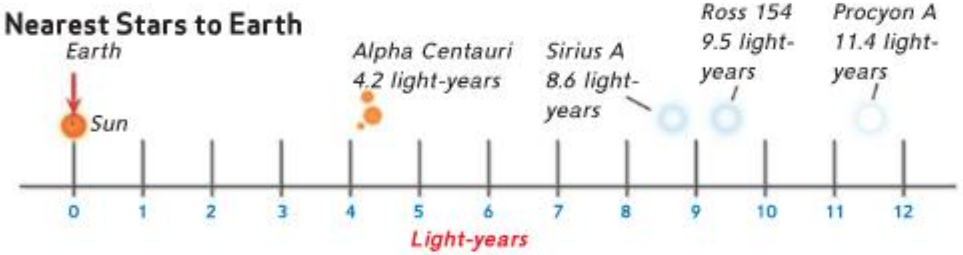
To simplify the writing of such large distances, astronomers use a unit called a light-year. A **light-year** is the distance light travels in one year, which is nearly 10 trillion km (6 trillion mi). Proxima Centauri is 4.2 light-years from Earth.

When you observe a distant star, you are seeing what it looked like in the past. A star you observe today may have stopped glowing millions of years ago. However, its light is still making its way through space. The light we see from the Proxima Centauri system left there about 4.2 years ago.

SKILL BUILDER

Read a Diagram
In this diagram, Earth is right next to the Sun at 0. Count the light-years from Earth-Sun to Alpha Centauri.

Nearest Stars to Earth



FACT CHECKER

A light-year is not a measure of time, but of distance.

Star Cycles

Stars form when matter comes together and starts to give off energy. Stars go through stages, or cycles, between their beginning and ending. Different kinds of stars have different cycles. The cycle of a star depends on how much hydrogen the star contains. A star's cycle ends when it stops giving off energy.

A star forms out of a nebula. A **nebula** is a huge cloud of gases and dust. Gravity pulls the mass of the nebula, most of which consists of hydrogen gas, closer together. As hydrogen atoms move closer, they collide with one another. These collisions produce heat, and the temperature in the cloud rises. When the temperature reaches at least 10,000,000° Celsius (18,000,000° Fahrenheit), hydrogen atoms begin combining to form a new gas, helium. This process gives off tremendous amounts of heat and light. The nebula becomes a protostar, or beginning star. The protostar continues to gain mass because of its gravitational pull. Its heat makes it glow.

The Sun, and other stars like it, started with a medium amount of hydrogen. That hydrogen is the fuel that produces energy in the Sun. For a few billion years, hydrogen atoms continue combining to form helium, and the star increases in temperature.

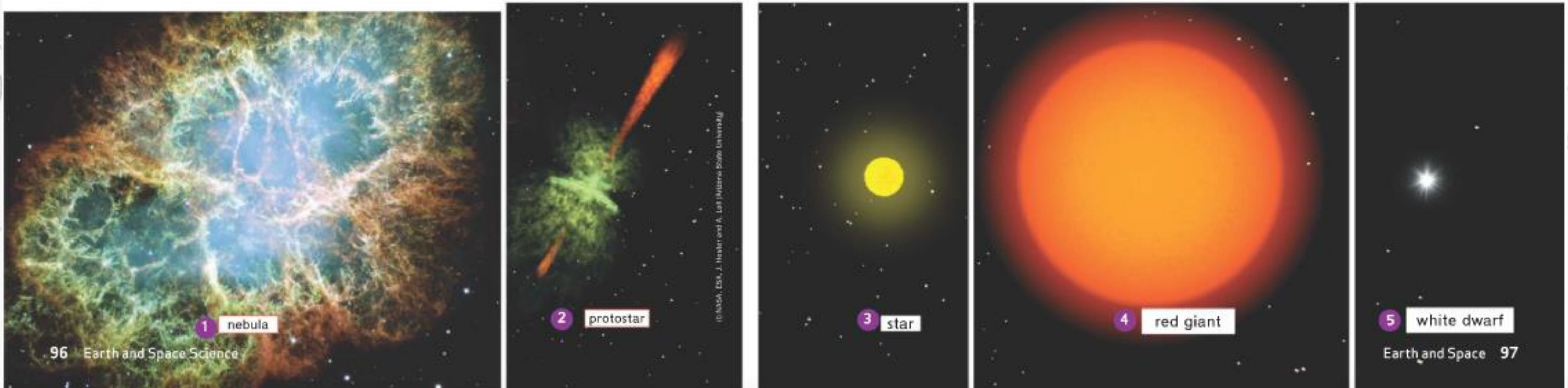
Eventually the heat forces the hydrogen on the edge of the star to expand into space. As the expanding hydrogen moves farther from the center of the star, it cools and turns red. At this stage in its cycle, the star has become a red giant. A red giant is many times larger than the original star. In the star's core, the temperature has risen to about 100,000,000°C (180,000,000°F). Helium atoms now combine to form atoms of carbon.

When all the helium is gone, the star can no longer combine helium to form carbon. Now the star begins to cool and shrink, becoming a white dwarf. A **white dwarf** is a small and very dense star that shines with a cooler white light. The white dwarf stage is the end of a medium-sized star's cycle.

About 10 billion years pass during this cycle. Because the Sun is approximately 5 billion years old, it is about halfway through the cycle.

SKILL BUILDER

Read a Diagram
Follow the numbers to better understand the stages of a medium-sized star. The Sun is in stage 3 of this cycle.



Star Cycles of Larger Stars

Stars that start off with greater amounts of hydrogen end their cycle differently. After they become red giants, the temperature of the core of these stars increases to about 600,000,000°C (1,080,000,000°F). At this temperature, their atoms combine to form atoms of iron.

Eventually the iron core produces more energy than gravity can hold together, and the star explodes. The exploding star is called a **supernova.** Supernovas shine brightly for days or weeks and then fade away. A supernova will form a new nebula.

If a star is very massive, it may end its cycle as a black hole. A **black hole** is an object that is so dense and has such powerful gravity that nothing can escape from it, not even light.

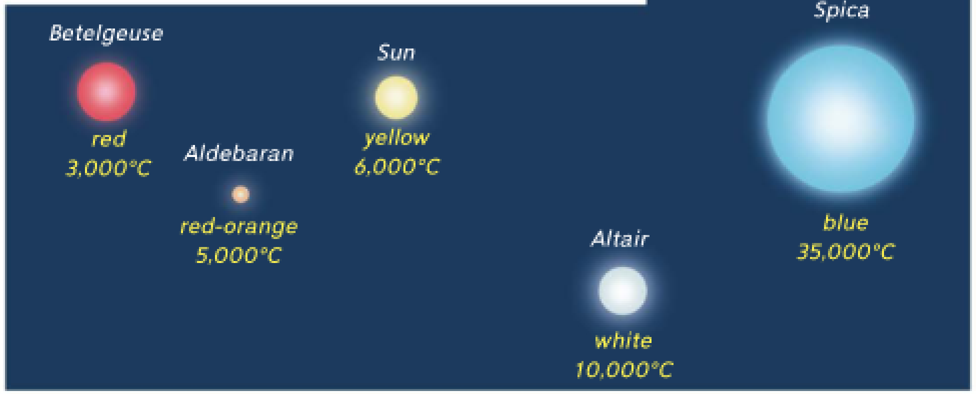
SKILL BUILDER

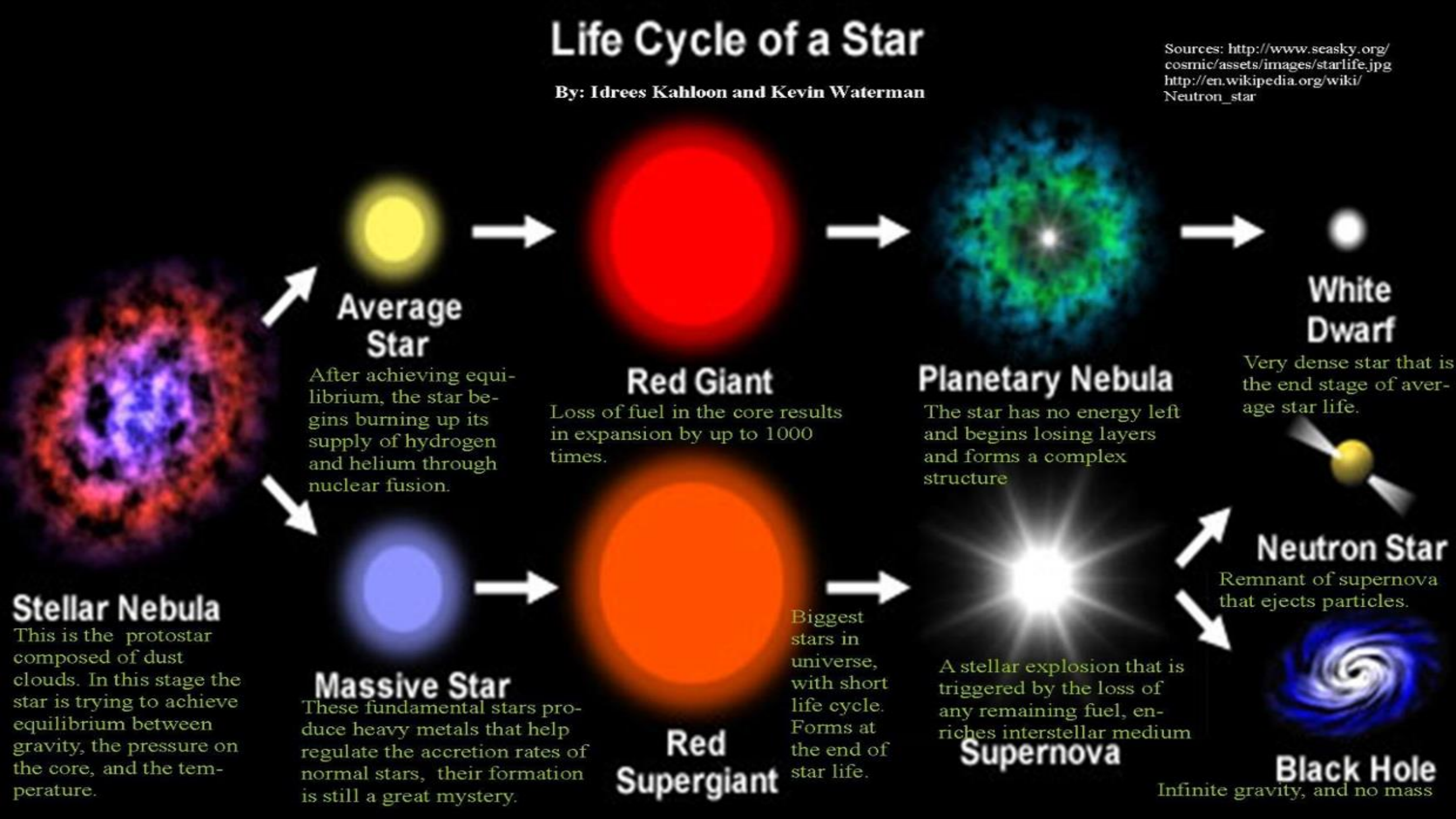
Read a Diagram
Look for a pattern between temperature and color in these different stars.

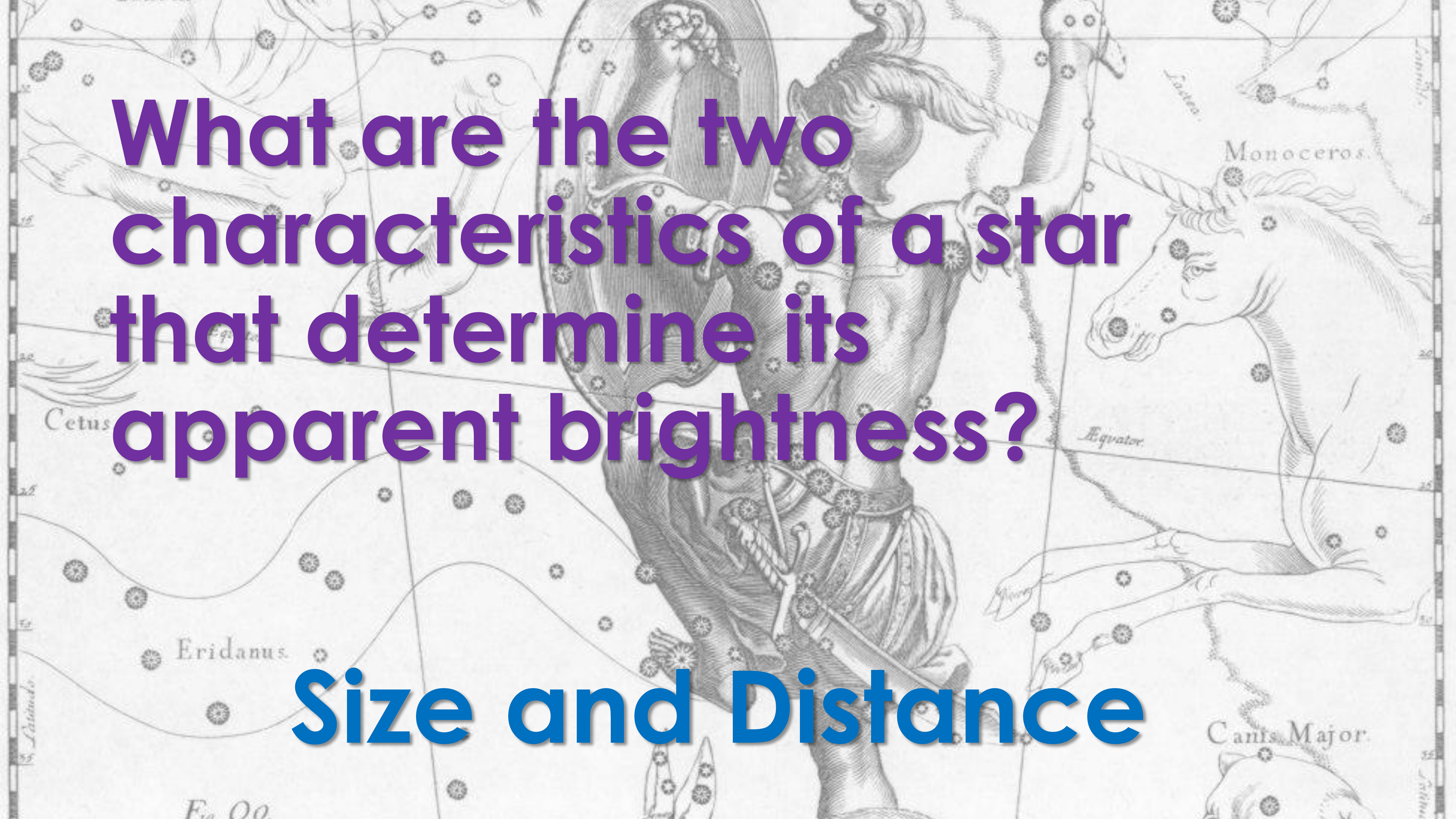
Star Classification

Stars are characterized by their size, color, and temperature. The Sun is a medium-sized yellow star with a surface temperature of about 6,000°C (11,000°F). Giant stars have diameters that are 10 to 100 times that of the Sun. Super giants may have diameters that are 1,000 times that of the Sun. Neutron stars are the smallest stars and are 60,000 times smaller than the Sun.

Color and Surface Temperatures of Stars




Life Cycle of a Star
By: Idrees Kahloon and Kevin Waterman
Sources: http://www.seasky.org/cosmic/assets/images/starlife.jpg
http://en.wikipedia.org/wiki/Neutron_star
Stellar Nebula
This is the protostar composed of dust clouds. In this stage the star is trying to achieve equilibrium between gravity, the pressure on the core, and the temperature.
Average Star
After achieving equilibrium, the star begins burning up its supply of hydrogen and helium through nuclear fusion.
Red Giant
Loss of fuel in the core results in expansion by up to 1000 times.
Planetary Nebula
The star has no energy left and begins losing layers and forms a complex structure
White Dwarf
Very dense star that is the end stage of average star life.
Massive Star
These fundamental stars produce heavy metals that help regulate the accretion rates of normal stars, their formation is still a great mystery.
Red Supergiant
Biggest stars in universe, with short life cycle. Forms at the end of star life.
Supernova
A stellar explosion that is triggered by the loss of any remaining fuel, enriches interstellar medium
Neutron Star
Remnant of supernova that ejects particles.
Black Hole
Infinite gravity, and no mass

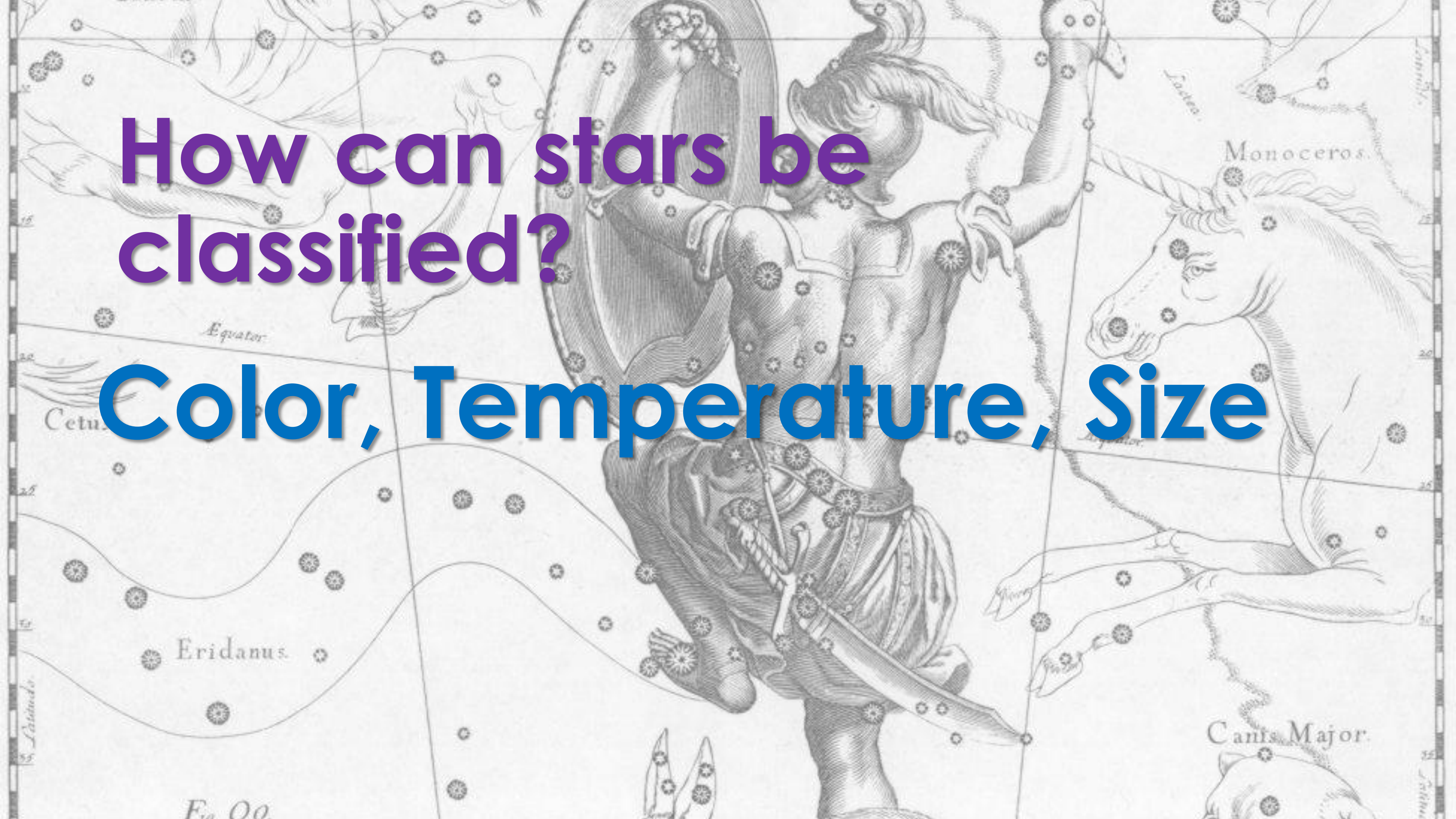


What are the two characteristics of a star that determine its apparent brightness?

Size and Distance

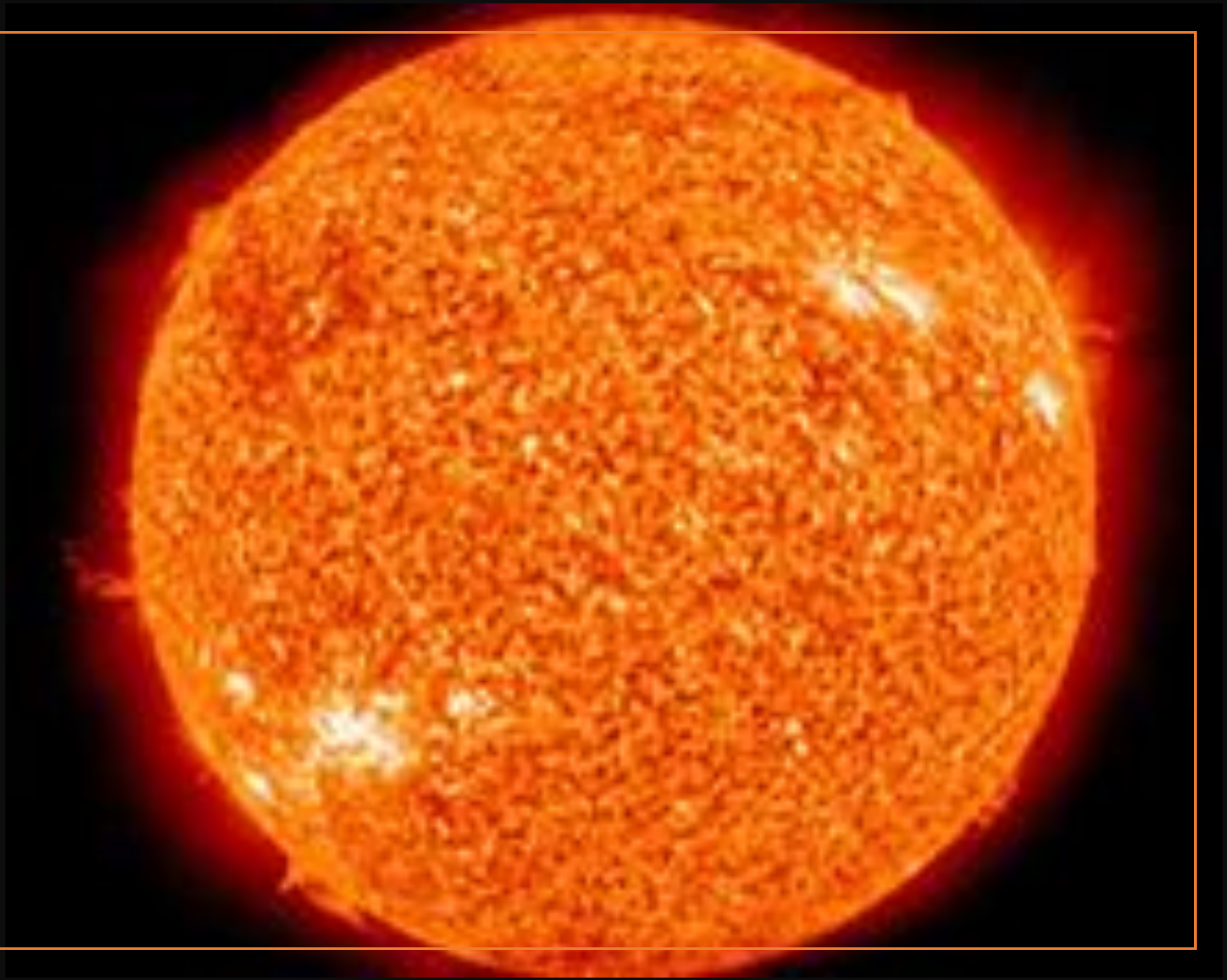
How can stars be classified?

Color, Temperature, Size



Star	An object that creates its own energy; light and heat
Star cycle	The stages of a star's life, from birth to fuel exhaustion
Nebula	A cloud of dust and gas where stars are formed
Supernova	The explosion of a large star when its fuel is exhausted
Black Hole	When a very large star collapses in on itself; very strong gravity
White Dwarf	The end of an average star's life; it turns into a small dense star

Stars 101



6. What determines a star's apparent brightness? Choose two correct answers.
    - a. the distance the sun is from Alpha Centauri
    - b. the distance a star is from Earth
    - c. the temperature difference between a star and Earth
    - d. the number of light-years a star is from Earth

What do you notice?

Constellations

3 dimensional art made of stars

Constellations

When people in ancient cultures looked at the night sky, they saw patterns in the stars. These patterns are called **constellations.** They were named after animals, fictional characters, or objects.

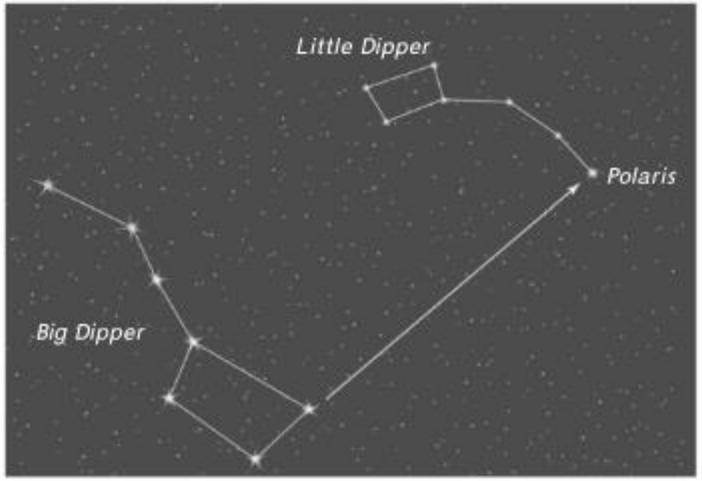
Star patterns have been useful to ancient and modern travelers. For example, if you can see either the Big Dipper or the Little Dipper in the night sky, you can use them to easily find Polaris, the North Star. If you travel in the direction of Polaris, you willbe moving north.

The ancient Greeks divided the sky into 12 sections and named some constellations after characters from Greek myths, such as the hunter Orion and the hero Hercules. The ancient Chinese divided the sky into four major regions. The name of each region included a color, an animal, and a direction. For example, the western region was called the White Tiger of the West.

Today, astronomers divide the sky into 88 constellations. Many of the ancient names for constellations are still used today. Modern astronomers have named constellations visible in the Southern Hemisphere, which could not be seen by Ancient Greeks and Romans.

SKILL BUILDER

Read a Diagram
To find Polaris, first find the stars in the bowl of the Big Dipper.



Apparent Motion

The stars in the northern sky seem to circle around Polaris. The stars appear to move because of Earth's rotation. Although the stars appear to change position, their positions within constellations do not change.

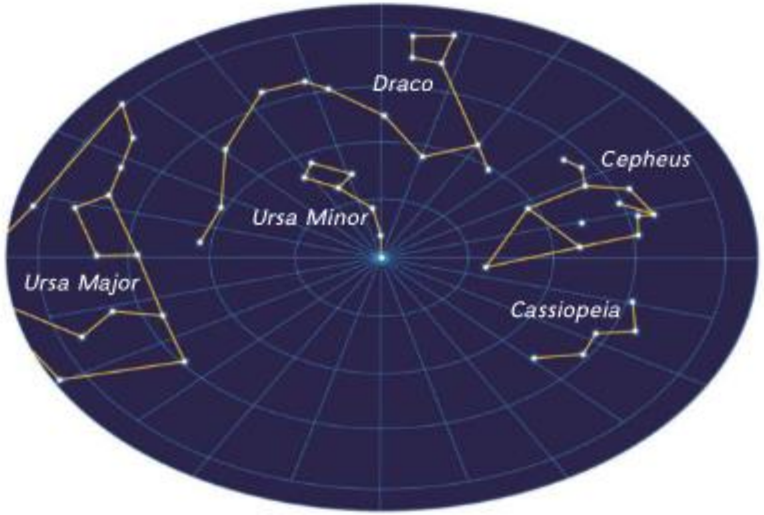
As Earth revolves around the Sun, different constellations are visible to an observer on Earth. For example, Orion is a winter constellation in the Northern Hemisphere. It can be seen rising in the eastern sky on winter evenings. As the season changes, Orion sets earlier and earlier each night. In May, Orion disappears from the night sky in the Northern Hemisphere. In June, the constellation Scorpius, the scorpion, becomes visible.

These seasonal changes are caused by Earth's orbit around the Sun. Each night, the position of most stars shifts slightly to the west. Soon the stars once visible in the west cannot be seen, and other stars appear in the east.

WORD STUDY

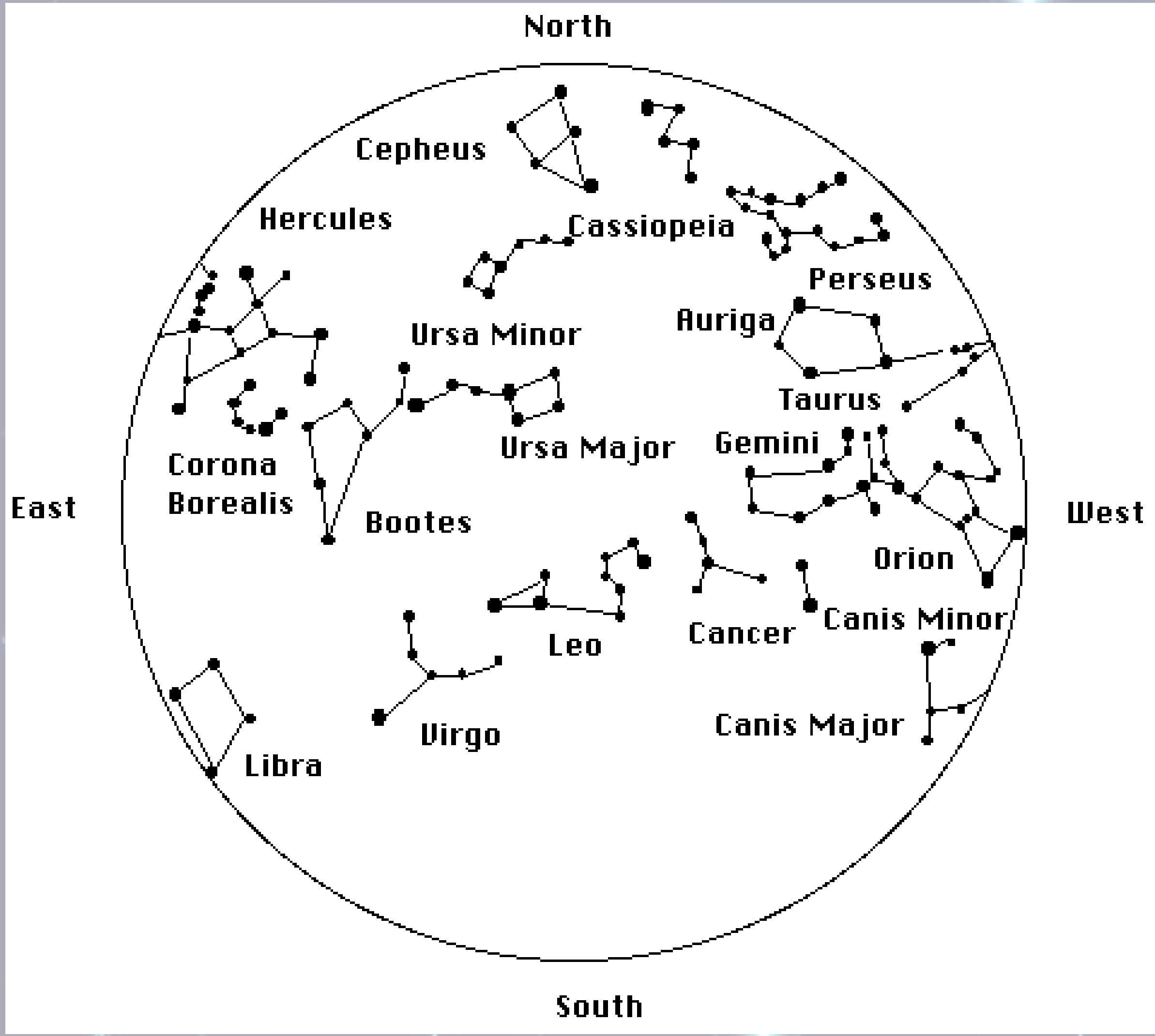
The word *circumpolar* comes from two words. *Circum means* "around," and *polar* means "of the poles."

A star map shows the locations of constellations in the night sky.

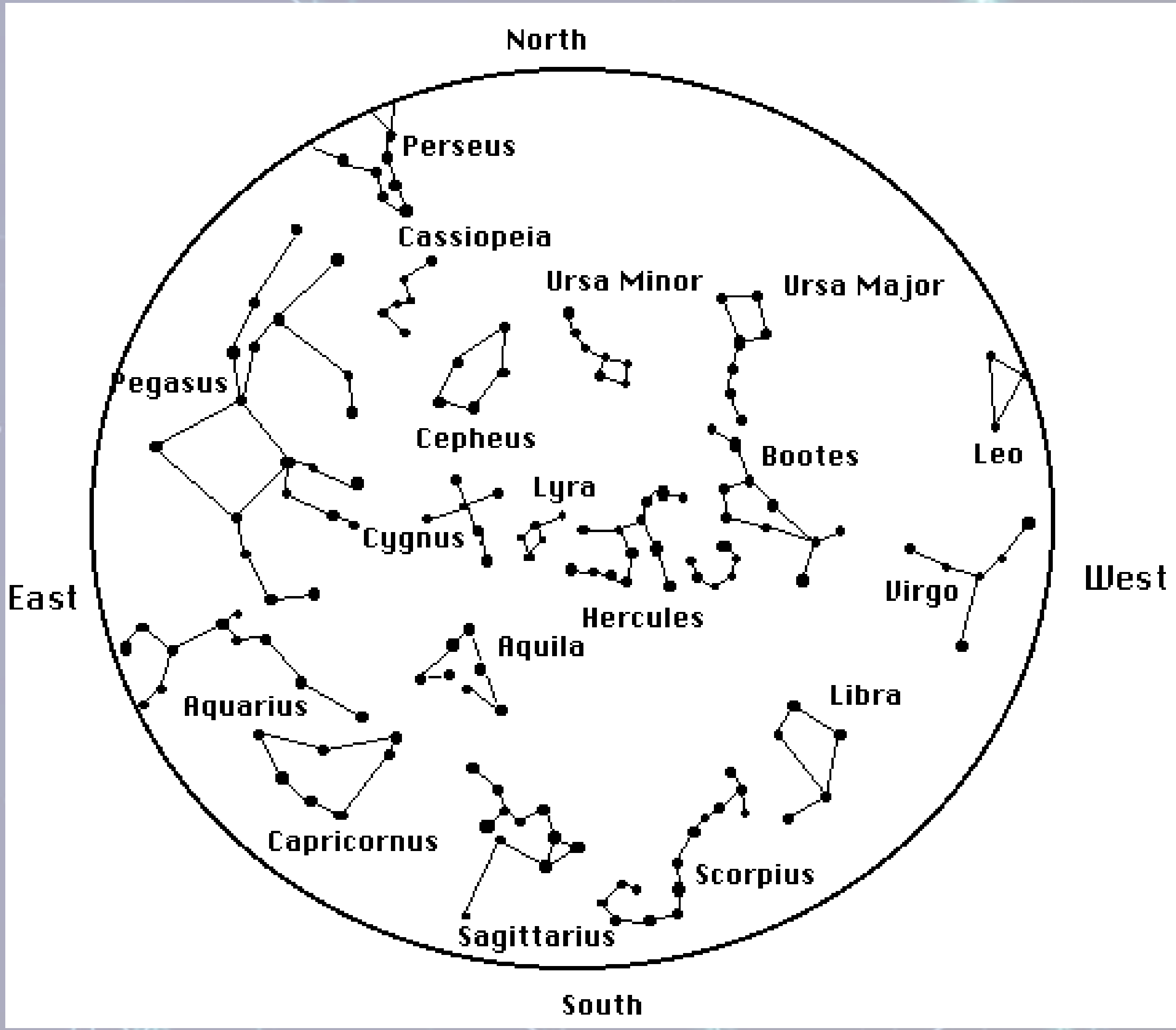


Northern Hemisphere

Spring

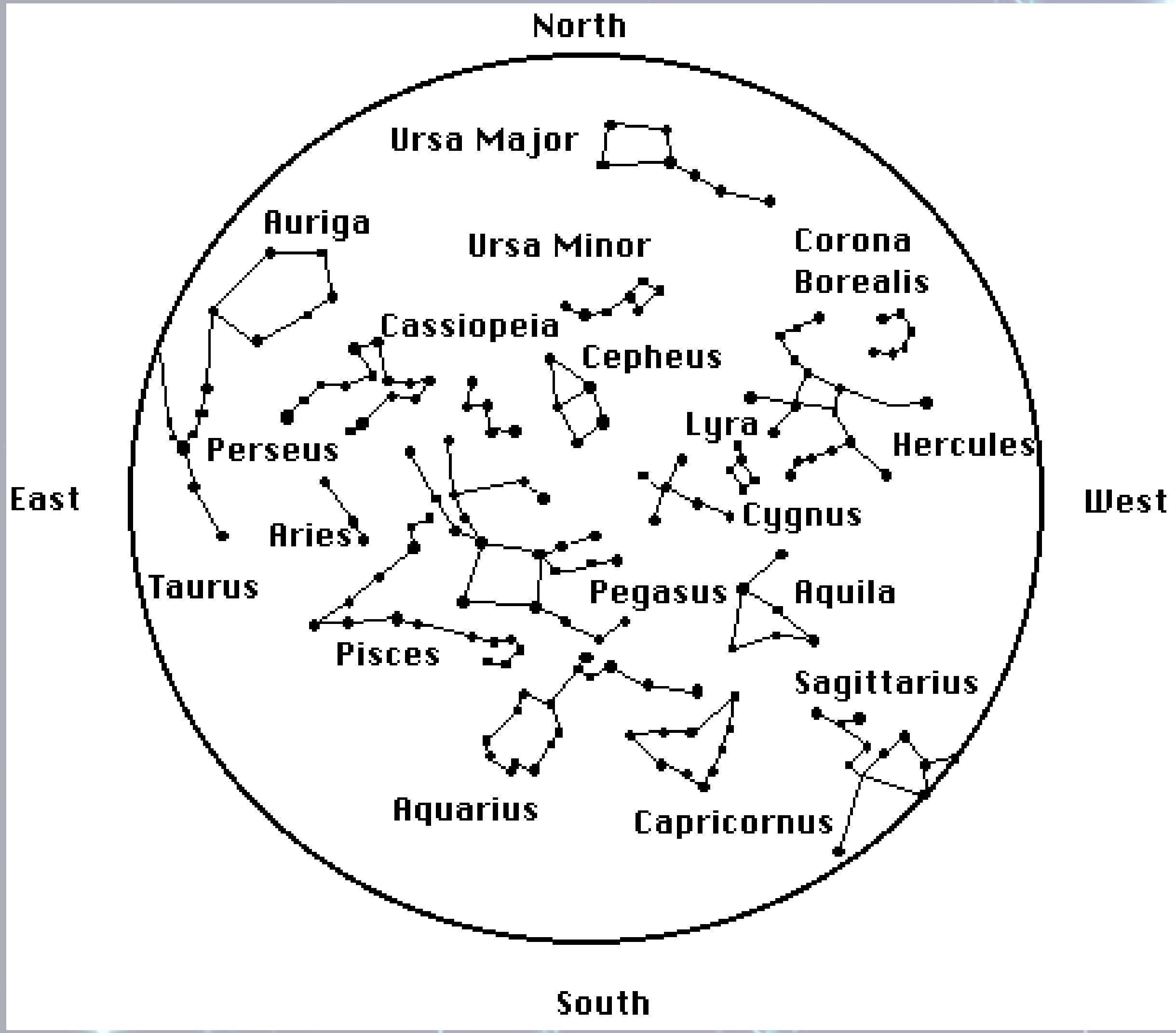


Summer

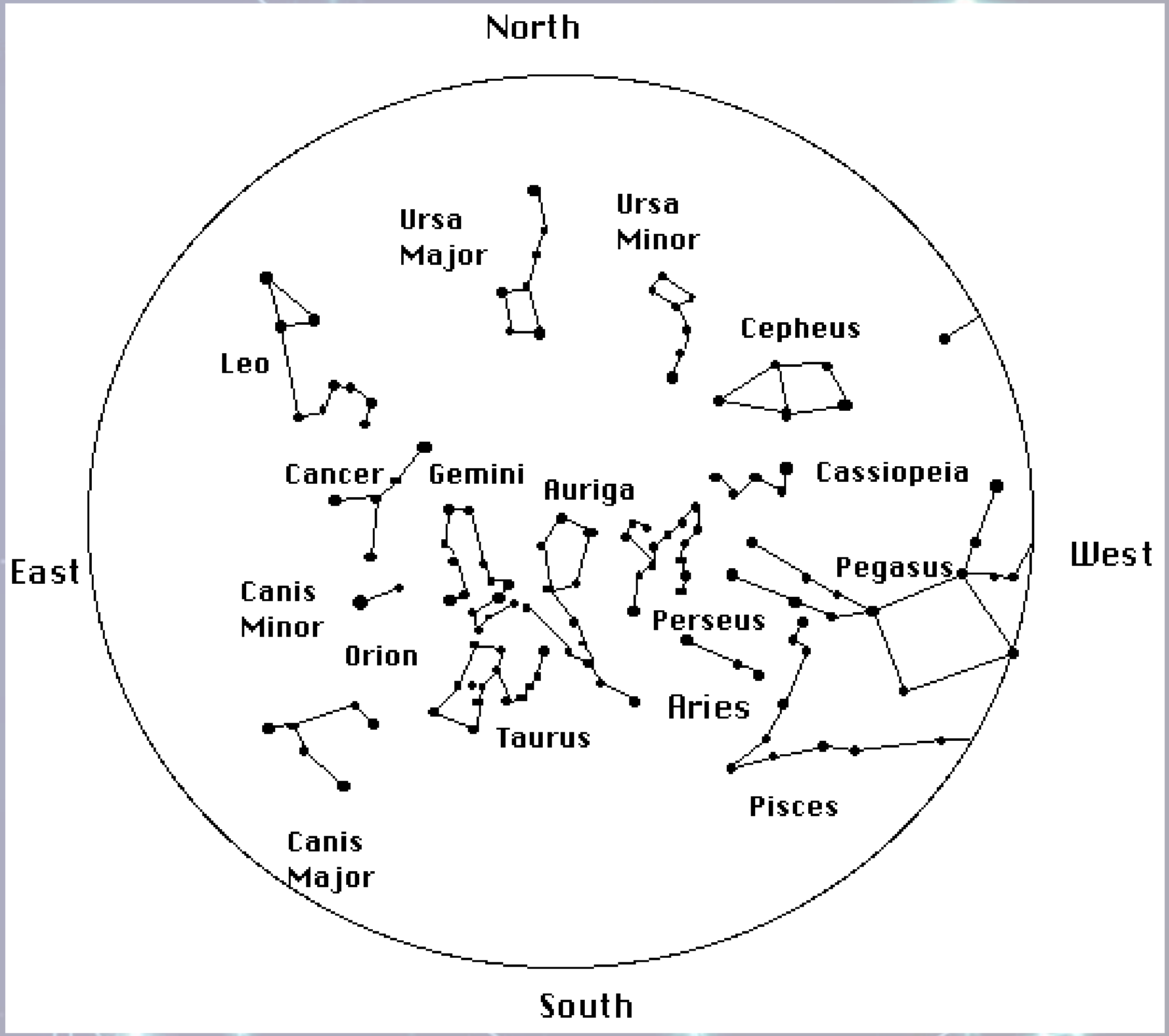


Northern Hemisphere

Fall



Winter



Why do we see different constellations at different times of the year?

The Revolution of the Earth around the sun!

35. Students studying constellations noticed that some constellations, like the Big Dipper, can be seen in the Tennessee night sky all year long. Other constellations can be seen only during certain parts of the year. One of the students explained why some constellations can be seen only during certain parts of the year.

1. All stars appear to revolve around the North Star in the night sky.
2. The Big Dipper is close to the North Star, so it appears to move in a small circle around the North Star and stays above the horizon all year long.
3. Some constellations revolve farther away from the North Star than the Big Dipper does.
4. Since they are farther away, some constellations appear to move in a large circle around the North Star.
5. These circles are so large that part of them goes below the horizon.
6. Therefore, some constellations stay below the horizon at night during certain parts of the year.

Which part of the student's explanation best describes why some constellations stay below the horizon at night?

A. Statement 1

B. Statement 2

C. Statement 3

D. Statement 5