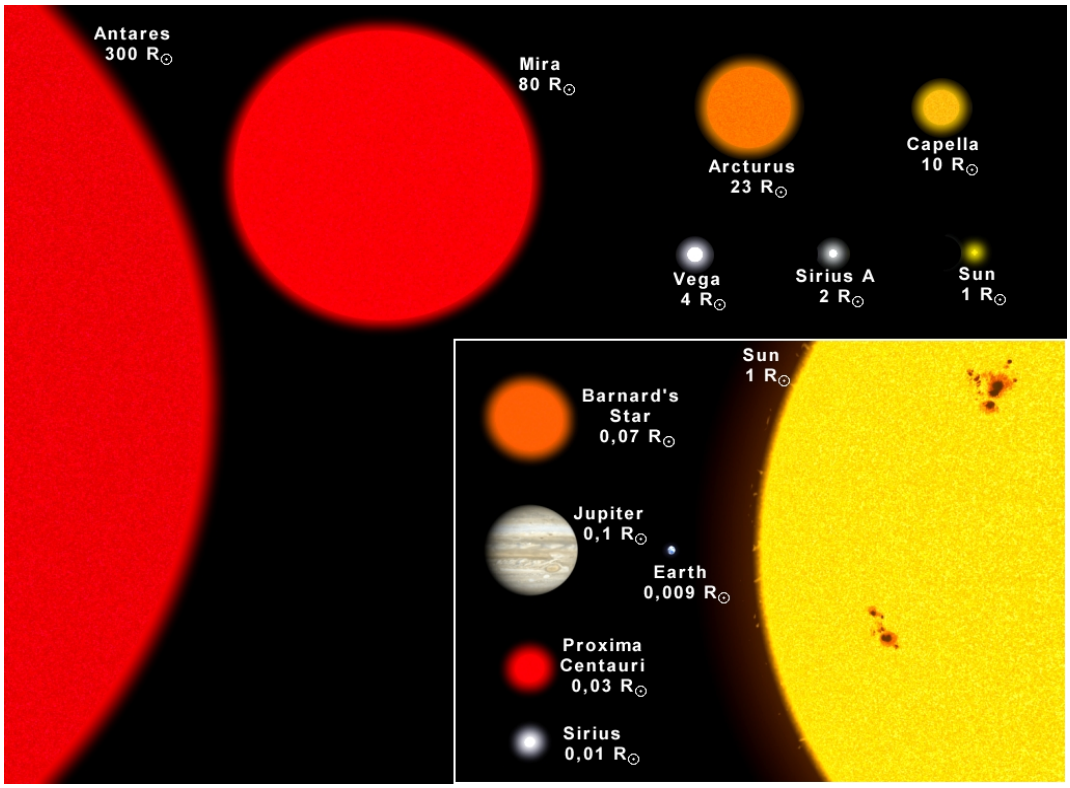
What is a Star

...and why we study them?

When we look up at the night-sky from a dark place on Earth, we see thousands of shining objects. Each of these brilliant but distant lights is a star, just like the Sun, although compared to the Sun, some of them are much more massive and luminous, others less. There are also great differences in the distances to the visible stars, some of them being quite far away, others relatively close - although even our closest neighbour, alpha Centauri, is still 4.2 light-years away. This means that it takes light 4.2 years to travel from the star to us, despite its speed of 300.000 km/second. Astronomers, however, measure distances in parsec, one parsec being around 3 light-years.

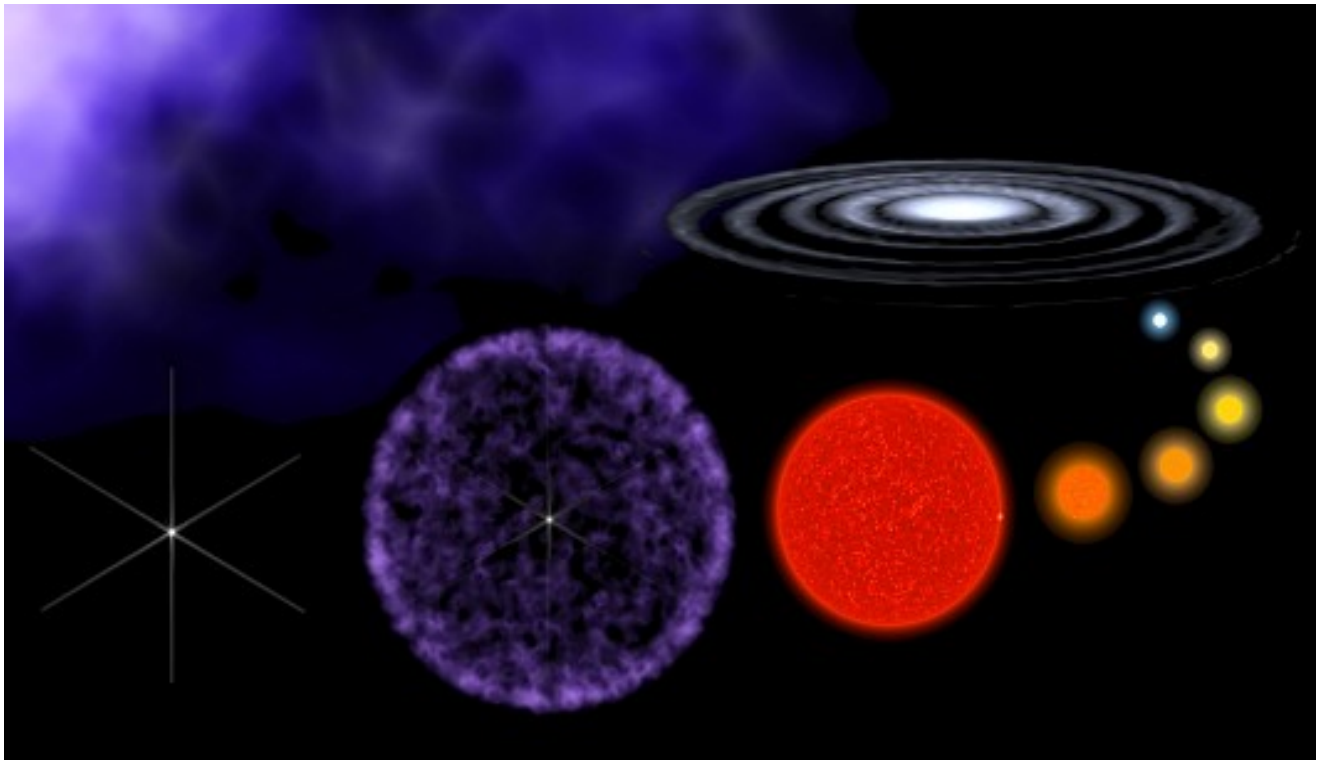
Some of the stars we see are very young, like the well-known Pleiades (the Seven Sisters), which are only a few million years old, others are several billion years old. The Sun is actually just an average sized star in the middle of its life - the only thing that makes the Sun special among stars is the fact that the Earth is in orbit around it.

Literally, a star is an enormous sphere of hot, glowing gas, many times larger and more massive than the Earth. The Sun, for instance, has a radius that is 100 times larger than the radius of the Earth, and it is 333000 times more massive. Although the stars all look quite similar, they span a large range in physical properties. In mass, the span is a factor 1000, the lightest stars having masses around 1/10 the mass of the Sun, the heaviest 100 times the mass of the Sun. In luminosity the range is even bigger, with a factor of 1 billion between the least and the most luminous stars. Imaging a 60W and a 60.000.000.000W light bulb next to each other to grasp this span in luminosity!



Starlife

The stars spend their lives producing energy by nuclear reactions. Due to very high temperatures in the core (several millions of degrees as compared to surface temperatures of several thousand degrees) and an enormous pressure, hydrogen is converted into helium through nuclear fusion. This releases energy which is emitted in the form of light, enabling the star to shine and thus to radiate energy for the benefit of, for instance, the life on Earth (or on planets orbiting other, distant stars?). This fusion process can continue for only a few million years for the most massive stars, which burn up their hydrogen fuel quickly, to many billion years for the less massive, less luminous stars.



At the late stages of a star's life, heavier elements are created by further nuclear fusion processes, before the star finally shreds its outer layers, leaving behind only a core, or explodes in a supernova explosion. It is only the most massive stars that end their life in this latter, spectacular way. These processes inside the stars will be discussed further on the following pages.

Stars and Galaxies

All the stars visible in the night-sky belong to our Galaxy, the Milky Way. Such a galaxy contains several hundred billion stars, of which the Sun is just one (and in fact, the Milky Way is just one among billions of galaxies in our universe), and it spans an enormous 100000 light-years in space. The Galaxy also contains large amounts of interstellar gas and dust from which new stars and planets are continuously being born. At the same time, the gas and dust are being re-supplied and enriched with heavy elements (like carbon etc), as old stars evolve and finally end their life. Except for hydrogen and helium, most of the elements making up the Earth (and its inhabitants) have been produced inside earlier generations of stars.

Stars are vital for Life

Stars are thus among the most fundamental and important objects in the universe. Not only to the astronomer, who seeks to understand the structure and evolution of the universe around us, but also to every living creature that relies on a star - like the Sun - to provide the energy that keeps life going. Furthermore, stars are actually the only objects outside our solar system for which reliable ages can be determined. This makes them vital to the understanding of the history and structure of the Universe.

With the naked eye we can only see stars in the vicinity of the Sun. More distant stars are too far away, making them too faint to be seen here from Earth. With a telescope, however, we can study stars throughout most of the Galaxy, and even stars in other galaxies as well. In the following pages, we will look more closely at what a star actually is, how stars work and evolve, and how they are studied by astronomers.