Stars

A star is a massive, luminous sphere of gas held together by gravity. The nearest star to Earth is the Sun, which is the source of most of the energy on Earth. Other stars are visible from Earth during the night, when they are not obscured by clouds.

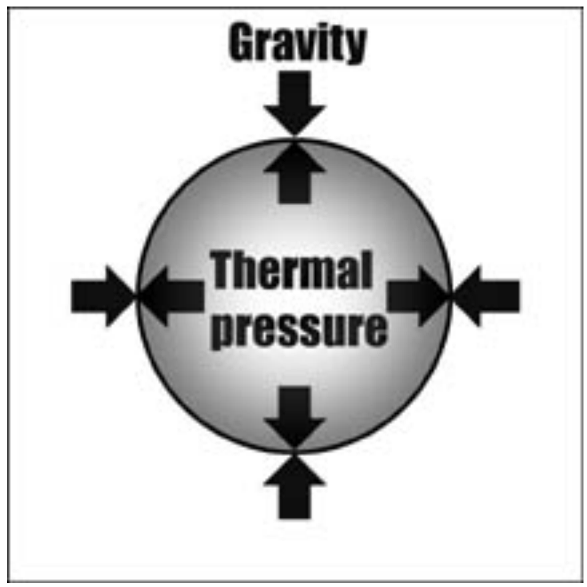
For at least part of their lives, stars shine due to thermonuclear fusion of hydrogen in their core. This fusion releases energy that radiates into outer space. Almost all naturally occurring elements heavier than helium were created by stars using some form of fusion.

The total mass of a star is the main factor that determines its evolution and eventual fate.

Formation

Stars begin their lives as huge clouds composed primarily of hydrogen, along with helium and small amounts of heavier elements. Such a cloud is called a **nebula**.

Gravitational forces within the nebula cause it to shrink. This shrinking slowly draws more and more gas to the center (core) of the nebula. As more material gathers in the core, it creates a tremendous amount of pressure directed outward.



The increase in pressure causes the temperature in the core to also increase. As the temperature rises, the hydrogen atoms in the core begin to move faster and faster.

Once the temperature in the core reaches around 15 million degrees Celsius, the hydrogen atoms are moving so fast that, when they collide, they fuse together to form helium atoms.

This fusion of two hydrogen atoms to form a helium atom (called **hydrogen fusion**) releases a tremendous amount of energy. This energy flows out through the star and, when it reaches the surface, radiates out into space. The ball of gas begins to shine as a new star.

Daily Life

While hydrogen fusion is taking place, the inward pull of gravity is exactly balanced by the outward pressure created by hydrogen fusion. During this period of its life, the star is stable.

Stars spend about 90% of their lifetime in this stable phase. Such stars are said to be on the **main sequence**, and are called **dwarf stars**.

How long a star remains on the main sequence depends on its mass. In general, the larger the star the faster it burns through its hydrogen (so larger stars have shorter lives). Small stars (called red dwarfs) may spend tens or even hundreds of billions of years on the main sequence.

It is estimated that our Sun will remain on the main sequence for 10 billion years (half of which has already passed).

The final stages of a star's life play out differently depending on its mass.

Death of Small Stars

Stars that are less than about eight times the mass of our Sun are considered medium and small stars.

Small and medium stars will fuse hydrogen into helium for billions of years until they run out of hydrogen. Once hydrogen fusion ends, gravity will cause the star to begin to collapse inward (since the outward pressure provided by fusion is gone).

This collapse causes an increase in pressure and temperature. Because of this increase, hydrogen in the mid-layers of the star become hot enough to fuse. The hydrogen begins to fuse into helium in a shell around the star's core.

The heat from this shell-fusion causes the outer layers of the star to expand far beyond its previous size. At this point, the star is a **red giant**.

The star's core continues to collapse until the core temperature reaches 100 million degrees Celsius. At this point, the helium in the core begins to fuse into carbon. Energy from this reaction sustains the star, keeping it from collapsing further.

The star will burn through its supply of helium much faster, and helium fusion will stop. The outer layers of the star will be blown off into space, and the star becomes a **white dwarf**. A white dwarf is a very small, very hot star.

With fusion no longer taking place, the white dwarf will slowly cool until it no longer radiates any energy.

Death of Large Stars

Stars that are more than eight times the mass of our Sun are considered large stars.

Large stars begin their lives the same way smaller stars do: by fusing hydrogen and helium. However, a large star burns hotter and faster, fusing all the hydrogen in its core to helium in less than 1 billion years. The star then becomes a **red supergiant** (similar to a red giant, only larger).

A red supergiant is so massive that, after helium fusion has ended, it will continue to produce higher core temperatures. Eventually, the core will become hot enough to fuse hydrogen, helium, and carbon atoms into heavier elements.

The red supergiant will continue fusing heavier elements until iron is formed. Iron is the heaviest element that will be fused in any star. As iron is fused, it will collect at the core of the star.

Once the iron core becomes large enough, it can no longer support its own mass. This core will suddenly collapse, causing the rest of the star to explode in a **supernova**.

Most of the matter in the star is blown away by the supernova explosion. What remains will be a **neutron star** or, in the case of the largest stars, a **black hole**.

Characteristics of Stars

Age

- most stars are between 1 and 10 billion years old (the universe is 13.7 billion years old)

Chemical Composition

- most stars in the Milky Way are around 71% hydrogen and 27% helium

Diameter

- neutron stars vary from 20 to 40 kilometers
- supergiants can be 650 times larger than the Sun

Mass

- one of the most massive stars known has a mass around 100 times that of the Sun
- 150 times the mass of the Sun is believed to be the upper limit for stars

Brightness

- how bright a star is depends on its size, temperature, and distance from Earth
- in general, bigger = brighter, hotter = brighter, and closer = brighter