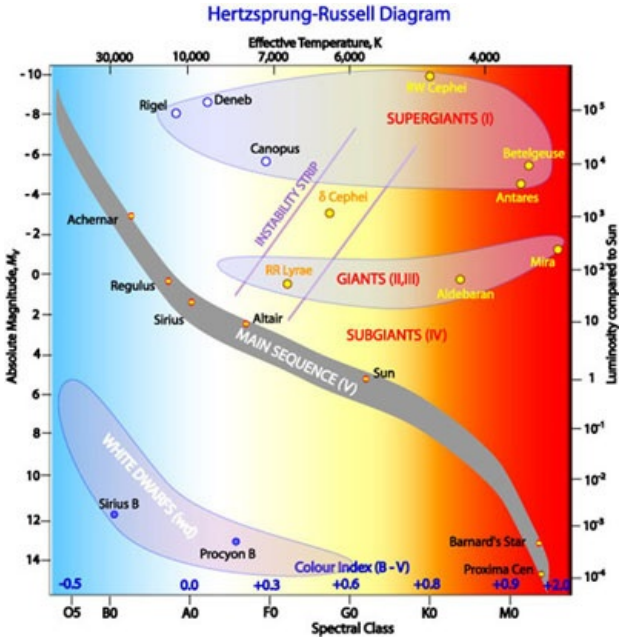
Hertzsprung-Russell Diagram

The **Hertzsprung-Russell diagram** (**HR diagram**) is one of the most important tools in the study of **stellar evolution**. Developed independently in the early 1900s by Ejnar Hertzsprung and Henry Norris Russell, it plots the temperature of **stars** against their **luminosity** (the theoretical HR diagram), or the colour of stars (or **spectral type**) against their **absolute magnitude** (the observational HR diagram, also known as a colour-magnitude diagram).
Depending on its initial **mass**, every **star** goes through specific evolutionary stages dictated by its internal structure and how it produces energy. Each of these stages corresponds to a change in the temperature and luminosity of the star, which can be seen to move to different regions on the HR diagram as it evolves. This reveals the true power of the HR diagram – **astronomers** can know a star's internal structure and evolutionary stage simply by determining its position in the diagram.



The Hertzsprung-Russell diagram the various stages of stellar evolution. By far the most prominent feature is the main sequence (grey), which runs from the upper left (hot, luminous stars) to the bottom right (cool, faint stars) of the diagram. The giant branch and supergiant stars lie above the main sequence, and **white dwarfs** are found below it.
Credit: R. Hollow, CSIRO.

This Hertzsprung-Russell diagram shows a group of stars in various stages of their evolution. By far the most prominent feature is the main sequence, which runs from the upper left (hot, luminous stars) to the bottom right (cool, faint stars) of the diagram. The giant branch is also well populated and there are many white dwarfs. Also plotted are the Morgan-Keenan luminosity classes that distinguish between stars of the same temperature but different luminosity. -->
There are 3 main regions (or evolutionary stages) of the HR diagram:

1. The **main sequence** stretching from the upper left (hot, luminous stars) to the bottom right (cool, faint stars) dominates the HR diagram. It is here that stars spend about 90% of their lives burning **hydrogen** into **helium** in their cores. Main sequence stars have a **Morgan-Keenan luminosity class** labelled **V**.
2. **red giant** and **supergiant** stars (luminosity classes **I** through **III**) occupy the region above the main sequence. They have low surface temperatures and high **luminosities** which, according to the Stefan-Boltzmann law, means they also have large radii. Stars enter this evolutionary stage once they have exhausted the hydrogen fuel in their cores and have started to burn helium and other heavier elements.

3. **white dwarf** stars (luminosity class **D**) are the final evolutionary stage of low to intermediate mass stars, and are found in the bottom left of the HR diagram. These stars are very hot but have low luminosities due to their small size.

The **Sun** is found on the main sequence with a luminosity of 1 and a temperature of around 5,400 **Kelvin**.
Astronomers generally use the HR diagram to either summarise the evolution of stars, or to investigate the properties of a collection of stars. In particular, by plotting a HR diagram for either a globular or open cluster of stars, astronomers can estimate the age of the cluster from where stars appear to turnoff the main sequence (see the entry on main sequence for how this works).
