The Life Cycle of Stars

by Christopher Boozer
Astrophysical and Planetary Sciences Department, University of Colorado, Boulder

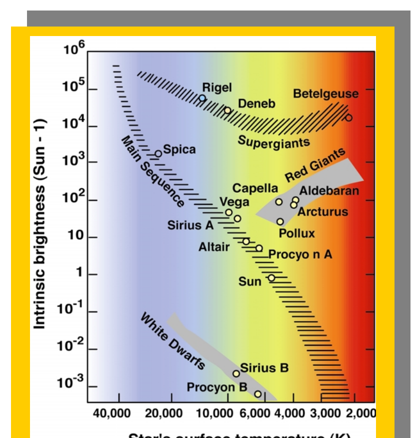
The stars in the night sky appear to be fixed and unchanging. Even the earliest records of humankind reveal little reason (except for the occasional comet and one good supernova) to think of stars as anything but eternal. We now realize that, while stars spend millions or billions of years with more or less the same properties and appearance, they do indeed have lifetimes. They are born, mature, experience middle age, and also die. While these words may seem a poetic attempt to attribute human qualities to stars, they are useful analogies to real physical processes.

In the vast emptiness of space, there are varying levels of gas densities. The birth of a star begins in regions of higher-density gas (mostly hydrogen, with some helium) and dust in space. These gas clouds are called **nebulae** (Greek for clouds), and can be many light-years across, several times the usual distance between stars.

Part of a nebula gets compressed into a knot of denser gas (by a star passing through it, two clouds bumping into each other, a big explosion,...). Gravity causes this part of the cloud to collapse. The atoms rub together, heating up. Scientists describe this as gravitational energy being converted into thermal energy. If there is enough mass, the core of the nebula may heat up to millions of degrees, enough for **nuclear fusion** to start. A new star is created when the remaining mass, consisting of dust and gases, blows away like a butterfly shedding its cocoon. This process normally takes anywhere from tens of thousands to a few hundreds of thousands of years.

The two characteristics of stars which determine their life cycles are their masses and their original compositions. A mature star may shine steadily for millions or even billions of years. The single biggest factor in the length of its life is the star's mass. Large, massive stars, such as **red giants** and **supergiants**, tend to burn out their hydrogen fuel quickly. Smaller stars are more fuel-efficient and last the longest.

But no matter the size, there is only so much hydrogen available inside the star. When the star eventually uses it up, it has lost its source of energy and pressure for internal support. What happens next also depends on the mass the star had. It could end up as a **white dwarf**, or as a **supernova** with remnants like **neutron stars**, **pulsars**, and **black holes**.



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Hertzsprung-Russell Diagram, showing characteristics of main sequence and other types of stars

Astronomers typically chart the paths of stars' lives as the **Hertzsprung-Russell Diagram** (H-R Diagram). This diagram graphs brightnesses (**luminosity**) along the **vertical axis** against temperatures along the **horizontal axis**. Middle-aged stars tend to fall in a diagonal band, the **Main Sequence**. There is a clear relationship between the temperature or color of a star and how much light it emits. An observer may not know the true brightness of a distant star, due to dust and gas somewhere between the star and the Earth obscuring measurements. From the star's color, the astronomer can consult the H-R Diagram for a fairly good estimate of its brightness.