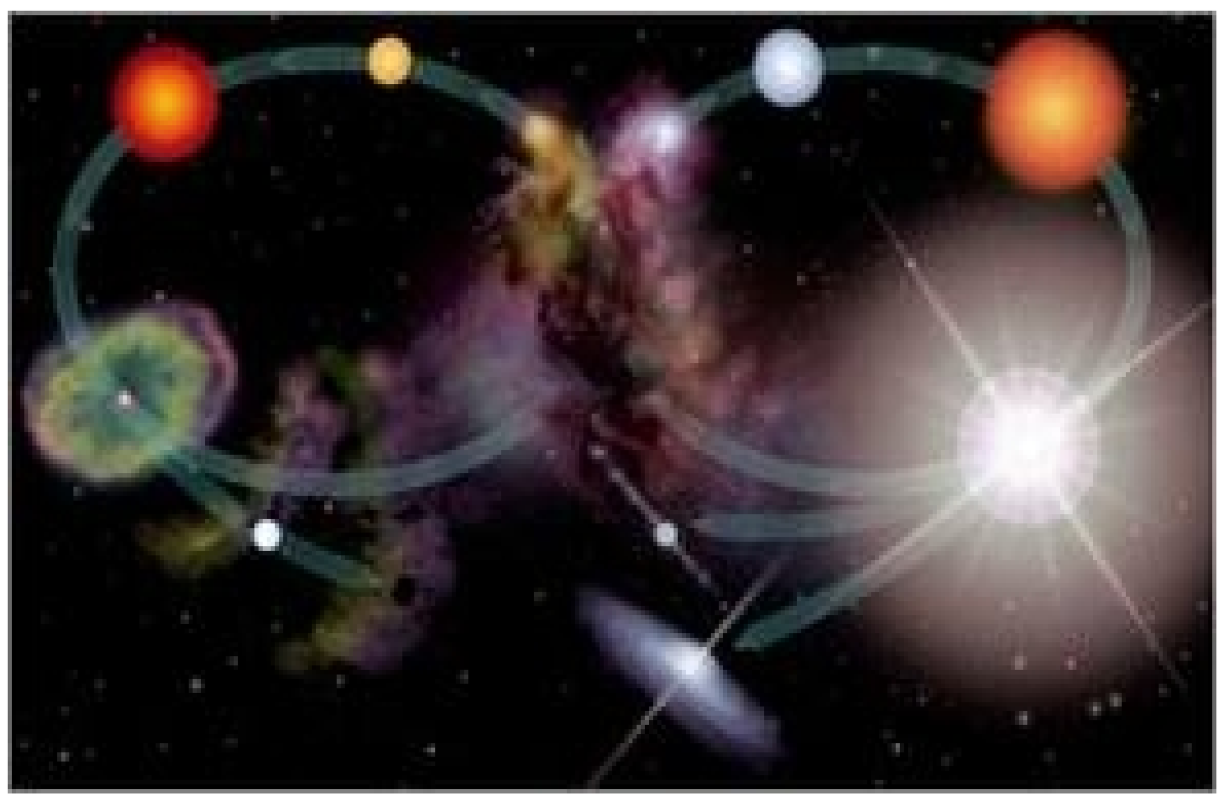
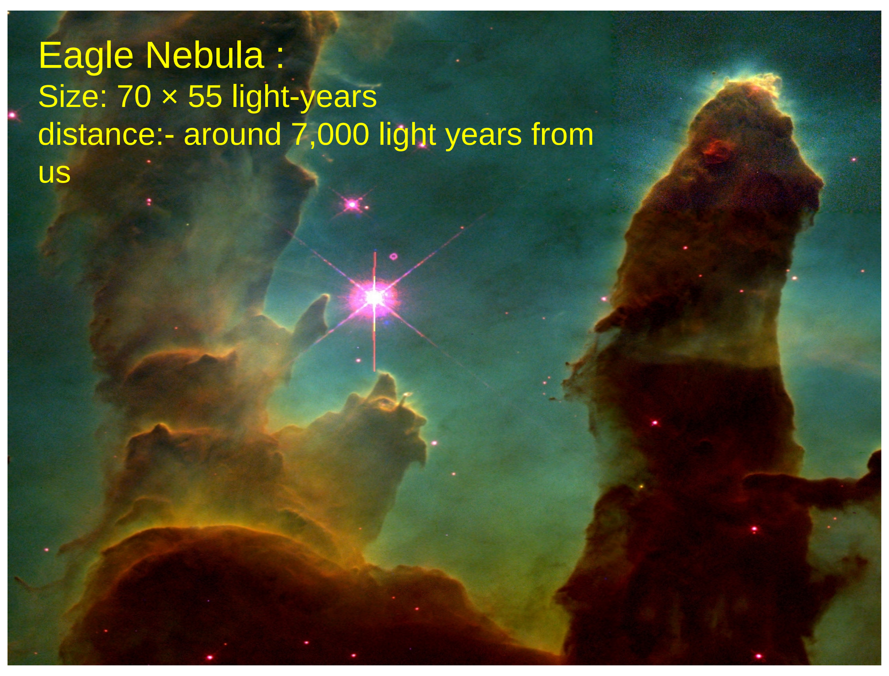
The Life Cycle of Stars

What is a star?

A star is a hot ball of gas, with nuclear burning at its core. Stars spend the majority of their lives fusing hydrogen, and when the hydrogen fuel is gone, stars fuse helium into carbon. The more massive stars can fuse carbon into even heavier elements, which is where most of the heavy elements in the universe are made.





Eagle Nebula :
Size: 70 × 55 light-years
distance:- around 7,000 light years from us

How does a star born?

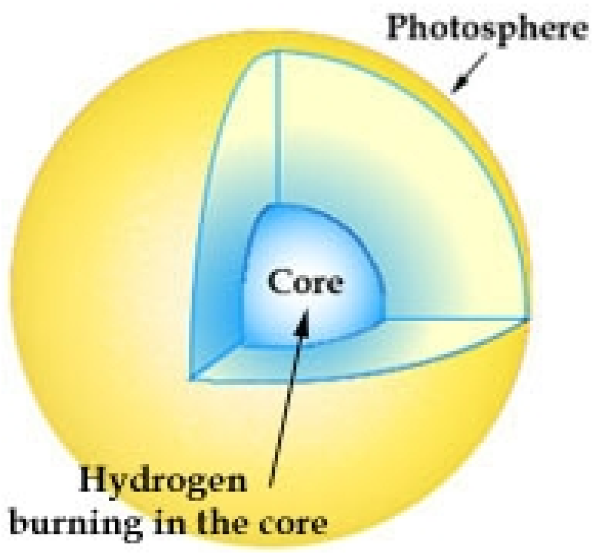
Stars are born in nebulae(97% hydrogen and 3% helium). Huge clouds of dust and gas collapse under gravitational forces, forming proto stars. It works as follows:

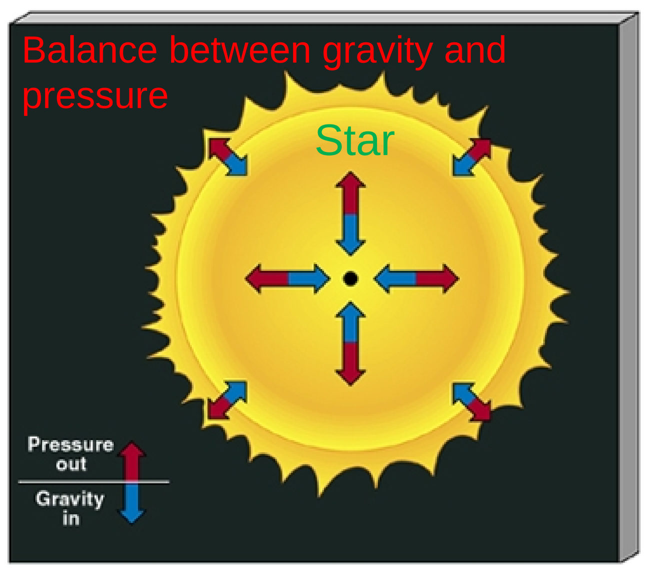
1. Gravity pulls gas and dust inward toward the core.
2. Inside the central region, temperature increases as gas atom collisions increase.
3. Density of the core increases as more atoms try to share the same space.
4. Gas pressure increases as atomic collisions and density increase.
5. The proto star's gas pressure RESISTS the collapse of the nebula.
6. When gas + radiation pressure = gravity, the proto star has reached equilibrium and a star forms.

Horsehead Nebula:
size: around 23 x 4 light years
Distance: around 1300 light years from us

There are two options for a proto star at this point:

1. If a critical temperature (107 K)in the core of a proto star is not reached, nuclear burning doesn't start and the star ends up a brown dwarf. A brown dwarf never gets "star" status.
2. If a critical temperature in the core of a proto star is reached, then nuclear fusion begins. We identify the birth of a star as the moment that it begins fusing hydrogen in the core into helium.





Equilibrium between gravity and gas pressure: the life goal of a star

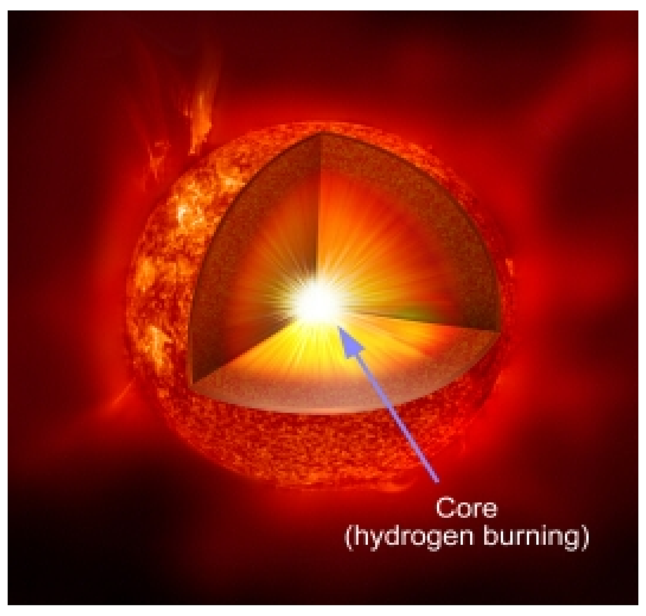
How star live and die is determined by the battle between gravity and gas pressure, known as equilibrium**.**

What determines how long you will live? When your body doesn't maintain its proper pH, or acid balance (for whatever reasons) your body shuts down. Biologists call this **homeostasis**, which means balance or equilibrium.

A star needs to maintain a balance too – but this balance is between gas pressure and gravity, the duration of which depends on star's mass.

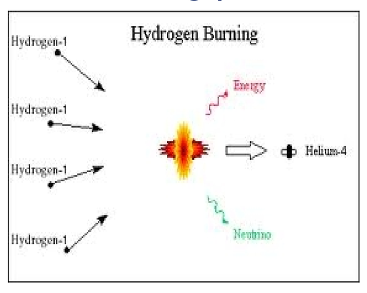
Larger stars have more fuel, but they have to burn (fuse) it faster in order to maintain equilibrium. Hence large stars use all of their fuel in a shorter length of time. A smaller star has less fuel, but its rate of fusion is not as fast. Therefore, smaller stars live longer than larger stars because their rate of fuel consumption is not as rapid.

Various stages of evolution:



The start of a star's life: Hydrogen Burning :

1. Hydrogen burning starts when core temperature reaches to 200 million Kelvin.
2. Hydrogen nuclei combine to form Helium nuclei. Tremendous amount of energy is released through the following process.

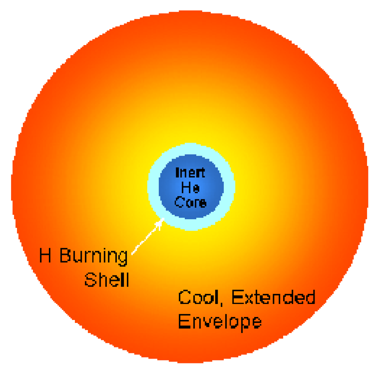


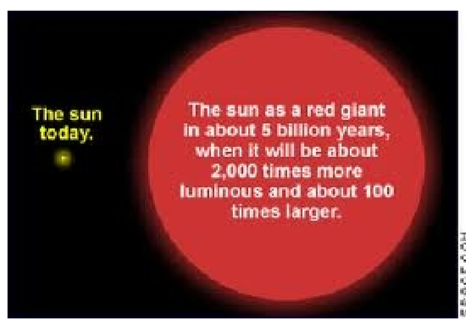
3. A star spends its most of the time on this stage. This stage may last up to billion years for low mass stars.

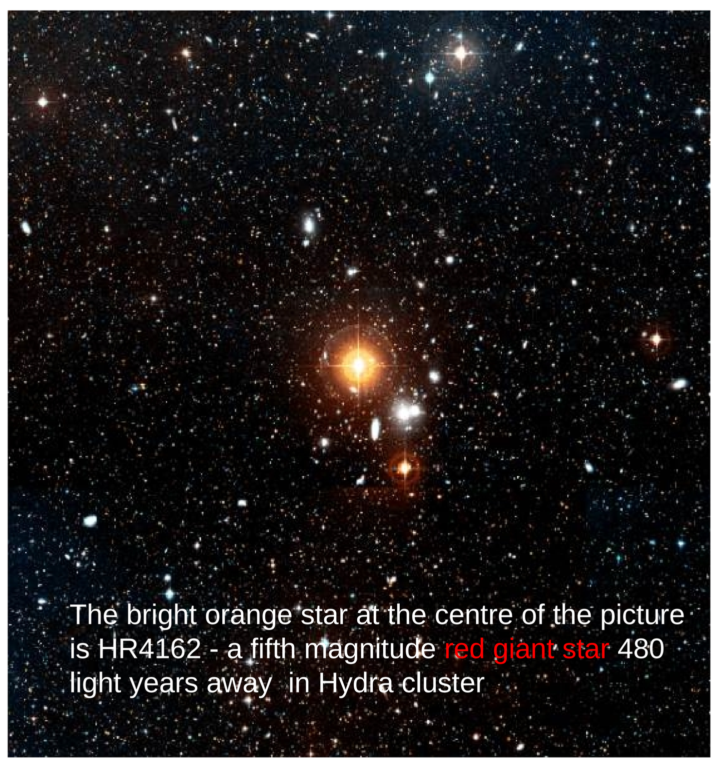
The beginning of the end: Helium Burning:-

1. Helium burning starts when hydrogen no longer exist in the core. The star is forced to burn helium in an effort to maintain stability. It starts at around thousand million Kelvin temperature .
2. Gravity keeps contracting the core to maintain equilibrium, and as the core contracts the atoms are packed together even tighter than before. Density increases.
3. The outer shell of star expands in an effort to help heat from the core to escape into space. At this point, the star is often termed a red giant.

Typical brightness of a red giant star is 1500 times that of sun and diameter is around hundred times that of sun.







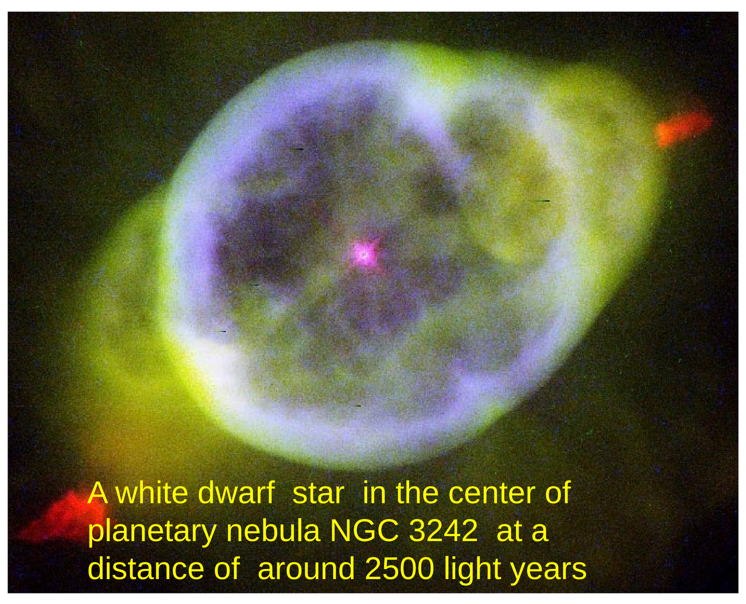
The bright orange star at the centre of the picture is HR4162 - a fifth magnitude red giant star 480 light years away in Hydra cluster

The end of star : Carbon Burning (this may be another beginning):

When the helium in the core is gone the core needs to maintain temperature to keep the gas pressure up; otherwise the star cannot resist gravity, the core contracts contract again to initiate the last type of fusion – carbon burning. The fate of the star is now decide by its mass.

Low-Mass Stars (one solar mass or less) :

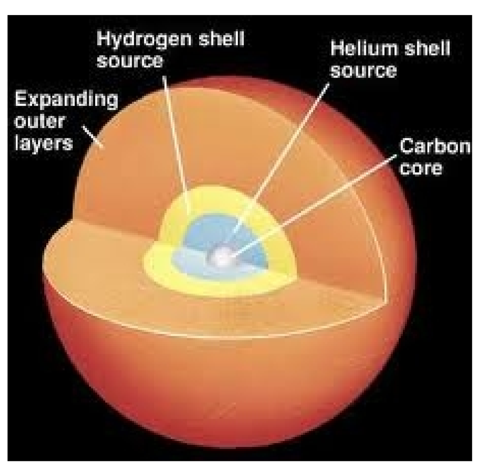
1. For a low mass star, the core never reaches the ignition temperature of carbon burning .A low mass star becomes the white dwarf.
2. The size of the white dwarf is close to that of earth, and the outer layers are planetary nebula.
3. Since the core is out of fuel, the white dwarf will eventually cool to a black dwarf in billion years time.



A white dwarf star in the center of planetary nebula NGC 3242 at a distance of around 2500 light years

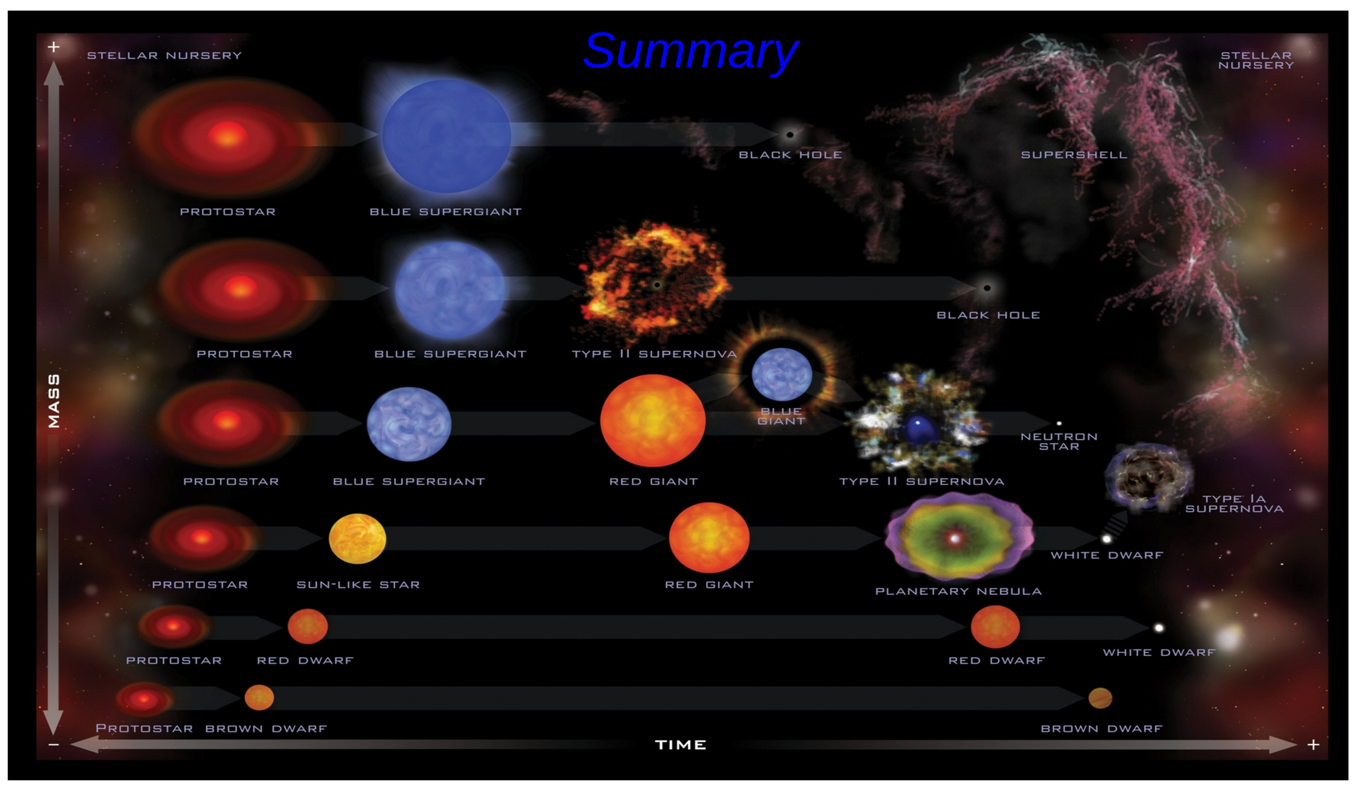
Medium-Mass Stars (one solar mass to 3.0 solar mass) :

1. For this range of mass core temperature reaches to ignition temperature of carbon burning.
2. Carbon burning occur so rapidly and with so much energy that the star blows apart in an explosion called a **SUPERNOVAE**.
3. The outer layers of the star blast into space, and the core is crushed to immense densities thereby forming a **neutron star. The size of neutron star is around the size of Pune city and mass roughly one and half times that of sun.**



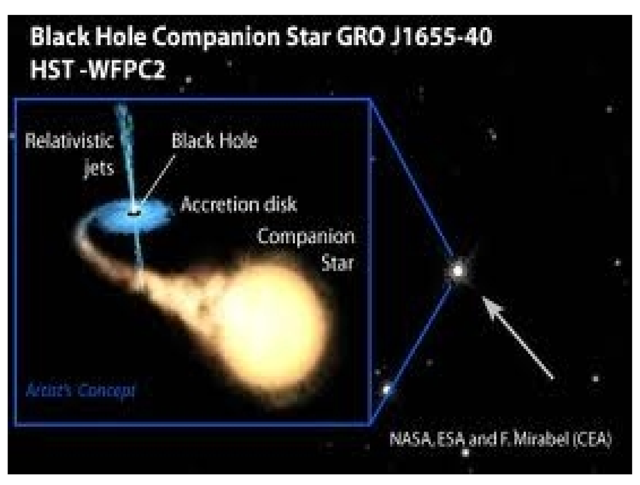
Supernovae 1994D in galaxy NGC 4526. Note that the brightness of supernovae event is comparable with the total brightness of the galaxy itself.

The graphic to the left shows a wide-field view of the Puppis A supernova remnant along with a close-up image of the neutron star, known as RX J0822-4300, that is moving at a blistering pace. Astronomers think Puppis A was created when a massive star ended its life in a supernova explosion about 3,700 years ago, forming a neutron star.



Massive Stars (3.0 solar masses or larger) :

The largest mass star may become the black hole.



For a detail understanding for the various types of stars see the poster titled "Types of Stars" .