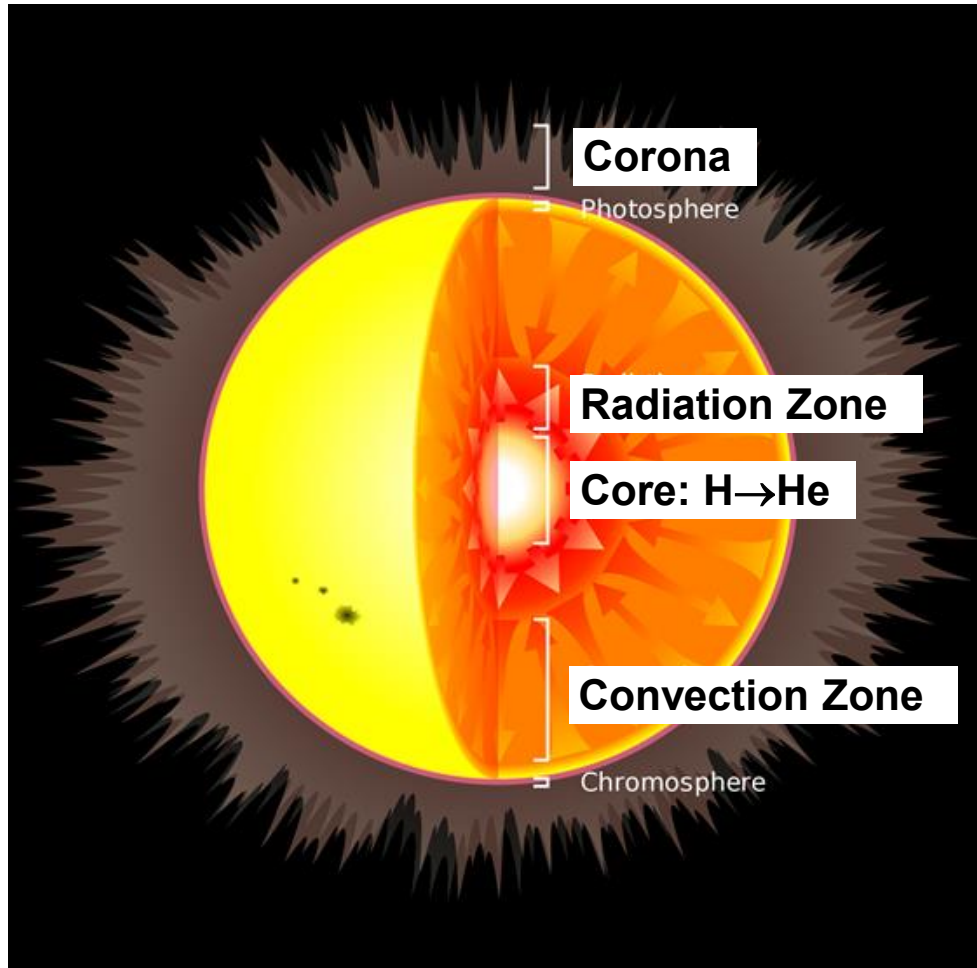


Stars

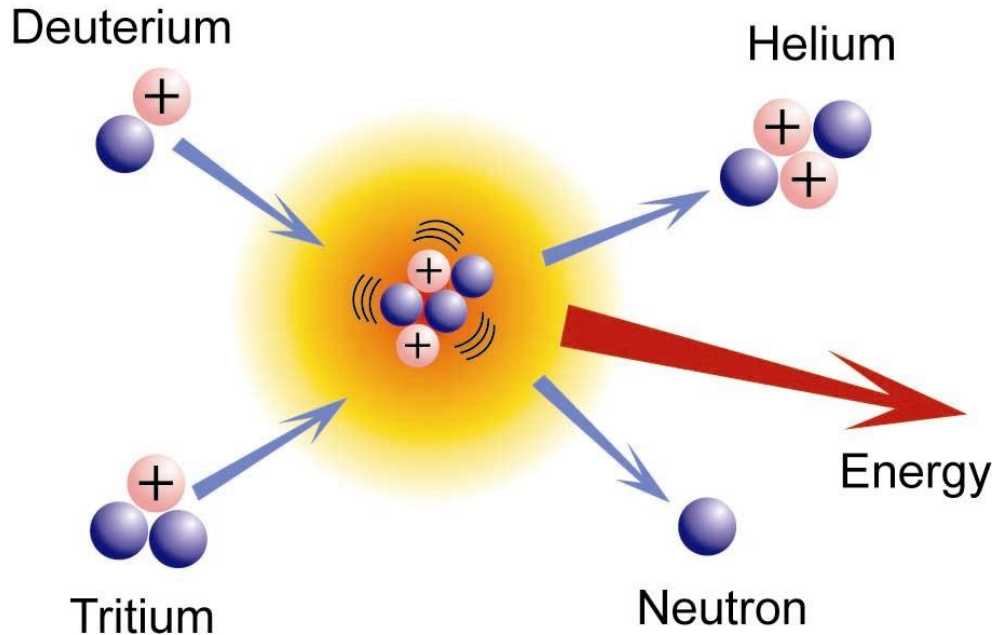
A star is a massive, luminous **sphere of plasma** held together by its own gravity. All stars are made primarily of Hydrogen and Helium.



- Most stars are between **1 billion** and **10 billion** years old.
- Some stars may even be close to 13.8 billion years old—the observed age of the Universe.
- Most of a star's life is in a state of **nuclear fusion** converting H to He; energy from the nuclear reactions is released as electromagnetic **radiation**.

Nuclear Fusion - the joining of two atomic nuclei to form a larger one

REVIEW



- In order to fuse, **two atomic nuclei must be brought close enough together** (*confinement requirement*) so the electrostatic repulsion can be overcome by the attractive nuclear force.
- If matter is sufficiently **heated** (*plasma state*), **thermonuclear fusion** reaction may occur due to **collisions between the particles of extreme thermal kinetic energies**.
 - In nature, extremely high temperature conditions exist in the **cores of active stars**.

Formation of a Star

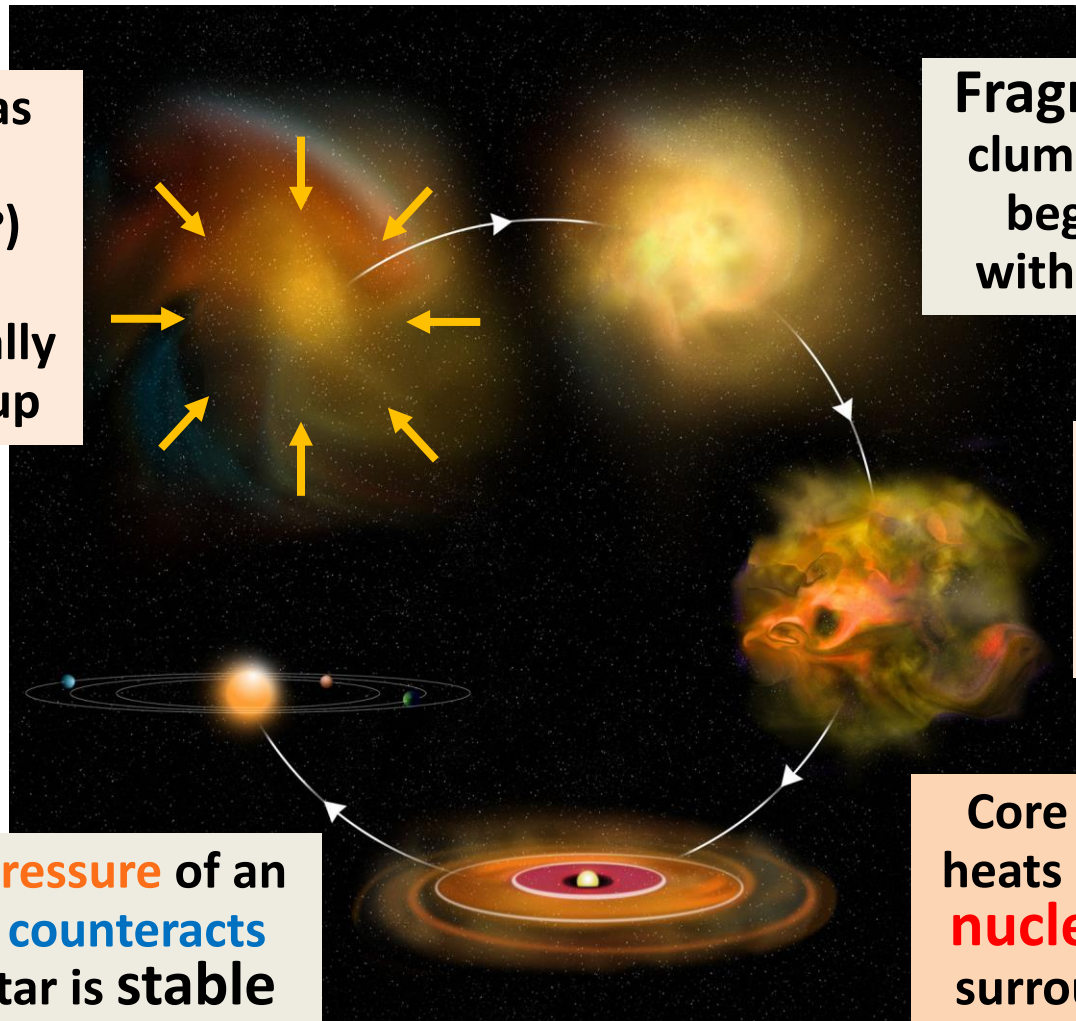
Cloud of gas and dust (*nebulae*) collapses gravitationally and heats up

Fragmentation: clumps of matter begin to form within the cloud

Dense cores - protostars - form within each clump

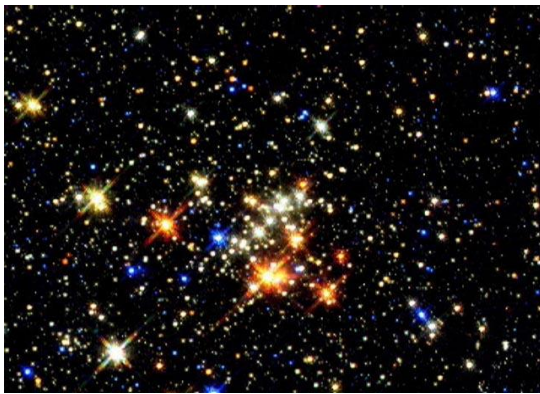
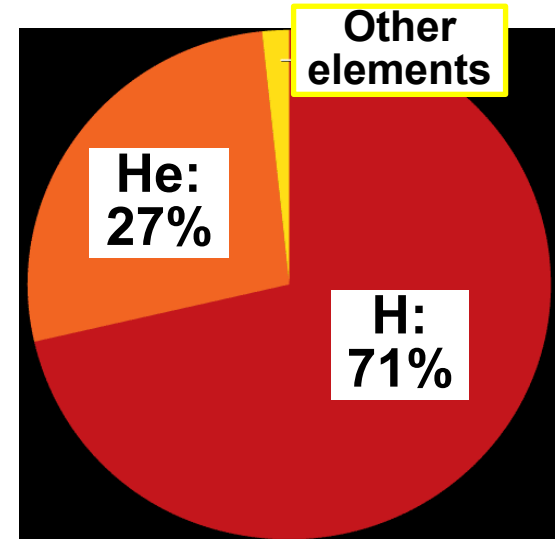
Radiation pressure of an active star counteracts gravity: a star is stable (*hydrostatic equilibrium*) while fusion is ongoing

Core condenses and heats enough to begin **nuclear fusion**; the surrounding material flattens into a spinning protoplanetary disc



Properties of Stars

- **Composition:** mostly H and He (stars in our Milky Way galaxy are composed of about 71% hydrogen and 27% helium).



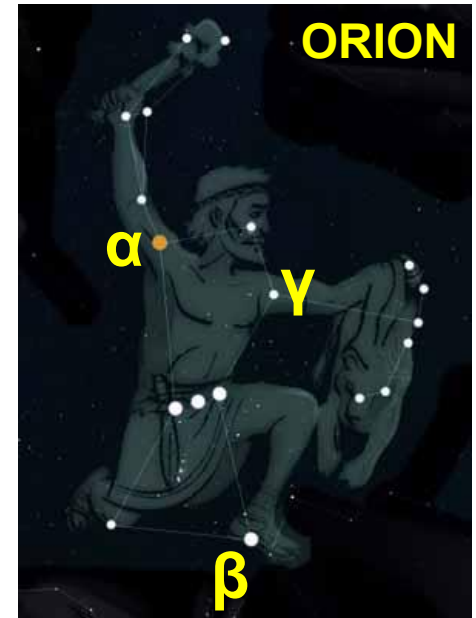
- **Color:** stars come in many different colors; the color tells us the star's *temperature* (blue is HOT, red is COLD).
- **Luminosity:** the total amount of energy radiated by a star into space each second (depends on size and mass)
- **Brightness:** apparent energy that *reaches us* (how bright a star appears to be due to how close or far away it is).

These properties depend primarily on a star's **initial mass** at birth (*i.e. its parent nebula size*) and its **stage of life**.

Classification of Stars

- In the past, stars were classified based on:
 - their **brightness** (in the order of Greek letters: *alpha*, *beta*, *gamma*...)
 - their **location** in the sky (*constellation*)
- This classification is still reflected in the names of the brightest stars, those that can be seen with the naked eye, for example:

α -Orion (Betelgeuse) β -Orion (Rigel)
 γ -Orion (Bellatrix)

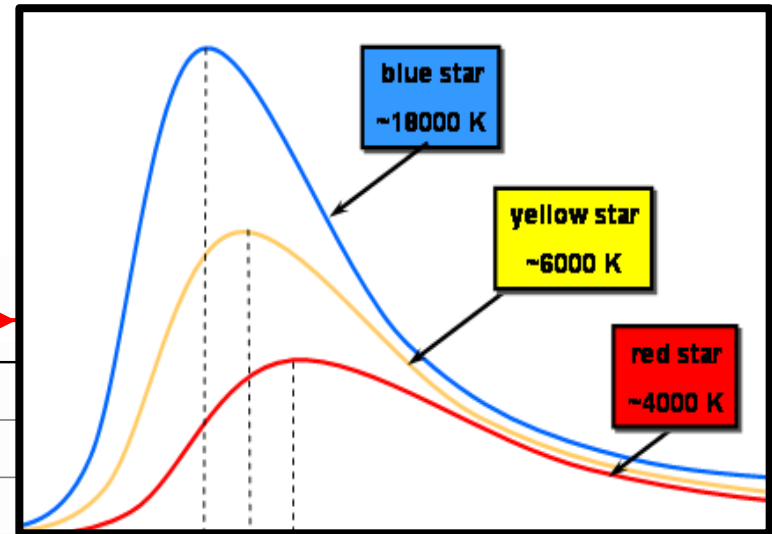
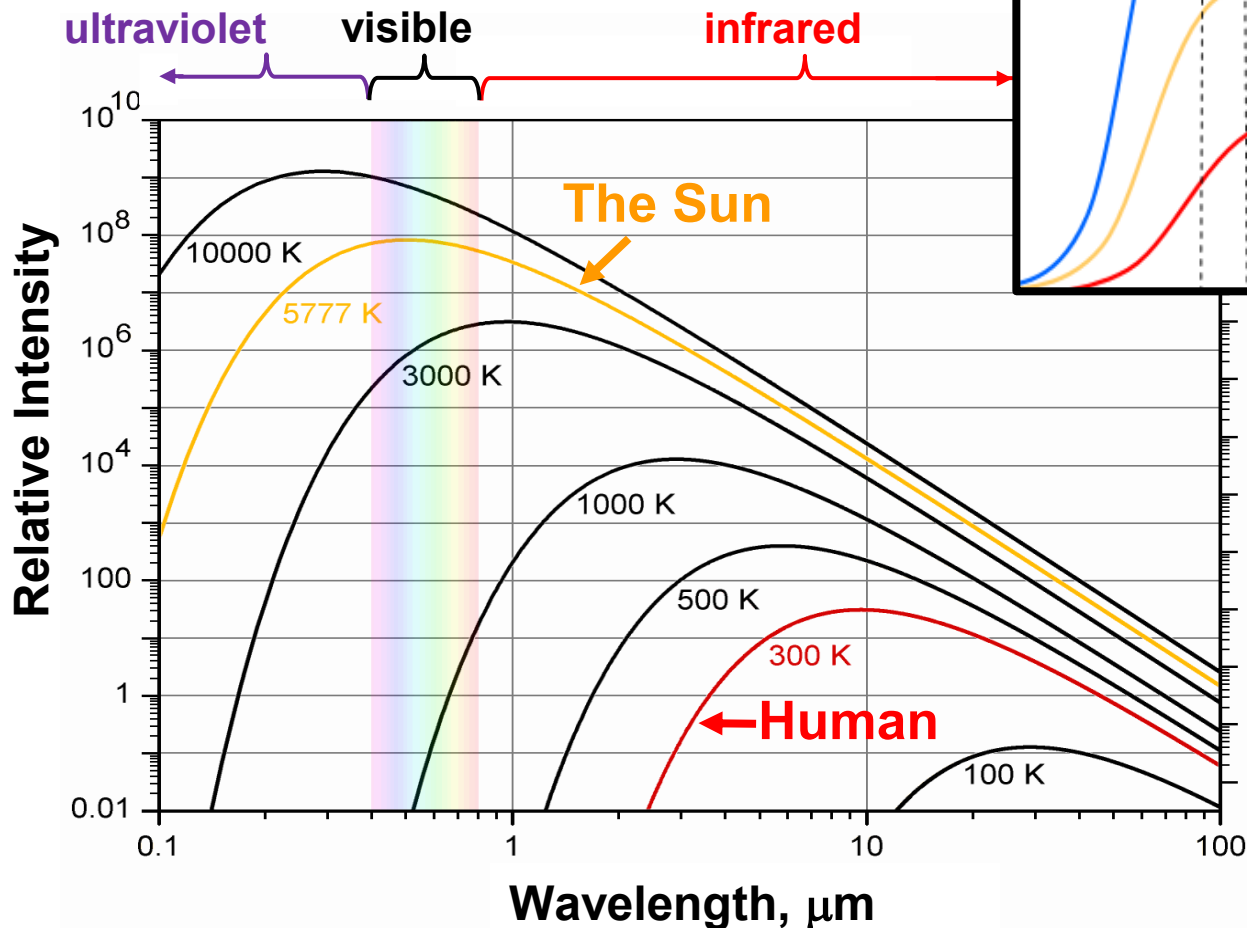


- Starting from the 20th century, stars are classified by their **luminosity (energy rate)** and **surface temperature**.



Colors of the Stars

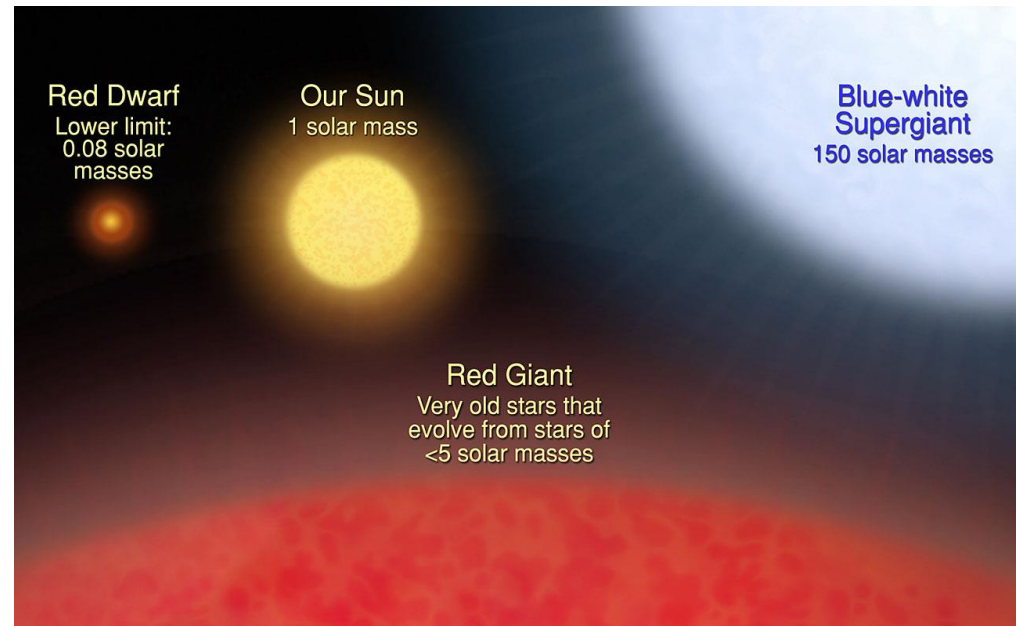
All normal matter emits electromagnetic radiation if its temperature is above absolute zero.



As the object surface temperature increases, the peak of the radiation curve moves to higher intensities and shorter wavelengths.

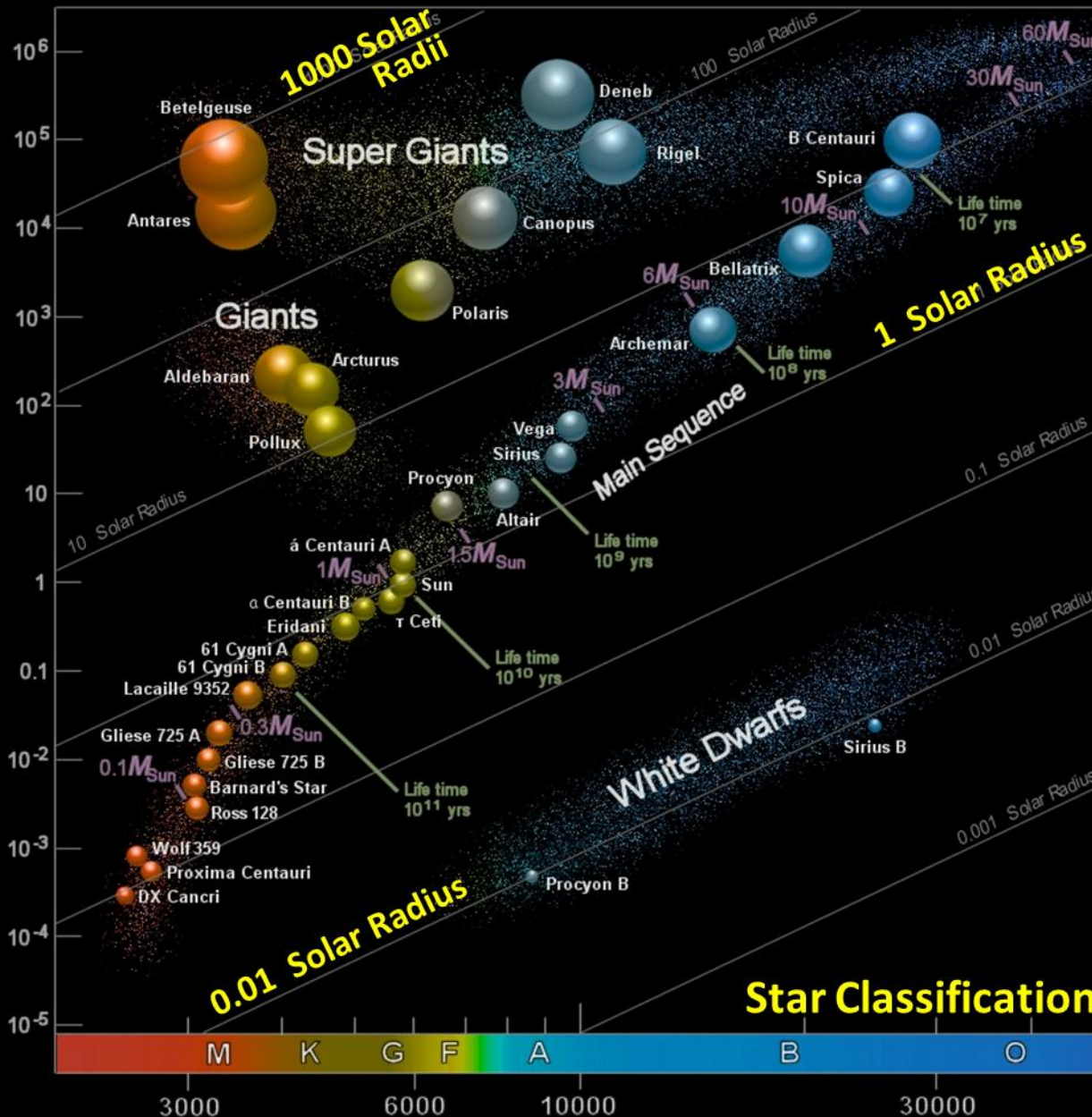
How big can a star be?

- Stars range in size from **neutron stars***, which vary anywhere from 20 to 40 km (~25 mi) in diameter, to **Supergiants** with diameters of several hundred times the size of the Sun (largest known are over 1500 times the size of the Sun).
- **Red Giants** have diameters 10 to 100 times that of the Sun; their *mass*, however, can range from a *fraction of the Sun's mass to only a few solar masses*. A red giant is a “bloated” star near the end of its life.
- **Medium-size or dwarf stars** are about as large as the **Sun** (the Sun is 1.4 million km, or 430 million mi, in diameter, and its mass is about 2×10^{30} kg, or 4×10^{30} lb).
- White dwarfs are very small stars*, smaller than the distance across Asia.



The HR (Hertzsprung- Russell, 1910) Diagram

Star Brightness (Solar Units)



(←lower) Star Surface Temperature (Kelvin) (higher→)

- A major step towards our understanding of stellar evolution or "the lives of stars".
- Temperature (x) vs Luminosity (y) plot
- Stars tend to group into certain areas.
- Most of the stars occupy the region in the diagram along the line called the **main sequence**, in the order of their mass (*shown in M_{Sun}*).