Evolution Cycle of Stars

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Nebula

- A nebula is a cloud of gas (hydrogen) and dust in space. Nebulae are the birthplaces of stars.
- Types of nebula are:

  - Emission Nebula

  - Reflection Nebula

  - Dark Nebula

  - Planetary Nebula

Types of Nebula

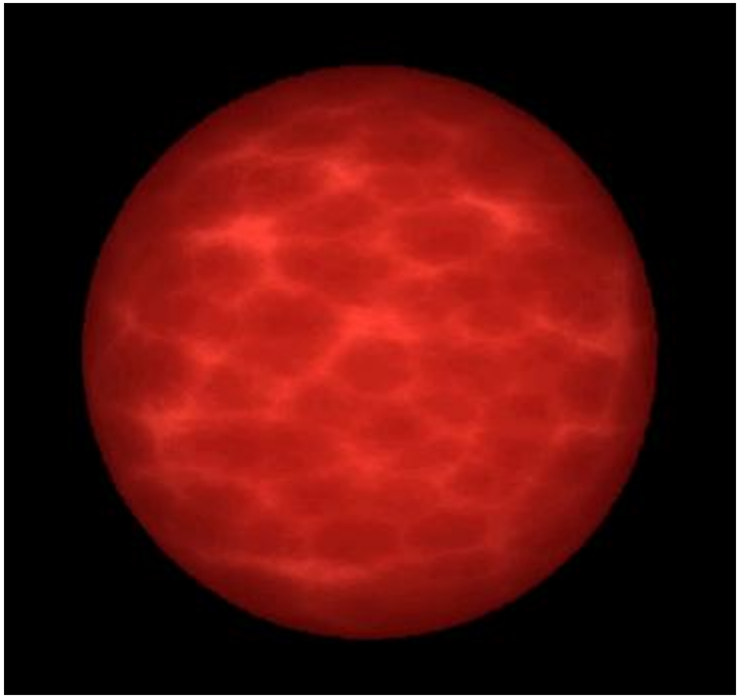
- An Emission Nebula e.g. such as Orion nebula, glows brightly because the gas in it is energized by the stars that have already formed within it.
- In a Reflection Nebula, starlight reflects on the grains of dust in a nebula.
- Dark Nebula are dense clouds of molecular hydrogen which partially or completely absorb the light from stars behind them.
- Planetary Nebula are the outer layers of a star that are lost when the star changes from a red giant to a white dwarf.

Stars

- A star is a luminous globe of gas producing its own heat and light by nuclear reactions (nuclear fusion). They are born from nebulae and consist mostly of hydrogen and helium gas.
- The brightest stars have masses 100 times that of the Sun and emit as much light as millions of Suns while the faintest stars are the red dwarfs, less than one-thousandth the brightness of the Sun.
- Brighter stars live a lesser lifetime.
- The smallest mass possible for a star is about 8% that of the Sun (80 times the mass of the planet Jupiter), otherwise nuclear reactions do not take plac

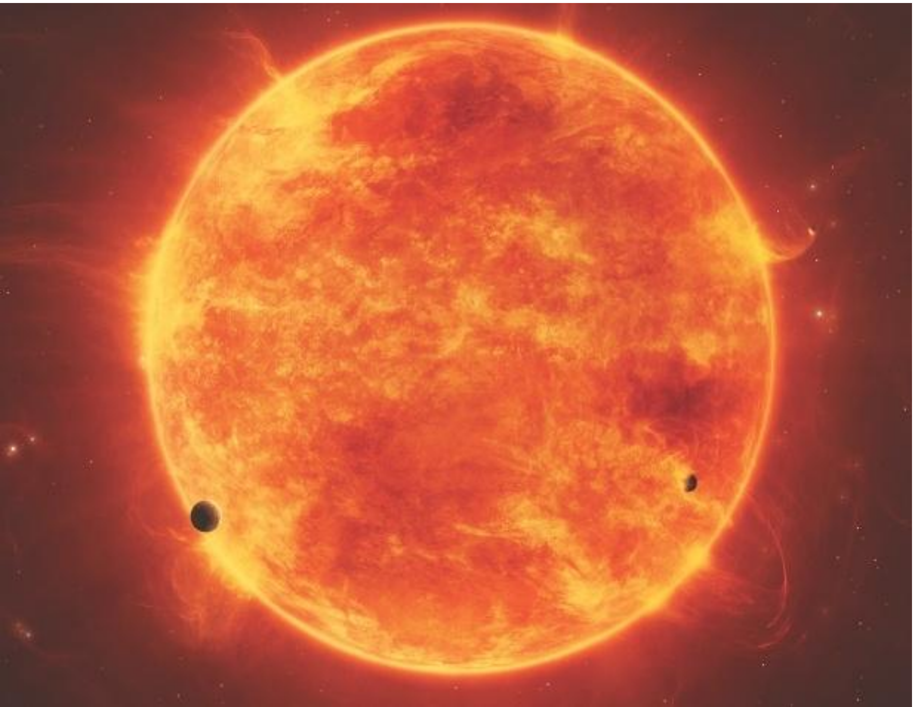
Brown Dwarf

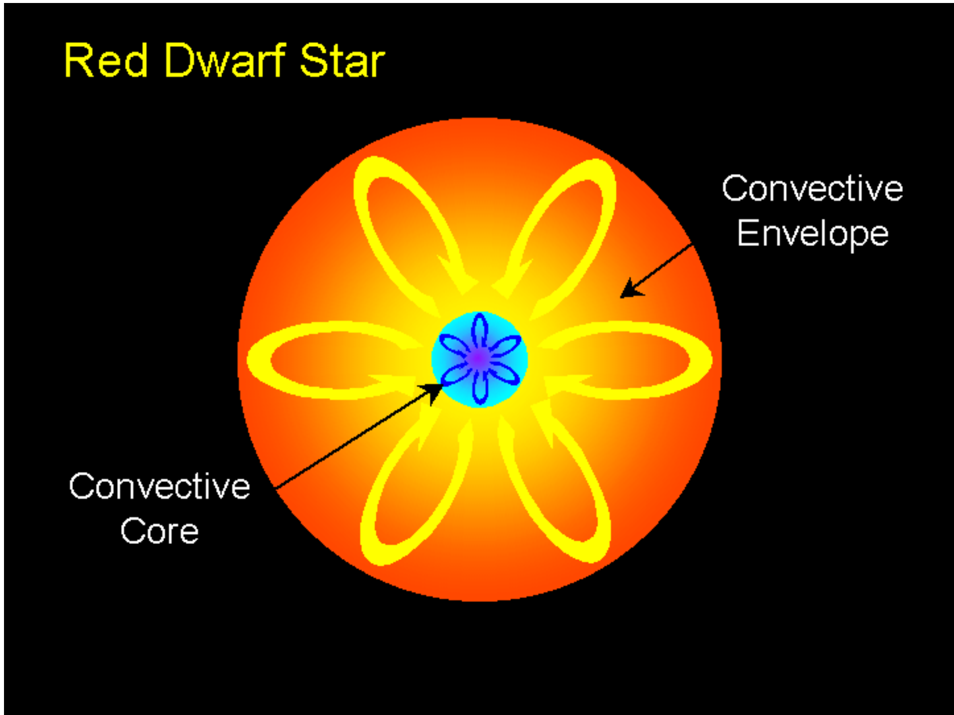
- Objects with less than critical mass shine only dimly and are termed brown dwarfs. They are technically not stars.



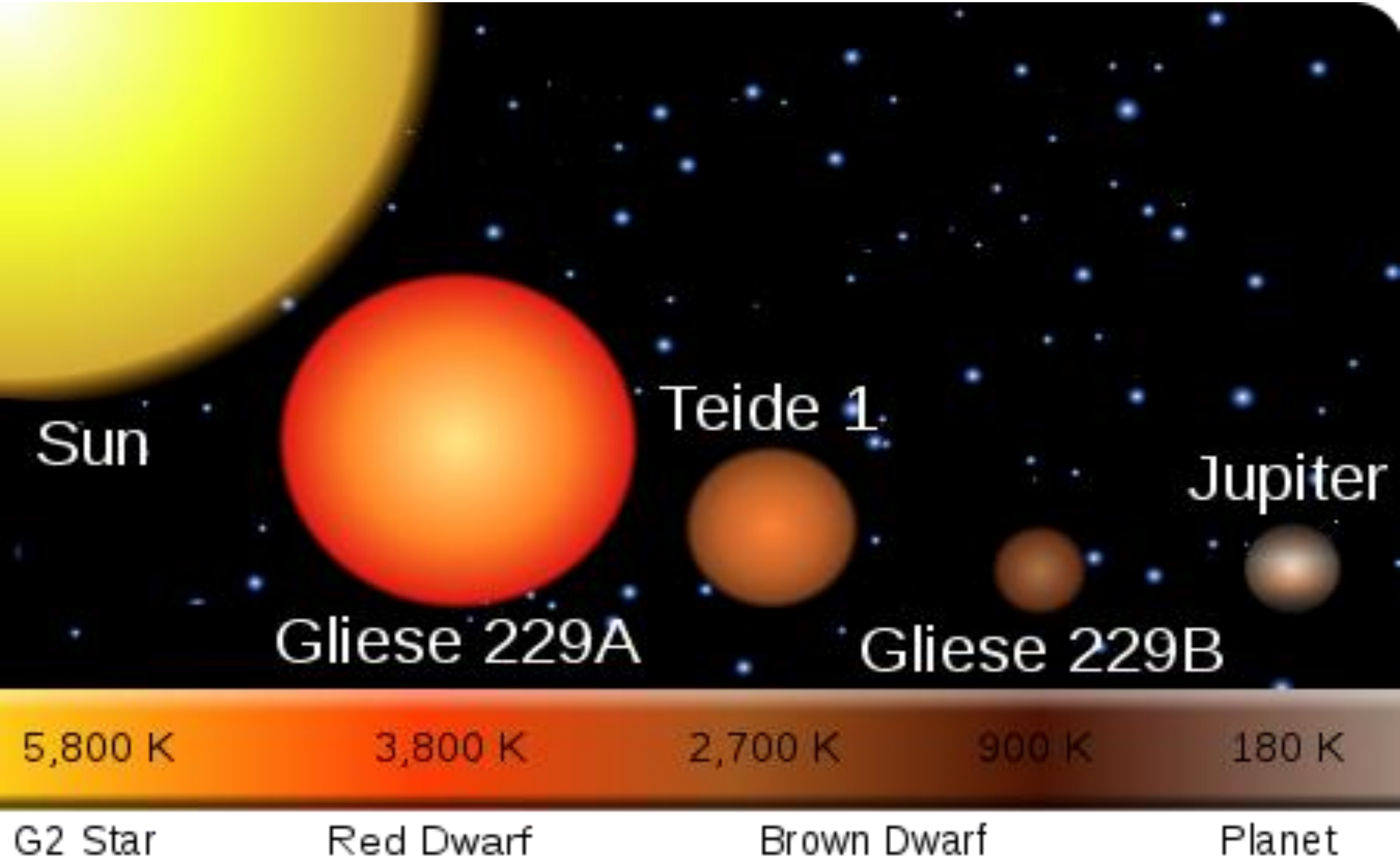
Red Dwarf

- These are very cool, faint and small stars, approximately one tenth the mass and diameter of the Sun. They burn very slowly and have estimated lifetimes of 100 billion years. Proxima Centauri and Barnard's Star are red dwarfs.



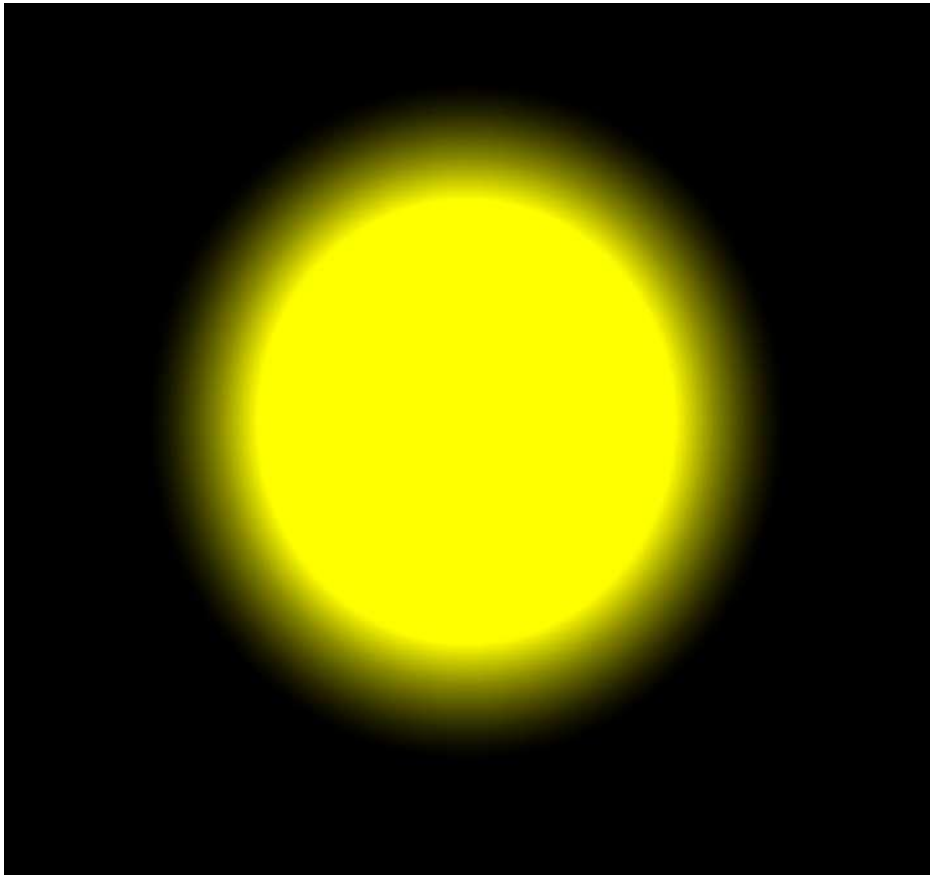


Brown Dwarf vs Red Dwarf



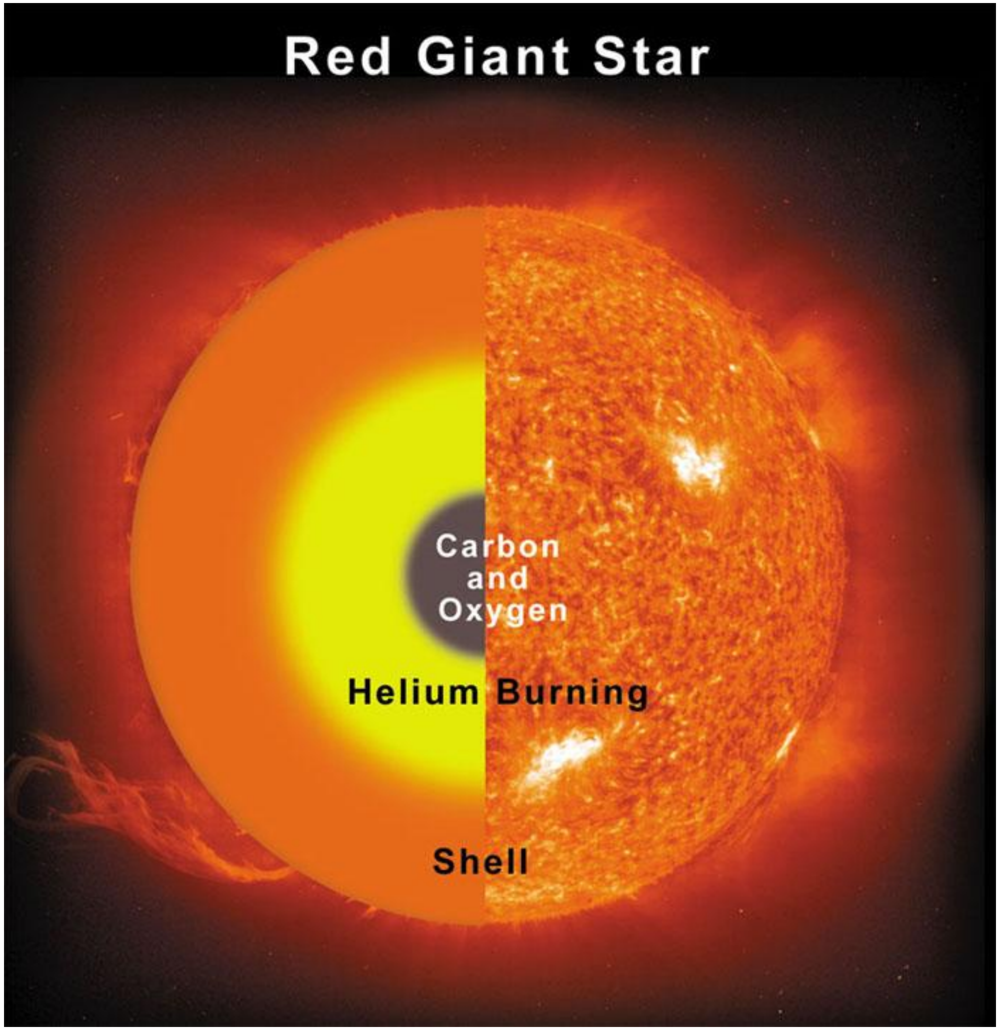
Yellow Dwarf

- A G-type main-sequence star, often called a yellow dwarf, or G dwarf star, is a main-sequence star of spectral type G.
- Such a star has about 0.8 to 1.2 solar masses and surface temperature of between 5,300 and 6,000 K.
- They become brighter in time. Sun is Yellow Dwarf.



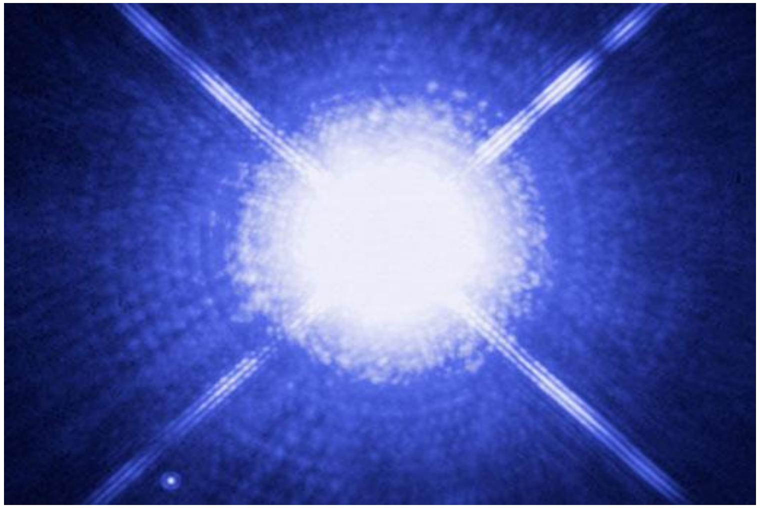
Red Giant

- This is a large bright star with a cool surface. It is formed during the later stages of the evolution of a star like the Sun, as it runs out of hydrogen fuel at its centre and the helium causes it to swell.
- Red giants have diameter's between 10 and 100 times that of the Sun. They are very bright because they are so large, although their surface temperature is lower than that of the Sun, about 2000-3000 C.



White Dwarf

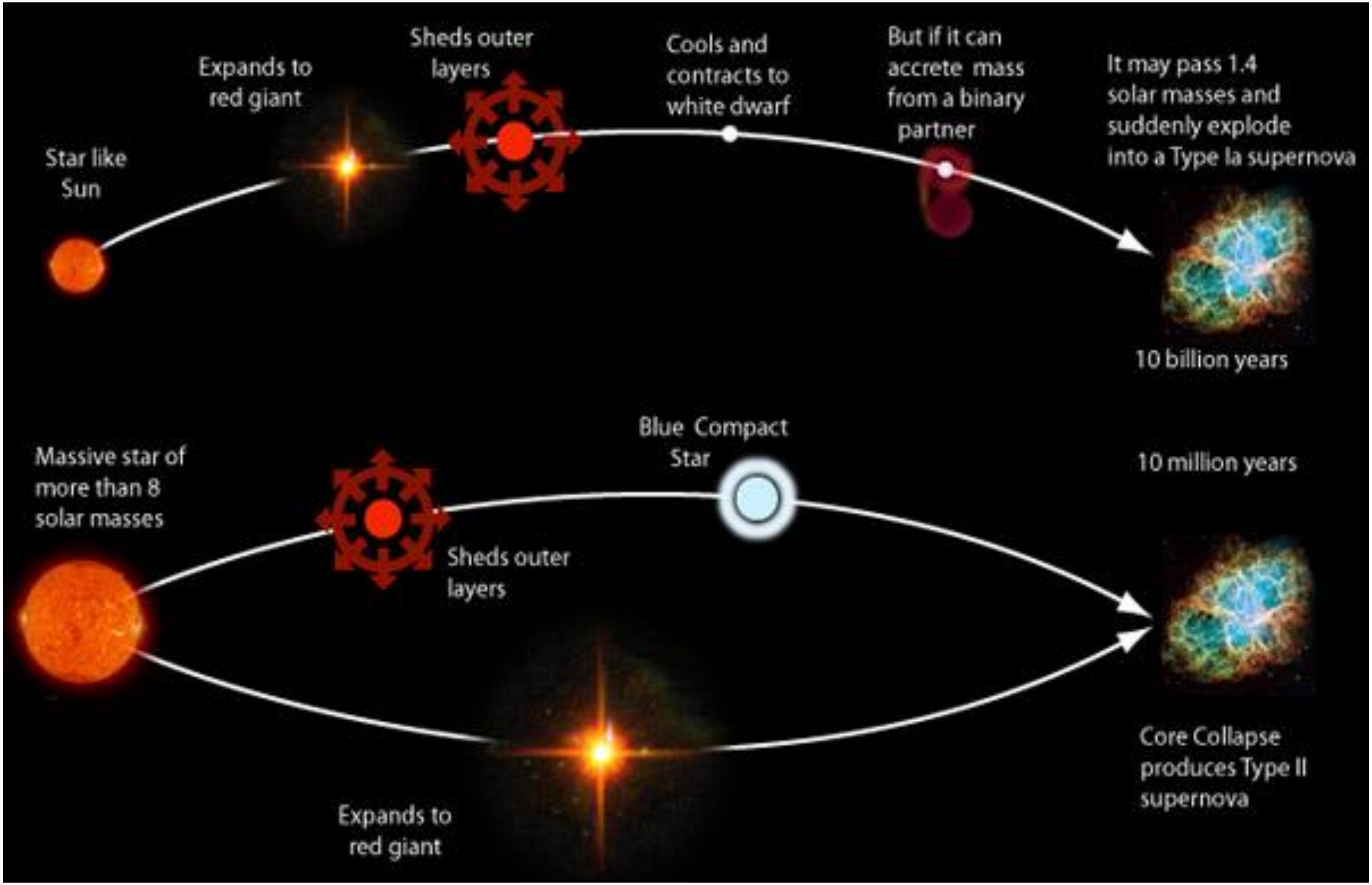
- This is very small, hot star, the last stage in the life cycle of a star like the Sun.
- White dwarfs have a mass similar to that of the Sun, but only 1% of the Sun's diameter; approximately the diameter of the Earth. The surface temperature of a white dwarf is 8000C or more, but being smaller than the Sun their overall luminosity's are 1% of the Sun or less.
- White dwarfs are the shrunken remains of normal stars, whose nuclear energy supplies have been used up. White dwarf consist of degenerate matter with a very high density due to gravitational effects, i.e. one spoonful has a mass of several tons.
- White dwarfs cool and fade over several billion years.



Supernova

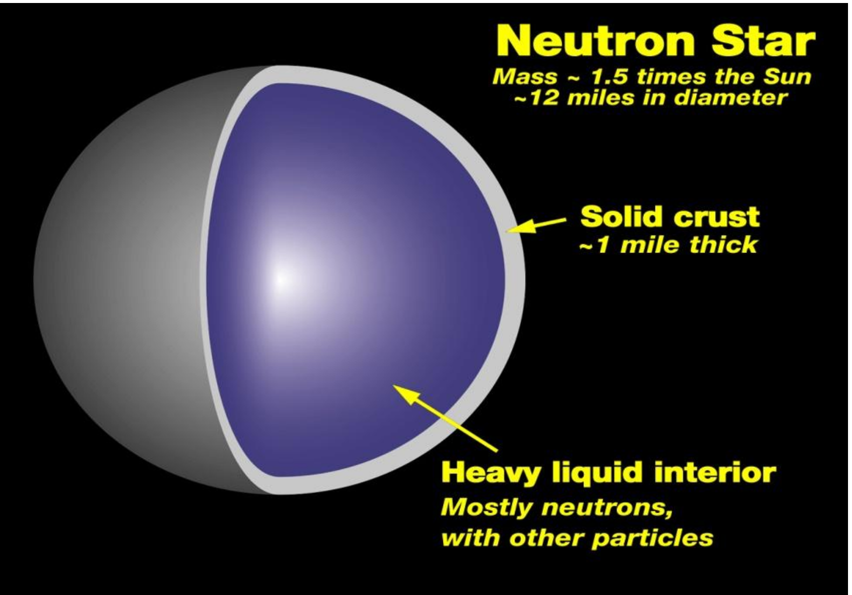
- This is the explosive death of a star, and often results in the star obtaining the brightness of 100 million suns for a short time.
- Supernovae are thought to be main source of elements heavier than hydrogen and helium.

Supernova Cycle



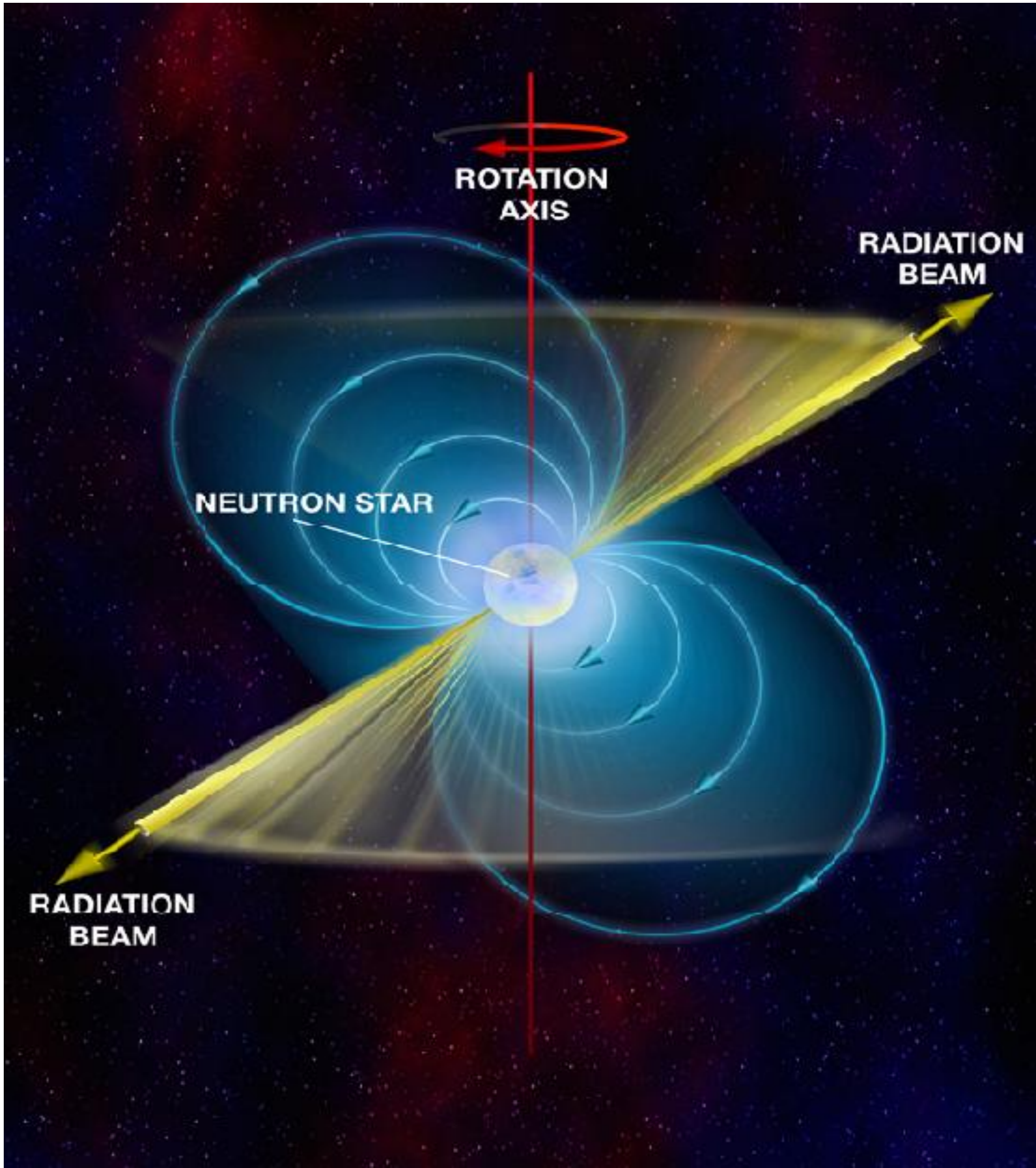
Neutron Stars

- These stars are composed mainly of neutrons and are produced when a supernova explodes, forcing the protons and electrons to combine to produce a neutron star.
- Neutron stars are very dense. Typical stars having a mass of three times the Sun but a diameter of only 20 km. If its mass is any greater, its gravity will be so strong that it will shrink further to become a black hole.



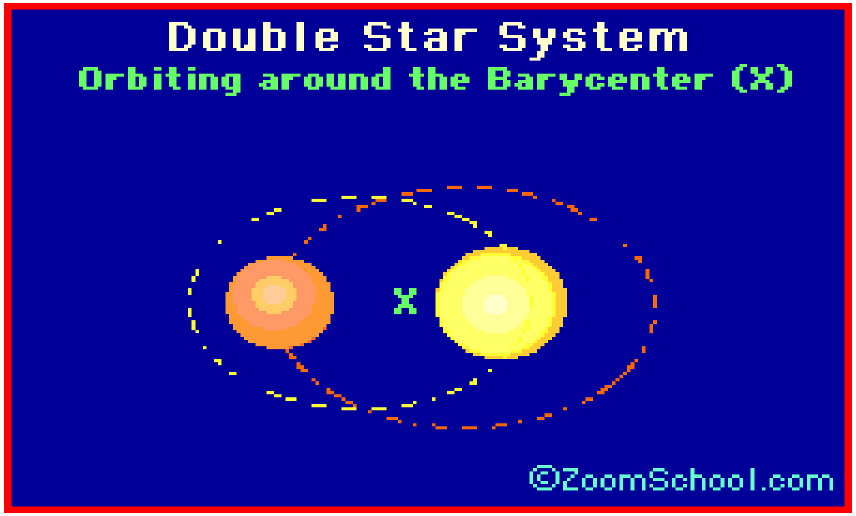
Pulsars

- Pulsars are believed to be neutron stars that are spinning very rapidly.



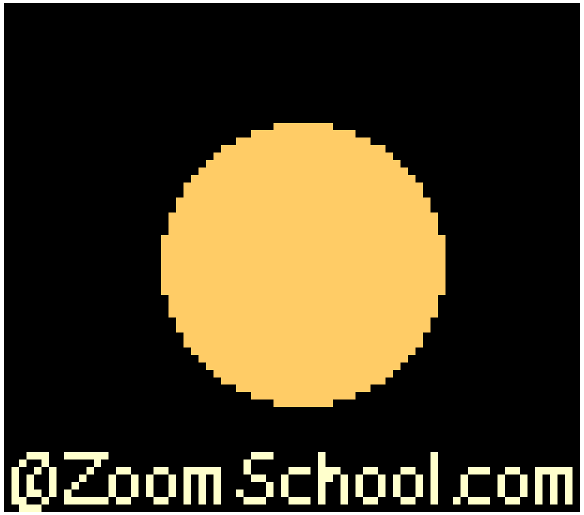
Binary Star System

- A binary star is a system of two stars that rotate around a common center of mass (the barycenter). About half of all stars are in a group of at least two stars.
- Polaris (the pole star of the Northern Hemisphere of Earth) is part of a binary star system.



Cepheid Variable Stars

- Cepheid variables are stars that regularly pulsate in size and change in brightness. As the star increases in size, its brightness decreases; then, the reverse occurs.
- Cepheid Variables may not be permanently variable; the fluctuations may just be an unstable phase the star is going through.

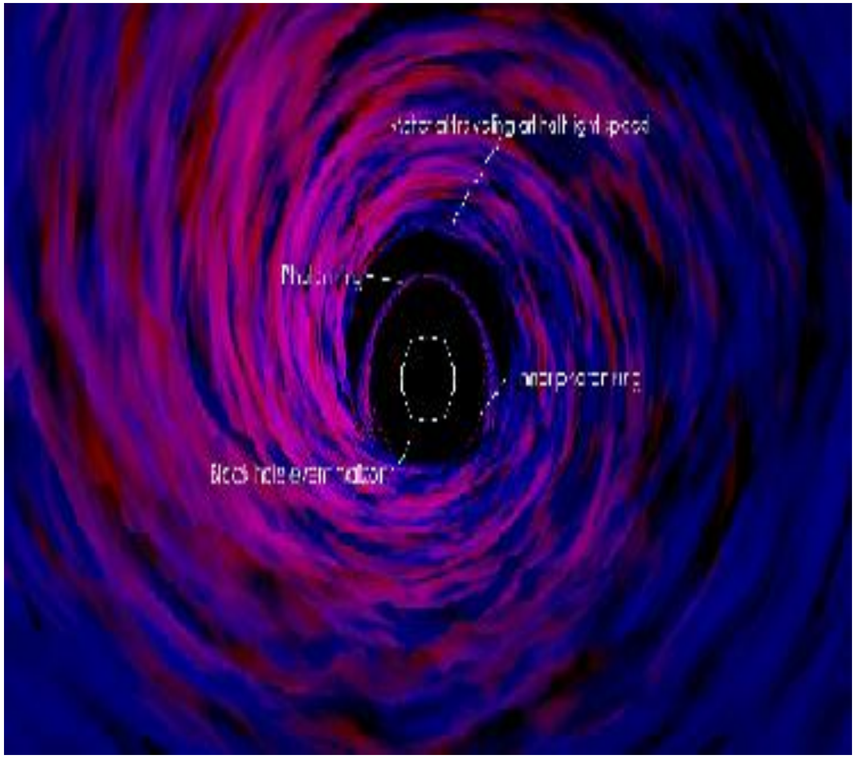


Black Holes

- Black holes are believed to form from massive stars at the end of their life times. The gravitational pull in a black hole is so great that nothing can escape from it, not even light. The density of matter in a black hole cannot be measured. Black holes distort the space around them, and can often suck neighboring matter into them including stars.

Black Holes

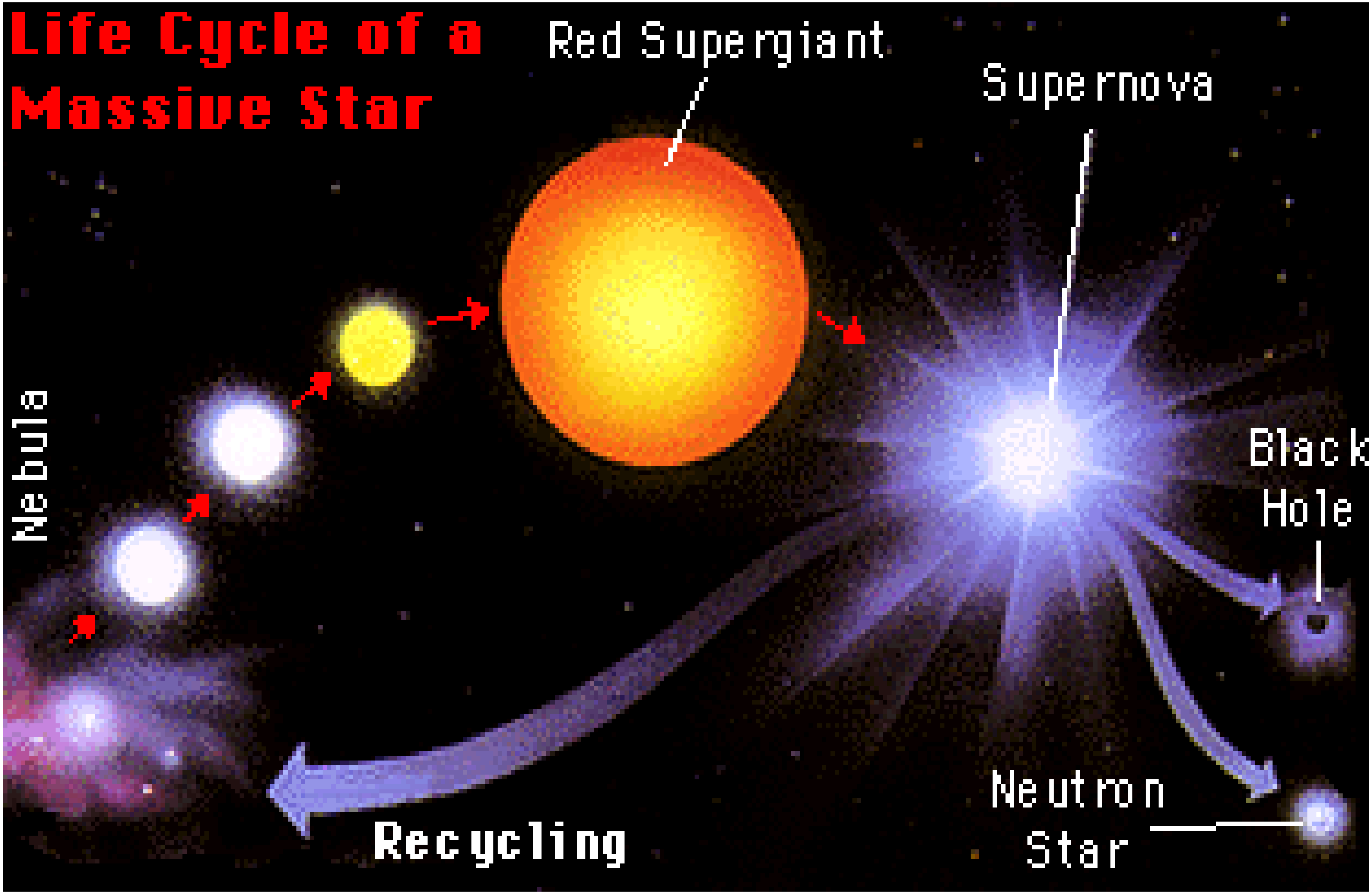
Heart of Galaxy NGC 1277 –
17 billion solar mass



Properties of Black Holes

- Black Holes have no hair. (Most properties are extinguished such as physical perturbations)
- Angular momentum of blackholes are preserved. (If they were spinning, they will continue to spin)
- The mass of the black hole determines its size: the radius of its event horizon (also called the Schwarzschild radius). Any matter outside the event horizon can - at least theoretically - still escape.
- A good approximation for the radius of the event horizon is 3 km for each solar mass. So, a black hole with 10 solar masses has an event horizon of 30 km

Life Cycle of a Massive Star

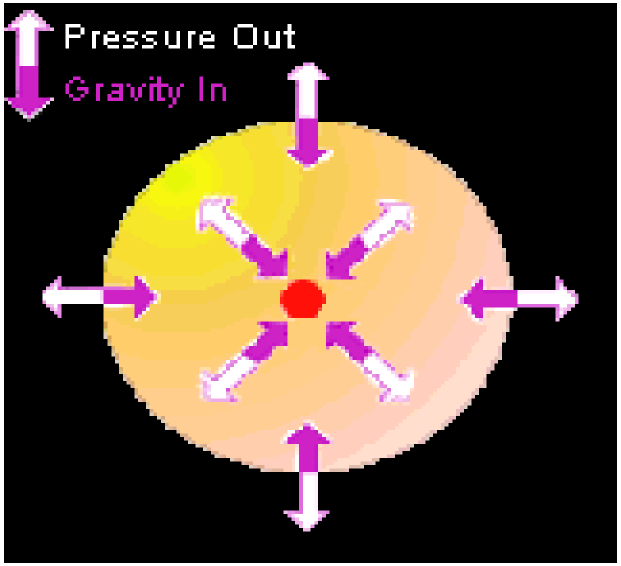


Main Sequence Lifetimes

- The luminosity of a star is a measure of how fast a star is using its nuclear fuel. The mass of a star indicates how much fuel is available. The lifetime of a star in any given evolutionary stage is given by the amount of available fuel for that stage divided by the rate of consumption of that fuel; in other words, lifetime is proportional to the mass divided by the luminosity.

Gravity-Pressure Equilibrium

- The Sun and other stars shine as a result of nuclear reactions deep in their interiors. These reactions change light elements into heavier ones and release energy in the process. The outflow of energy from the central regions of the star provides the pressure necessary to keep the star from collapsing under its own weight



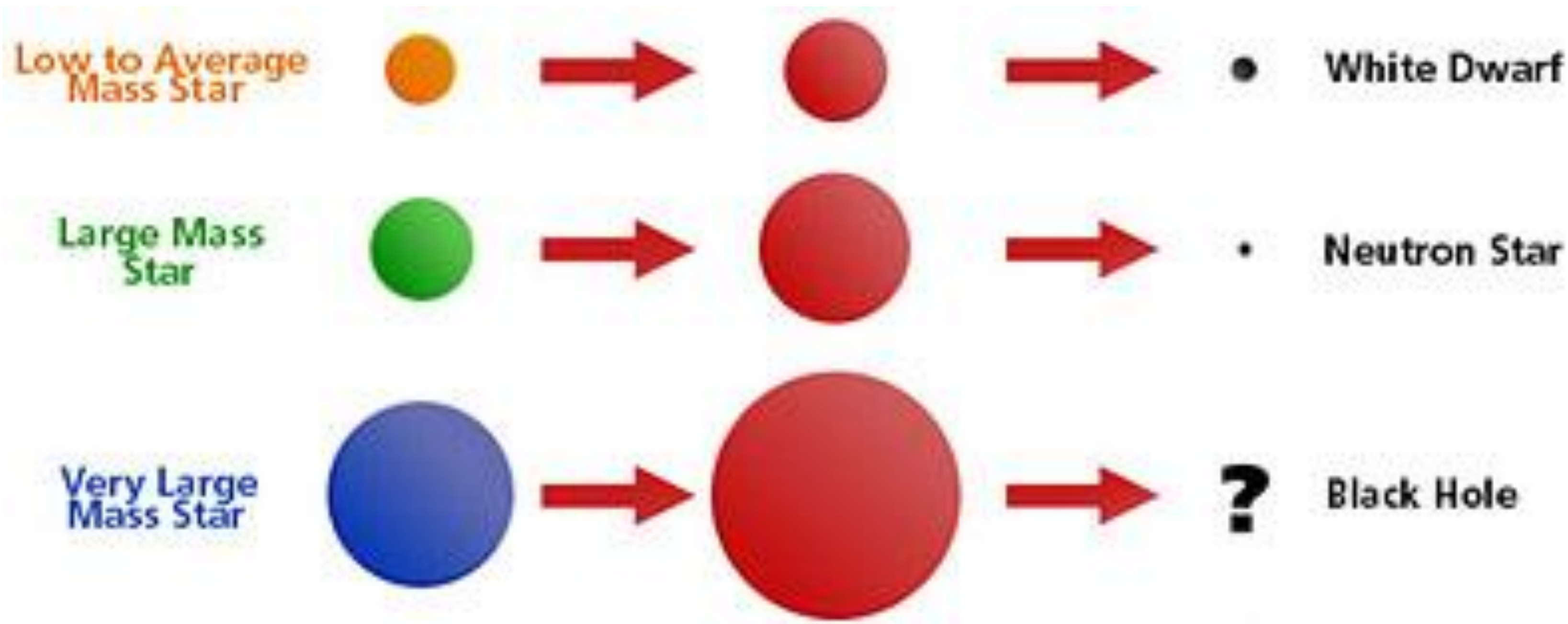
Lifeterm of Stars

TABLE 1 Approximate Main Sequence Lifetimes

Stellar Mass	Main Sequence Lifetime
50 $M_\odot$	5×10^5 years
25 $M_\odot$	3×10^6 years
10 $M_\odot$	3×10^7 years
2 $M_\odot$	2×10^9 years
1 $M_\odot$	9×10^9 years
0.5 $M_\odot$	6×10^{10} years
0.1 $M_\odot$	3×10^{12} years

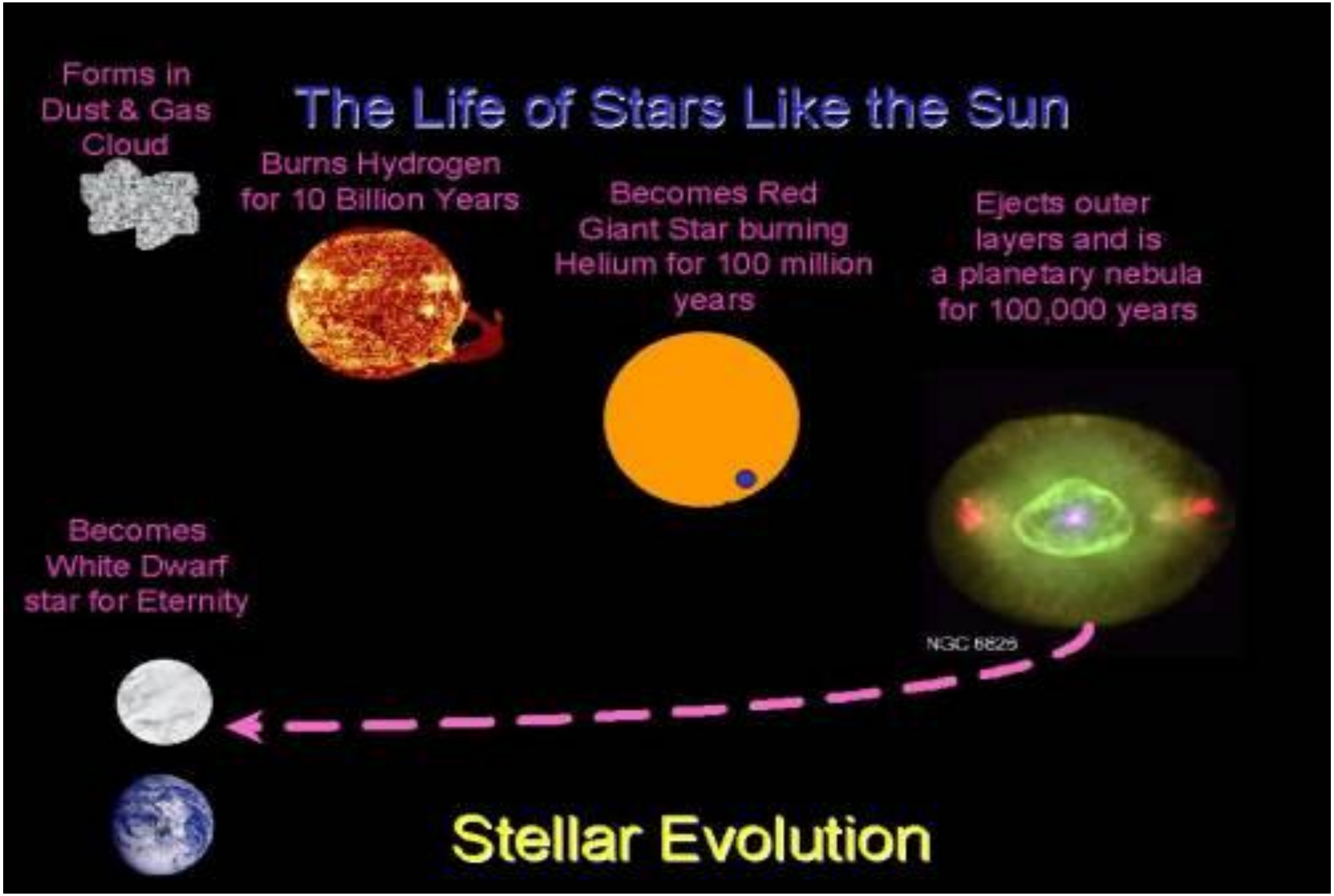
Fate of Star and Mass

- The fate of a star depends mainly on its mass.



The fate of a star depends on its mass (size not to scale)

Life of Stars Like Sun



Stellar Evolution