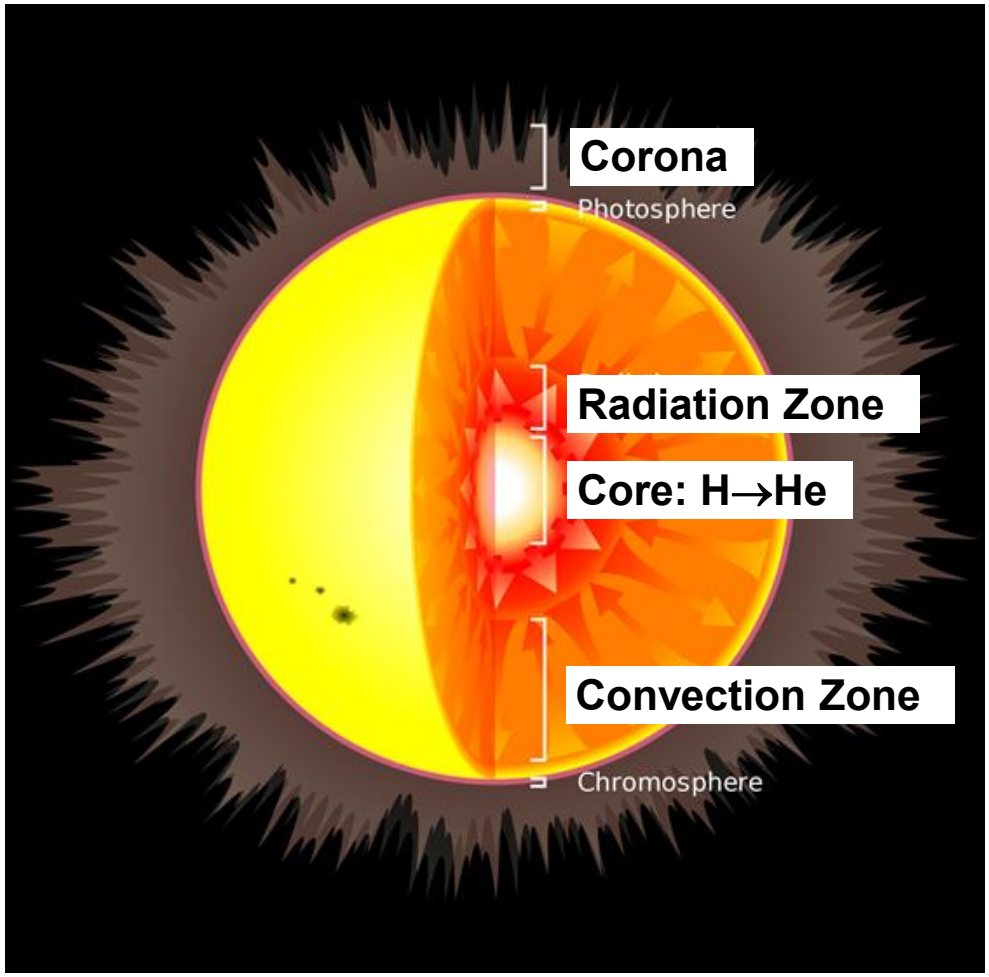
Stars

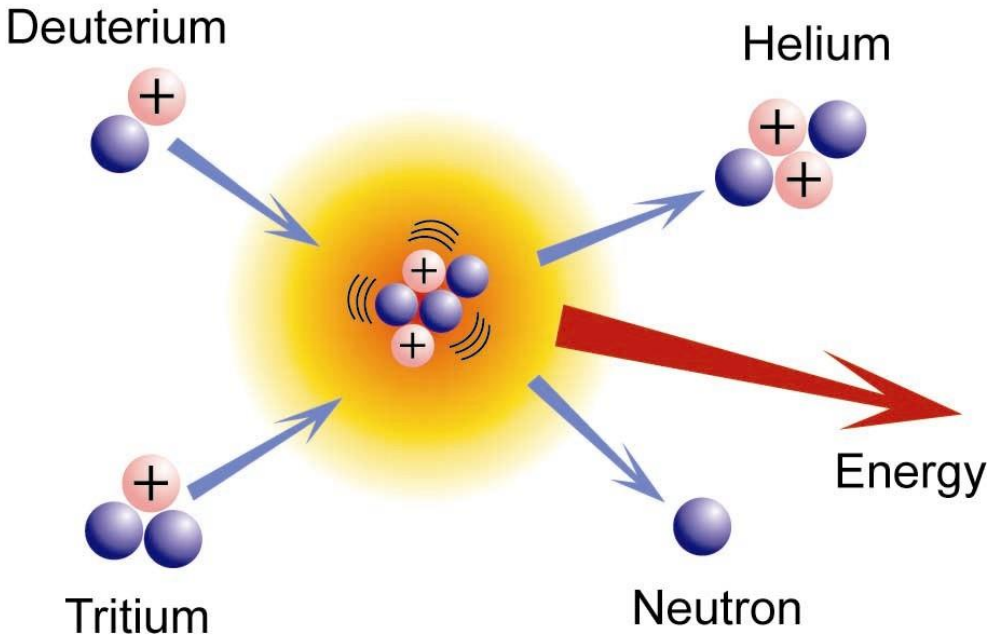
A **star** is a massive, luminous **sphere of plasma** held together by its own gravity. All stars are made primarily of **Hydrogen** and **Helium**.



- 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

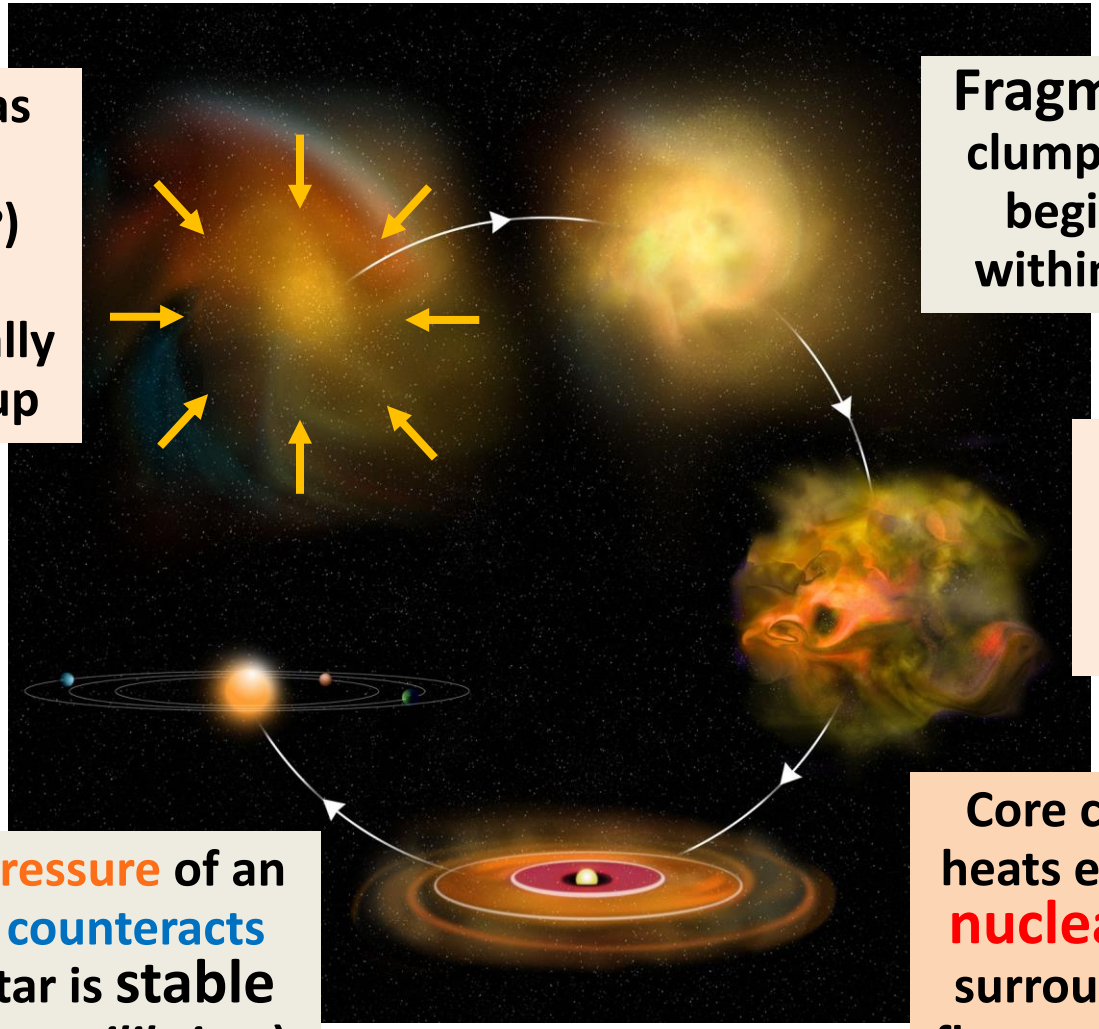


- In order to fuse, two atomic nuclei must be brought close enough together (*confinement requirement*) so the electrostatic repulsion can be overcome by the attractive nuclear force.

- 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

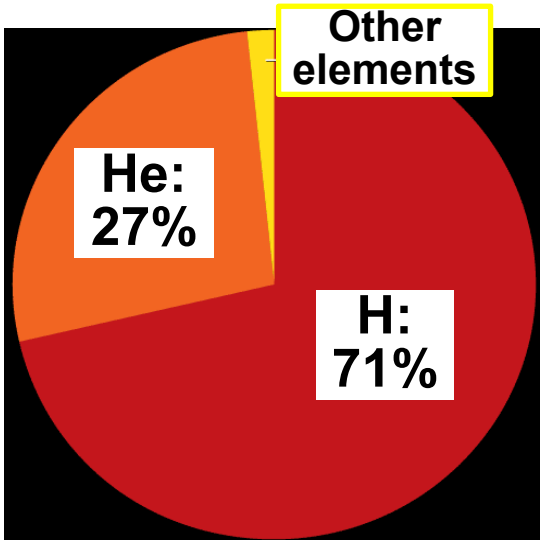
Fragmentation: clumps of matter begin to form within the cloud

Dense cores - **protostars** - form within each clump

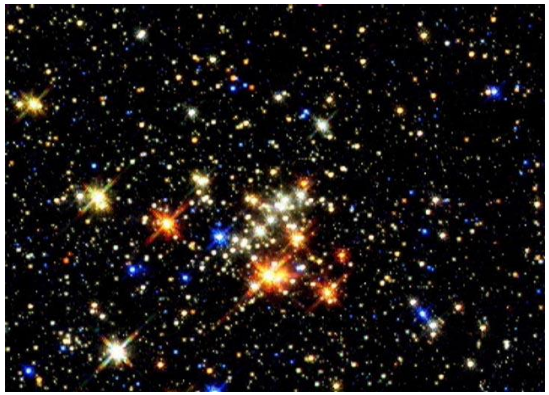
Core condenses and heats enough to begin **nuclear fusion**; the surrounding material flattens into a spinning protoplanetary disc

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

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)

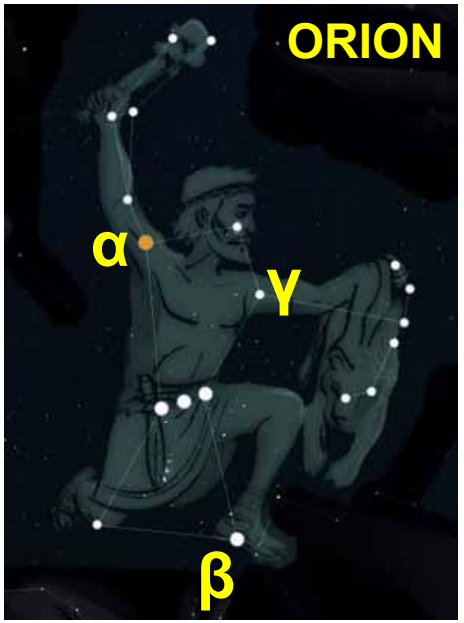
- **Brightness**: apparent energy that *reaches us* (how bright a star appears to be due to how close or far away it is).

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:**

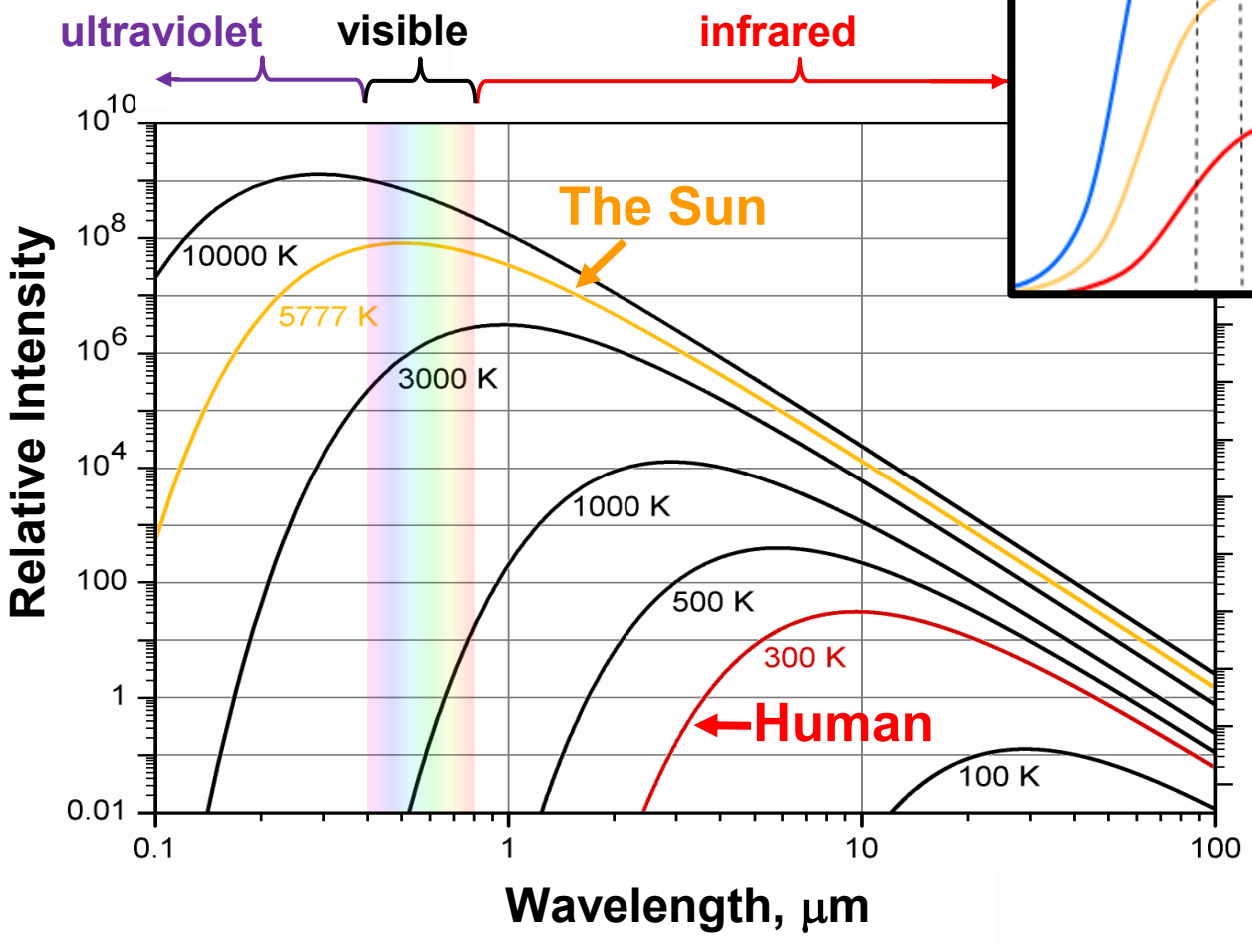
α-Orion (Betelgeuse) β-Orion (Rigel)
γ-Orion (Bellatrix)

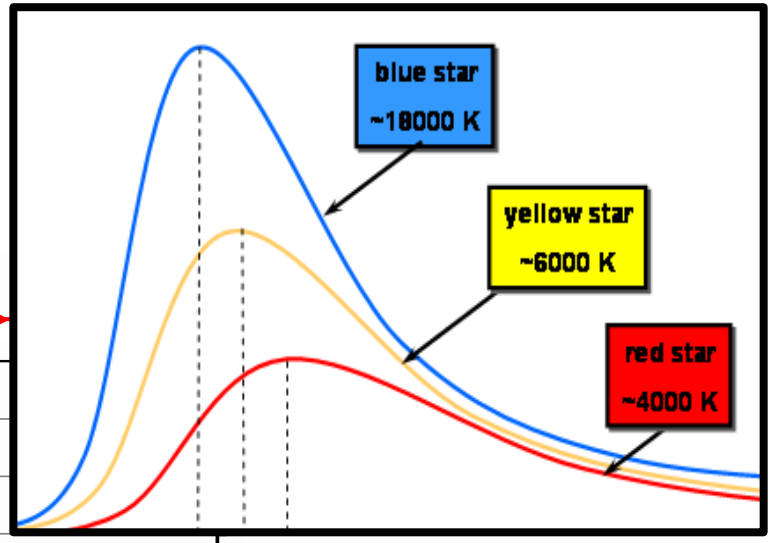


- **Starting from the 20th century, stars are classified by their luminosity (energy rate) and surface temperature.**

Colors of the Stars

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

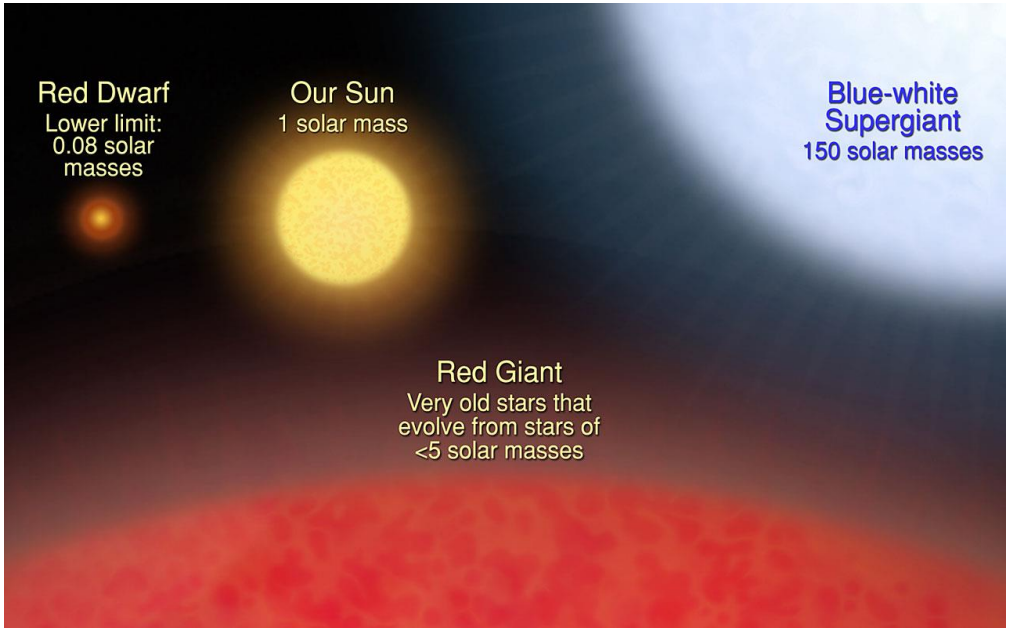




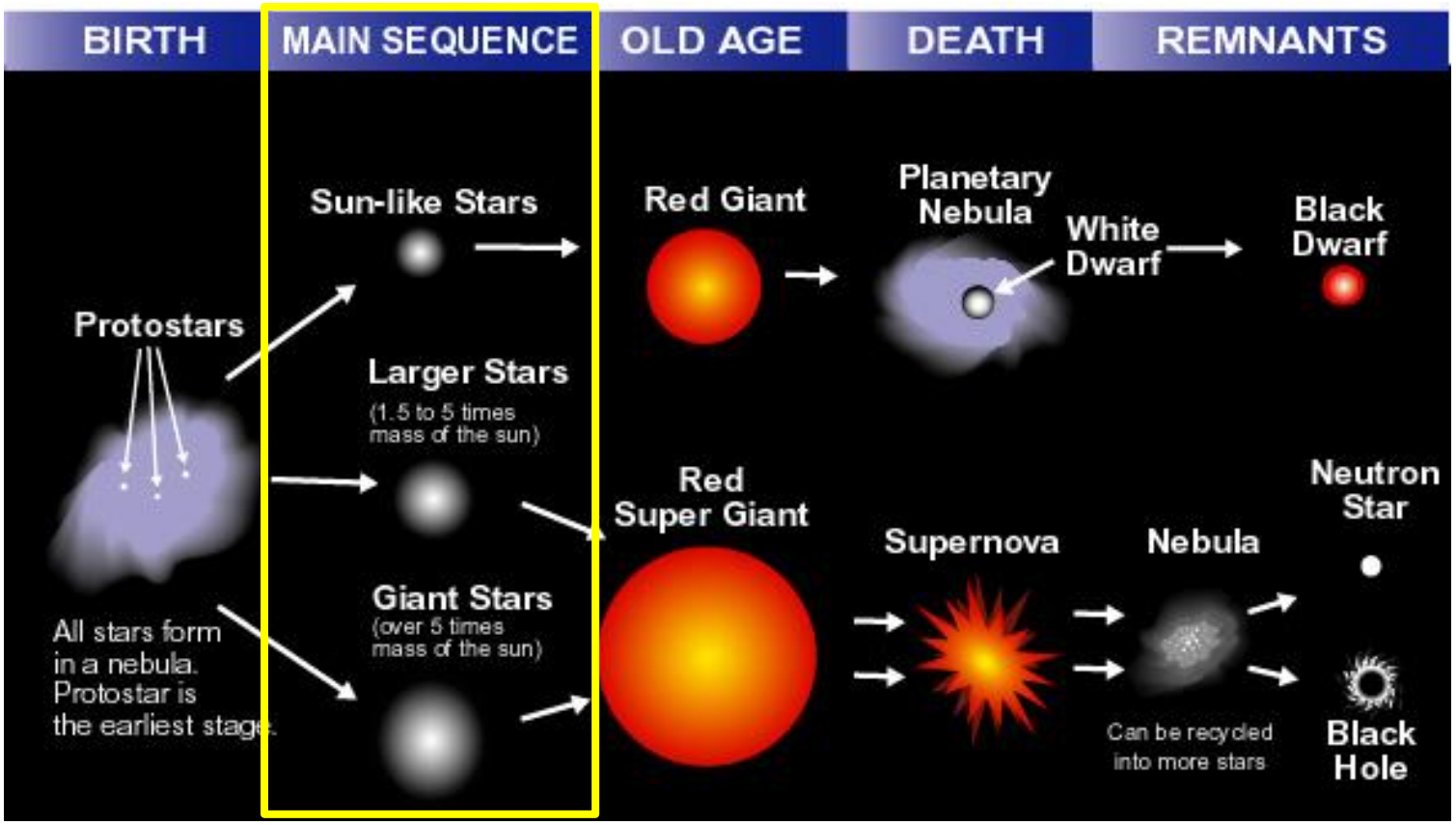
As the object surface temperature increases, the peak of the radiation curve moves to higher intensities and shorter wavelengths.

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 $2x10^{30}$ kg, or $4x10^{30}$ lb).**
- **White dwarfs are very small stars*, smaller than the distance across Asia.**



Life Cycle of a Star



Protostar – superheated gas, earliest stage of a star; Red Giant and Red Super Giant - stars that have exhausted the supply of hydrogen in their cores and are fusing helium to carbon and oxygen; Supernova - a stellar explosion; White Dwarf – very dense stellar remnant that has no energy source and gradually cools down over billions of years to become Black Dwarf, however *no black dwarfs are expected to exist in the Universe yet*!