

# The Life of a Star

Image Credit: NASA / ESA



**M42, the Orion Nebula** This star forming region is 1200 light years from the Sun.

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In the northern hemisphere the winter sky is dominated by the constellation Orion. Below Orion's belt you might just be able to see a small fuzzy patch – the Orion Nebula. This is part of a huge region of star formation.

“giant stars have a kind of rock and roll life-style”

Some of these giant clouds of gas and dust may begin to condense (perhaps triggered by the shock waves from supernova explosions). As more and more gas comes together the temperature inside the proto-star rises, eventually reaching a critical level allowing thermonuclear reactions to begin. The gas cloud has become a new star. Gravity continues to try to collapse the star in on itself while at the same time energy created by the thermonuclear reactions tries to blow the star apart. Once a dynamic equilibrium

is reached the proto-star has joined the Main Sequence. How long it remains on the Main Sequence depends on how fast it burns up its supply of hydrogen fuel in the core. Very hot, bright stars like the giant O-type stars have a kind of live fast die young – rock and roll life style while small cool M-type stars live a quiet life, never really attracting attention to themselves and living to a ripe old age. Our Sun is a middle aged Main Sequence star. But of course it won't last for ever. What will happen to the Sun as the fuel runs out? Well fortunately none of us will be around to experience this. As the hydrogen runs out the core will collapse increasing the density and temperature enough to allow helium fusion reactions to occur; meanwhile the outer layers will cool and expand. The Sun will have become a red giant, swallowing up Mercury and possibly Venus in the process. Any life that does exist on Earth will not survive. The oceans and the atmosphere will be blown off into space: our blue green planet will become a scorched lifeless ball of rock. Of course the new fuel (helium) will not last forever either and the core will go through a series of collapses; each resulting in the creation of new heavier elements and new thermonuclear reactions; the carbon in your DNA and the iron in your blood were all created in a star that is now dead. The outer layers will expand into thin shells of gas which move away from the sun out into interstellar space. The sun will now have become a planetary nebula.

“the red giant tears itself apart in a supernova explosion”

The tiny white dwarf star at the centre of the planetary nebula will slowly cool and fade becoming a cold black dwarf. This description of the Sun's fate is true for all stars up to 1.5 solar masses. Heavier stars (between 1.5 and 3 solar masses) have a different fate.

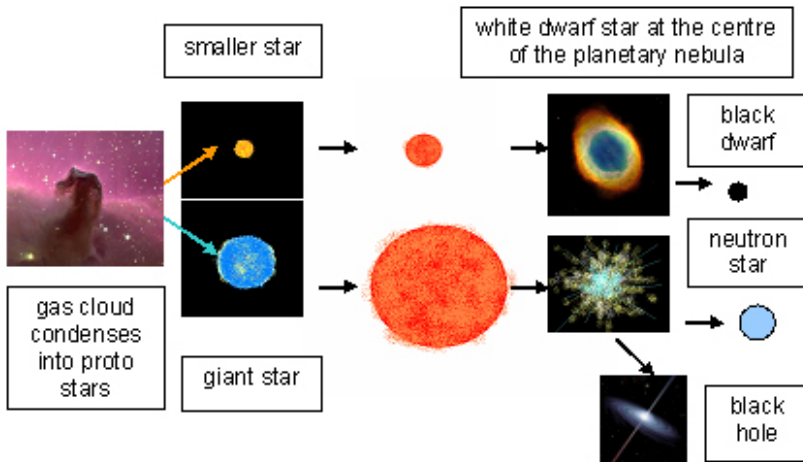


Image Credit: Paul O'Neill

**Unto their manifold dooms** Stars can end their lives in several ways depending on their mass.

Rather than becoming a red giant they become a red super giant. After this stage things become more violent. Instead of gentle billowing gas shells being ejected into space (a planetary nebula) the red super giant tears itself apart in an unbelievably violent explosion called a supernova. As the radiation and debris clear, a neutron star emerges. This tiny object, about 20 km in diameter, is all that's left of the massive super giant. It is so dense that a teaspoon of its material would weigh one hundred million tonnes. Stars larger than three solar masses also explode in a supernova, but the remaining material collapses in on itself so much it becomes a black hole.



**The Helix Nebula** This planetary nebula is 450 light years from the Sun.

Image Credit: NASA, WYRN, NAOJ, ESA, Hubble Helix Nebula Team, M. Meixner (STScI), &amp; T. A. Rector (NRAO)