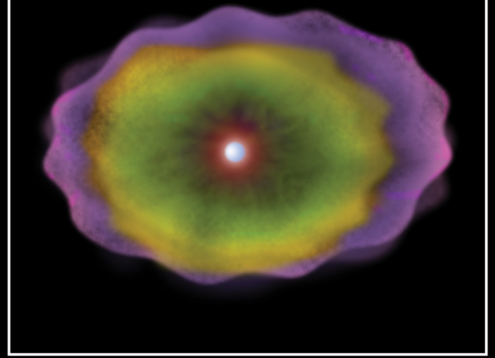
END PHASES

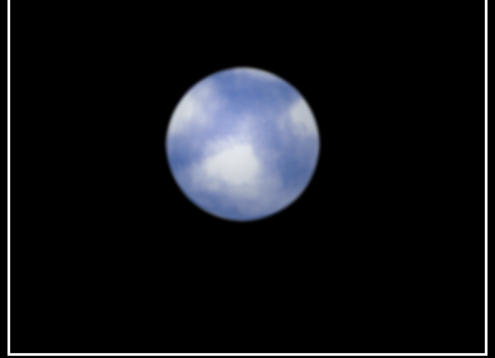
A star's ultimate fate depends on its mass. It can fade into obscurity (brown dwarf or red dwarf), become a white dwarf (sun-like stars), explode as a supernova and leave behind a neutron star or a black hole (massive to very massive stars), or be disrupted entirely (white dwarfs in close binary systems, or extremely massive stars).

PLANETARY NEBULA



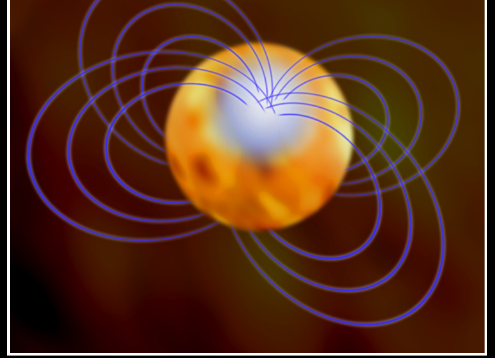
A nebula produced after an exhausted giant star puffs off its outer layer and leaves behind a smaller, hot star.

WHITE DWARF



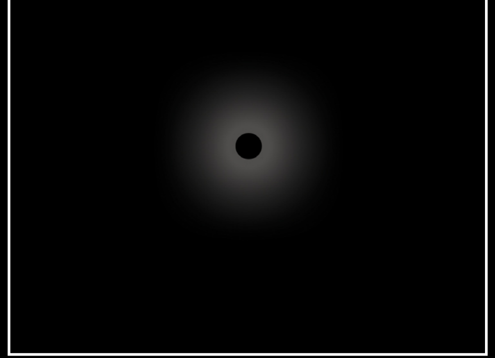
The end phase of a Sun-like star in which all the material contained in the star, minus the amount blown off in the red giant phase, is packed into a volume one millionth the size of the original star.

NEUTRON STAR



An extremely compact star produced by the collapse of the core of a massive star in the supernova process.

BLACK HOLES

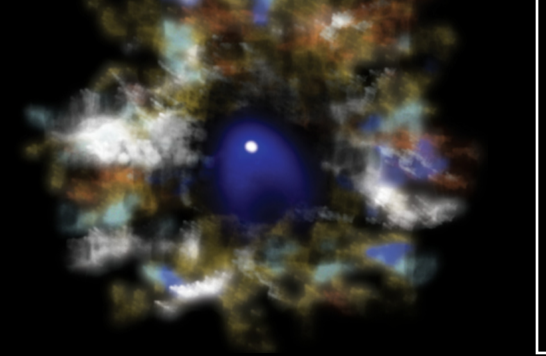


If the core of a collapsing star has a mass that is greater than three Suns, no known force can prevent it from forming a black hole.

TYPE IA SUPERNOVA

An explosion produced when a white dwarf becomes unstable due to the accretion of too much material or merger with another white dwarf.

TYPE II SUPERNOVA



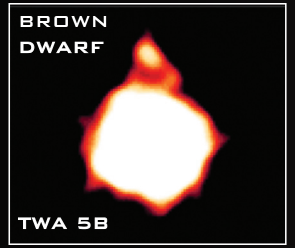
A supernova that occurs when a massive star has used up its nuclear fuel and its core collapses to form either a neutron star or a black hole, triggering an explosion.

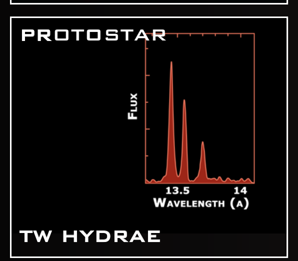
PAIR-INSTABILITY SUPERNOVA

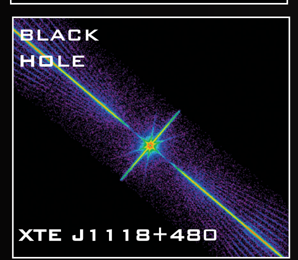
A rare type of explosion predicted to occur as a consequence of the extremely high temperatures in the interiors of stars having masses of about 200 suns.

SUPERSHELLS

The combined activity of many stellar winds and supernovas create expanding supershells that can trigger the collapse of clouds of dust and gas to form new generations of stars.







The Milky Way galaxy contains several hundred billion stars of various ages, sizes and masses. A star forms when a dense cloud of gas collapses until nuclear reactions begin deep in the interior of the cloud and provide enough energy to halt the collapse.

Many factors influence the rate of evolution, the evolutionary path and the nature of the final remnant. By far the most important of these is the initial mass of the star. This handout illustrates in a general way how stars of different masses evolve and whether the final remnant will be a white dwarf, neutron star, or black hole.

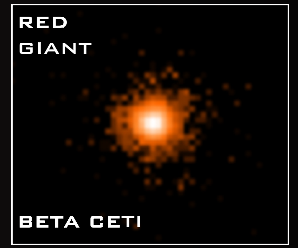
Stellar evolution gets even more complicated when the star has a nearby companion. For example, excessive mass transfer from a companion star to a white dwarf may cause the white dwarf to explode as a Type Ia supernova.

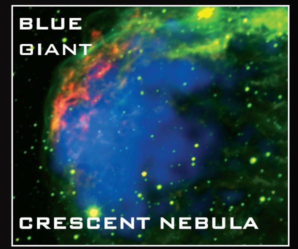
The terms found in the boxes on the previous pages and in the Chandra images shown here can be matched to those in the main illustration. These give a few examples of stars at various evolutionary stages, and what Chandra has learned about them. X-ray data reveal extreme or violent conditions where gas has been heated to very high temperatures or particles have been accelerated to extremely high energies. These conditions can exist near collapsed objects such as white dwarfs, neutron stars, and black holes; in giant bubbles of hot gas produced by supernovas; in stellar winds; or in the hot, rarified outer layers, or coronas, of normal stars.

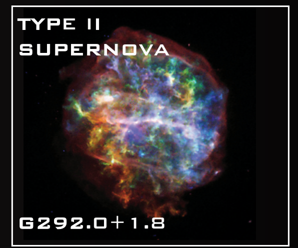
FOR MORE INFORMATION, GO TO:

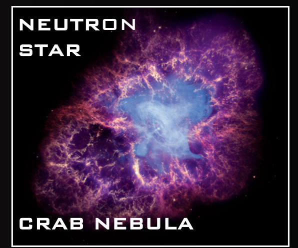
HTTP://CHANDRA.SI.EDU/XRAY_SOURCES/

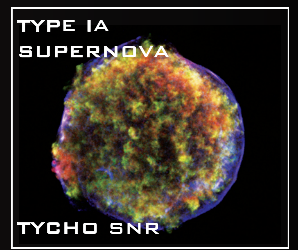
NASAs Marshall Space Flight Center, Huntsville, Ala., manages the Chandra program for the agency's Science Mission Directorate. The Smithsonian Astrophysical Observatory controls science and flight operations from the Chandra X-ray Center in Cambridge, Mass.

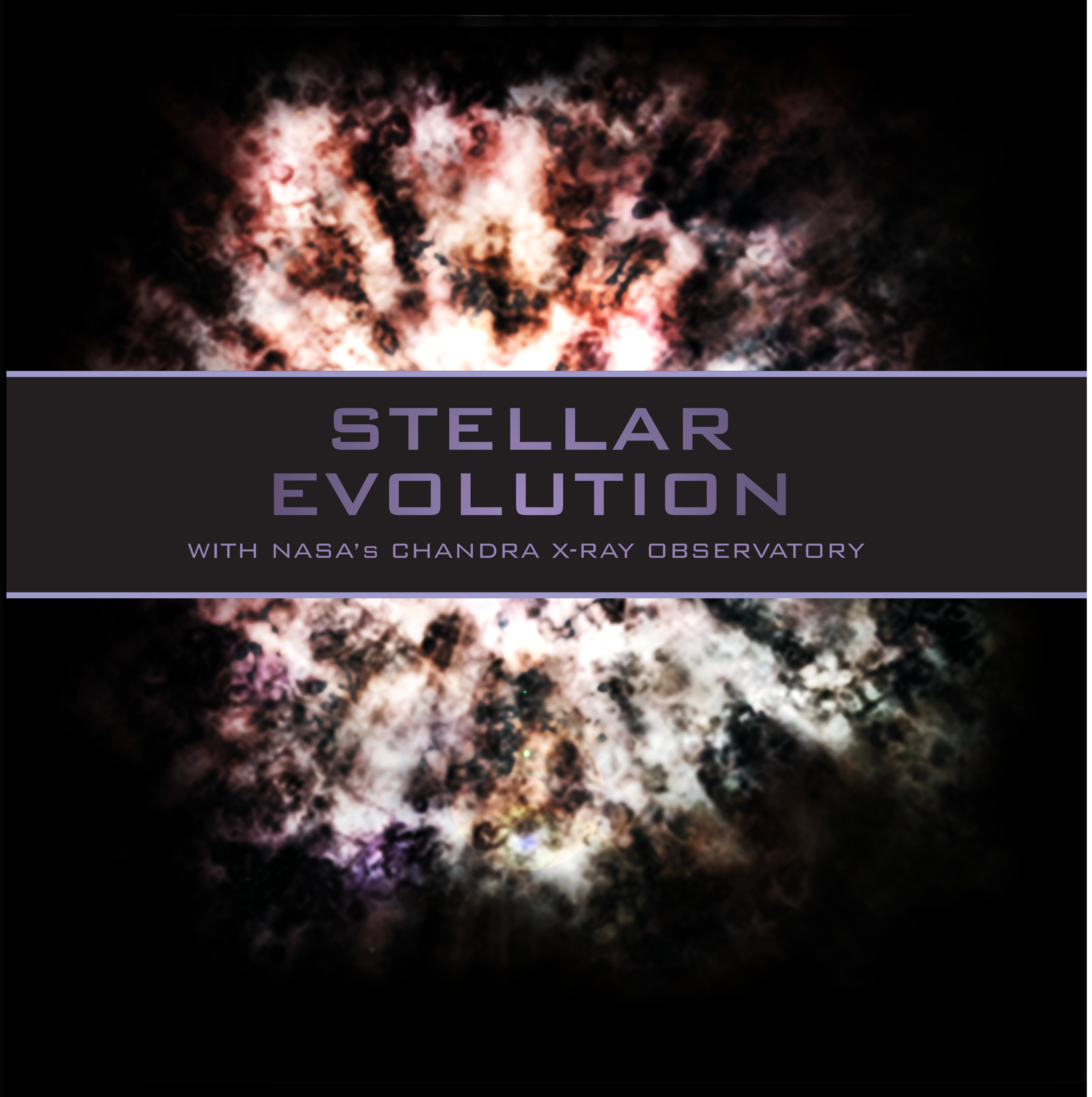






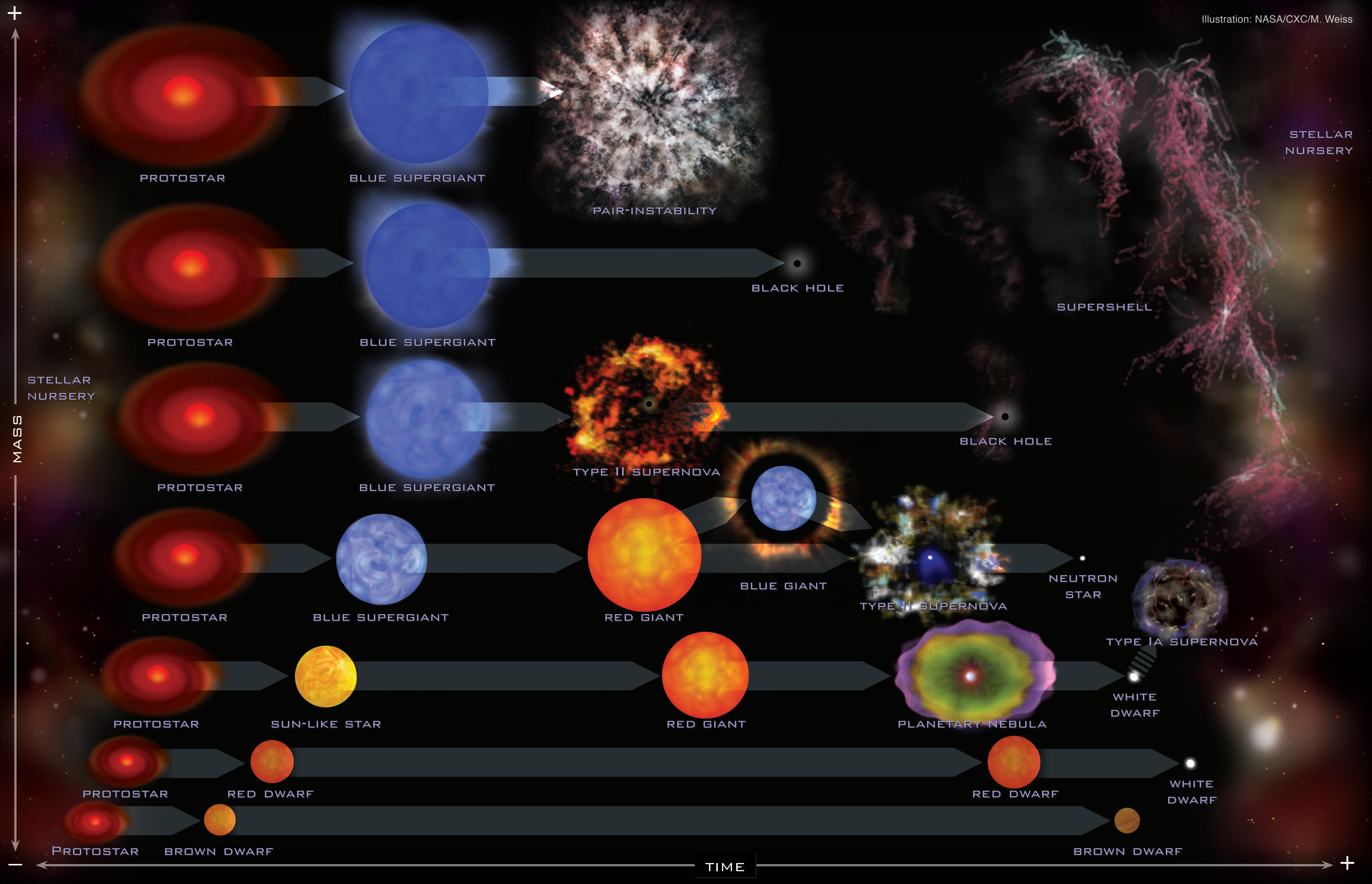


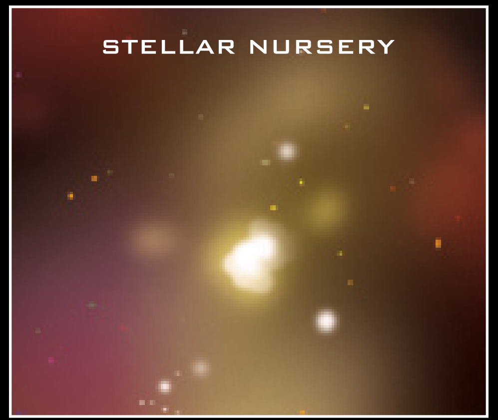




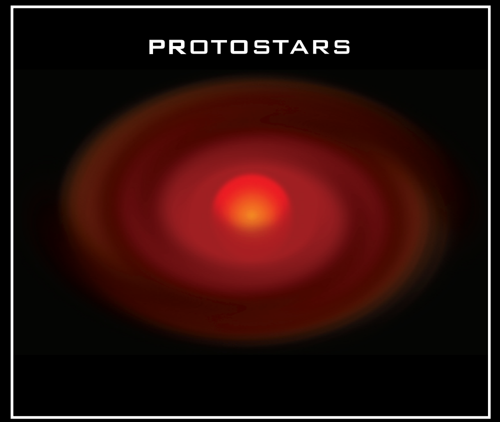
STELLAR EVOLUTION

WITH NASA's CHANDRA X-RAY OBSERVATORY



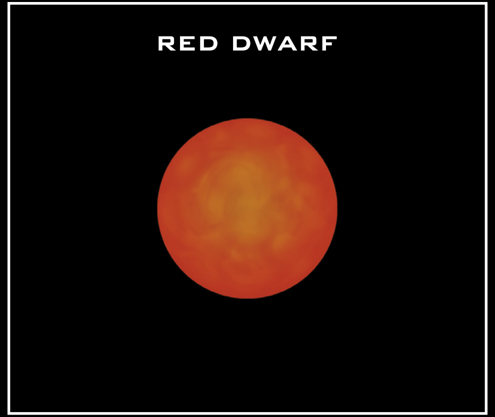


Large cold clouds of dust and gas where stars form.

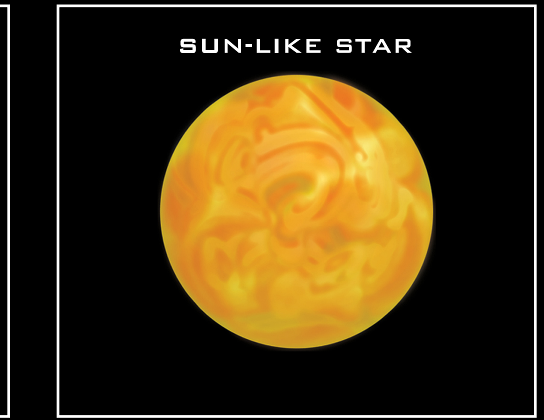


The stage in the formation of a star just before nuclear reactions ignite.

An object with a mass less than about 8% of the mass of the Sun, but about 10 times greater than that of Jupiter.



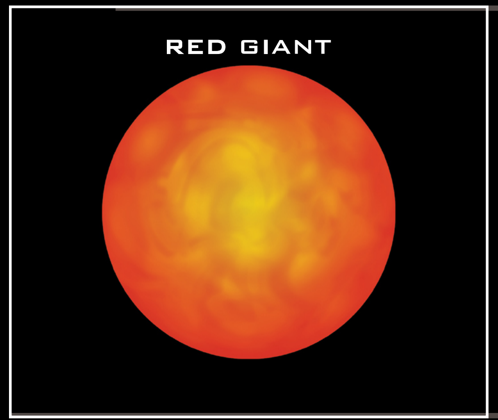
A star with a mass approximately 8% and 50% of the mass of the Sun.



A star with mass between about 50% and 10 times that of the Sun

Stars much more massive than the Sun.

INTERMEDIATE PHASE



A phase in the evolution of a star after nuclear fusion reactions that convert hydrogen to helium have consumed all the hydrogen in the core of the star, and energy generated by hydrogen fusion in the shell causes the star's diameter to greatly expand and cool.

After a massive red giant star ejects its outer layers, its hot inner core is exposed, and it becomes a blue giant star.