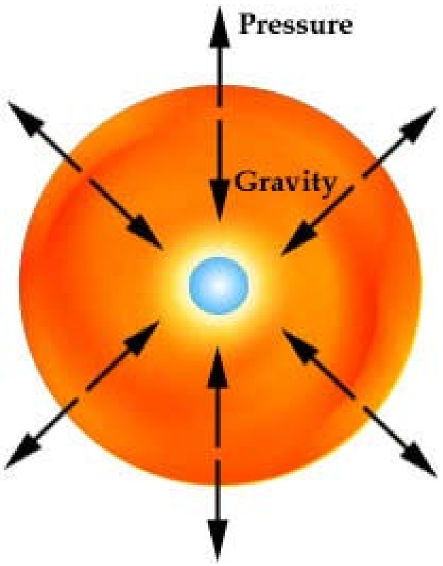
Life cycle of Stars
(Stellar Evolution)

I. <u>Life cycle of Stars (Stellar Evolution)</u>

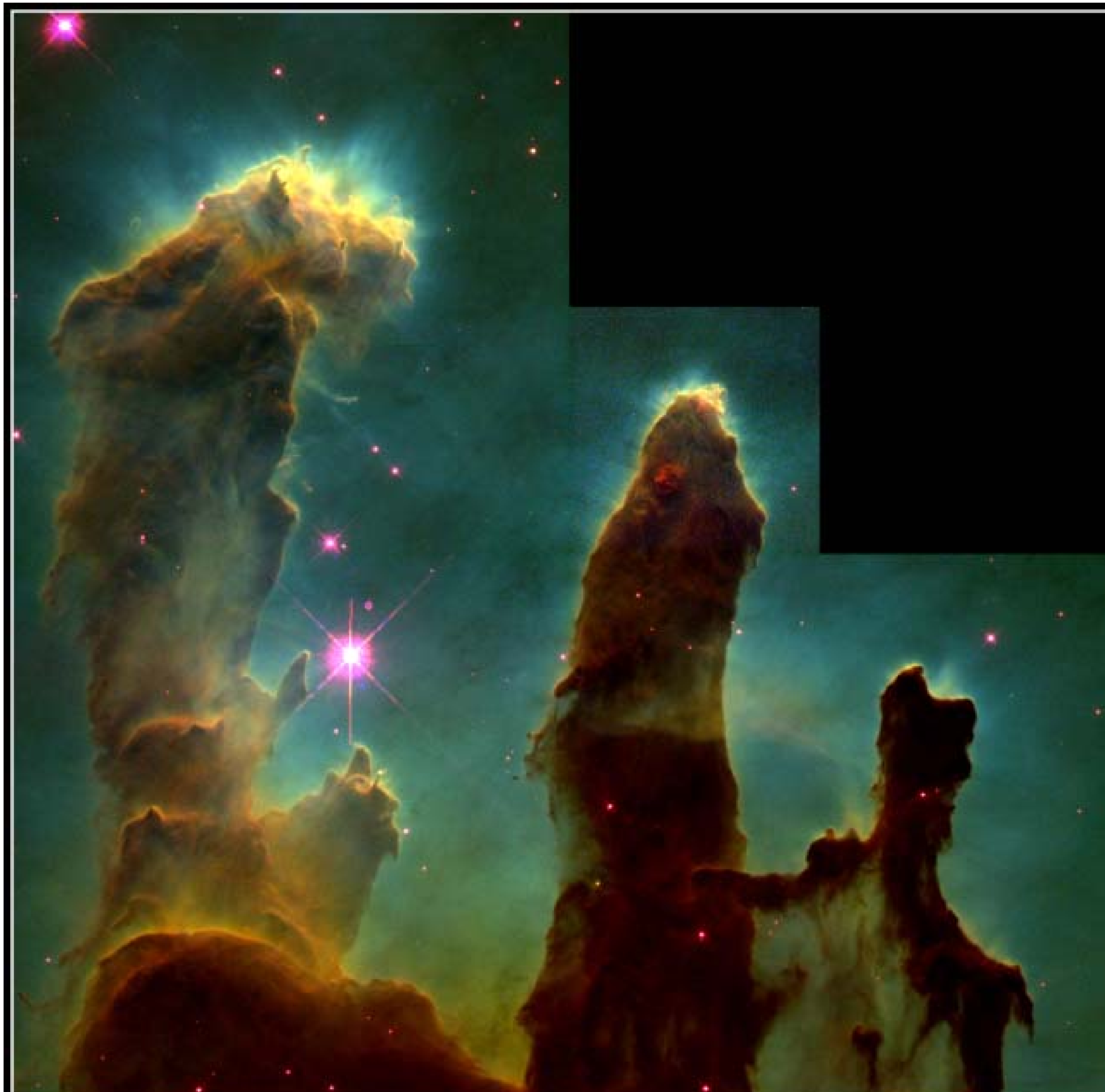
A. **Nebula-** H gas; Stellar nursery ("baby stars");
protostar = no nuclear fusion.

↑ H = ↑ gravity.

Causes an ↑ in internal pressure (temperature) in the core (from gravity).



Causes nuclear fusion to start, which starts “nuclear pressure” outward.



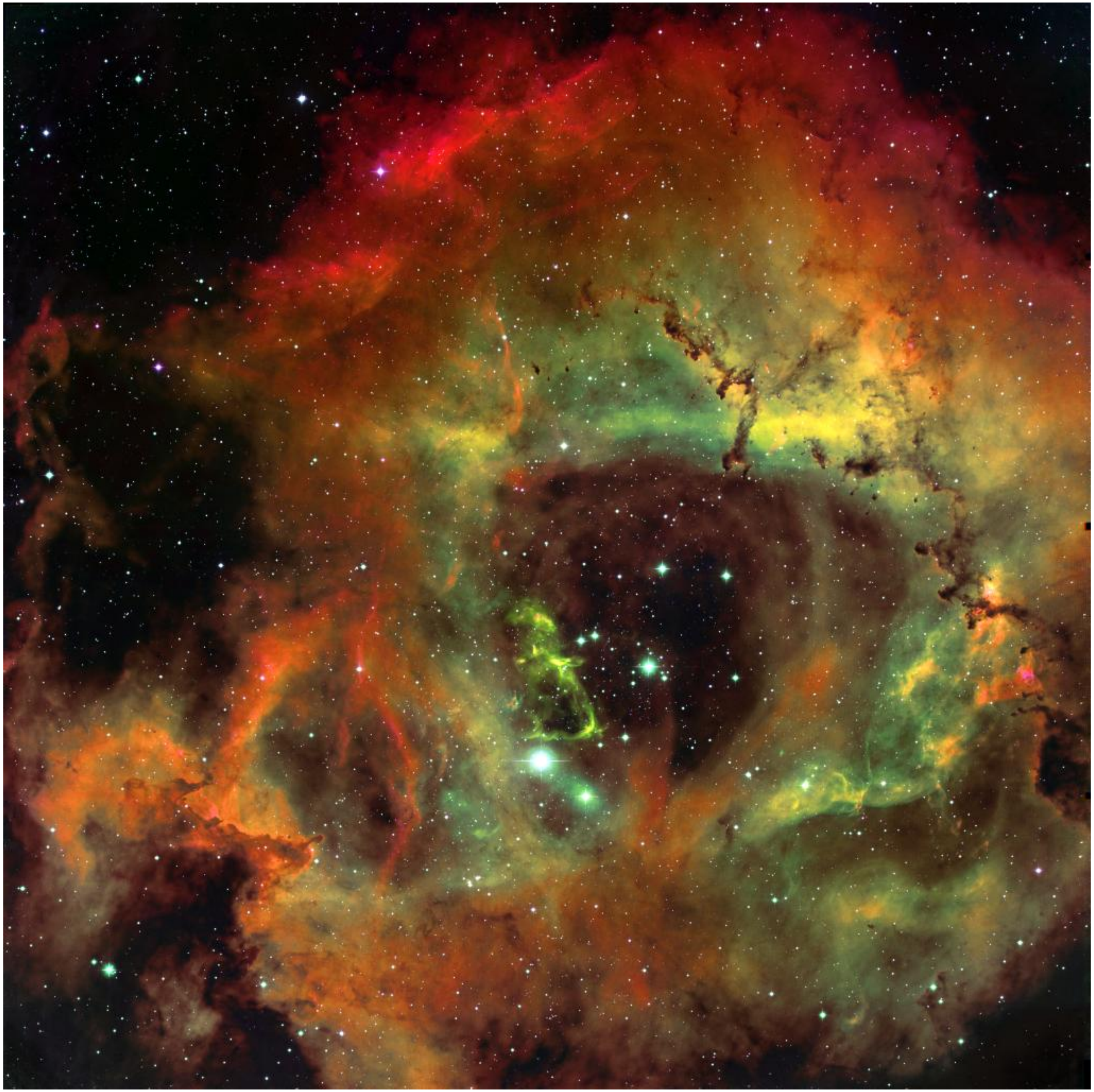
Gaseous Pillars • M16 HST • WFPC2

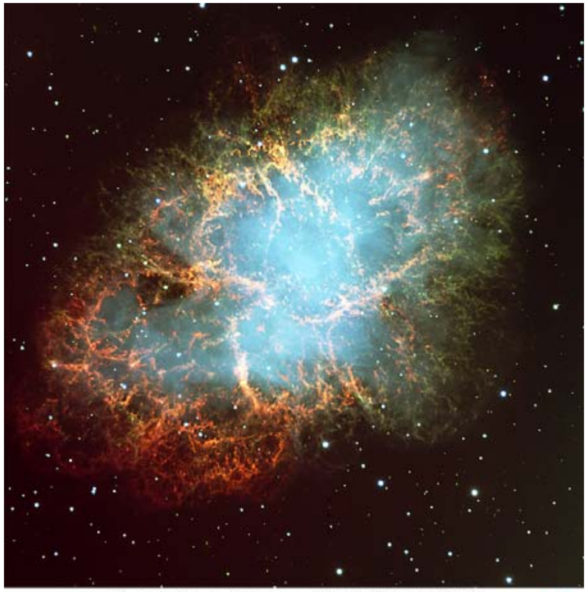
PRC95-44a • ST ScI OPO • November 2, 1995

J. Hester and P. Scowen (AZ State Univ.), NASA

NGC 3603
Hubble Space Telescope • WFPC2

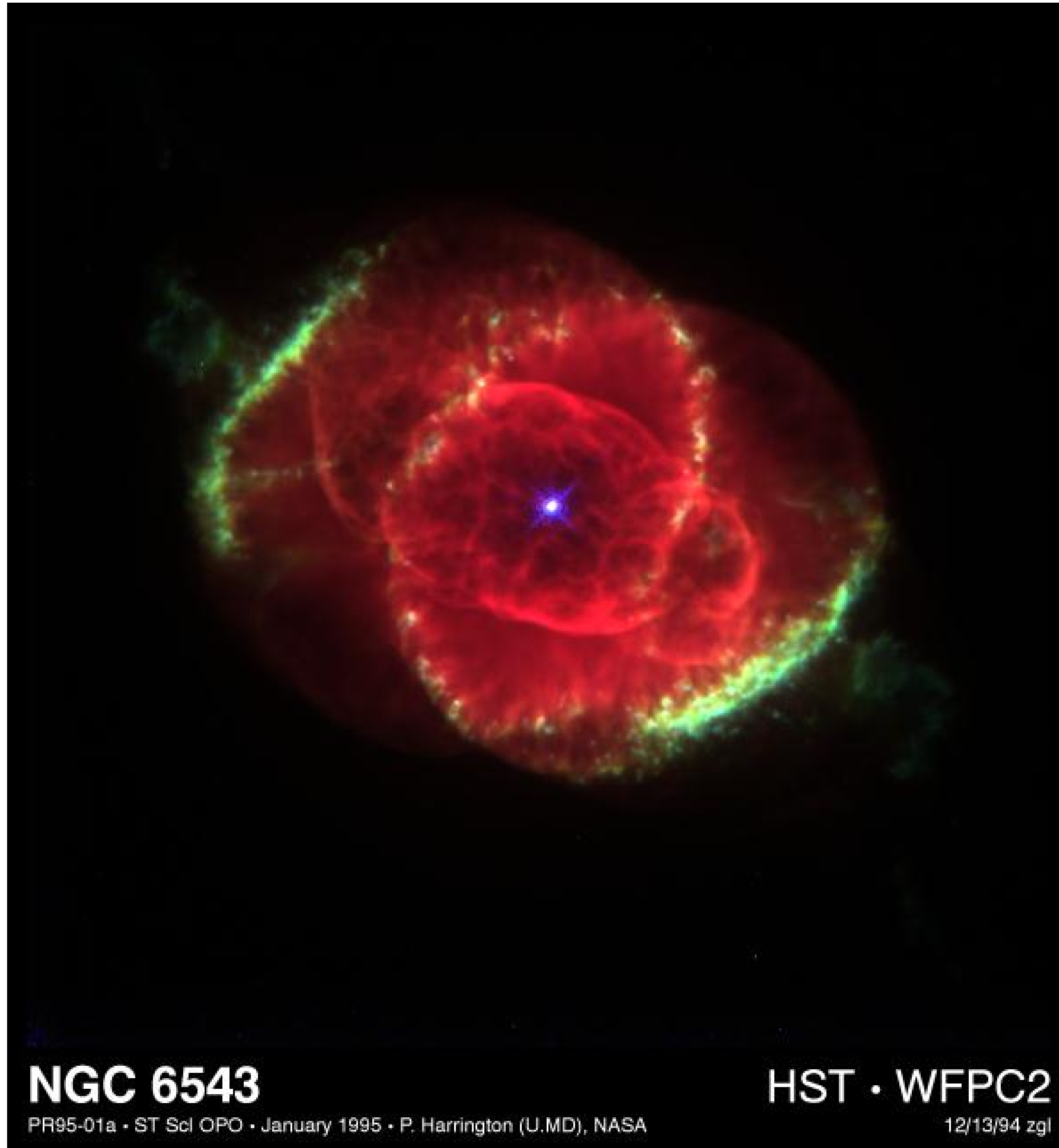
PRC99-20 • STScI OPO
Wolfgang Brandner (JPL/IPAC), Eva K. Grebel (University of Washington),
You-Hua Chu (University of Illinois, Urbana-Champaign) and NASA





The Crab Nebula in Taurus (VLT KUEYEN + FORS2)

ESO PR Photo 40f/99 (17 November 1999) © European Southern Observatory



Planetary Nebula M2-9 HST • WFPC2

PRC97-38a • ST ScI OPO • December 17, 1997

B. Balick (University of Washington) and NASA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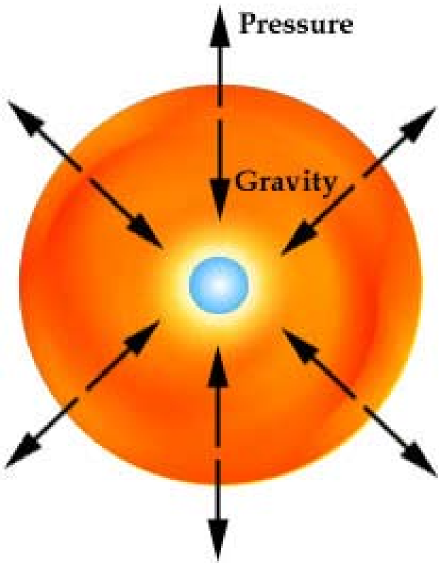
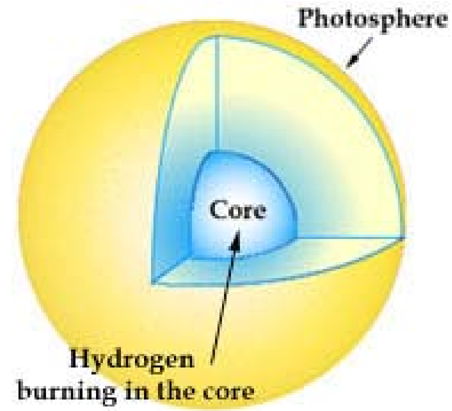
Too much gravity- nuclear fusion starts and then stops because gravity wins and causes the H gas to dissipate back into the nebula.



Too little gravity- Core temp. never reaches 9×10^6 ^{O}K range needed for nuclear fusion. Object becomes a "brown dwarf". About 10 X's the size of Jupiter all the way to 1/10 the size of the sun.

When the force from nuclear fusion, in the core, equals the force of gravity, from the mass of the star, then the star is stable and is now a main sequence star. The two forces, gravity and nuclear fusion (pressure), **are never equal** therefore we see the surface of the sun, the photosphere, PULSE, as the two forces battle against one another. *See whiteboard*

B. **<u>Main Sequence Star</u>**



Many different types: colors, sizes, temperatures.

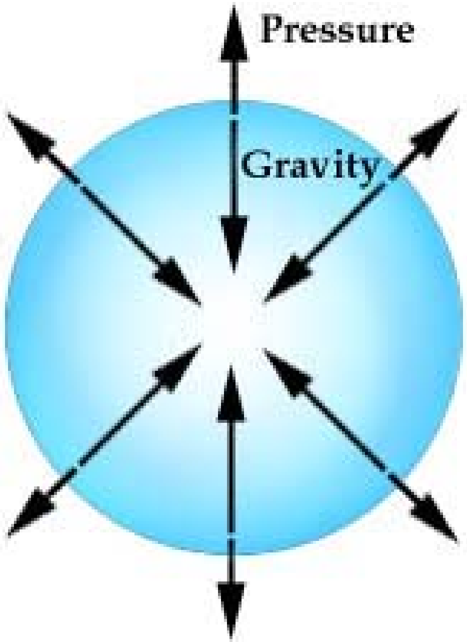
One common point- they all fuse H → He in their cores.

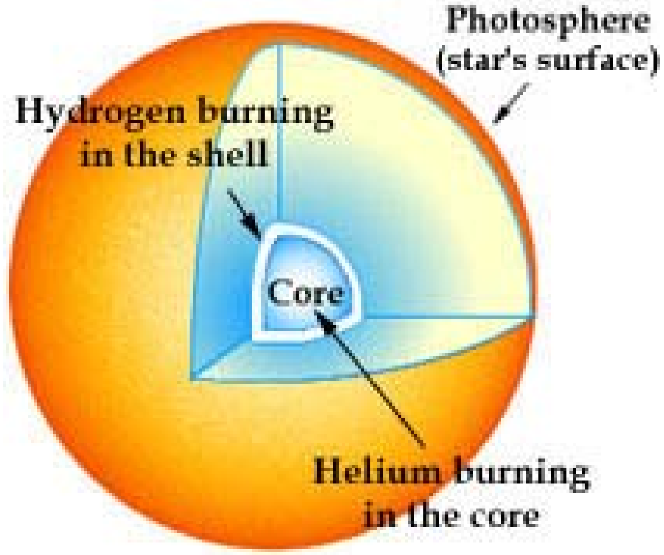
~80 % of their “life span”

Since stars are of finite size, they will eventually use up their nuclear fuel and run out of energy (run out of H in their core).

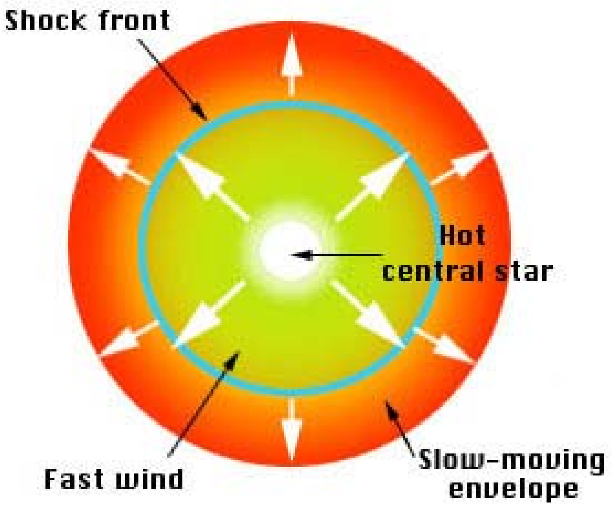
Star will then start to fuse, in their core, He → into larger elements. **<u>There is a problem with this:</u>**

He fusion → less energy then H fusion. Therefore the star starts to collapse (gravity wins). This collapse then causes the core temperature to ↑, which causes the temperature around the core to ↑ which now causes the H around the core to start nuclear fusion again. This causes extra energy to be produced, *making the star expand*.


Pressure
Gravity


Photosphere
(star's surface)
Hydrogen burning
in the shell
Core
Helium burning
in the core

C. **Giant Stage**

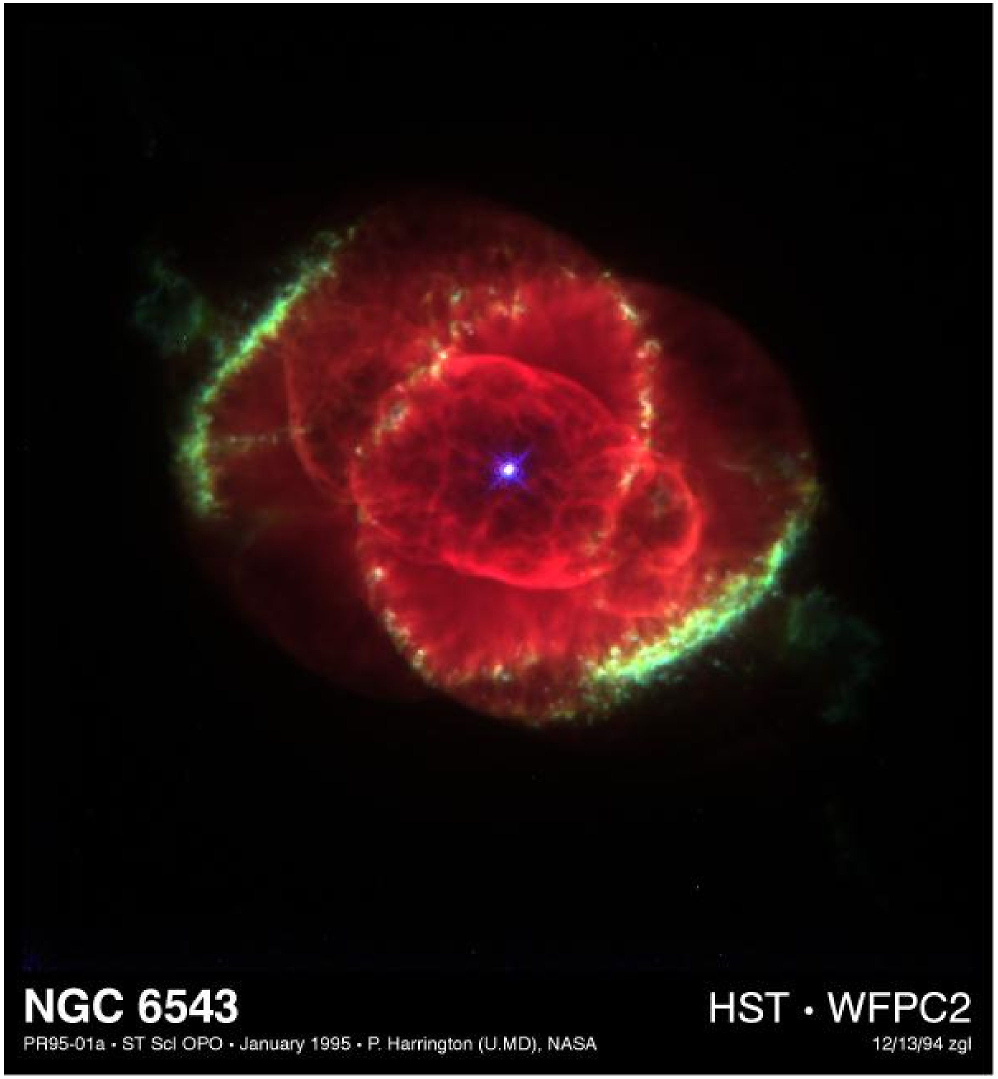


Red Giants are very large-
100s X bigger then the sun.

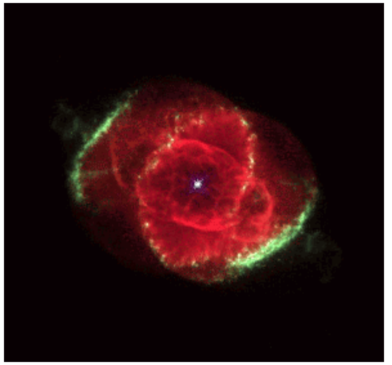
Because the sun is expanding,
the surface temperature is ↓

Core starts to produce C (even less energy is produced then in He fusion).

He flash- releases lots of energy; ~1/3 of the outer star is hurled into space → a planetary nebula; *see whiteboard*



C_1: **White dwarf** (from planetary nebula)



-What is left over after the He flash (the white dot to the right).

C_2: **Black dwarf**

Dead star (ROCK); 100 % Fe; Still has LOTS of gravity.

D: **Super Giant Stage**

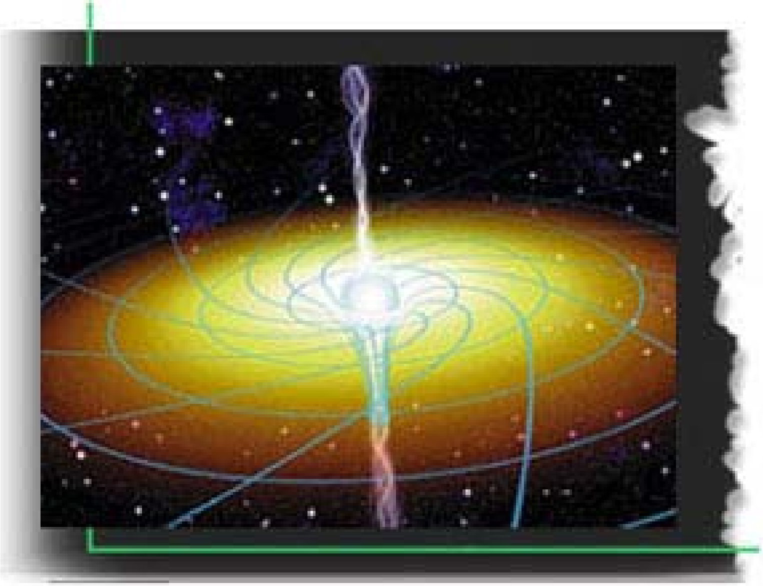
Super Giants are **large** (beyond our comprehension- 1000 Xs bigger then the sun.

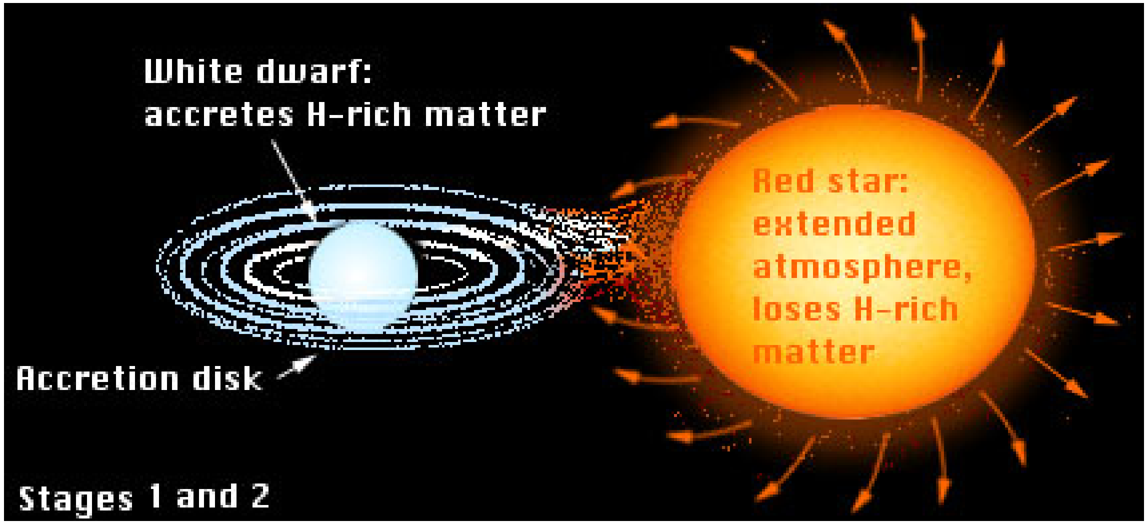
The same thing happens as in the giant stage, except instead of a He flash you have a “Hydrogen flash”; *see whiteboard*

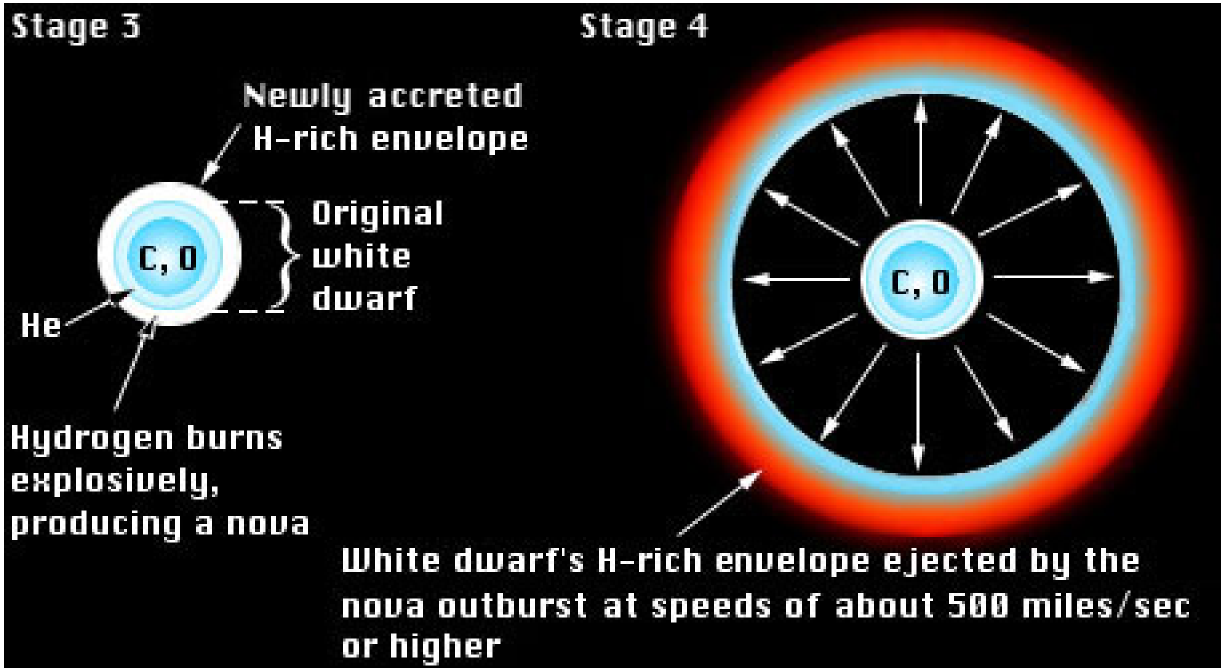
Medium sized super giants produce a **nova**

The largest super giants produce a **super nova**

D_1: Neutron star




White dwarf:
accretes H-rich matter
Red star:
extended
atmosphere,
loses H-rich
matter
Accretion disk
Stages 1 and 2


Stage 3
Stage 4
Newly accreted
H-rich envelope
C, O
Original
white
dwarf
He
Hydrogen burns
explosively,
producing a nova
C, O
White dwarf's H-rich envelope ejected by the
nova outburst at speeds of about 500 miles/sec
or higher