Module 3 – Nautical Science

Unit 4 – Astronomy

Chapter 17 - The Stars

Section 1 – The Stars

What You Will Learn to Do

Demonstrate understanding of astronomy and how it pertains to our solar system and its related bodies: Moon, Sun, stars and planets

Objectives

1. Explain the theory adopted as the common unit of astronomical distances
2. Explain the system used to classify stars
3. Describe the method used for determining a star’s brightness
4. Explain the life cycle of a star

Objectives

5. Explain the terms used to identify temporary stars from 134 B.C. to the present
6. Describe the three Nebulae stars and their makeup
7. Describe the binaries and star clusters
8. Describe the characteristics of our galaxy and the three ways other galaxies are classified according to their shapes

Key Terms

CPS Key Term
Questions 1 - 33

Key Terms

Light-year -	The distance traversed by light in one mean solar year, about 5.88 trillion miles; used as a unit in measuring stellar distance
Parsec -	A unit of distance equal to that required to cause a heliocentric parallax of one second of an arc, equivalent to 3.26 light-years

Key Terms

Constellation -	The grouping or relative position of the stars; Any of various groups of stars to which definite names have been given, as Ursa Major, Ursa Minor, Cancer, Orion, Cassiopeia
Apparent magnitude -	The magnitude (brightness) of a star as it appears to an observer on the Earth

Key Terms

Absolute magnitude -	The magnitude (brightness) of a star as it would appear to a hypothetical observer at a standard distance of 10 parsecs or 32.6 light-years away
Luminosity -	The brightness of a star in comparison with that of the Sun There is a unique luminosity value that corresponds with every absolute magnitude value

Key Terms

Spectrum-luminosity diagram, or Hertzsprung-Russell diagram - A scatter graph of stars showing the relationship between the stars' absolute magnitude (brightness)s or luminosities versus their spectral types or classifications and effective temperatures (color)

Also called H–R diagram or HRD

Key Terms

Supergiant -	Massive, extremely luminous stars, with absolute magnitudes in the negative range; Rigel, Antares, Polaris are examples. Supergiants have short lifespans of only 10 to 50 million years.
Blue giant -	A giant star, with five to eight times the mass of the Sun or more; its hot temperature gives it its blue color

Key Terms

Red giant -	A star that has grown to a massive size as the hydrogen in its core is consumed, and the outer shells expand. As a giant star, it consumes fuel at a tremendous rate.
Main-sequence star -	A narrow band in the Hertzsprung-Russell diagram in which 98% of all observed stars are plotted

Key Terms

White dwarf - A low-mass star that has exhausted its nuclear fuel and its core has collapsed, becoming denser

They are hot, but very faint.

A white dwarf can survive for many billions of years, gradually cooling to become a black dwarf.

Key Terms

Red dwarf - A star formed in an environment of limited dust and gas ; A red dwarf star will shine dimly for many tens of billions or perhaps trillions of years.

Nebula, -ae - An expanding shell of thinly ionized gas that is ejected from and surrounds a hot, dying star of about the same mass as the Sun

Key Terms

Neutron star - Extremely dense stars that are formed when the core of a massive star undergoes gravitational collapse at the end of its life

Habitable zone - The range of distance from a star where liquid water might pool on the surface of an orbiting planet; regions neither too hot nor too cold to support life

Key Terms

Population I stars -	A classification based on location Population I stars are in regions with substantial dust and gas. They are young stars, still forming, growing and adding mass.
Population II stars -	Older stars that have used up the available supply of raw material from space and are near the ends of their lives as luminous stars.

Key Terms

Black hole - A theoretical massive object, formed at the beginning of the universe or by the gravitational collapse of a star exploding as a supernova, whose gravitational field is so intense that no electromagnetic radiation can escape

Key Terms

Exoplanet, or extrasolar planet -	Planets orbiting distant stars, distinguished by a wobbling movement or a minor periodic dimming, as observed through powerful Earth-based telescopes
Rogue planet -	Exoplanets that roam freely through interstellar space, away from any central stars; also called interstellar planets

Key Terms

Nova, -ae -	A star that suddenly becomes thousands of times brighter and then gradually fades to its original intensity
Supernova, -ae -	The explosion of a star, possibly caused by gravitational collapse; most of the star’s mass is blown away at very high velocity, leaving behind an extremely dense core

Key Terms

Cepheid variable, or pulsating star -	A variable star in which changes in brightness are due to alternate contractions and expansions in volume
Pulsar -	A relatively young, very dense neutron star spinning at incredible rates; most likely the remnants of supernova explosion

Key Terms

Star clusters -	A large group of stars, drawn together due to gravitational attraction
Binaries, or double stars -	A system of two stars that revolve about their common center of mass

Key Terms

Galaxy - A large system of stars held together by mutual gravitation and isolated from similar systems by vast regions of space

There are three classifications based on shape: ellipsoidal, spiral and irregular.

Key Terms

Ellipsoidal galaxy -	Galaxy distinguished by its clearly defined, symmetrical shape, which may range from a sphere to a circle
Spiral galaxy -	Galaxy distinguished by its distinct nucleus with one or more spiral arms
Irregular galaxy -	Galaxy distinguished by its lack of a well-defined shape

Key Terms

Dark matter -	Material theorized to be present in the universe based solely on observation of gravitational effects on the visible matter and structure of the universe
Dark energy -	Energy theorized to cause anomalies, such as expansion of the universe, that cannot be explained by known theories of gravity and relativity

Opening Question

What are two units of measurement for distance in space?

1.

2.

3.

(Use CPS "Pick a Student" for this question.)

Warm Up Questions

CPS Lesson
Questions 1 - 2

Introduction

Stars are distant suns in space. The closest star to our solar system is our Sun.

The universe contains literally billions upon billions of stars.

Introduction

Proxima Centauri is the next closest star to Earth after the Sun, at about 26.4 trillion miles, or 4.24 light-years away.

Introduction

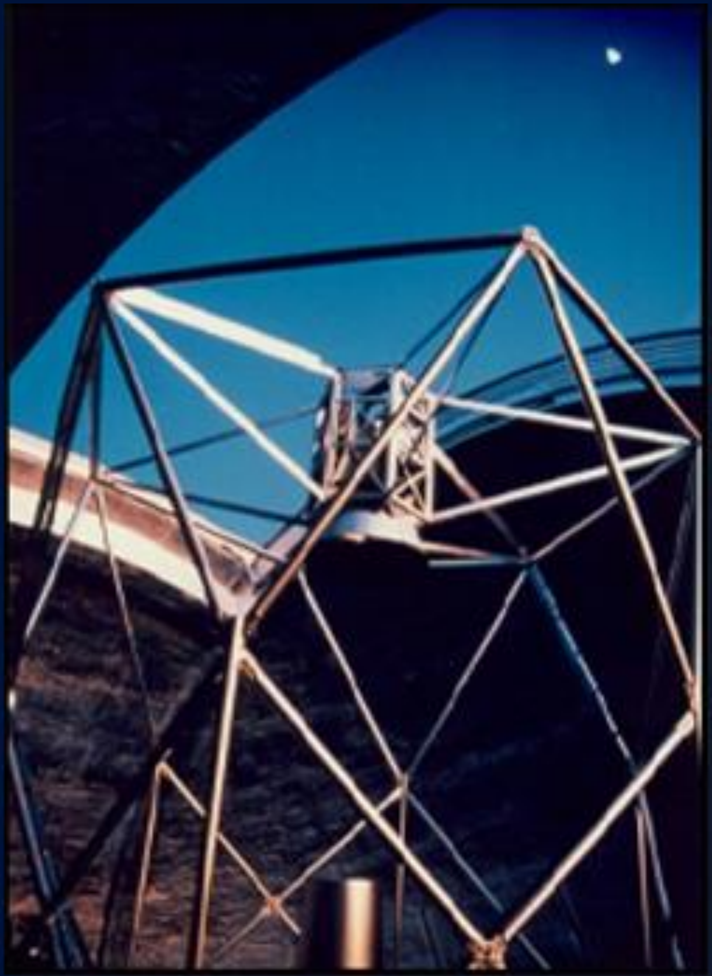
Miles or kilometers are useless in measuring such great distances. So, light-years are used.

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

Introduction

When astronomers say a star is “10 light-years away,” they mean it takes 10 years for the light to travel from the star to their observatory.

Introduction



Modern telescopes can see out to distances of billions of light-years.

When a larger unit is more practical for measuring distances, parsecs are used. One parsec is 3.26 light-years.

Introduction

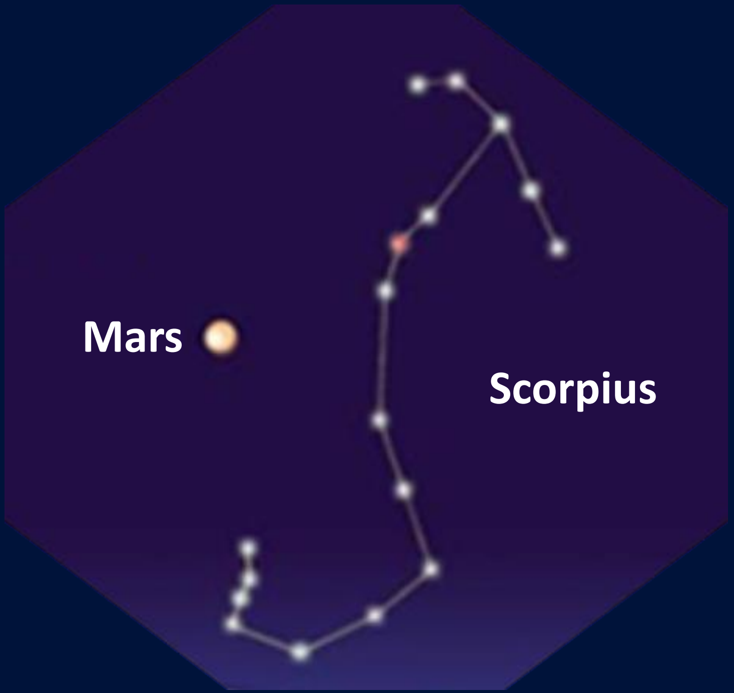
Astronomers see distant galaxies as they were millions or billions of years ago, effectively "looking back in time."

Nearby stars, like our Sun, can be seen easily.

However, most of the other stars we see in the sky are giant or supergiant stars.

Constellations

Since ancient times, patterns formed by the brightest stars have sparked imaginations to give names to the shapes. These patterns are now called constellations.

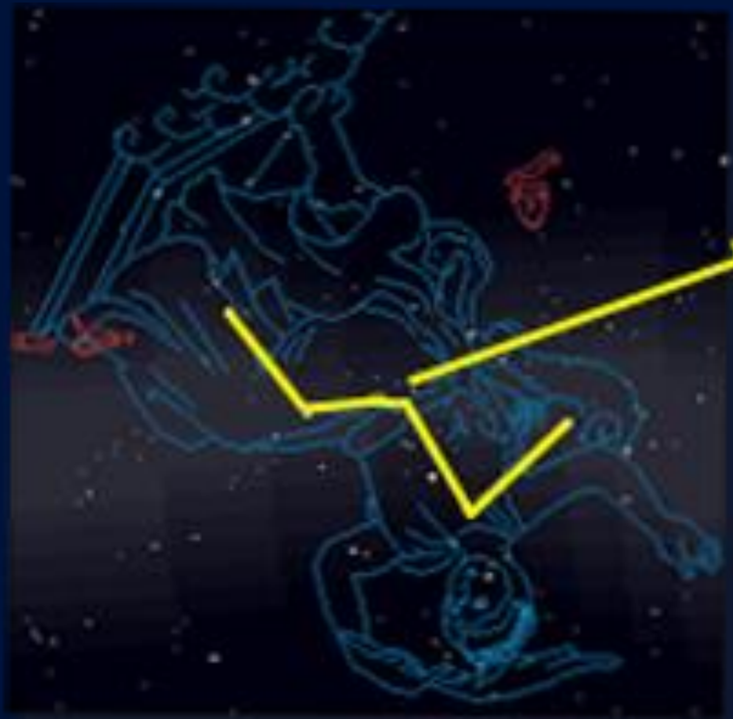


Greek astronomer Hipparchus observed a new star in the constellation of Scorpius in 134 B.C.

Constellations

Another Greek astronomer, Tycho Brahe, observed a new star in the constellation of Cassiopeia in 1572.

Brahe



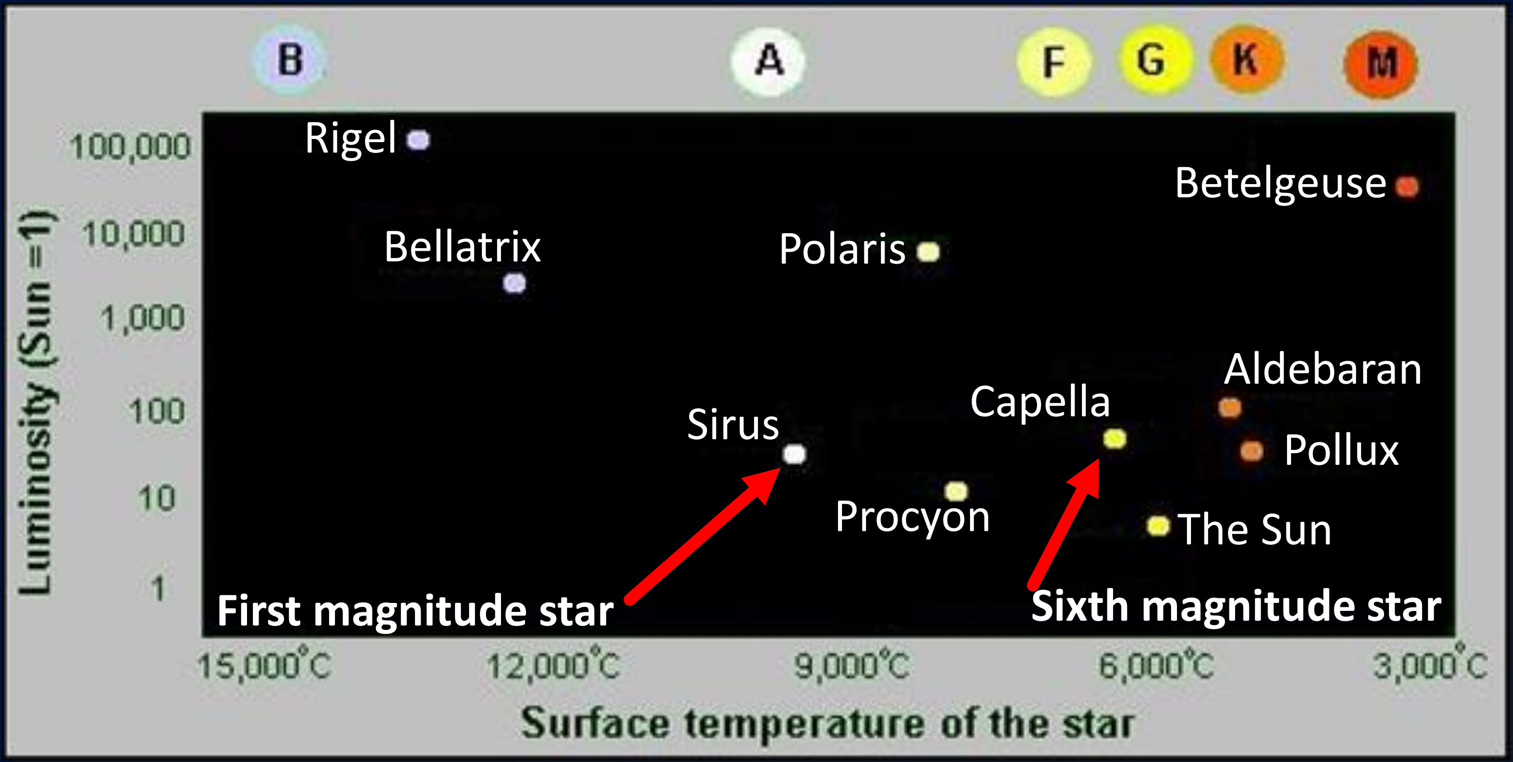
Stars Classified

The relative brightness of a celestial body is called its magnitude.

Astronomers call the brightness of a star as it appears to an observer on Earth its apparent magnitude.

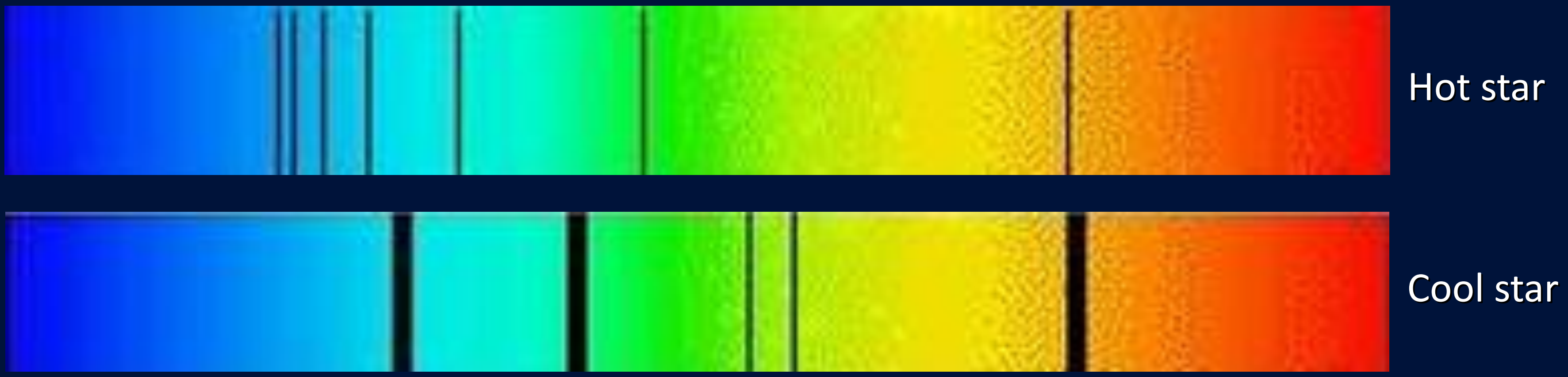
Stars Classified

First magnitude stars are about one hundred times brighter than sixth magnitude stars.



Stars Classified

The nature of a star can best be determined by the spectrum of its temperature and color.



Stars Classified

There is a relationship between color and luminosity (brightness):

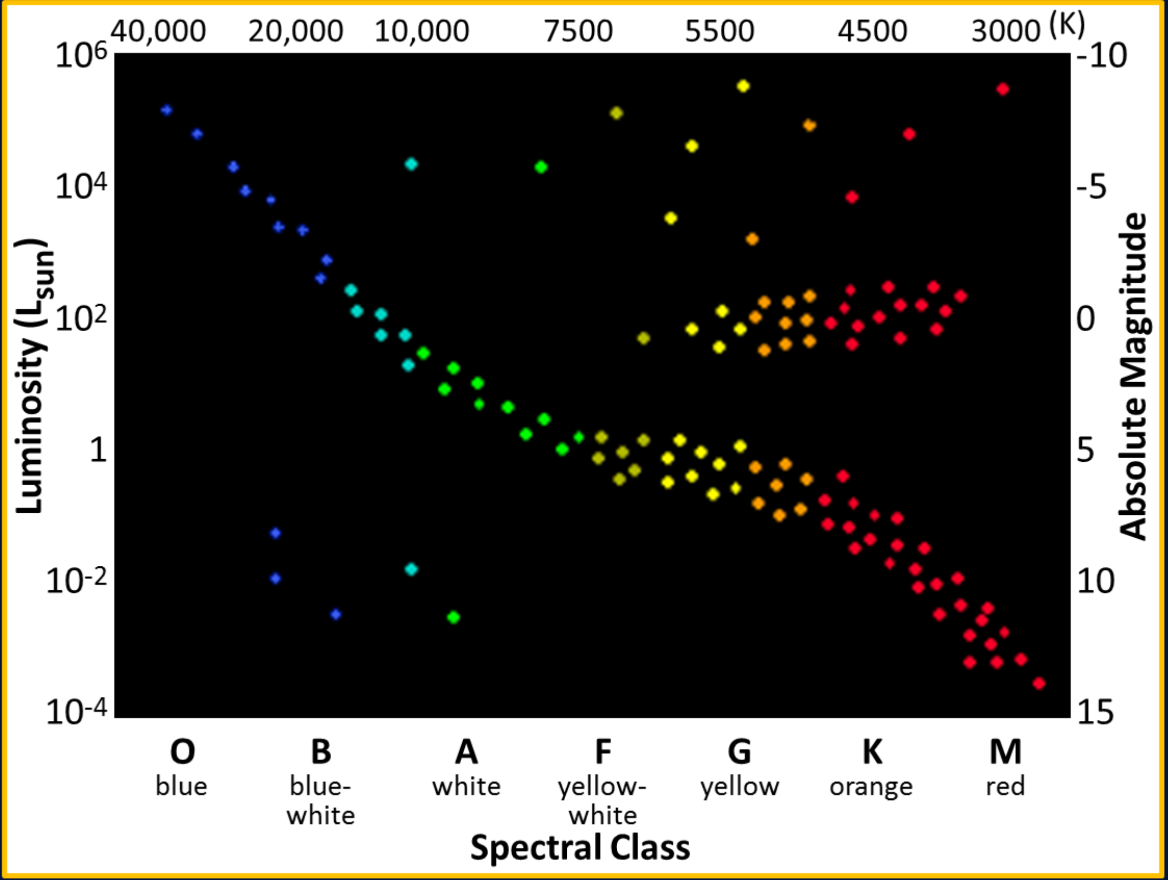
- Blue (O)
- Blue-white (B)
- White (A)
- Yellow-white (F)
- Yellow (G)
- Orange (K)
- Red (M)

- Colors range from blue through white, yellow, orange, and red.
- Our Sun, a yellow star, is average in brightness and temperature.
- Blue stars are large and bright.
- Red stars are usually smaller and dimmer.

Stars Classified

Schematic Hertzsprung-Russell Diagram, or H-R Diagram

The spectrum-luminosity diagram graphs stars by color (spectrum) and magnitude or stellar brightness (luminosity).

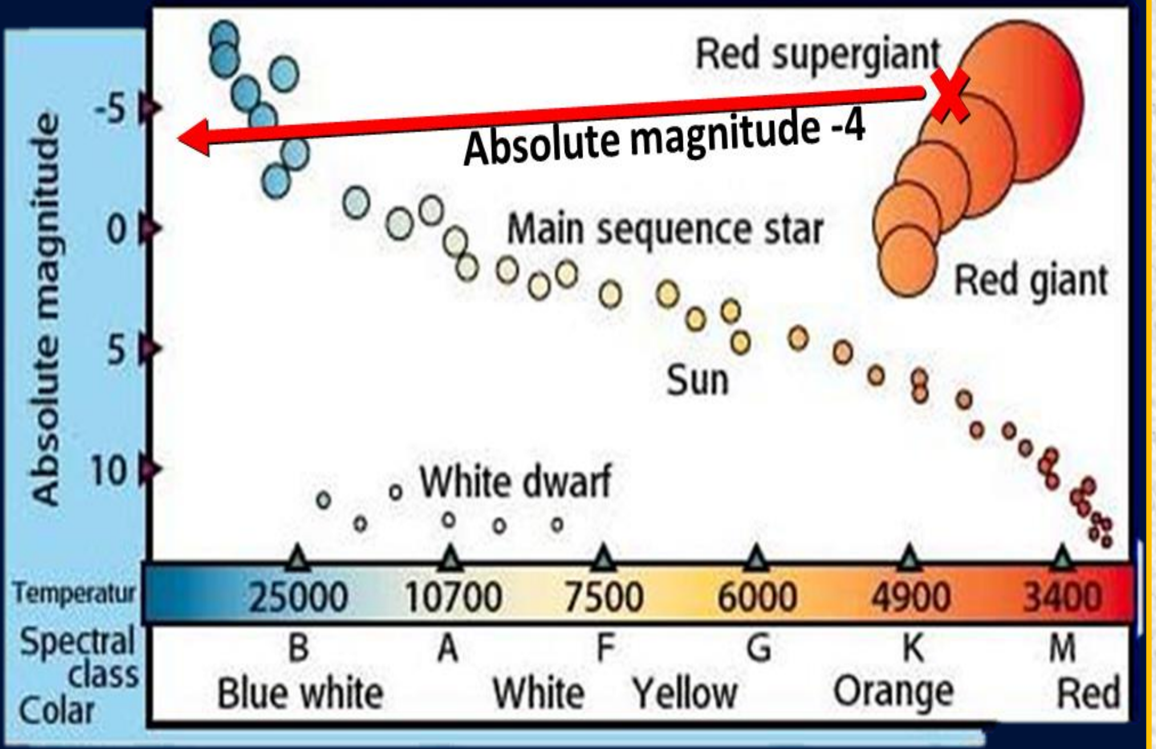


Stars Classified

Our Sun has an absolute magnitude of +5. Giant stars have an absolute magnitude of 0, making them 100 times brighter than the Sun.

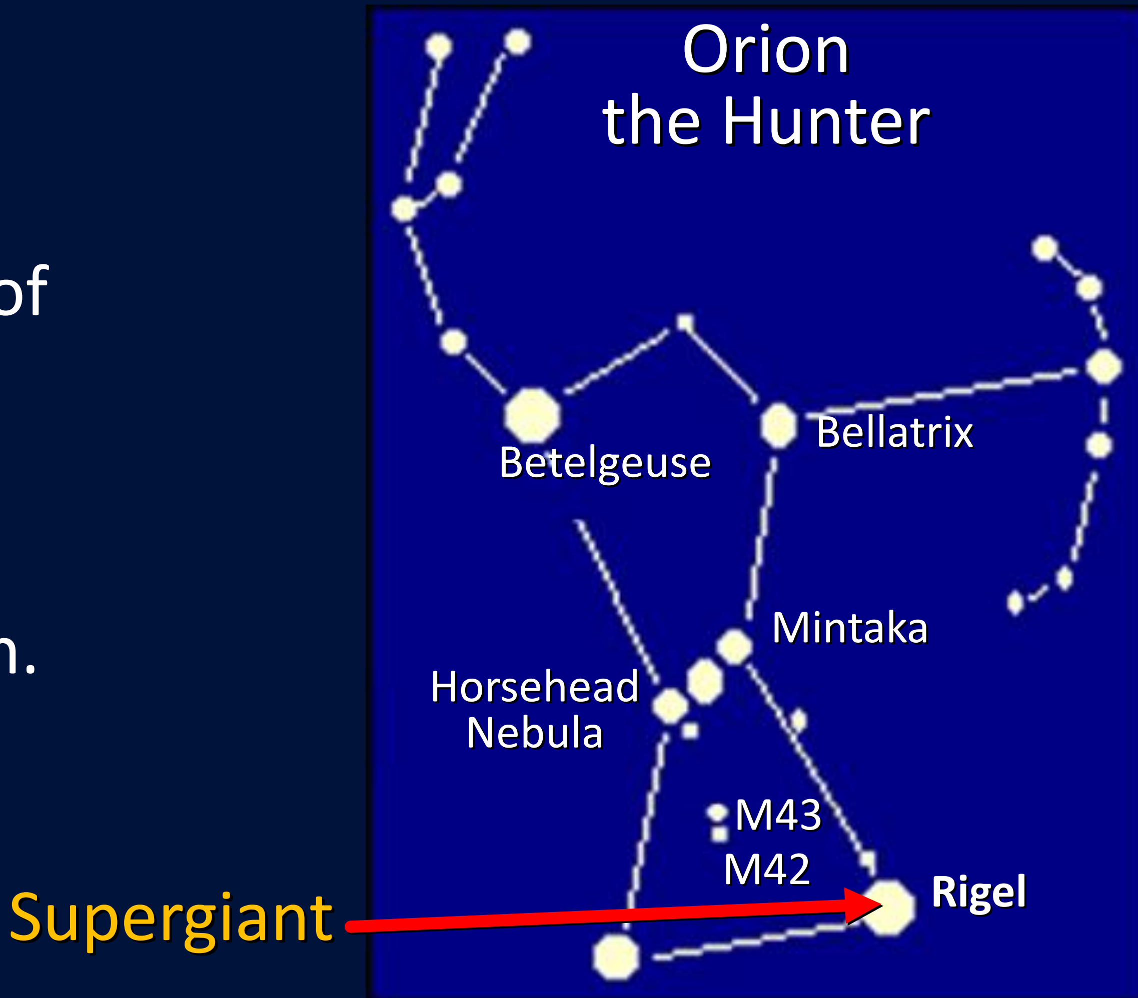
Supergiant stars are as much as one million times as bright.

Their absolute magnitudes are in the negative range

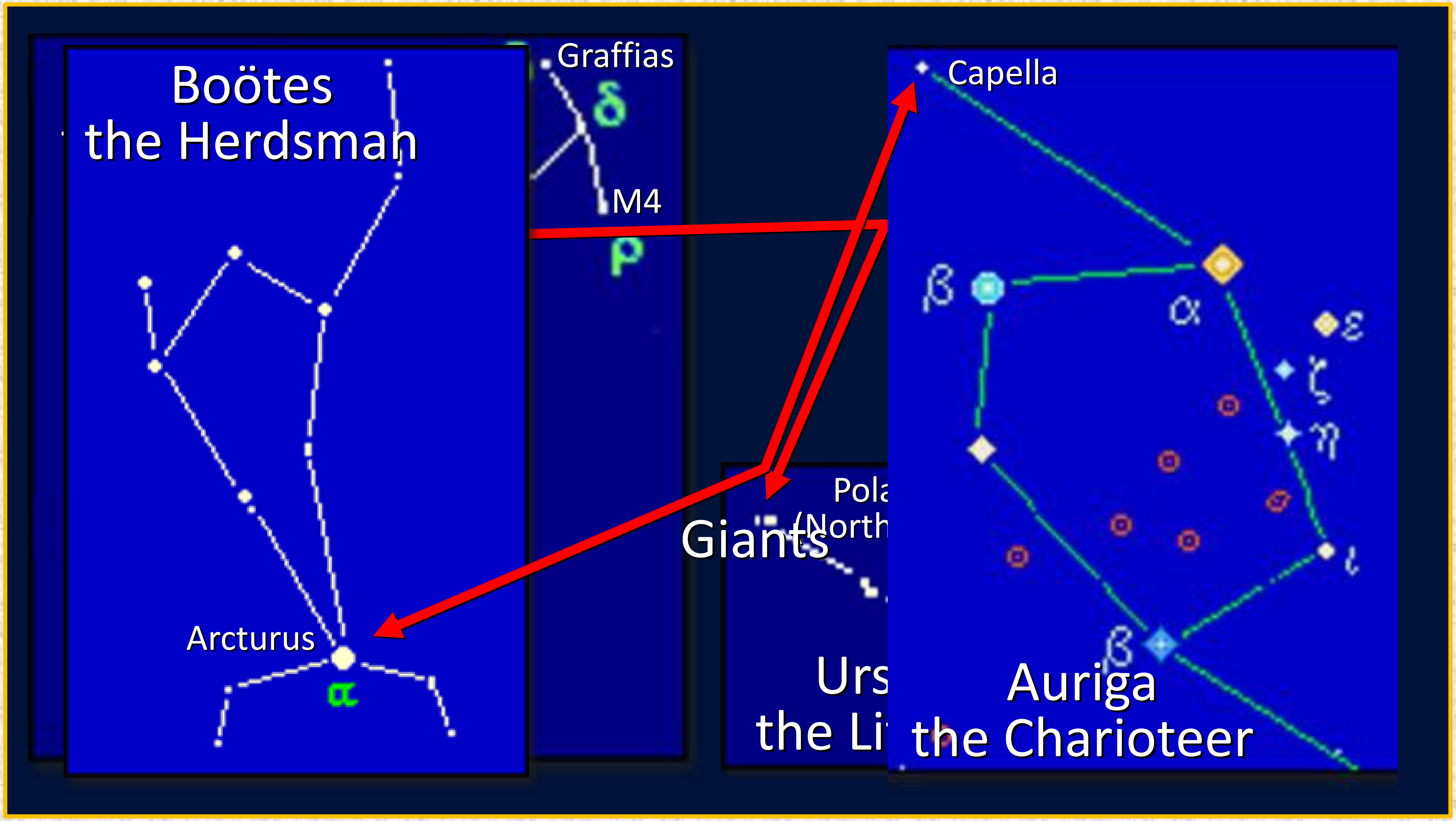


Stars Classified

Constellations were based on configurations of the larger, brighter stars that could be seen from Earth.

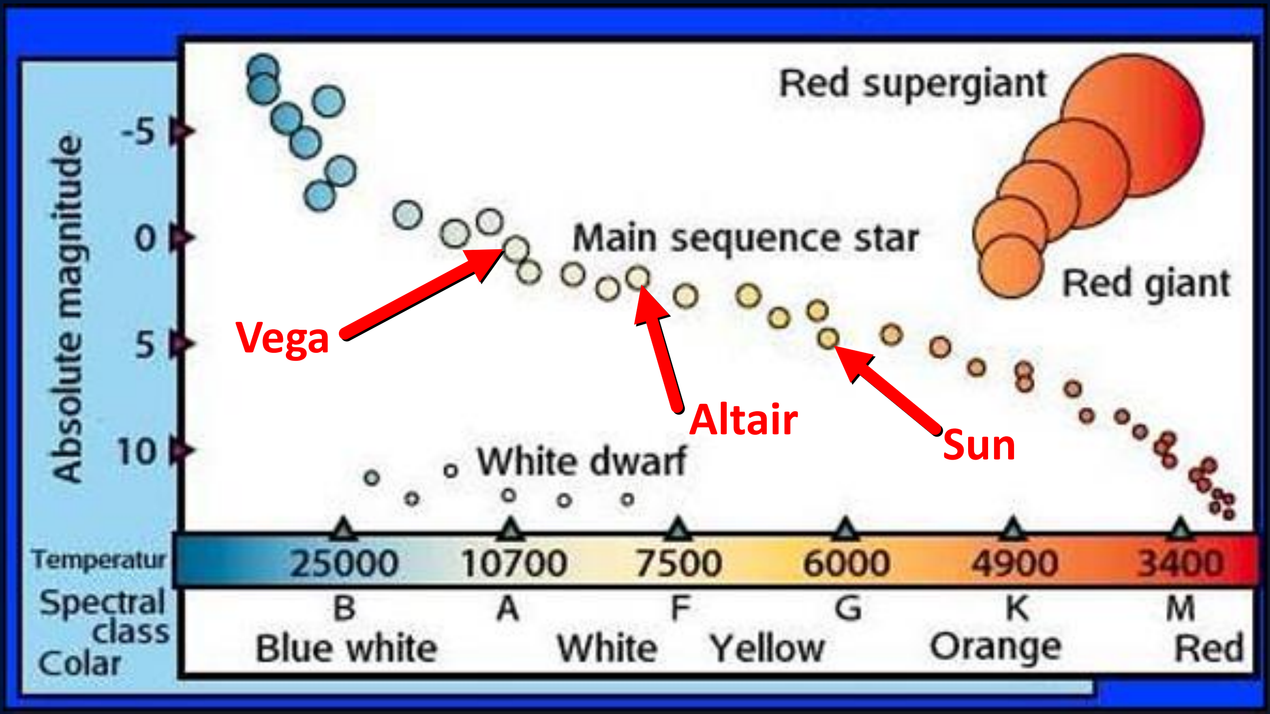


Stars Classified



Stars Classified

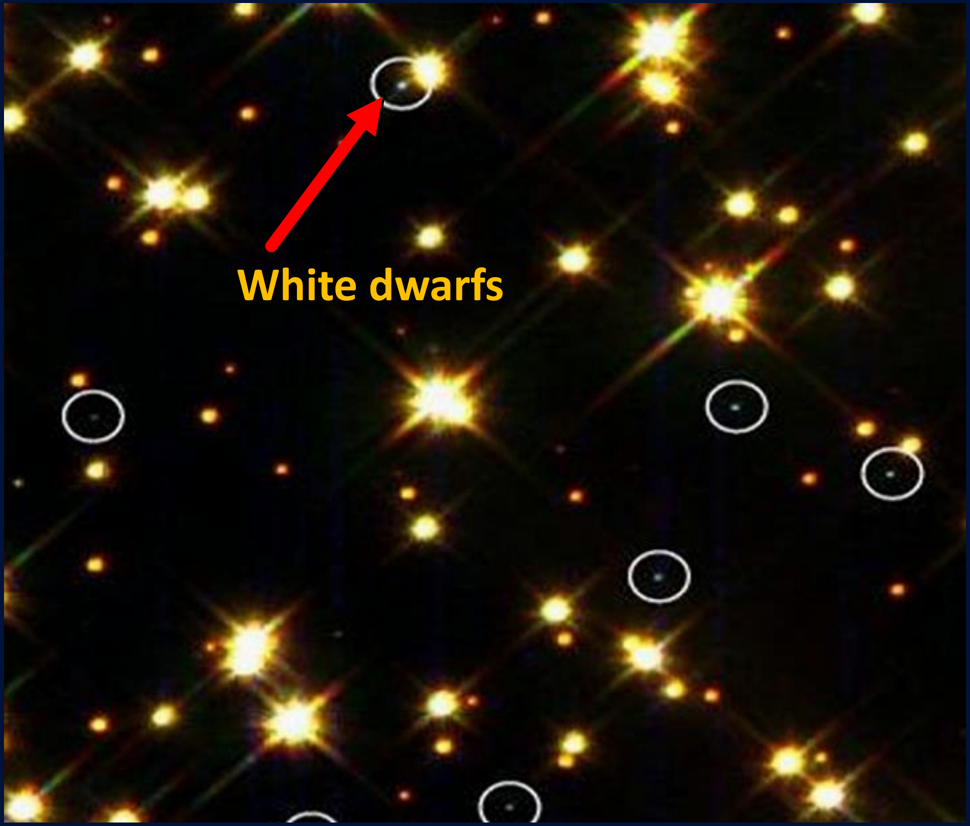
Vega, Altair and the Sun are medium-sized, and, like most stars, they are main-sequence stars in the H-R graph.



Stars Classified

White dwarf characteristics:

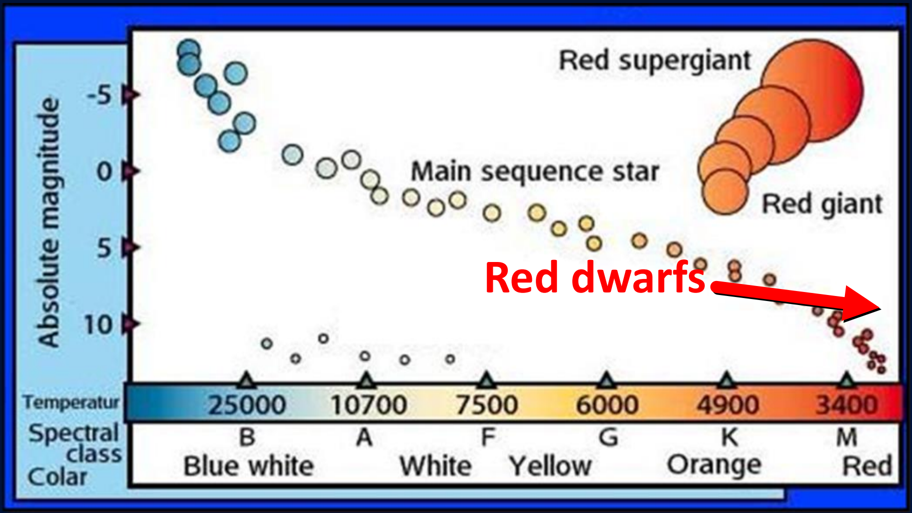
- at least 100 times fainter than the Sun, but much hotter
- about the same mass as the Sun, but are smaller in size
- denser than any substance on Earth



Stars Classified

Red dwarf characteristics:

- estimated to be about 75% of all stars in our galaxy
- emit mostly infrared light
- life cycle may be tens of billions longer than our Sun



Stars Classified

Proxima Centauri, our nearest neighboring star, is a red dwarf.

Stars in our galaxy are also classified by <u>location</u> in two distinct groups, Population I and Population II.

Stars Classified

Population I stars are found in regions where there is a great amount of dust and gas, such as the area near our Sun. They are young stars, still forming and adding mass.

Stars Classified

Population II stars are found in regions essentially free of dust and gas.

They have used up the available supply of raw material from space and are, relatively speaking, near the end of their lives as luminous stars.

Life Cycle of Stars

Stars begin as huge, cold, dark spheres of gas and dust called nebulae. Astronomers are still trying to determine the origin.

Stars are being born today out the nebulae of the Milky Way, our galaxy of stars.

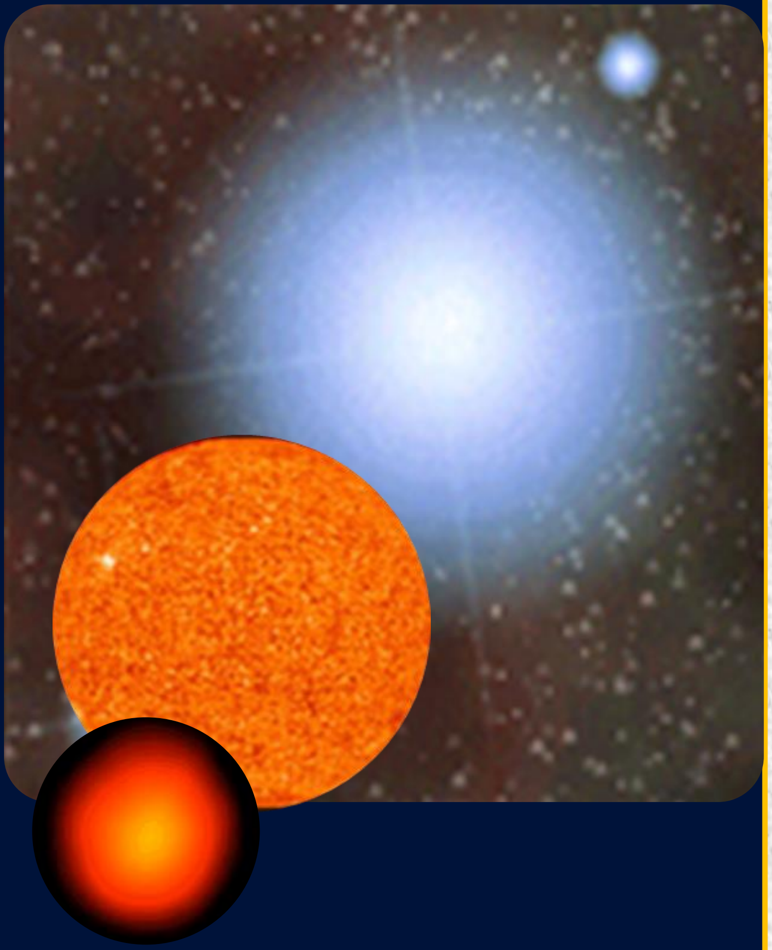
How much gas and cosmic dust becomes locked together by gravity helps determine the kind of star born.

Life Cycle of Stars

A lot of material means the star will probably be a blue giant.

If it's like most stars, it will be a yellow star, like our Sun, and have a much longer "life."

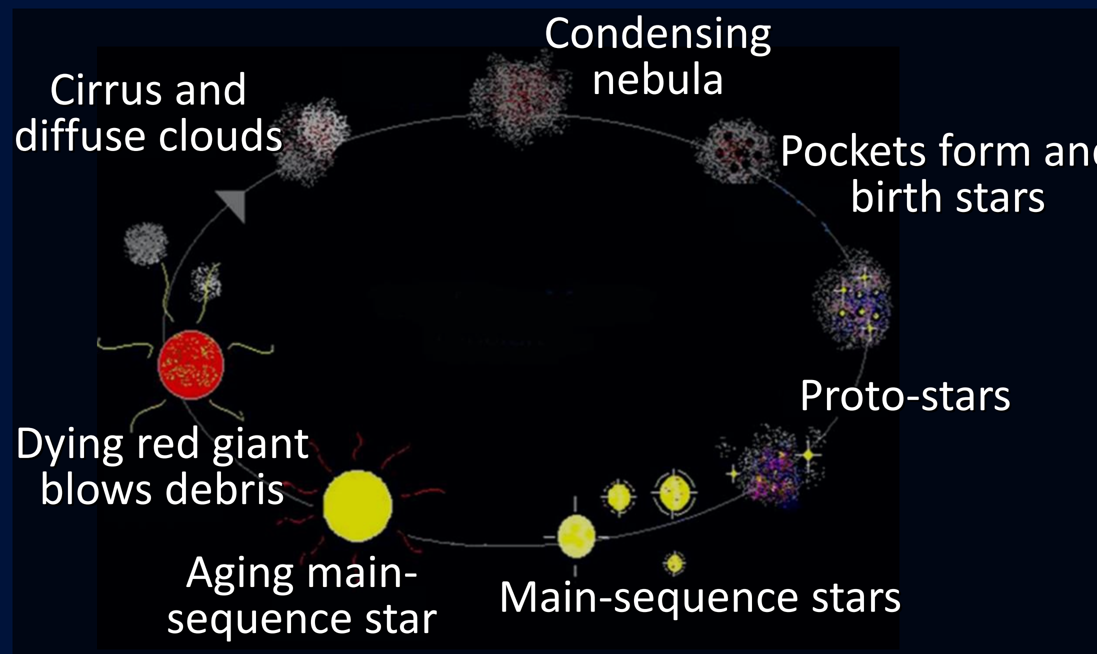
If there is even less dust and gas, it will become an orange dwarf that will live on for billions of years.



Life Cycle of Stars

The more fuel there is to burn, the greater the heat and consumption rate.

Start of cycle



The rate of fuel consumption is set at the beginning and doesn't vary.

Once the hydrogen-to-helium fusion cycle begins, it continues until the hydrogen is exhausted.

Life Cycle of Stars

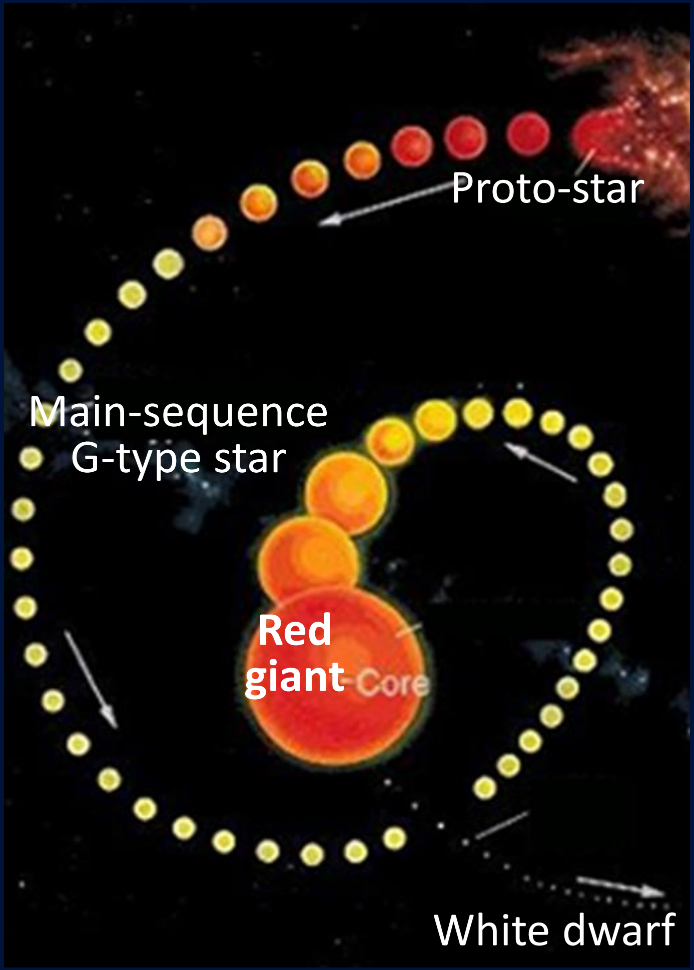
Birth of a Sun:

- Radiation pressure increases
- Temperature and pressure build, and the ball begins to glow
- The nuclear furnace begins working full time; the swirling gas ball glows, sending energy out into space as visible light and other electromagnetic radiation

Life Cycle of Stars

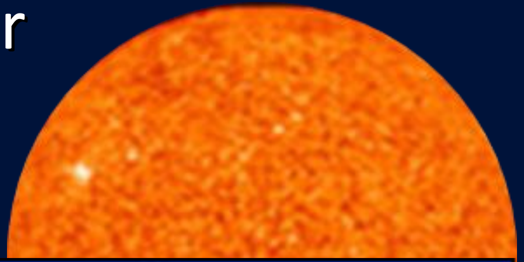
"Normal" Evolution of Stars

- Helium content builds
- Leftover hydrogen accumulates
- The star increases in size and luminosity
- It becomes a red giant
- It consumes fuel at a tremendous rate until its hydrogen is used up

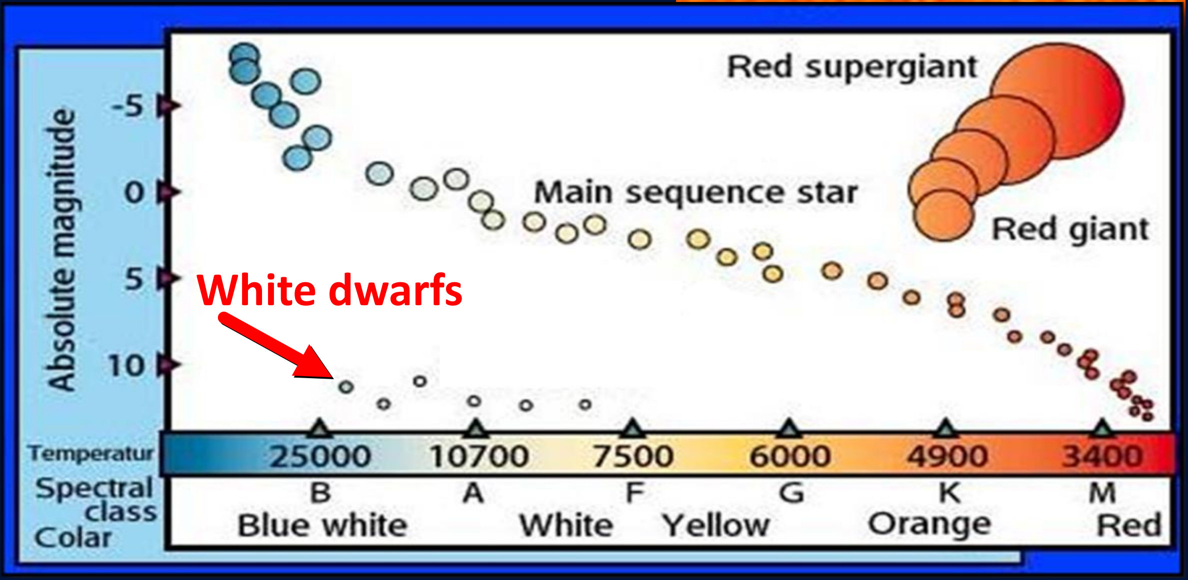


Life Cycle of Stars

Once the nuclear fuel is spent, the core of <u>most</u> stars slowly collapses. The star throws off outer layers, which become planetary nebulae that dissipate in tens of thousands of years.



The collapsed star becomes a dense white dwarf.



Life Cycle of Stars

Giant stars, once they exhaust their fuel, can explode as supernovae, their cores collapsing to form extremely dense neutron stars.

It is theorized black holes are the result of supergiant stars exploding.

Check On Learning Questions

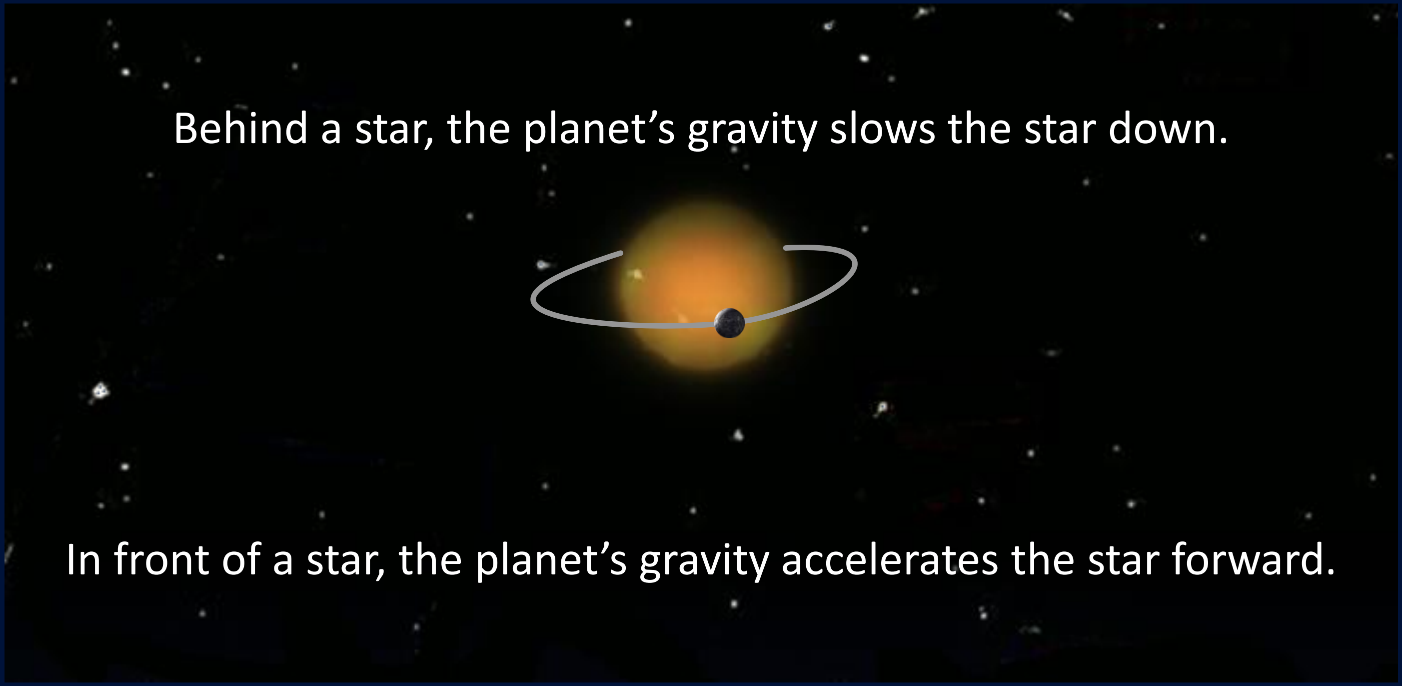
CPS Lesson
Questions 3 - 4

Exoplanets

Astronomers have discovered more than 3,500 planets orbiting other stars.

These extrasolar planets, or exoplanets, can be distinguished from other celestial bodies by watching the star for movement and visible dimming.

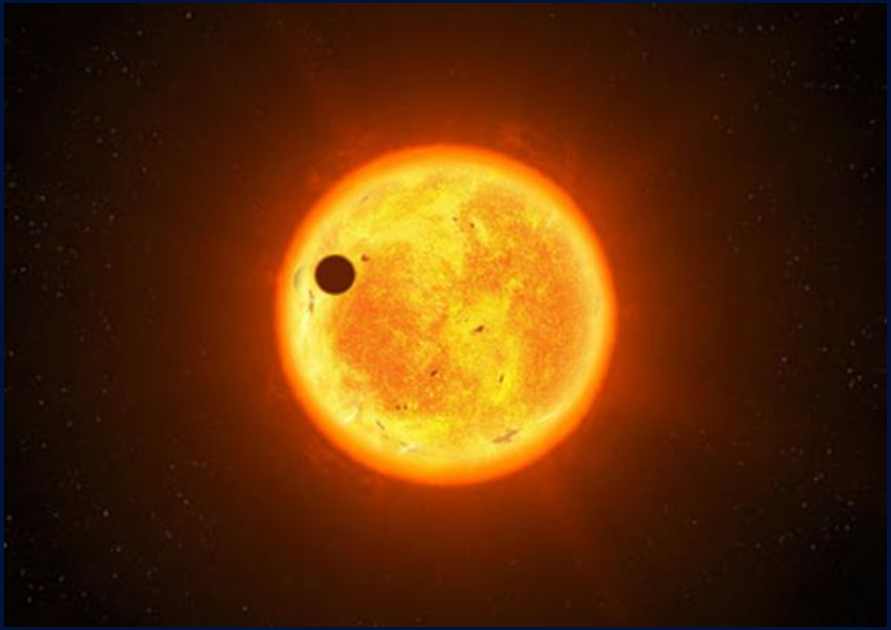
Exoplanets



This gravitational effect on the star being orbited causes a distinctive wobble as the star moves through space.

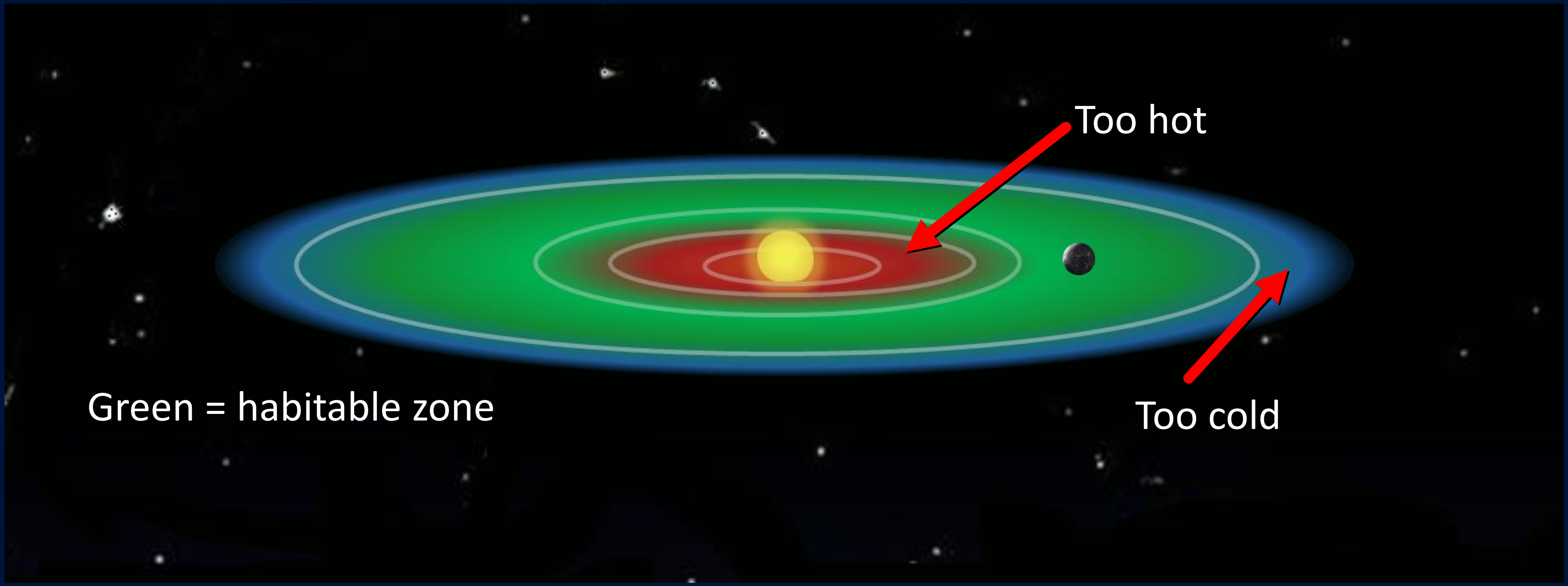
Exoplanets

The second primary indication of an exoplanet is a star that exhibits minor, periodic dimming, possibly caused by a planet passing across, or transiting, the star's disk.



Exoplanets

Astronomers hope to be able to identify which exoplanets orbit within habitable zones, neither too hot nor too cold to support life.



Exoplanets

Many exoplanets orbit red dwarf stars, which are not considered conducive to life.

Exoplanets that don't orbit a central star have been discovered. These rogue or Interstellar planets may have Been ejected into space from accretion disks.
Such disks are diffuse material in orbit around a central body, typically a young star.

Novae and Supernovae

There are two different events that make it seem a new star has appeared in the sky.

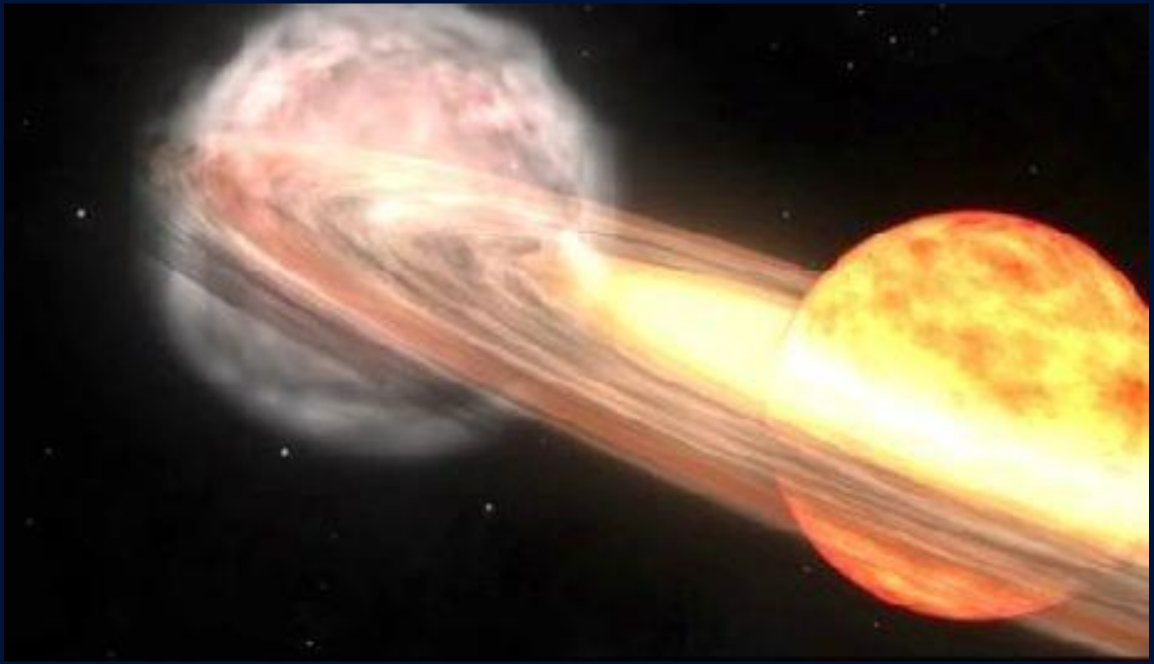
More correctly called “temporary stars,” these phenomena appear, then disappear after a few days or weeks.

Novae are the most common, with an estimated 40 each year appearing in the Milky Way galaxy.

Novae and Supernovae

Novae are thought to develop when a white dwarf star is in a binary system with a red giant star. The white dwarf draws hydrogen from the red giant.

The hydrogen ignites and the burst is seen as a sudden brightening.



Novae and Supernovae

Another "temporary star" originates with a supernova. Only about three supernovae are observed within the Milky Way in a century.

Supernovae blaze with a luminosity as much as a million times that of an ordinary star, sometimes outshining an entire galaxy of stars for a few weeks.

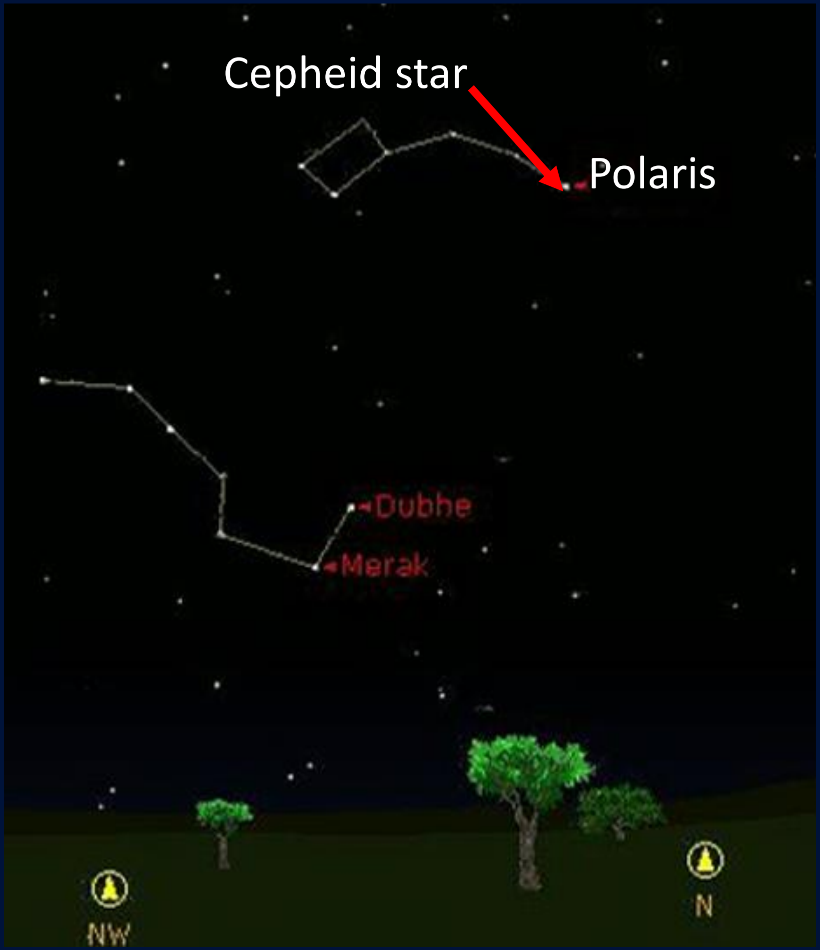
Novae and Supernovae

A supernova is thought to originate from the sudden collapse of a supergiant star, or from an implosion of a remnant neutron star formed after the collapse of a giant star.

Cepheid Stars and Pulsars

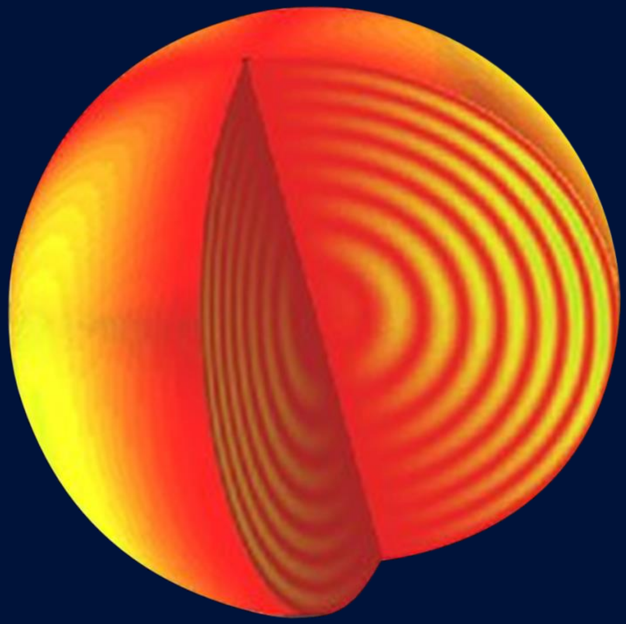
Astronomers use cepheid stars as a reference to classify other stars. These bright stars expand and contract in regular cycles, which can be seen as a variation in brightness.

This definite rhythm sets pattern called cepheid variables. A cepheid star is also called a pulsating star.



Cepheid Stars and Pulsars

When the star contracts, its internal pressure and temperature increase. The star expands in a sort of explosion. Then the process repeats itself.



The duration of this cycle can be used to calculate its absolute magnitude, which provides the corresponding luminosity value.

Cepheid Stars and Pulsars

When other methods of determining distances are not practical because of extreme distance, cepheid variables provide a valuable method for calculating star distance.

Cepheid Stars and Pulsars

Pulsars are relatively young, very dense neutron stars spinning at incredible rates, most likely the remnants of supernova explosions.

Moving much like a lighthouse beam, they seem to blink on and off as they rotate.

Pulsars rotate with such regularity, emitting beams of electromagnetic energy, that the timing of their beams rivals atomic clocks in precision.

Check On Learning Questions

CPS Lesson
Questions 5 - 6

Binaries and Star Clusters

Stars have a tendency to cluster together due to gravitational attraction.

These clusters are classified by appearance and population.

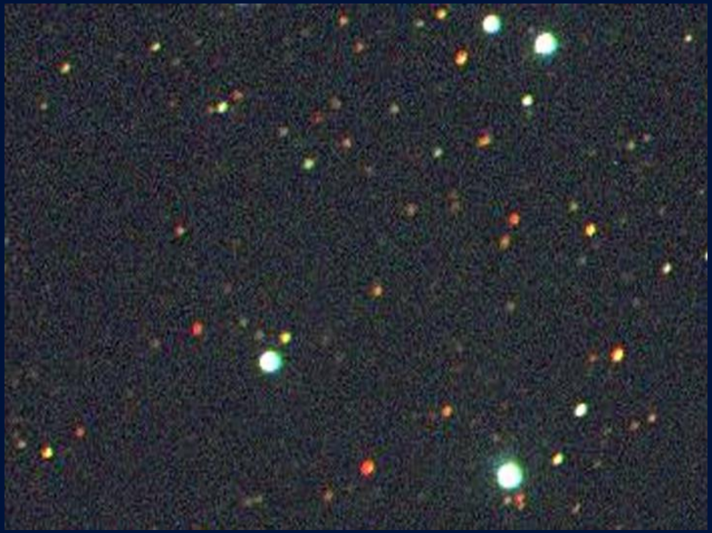
Binaries and Star Clusters

Pairs of stars are called binaries, or "double stars," that often orbit each other at fantastic speeds.

Larger groups of stars are called star clusters.

Binaries and Star Clusters

A moving cluster contains a few stars that travel in parallel lines.



Open clusters, sometimes called galactic clusters, are loosely grouped stars. They are often found in areas such as galaxies, where there are glowing masses of dust and gas.

Binaries and Star Clusters

Globular clusters contain countless stars. Some contain galaxies; some have as many as 100,000 stars.

Star clouds are clusters so thick that they look like glowing clouds.

Nebulae

Nebulae, clouds of gas and dust visible in the heavens, are among the most beautiful of all astronomical phenomena.

There are three kinds observable in the visible light spectrum.

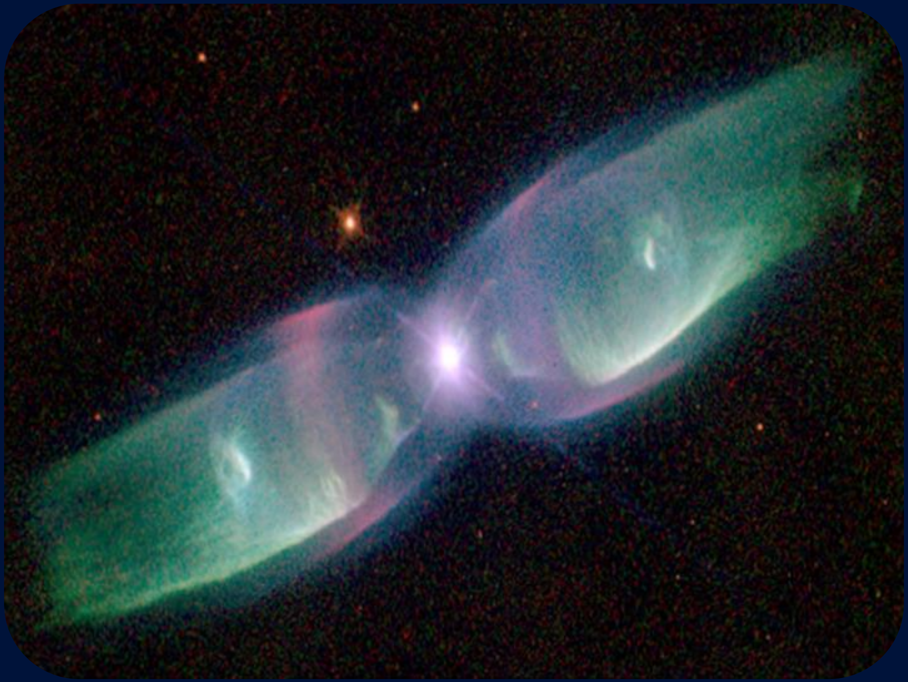
Nebulae

Bright nebulae glow and are illuminated by bright stars.

Dark nebulae are composed of the same gas and dust, but have no illuminating stars.

Nebulae

Planetary nebulae result from a nova or supernova explosion. These "temporary stars" may have dim dwarf stars, remnants of the explosion.



Galaxies

A galaxy is a huge collection of stars, star clusters, dust, and gas, all held together by gravitation.

On a clear summer night, you may see a wispy cloud across the northern sky—our galaxy.

Galaxies

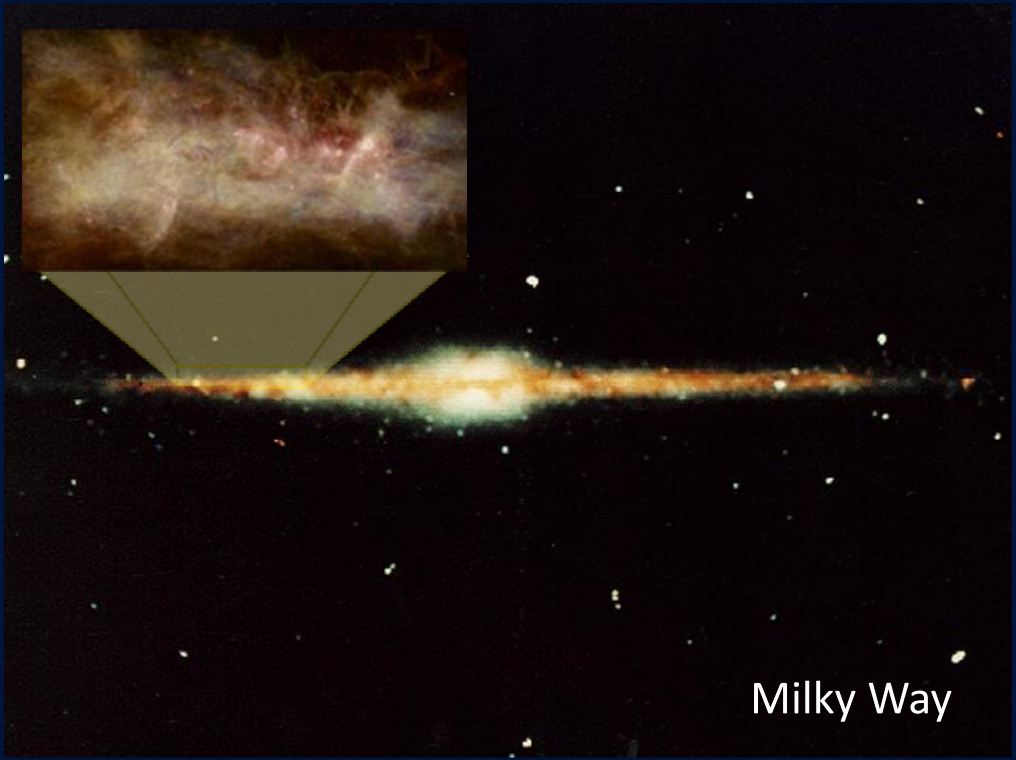
Our galaxy, the Milky Way, was once thought to be a nebula. However, we now know it is actually composed of billions of stars too far away to distinguish individually.

Milky Way

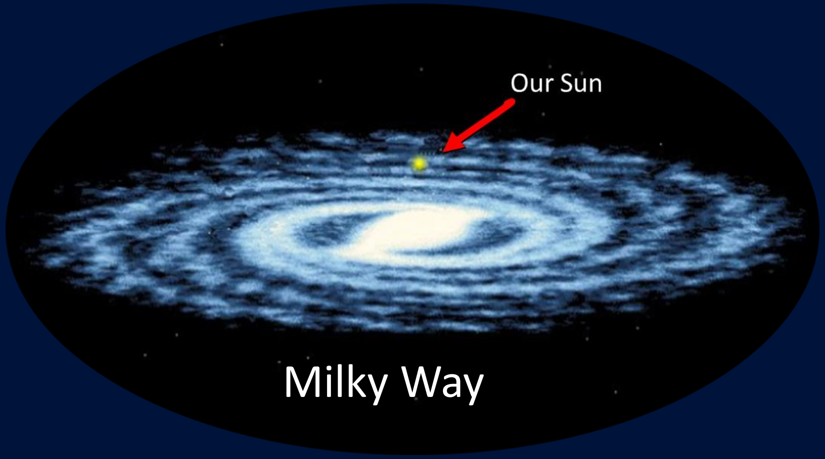
The Milky Way has over 400 billion stars revolving around a massive black hole in the constellation Sagittarius.

Galaxies

The huge amount of gas and dust fogging up the space between the stars obscures most of them from our view.



Galaxies



Our Sun is located two-thirds of the distance from the center of the galaxy to its outer rim.

Our Sun and the rest of our solar system revolve around the center of the galaxy at about 135 miles per second. It takes about 240 million years to complete one circuit.

Galaxies

Modern observatories have enabled astronomers to chart many distant galaxies, most of which have cepheid variables scattered throughout.

Distance can be roughly calculated by tracking the cepheid cycles.

Galaxies

Galaxy shapes fall into three major classifications.

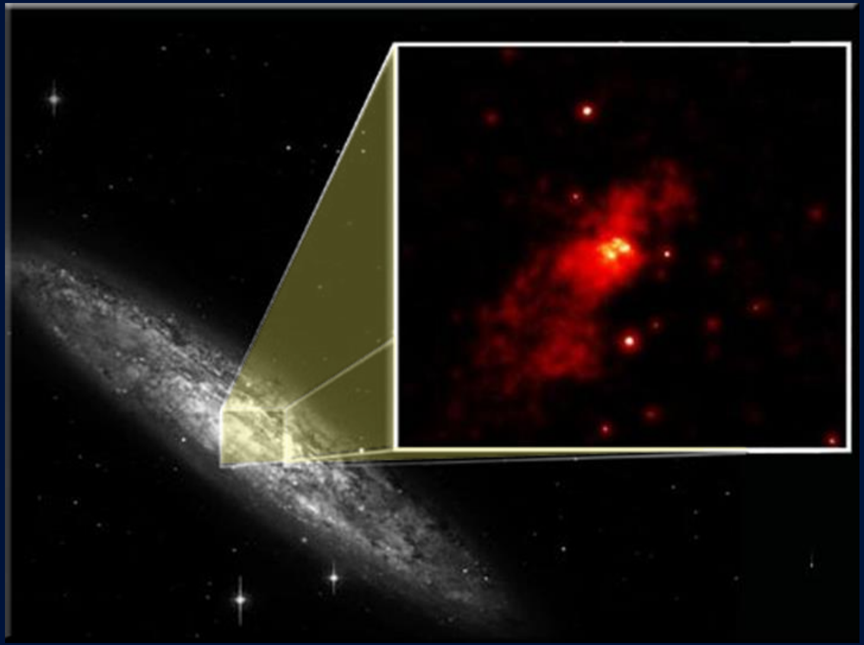
Ellipsoidal
clearly defined, symmetrical

Spiral
distinct nucleus, spiral arm(s)

Irregular
no regular shape

Supermassive Black Holes and Dark Matter and Energy

Recent *Hubble* and *Spitzer* telescopic observations led astronomers to conclude that there are supermassive black holes at the center of most galaxies.



Supermassive Black Holes and Dark Matter and Energy

The black hole at the center of our galaxy may have a mass equal to nearly two million times our Sun.

Supermassive Black Holes and Dark Matter and Energy

Astrophysicists and cosmologists have observed that certain matter exhibits behavior at odds with currently understood theory of motion.

One such example is that stars in our galaxy, regardless of their distance from the center, orbit at the same speed.

Supermassive Black Holes and Dark Matter and Energy

It is theorized that subatomic particles, undetected even with powerful telescopes, exert gravitational effects on visible matter and the structure of the universe.

They have called this invisible material dark matter.

Dark matter doesn’t seem to emit, reflect, or absorb light or any other electromagnetic radiation.

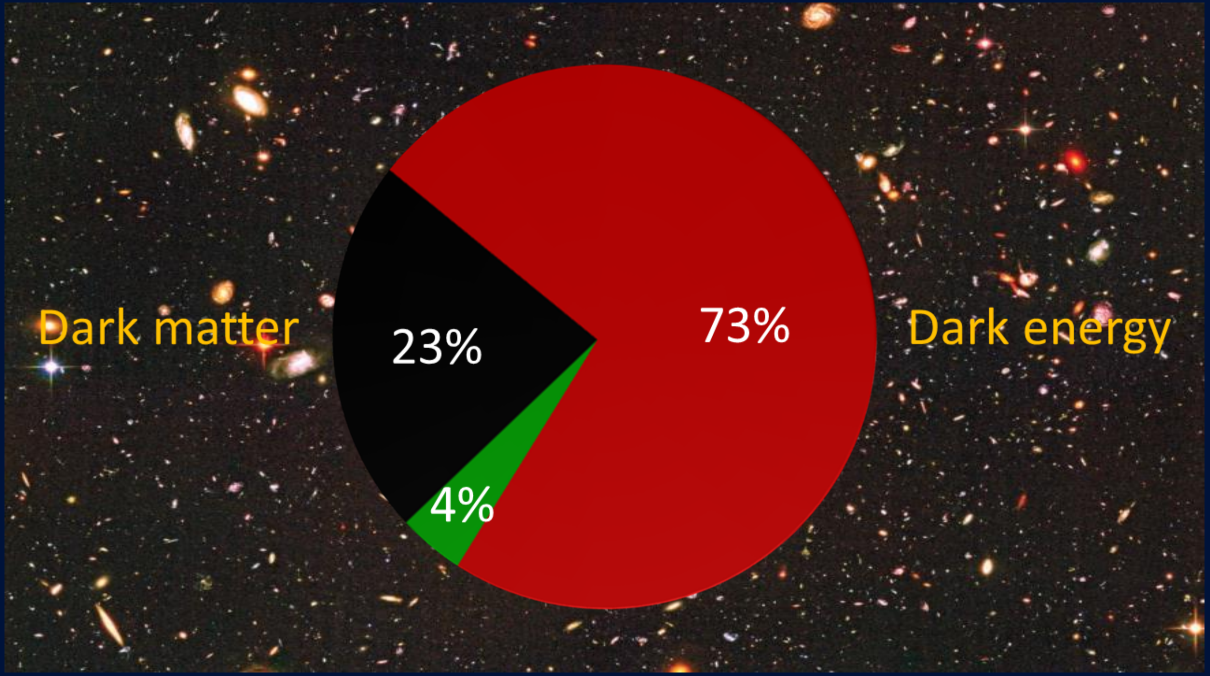
Supermassive Black Holes and Dark Matter and Energy

Dark energy is a theory applied to some remaining anomalies observed.

Distant galaxies are speeding away from our galaxy, and from each other, at rates and speeds proportional to their distances.

Supermassive Black Holes and Dark Matter and Energy

Conventional theories of gravity and relativity cannot account for this motion. Such unexplained activity is attributed to dark energy.



By some estimates, the observable universe, as we know it, constitutes only about 4%!

Review Question

Name three characteristics of white dwarf stars.

1.

2.

3.

(Use CPS "Pick a Student" for this question.)

Closing Questions

CPS Lesson
Questions 7 - 8

Questions?