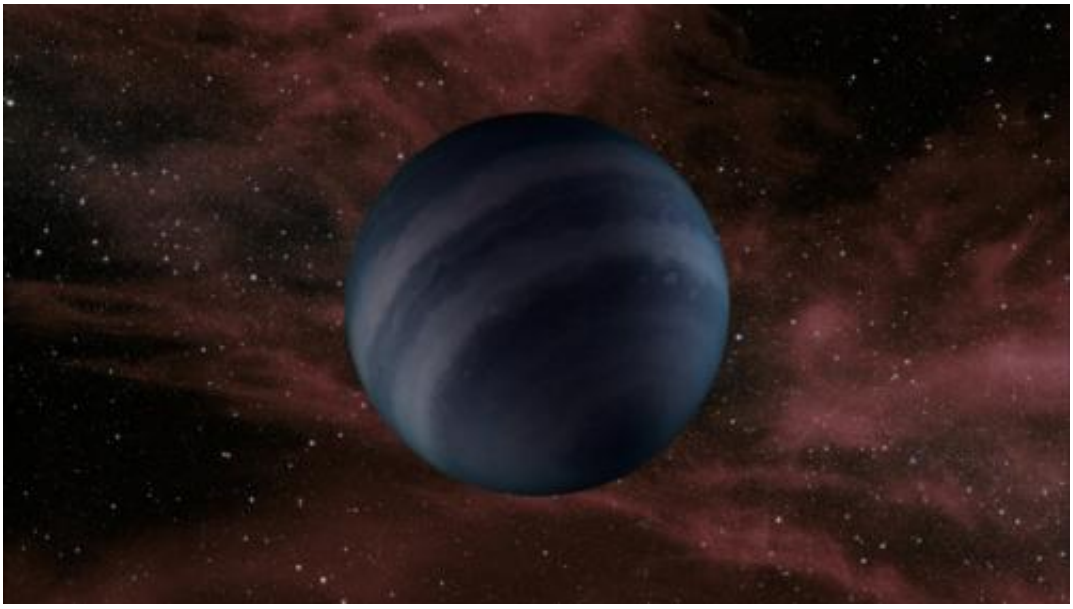
Explainer: What are stars?

November 4 2013, by Akila Jeeson-Daniel



This artist's conception portrays a free-floating brown dwarf, or failed star. Credit: NASA/JPL-Caltech

Twinkle, twinkle, little star, how I wonder what you are.

If we look up at the sky at night, we see millions of tiny diamond-like stars. These are actually balls of plasma (very hot gas) consisting of hydrogen and helium.

Stars are formed by the gravitational collapse of large clouds of cold gas. When the gas is compressed, it heats up and transforms into plasma.

The temperature of the star's core depends on the mass of the star. When the heat in the centre of the gas sphere is high enough (about four million degrees Celsius), nuclear fusion of hydrogen to helium occurs, generating bundles of light energy, known as photons.

Stars are measured in proportion to the mass and luminosity of our sun. In general, stars are classified as "dwarfs" if they are less bright than our sun, and "giants" if they are brighter.

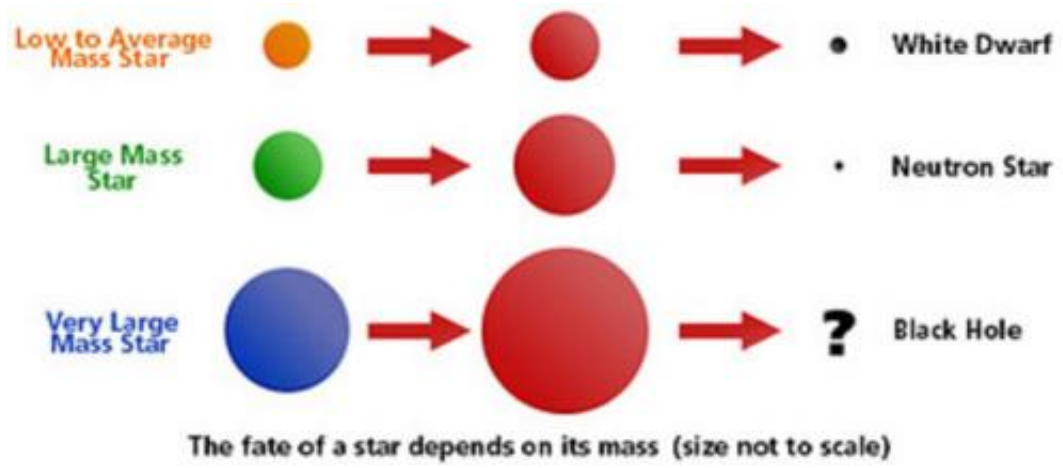
Getting started

In small plasma spheres (less than 8% of the mass of sun), the temperature of the core is not hot enough to start hydrogen fusion and it becomes a brown dwarf - also known as a "failed star", since it does not have enough mass to maintain fusion.

For stars more massive than brown dwarfs, fusion in the core produces light and heat, supporting the star from further collapse. This is called the "main-sequence" stage and is the longest living stage in a star's life.

Main-sequence stars

The exact length of the main-sequence stage depends on the star's mass: the lower the mass of the star, the longer it takes to burn up all its hydrogen. Our sun's main-sequence lifetime is about ten billion years, and it is approximately at the middle stage of its life now.



Credit: NASA

During the main-sequence phase, a star fuses all the hydrogen in its core to helium. As most of the hydrogen fuel is used, the core of the star starts contracting and more heat is produced.

The shell, where some hydrogen is still burning to form helium, starts expanding to dissipate the heat and the star becomes cooler and redder. This is called the red giant phase. Giant stars are between ten and a few thousand times more luminous than the sun.

Supergiants are even brighter, with luminosities more than 10,000 times the sun's (sometimes even going into the millions). Red supergiants have a radius of about 200 to 800 times that of the sun with a mass of about ten times the sun.

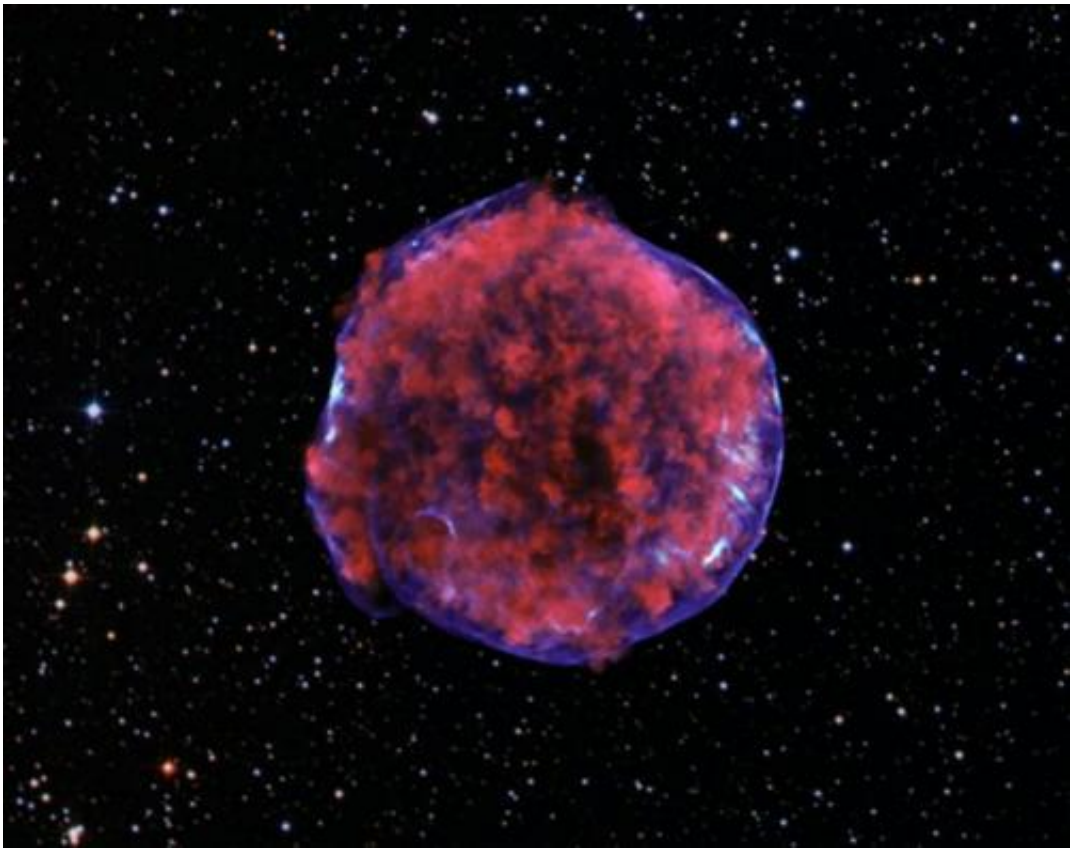
Very massive stars produce enough heat to become blue supergiants. They can be from ten to 100 times the mass of the sun.

Death of a star

A star like the sun will not have enough temperature in the core to sustain its outer layer and thus will expel its shell when it exhausts all the hydrogen. The shell then becomes a planetary nebula (essentially a cloud around the star), while the carbon-rich core cools and becomes a "white dwarf". Stars up to nine times the mass of the sun become white dwarfs with varying compositions.

Stars more massive than white dwarfs collapse and explode as violent supernovas, losing most of their mass into the surrounding medium. The small remnant iron core continues to collapse to the stage of being composed of mainly neutrons. It is then known as a neutron star.

Stars with a mass of more than 25 times that of the sun can leave a black hole behind after exploding. Black holes are formed when the core after the supernova explosion has a solar mass three times that of the sun.



Credit: The Tycho supernova remnant. X-ray: NASA/CXC/Rutgers/K.Eriksen et al.; Optical: DSS

Some of the debris left over after a supernova explosion eventually forms more stars and planets, which is why one might say that we are made of "star dust".

The Orion constellation

So how can we spot these failed stars, giants and supernovas in the night sky?

The Orion constellation, is a fascinating space to see some of the different types of stars in their various stages of life.

The brightest star in the Orion constellation, Rigel, is a blue supergiant about 20 times larger in mass and 100 times bigger in radius than the sun.

The second brightest star, Betelgeuse, is a red supergiant, about ten times the mass of the sun and about 1,000 times our sun's radius. Betelgeuse is also in the later stage of its life.

In the "sword" part of Orion is a fuzzy-looking area called the Orion Nebula. Here, new stars are formed in clouds of gas and dust called molecular clouds. These new stars emit light onto the gas around them, making the nebula glow. Some of the Orion Nebula's bright stars are visible to us, forming the constellation.

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Source: The Conversation