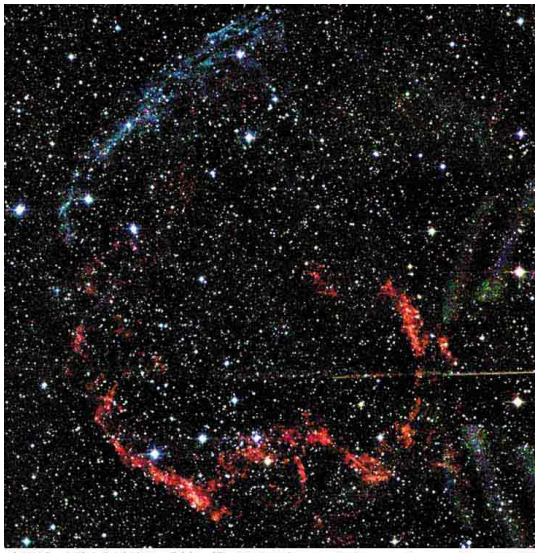
Stellar Aging



(left) the remnants of a star that exploded!

Aging Process of a "Low Mass" Star

Low mass stars (0.08 to 8 solar masses) undergo…

Birth

Main Sequence

Red Giant } Star Expands by 100 times!

Helium flash } Quick transition where helium core "explodes"

Horizontal Branch } Second lease on life

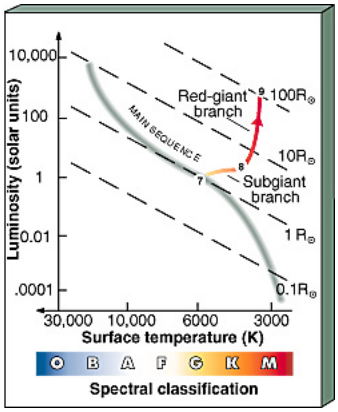
Super Giant } Quick expansion and march toward death

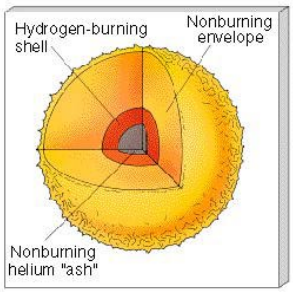
Planetary Nebula
White Dwarf
} Final stage with nebula surrounding stellar core. Later stages the nebula is gone and all that is left is the WD.

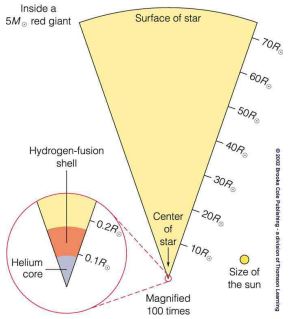
Red Giant Stage

Hydrogen shell burning + inert helium core

1. Radius increases
2. Temperature decreases
3. Luminosity increases



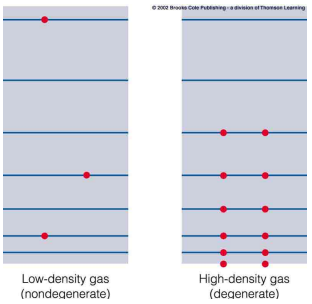


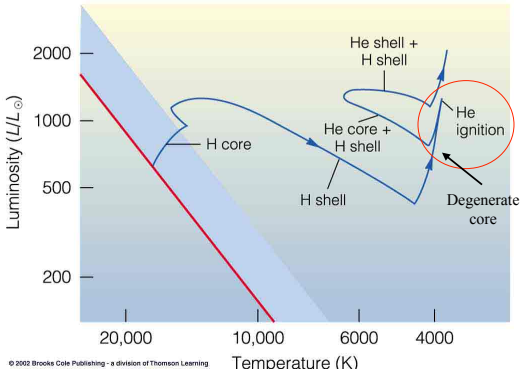


Helium Flash

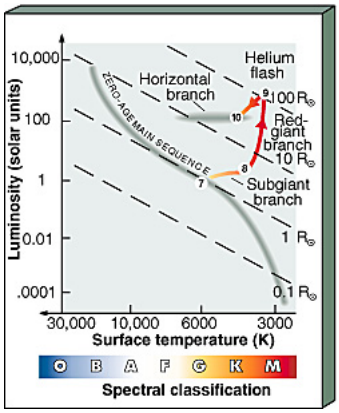
The helium gas building up in the core becomes degenerate matter. The gas is so dense and compact that the electron energies get compressed into "permitted states". The electrons get locked into these permitted energy states. This makes the core become "hard" and stops the gas from undergoing nuclear fusion… until too much gets built up and– boom. Then the star adjust very quickly to a Horizontal Branch Star.

Example of Permitted Energy States in a Degenerate Gas





Horizontal Branch



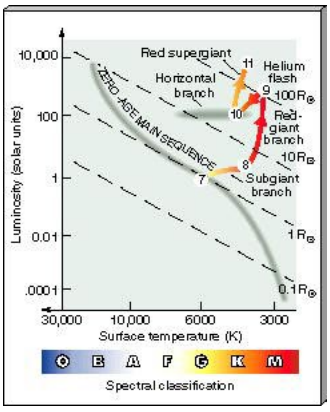
Once the helium core starts nuclear fusion of helium in to carbon, the star settles down again for a second "sequence" called the horizontal branch.

Helium Core burning + hydrogen shell burning

After the helium flash, the
1. Radius decreases
2. Temperature increases
3. Luminosity decreases

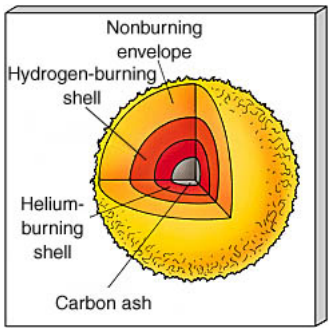
Super Giant Stage

The star (again)…
1. Radius increases
2. Temperature decreases
3. Luminosity increases

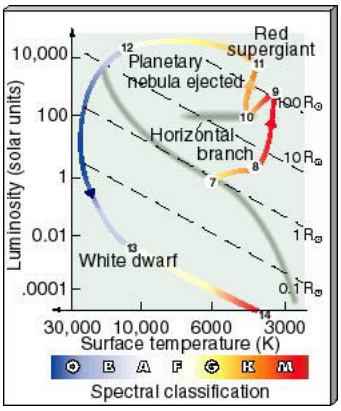


Aging off the horizontal branch, the star builds up a non-"burning" carbon and oxygen core.

The hydrogen shell feeds the helium shell; the helium shell feeds the core.



Planetary Nebula to White Dwarf (End point for **low mass** stars)



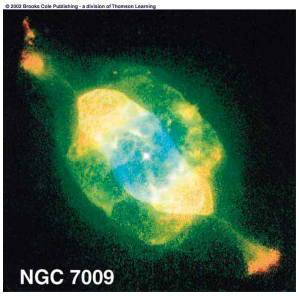
The carbon-oxygen core never "burns".

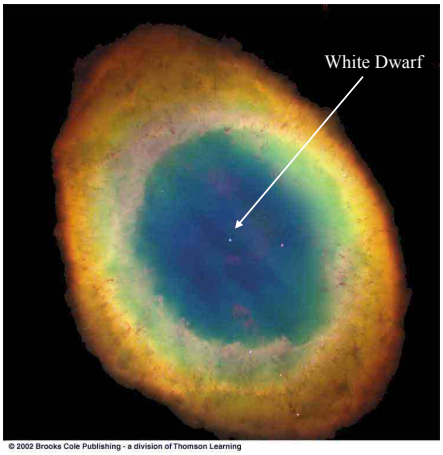
The helium shell becomes unstable, heating up and cooling down every 200,000 yrs.

This causes star to "hiccup" its envelope into space! This "ejected gas" forms a planetary nebula around the star.

This gas is thin and finally the star's carbon-oxygen core becomes visible. This core is very hot and very small (about the size of the Earth).

Some Planetary Nebulae





This carbon-oxygen core is the white dwarf.

The gas is degenerate and the star cannot contract further.

It reaches a mass-dependent minimum size called the Chandrasekhar limit.

The star cools very slowly by thermal conduction to space.