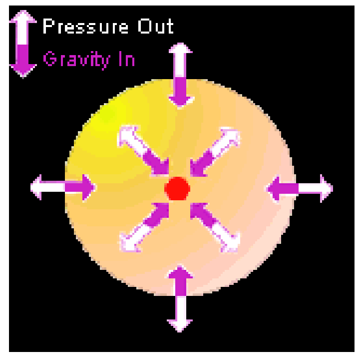
X-Ray Astronomy Field Guide

Stellar Evolution

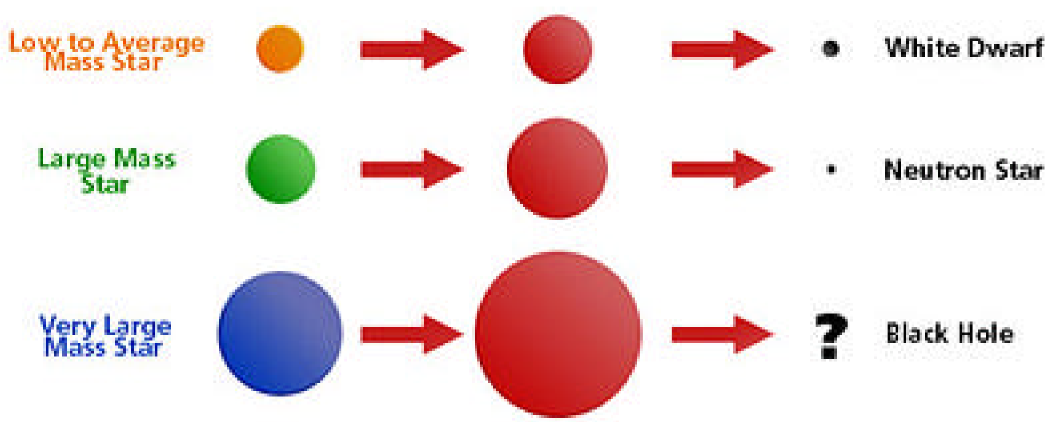
The Milky Way Galaxy contains several hundred billion stars of all ages, sizes and masses. A typical star, such as the Sun, radiates small amounts of X-rays continuously and larger bursts of X-rays during a solar flare.

The Sun and other stars shine as a result of nuclear reactions deep in their interiors. These reactions change light elements into heavier ones and release energy in the process. The outflow of energy from the central regions of the star provides the pressure necessary to keep the star from collapsing under its own weight.



A star collapses when the fuel is used up and the energy flow from the core of the star stops. Nuclear reactions outside the core cause the dying star to expand outward in the "red giant" phase before it begins its inevitable collapse.

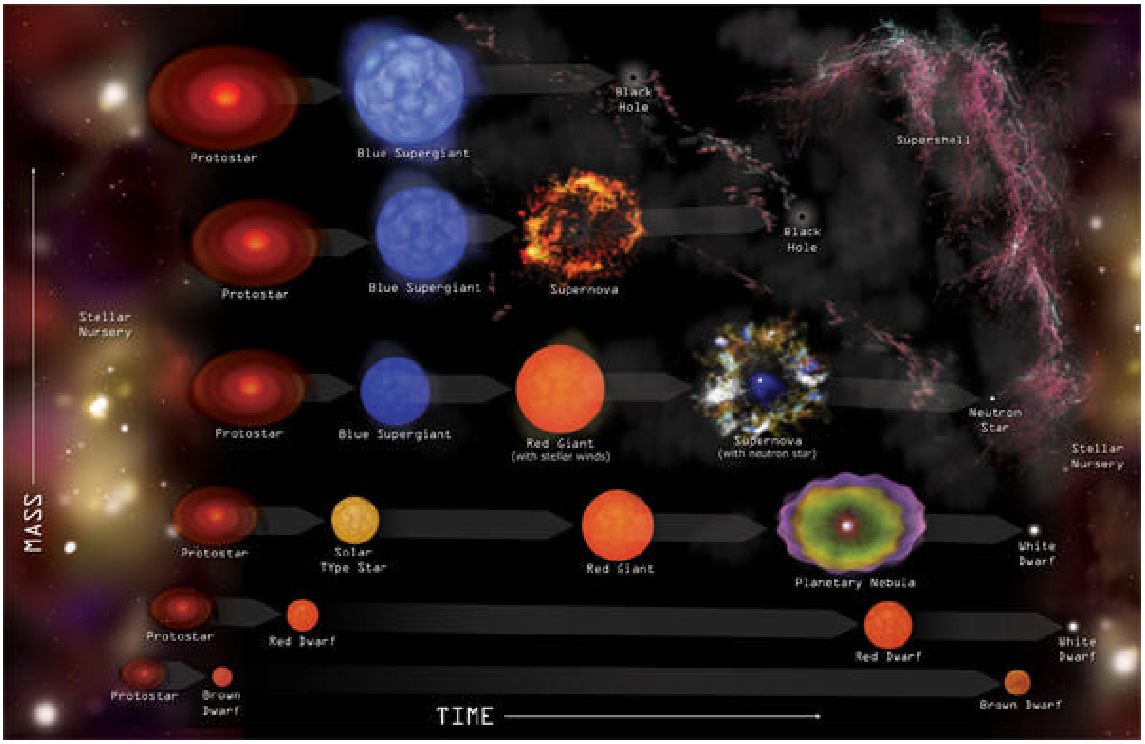
If the star is about the same mass as the Sun, it will turn into a white dwarf star. If it is somewhat more massive, it may undergo a supernova explosion and leave behind a neutron star. But if the collapsing core of the star is very great—at least three times the mass of the Sun—nothing can stop the collapse. The star implodes to form an infinite gravitational warp in space—a black hole.



The fate of a star depends on its mass (size not to scale)

The brightest X-Ray sources in our galaxy are the remnants of massive stars that have undergone a catastrophic collapse—neutron stars and black holes. Other powerful sources of X-rays are giant bubbles of hot gas produced by exploding stars. White dwarf stars and the hot, rarified outer layers, or coronas, of normal stars are less intense X-Ray sources.

To summarize, this tableau illustrates the ongoing drama of stellar evolution, and how the rate of evolution and the ultimate fate of a star depends on its mass.



Stars are formed in giant clouds of dust and gas, and progress through their normal life as balls of gas heated by thermonuclear reactions in their cores. Depending on their mass, they reach the end of their evolution as a white dwarf, neutron star or black hole. The cycle begins anew as an expanding supershell from one or more supernovas trigger the formation of a new generation of stars. Brown dwarfs have a mass of only a few percent of that of the Sun and cannot sustain nuclear reactions, so they never evolve.