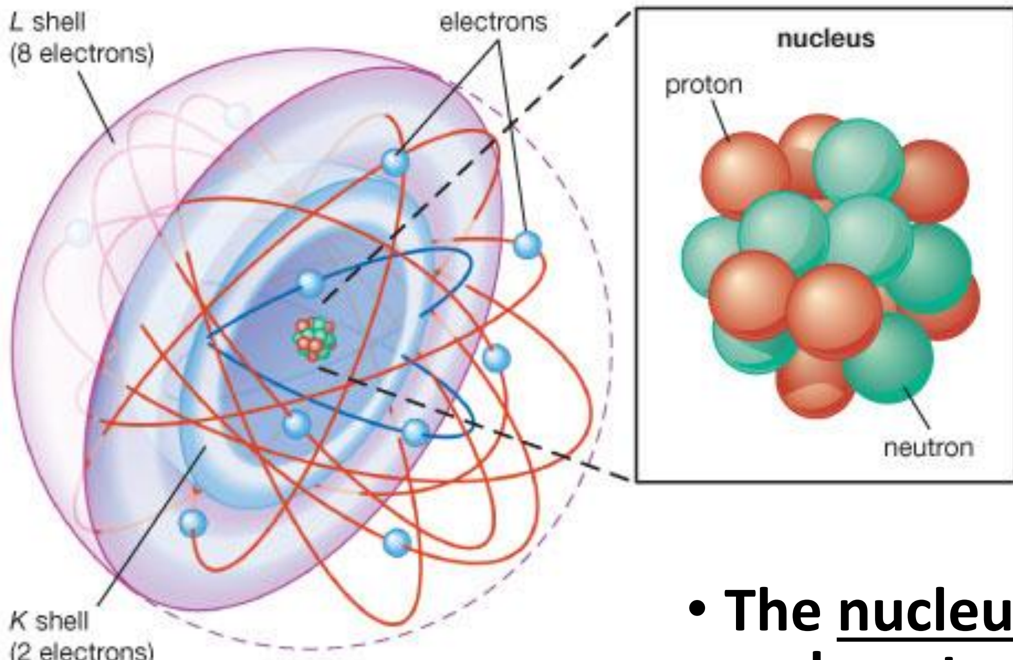
What Holds an Atom Together?



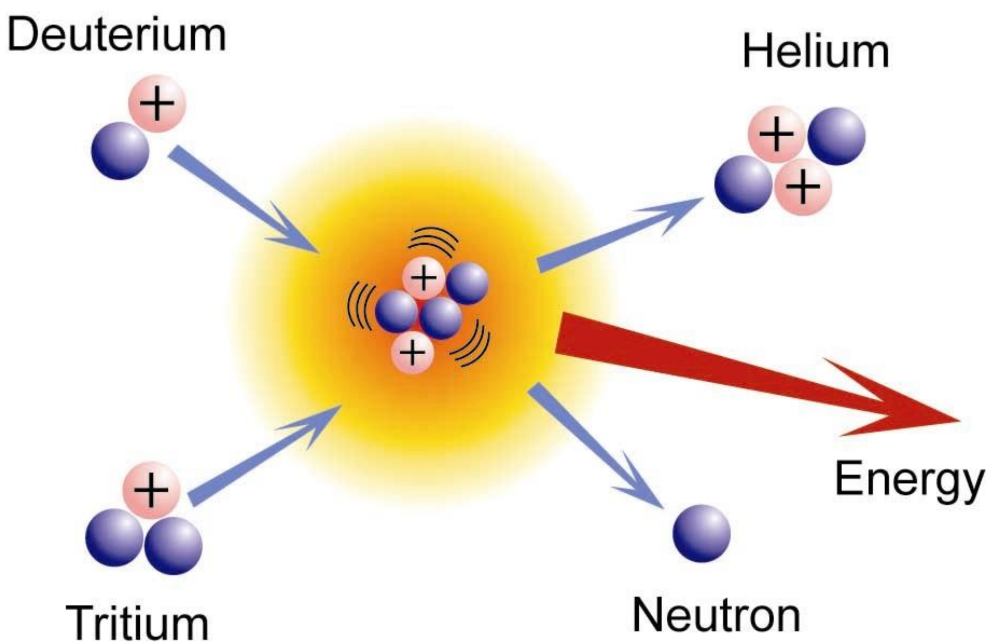
REVIEW

of atomic structure

- **The <u>electrons</u> are kept in orbit around the nucleus due to an <u>electromagnetic field</u> of attraction between the positive (+) charge of the protons and the negative (-) charge of the electrons.**
- **The <u>nucleus of protons and neutrons</u> is kept together by the <u>nuclear (strong) force</u>, which *opposes and overcomes the electromagnetic repulsion when particles are very close to each other (~1 fm!)*.**

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

REVIEW



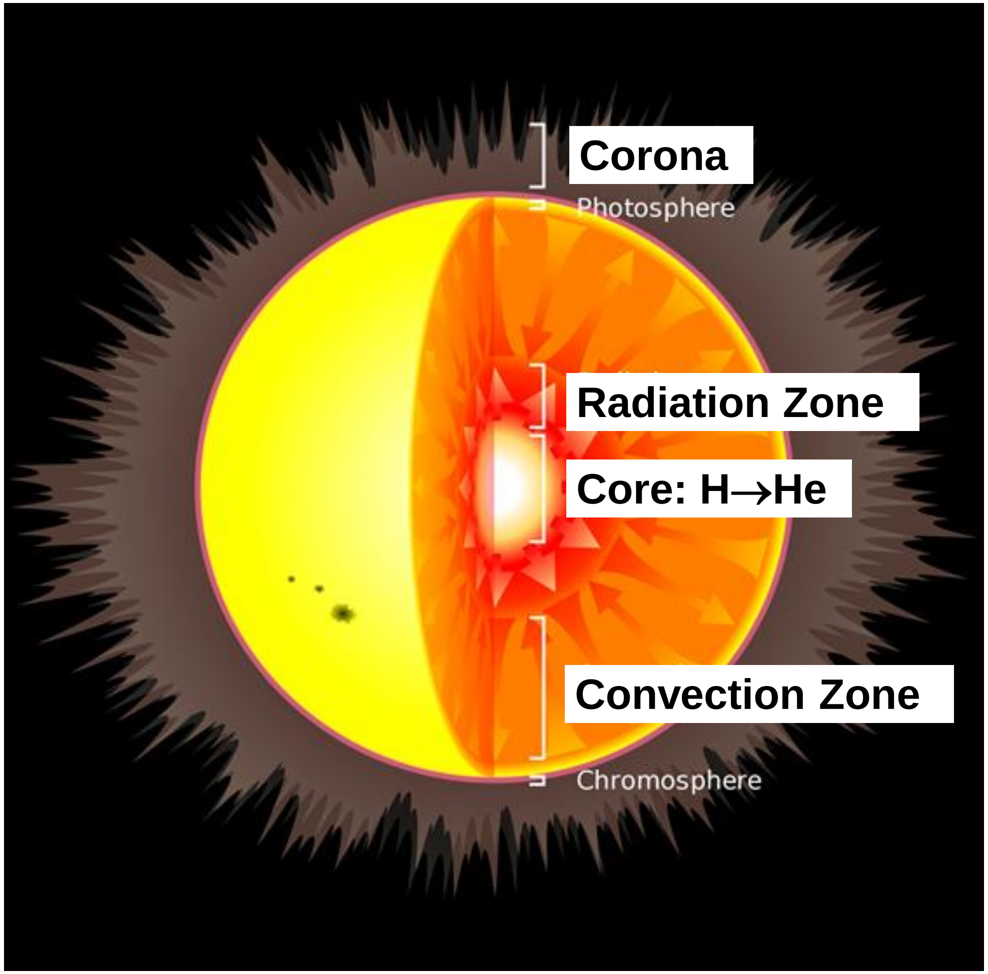
- In order to fuse, two atomic nuclei must be brought close enough together (*confinement requirement*) so the electrostatic repulsion can be overcome by the attractive nuclear force.

- 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.

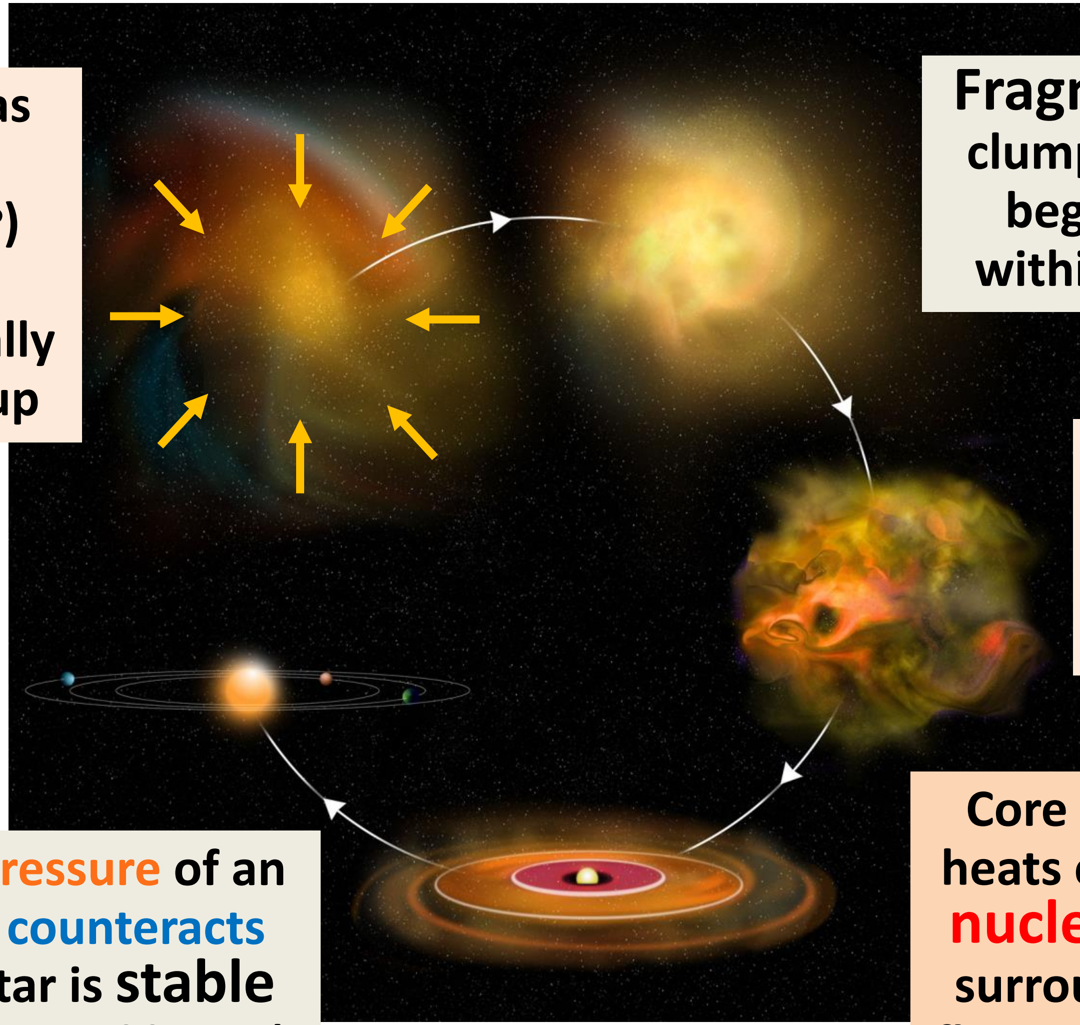
Stars

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.**

Formation of a Star



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

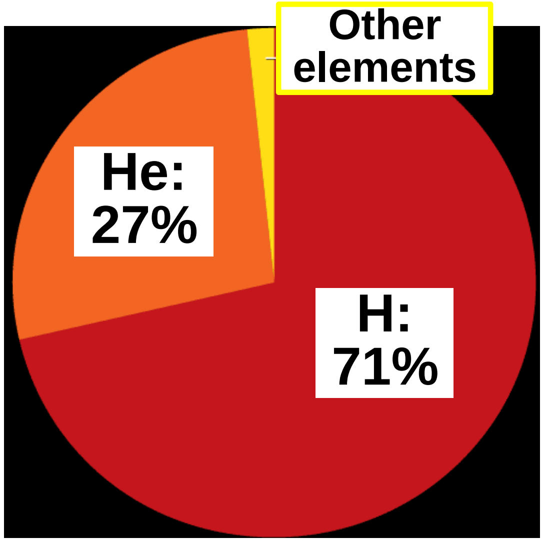
Fragmentation: clumps of matter begin to form within the cloud

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

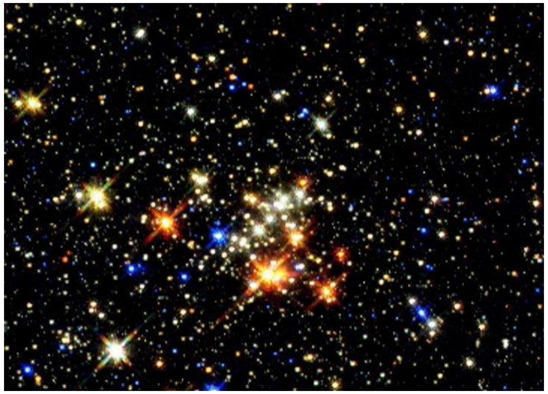
Core condenses and heats enough to begin **nuclear fusion**; the surrounding material flattens into a spinning protoplanetary disc

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).**

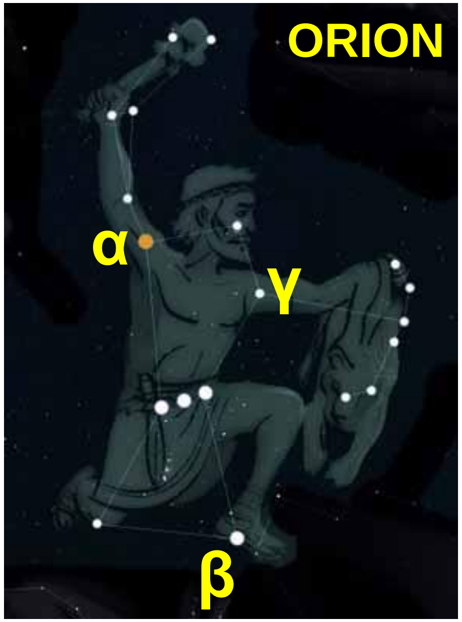


- **Color: stars come in many different colors; the color tells us the star's *temperature* (blue is HOT, red is COLD).**
- **Luminosity: the total amount of energy radiated by a star into space each second.**
- **Brightness: apparent energy that *reaches us* (how bright a star appears to be due to how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

- <u>In the past</u>, 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:

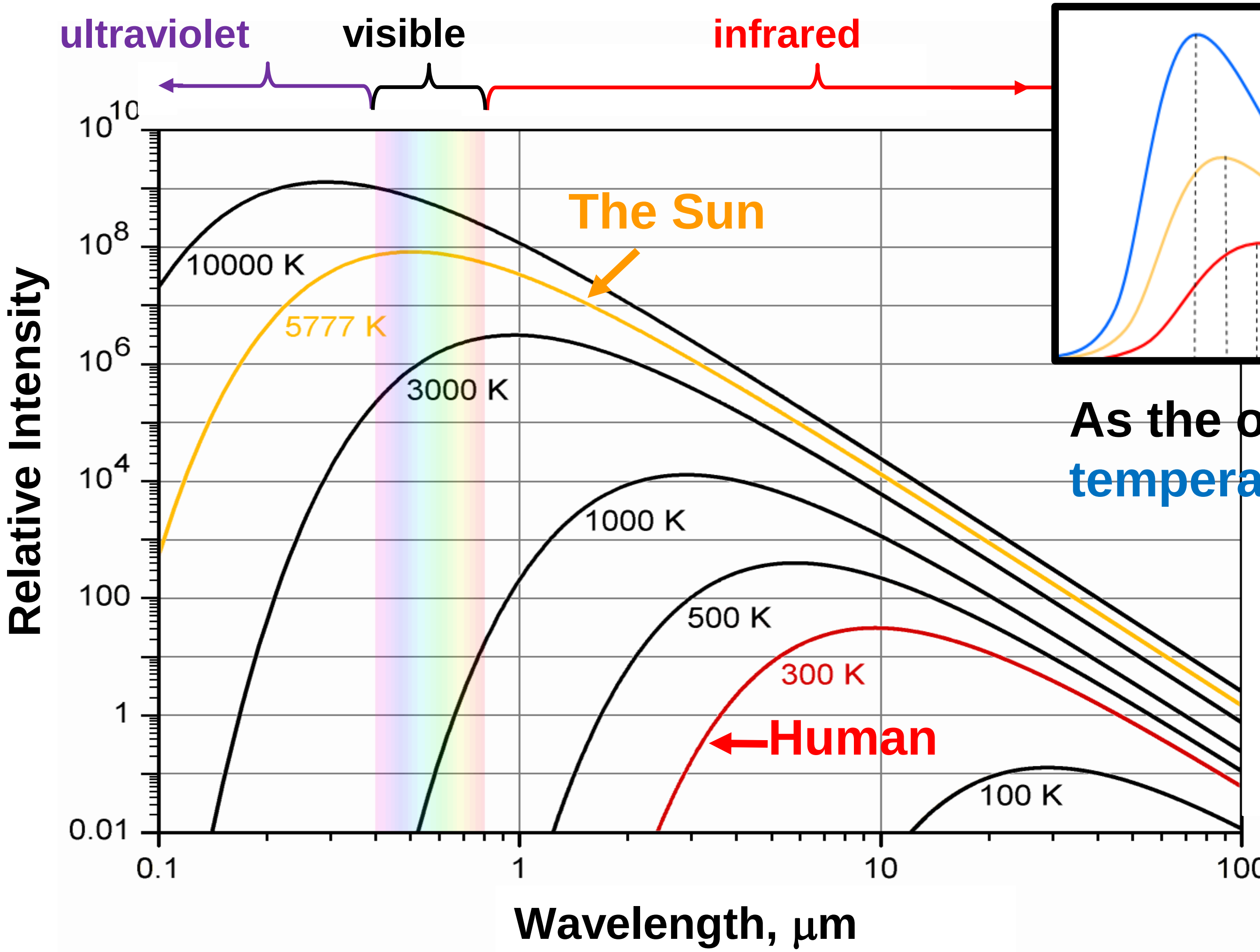
α-Orion (Betelgeuse) β-Orion (Rigel)
γ-Orion (Bellatrix)

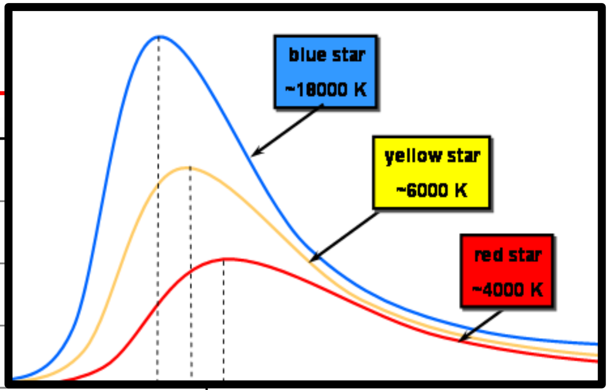
- <u>Starting from 20th century</u>, stars are classified by their luminosity (energy rate) and surface temperature.

Thermal Radiation

REVIEW

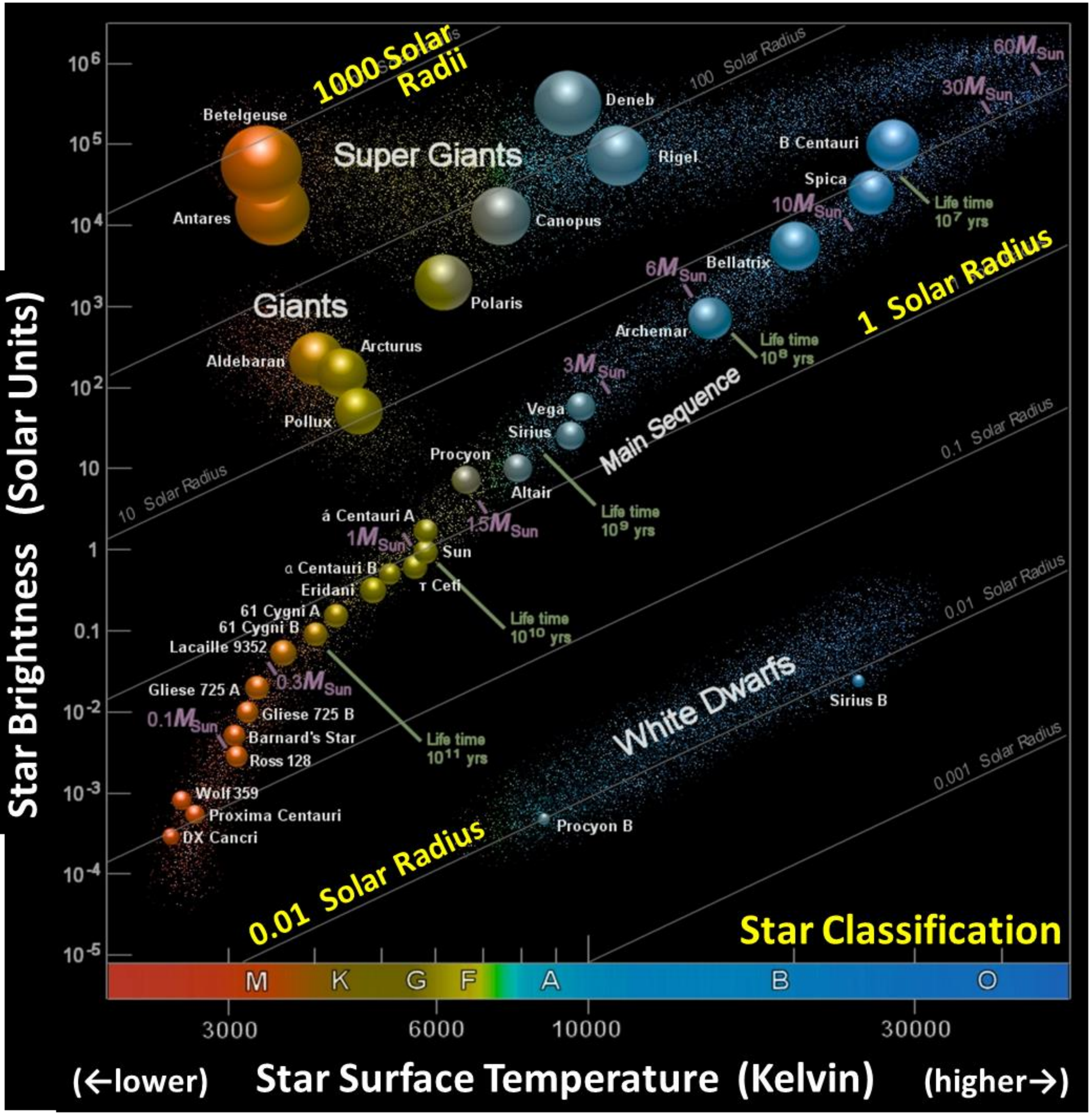
All normal matter emits electromagnetic radiation when it has a temperature above absolute zero.





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

The HR
(Hertzsprung-Russell, 1910)
Diagram



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