

The Future Sun

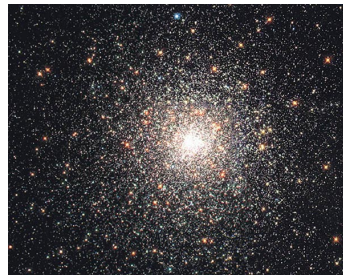
- Homework 5 is due 6:30am on Friday, 23 March.
- Public viewing sessions at MSU campus observatory.
 - Fri & Sat, 9-11pm, if it is not cloudy.
 - Mar 23 & 24
 - Apr 20 & 21
 - May 18 & 19
- Giants are dying stars; white dwarfs are dead stars
- Why does the sun die?
- What will the sun become when it dies?



Giants are dying stars; white dwarfs are dead stars

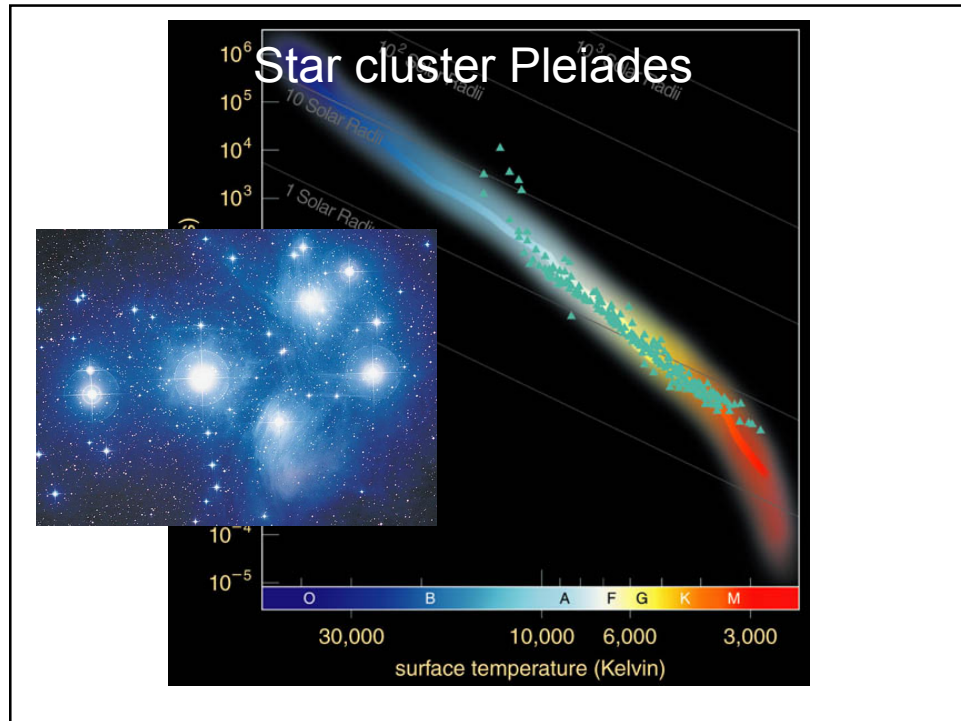
- Evidence on giants from star clusters
 - Compare members of a population
- All stars in a cluster are born at once.
 - Formation time is the collapse time of the cluster, which is very short.
- I am a G star like the sun. I have 100,000 fraternal twins, some weighing 30 times my mass, some 1/10 of my mass.

M80



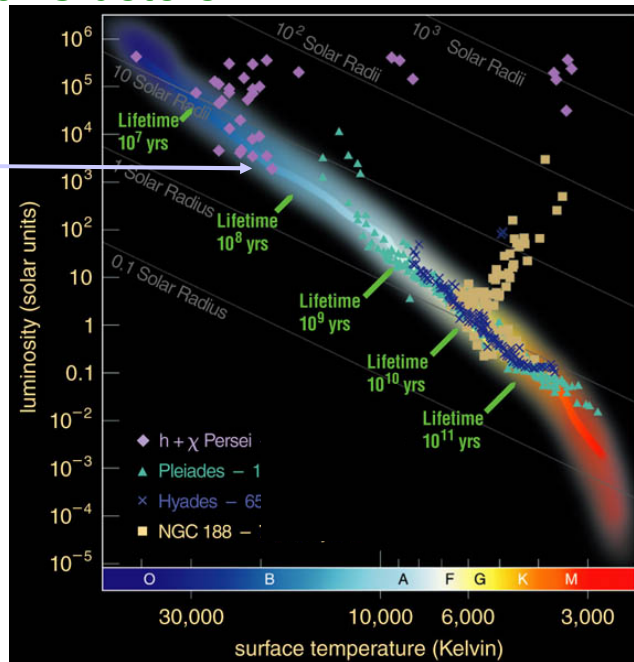
Pleiades



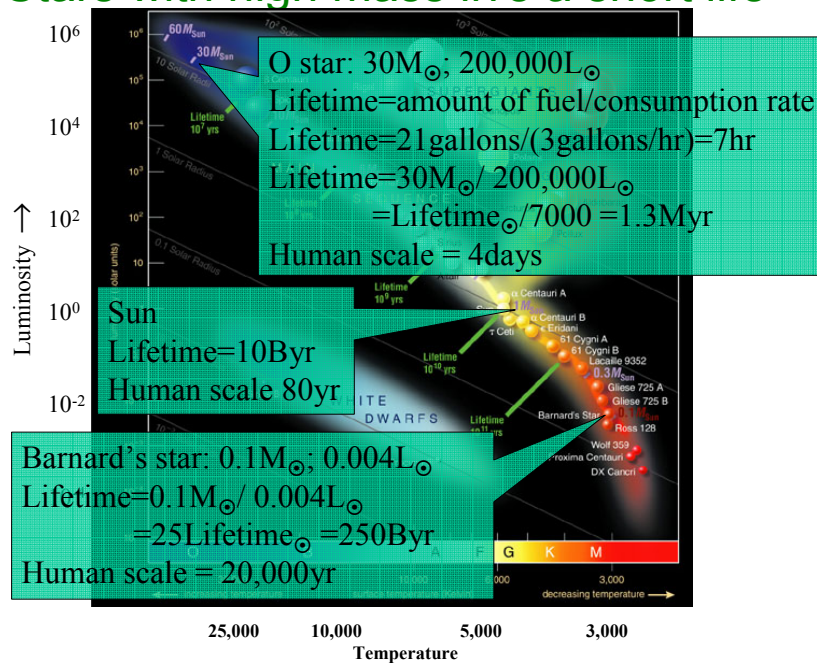


HR Diagram of Clusters

- Not all fainter stars were observed.
 - For all star clusters, main sequence extends to cooler stars beyond observations
- In what ways are HR diagrams of $\text{H} + \chi$ Perseus, Pleiades, Hyades, & NGC188 different?
- Q Which is false
 - a. Perseus has hotter stars than Pleiades.
 - b. Most stars are one the main sequence.
 - c. Perseus has small range of luminosity
 - d. Some clusters have giants.

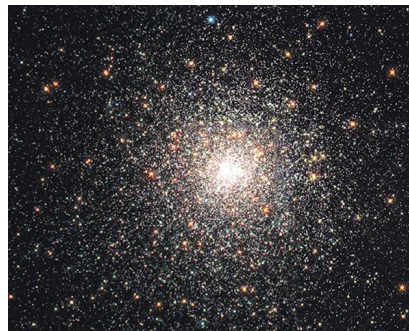


Stars with high mass live a short life



H-R Diagrams of star clusters

- Q2 There are no A stars in M80 because
 - they never formed.
 - they died and disappeared
 - all stars became redder as they get older.
 - they are too faint to see.

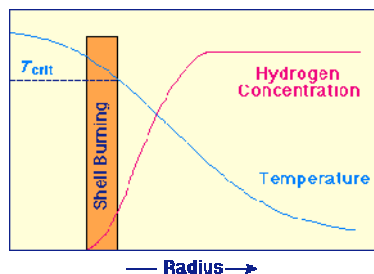


H-R Diagrams of star clusters

- Q3 The hottest dwarfs in Pleiades are A stars. The hottest dwarfs in M15 are F stars. Pleiades is ____ than M15.
 - older
 - younger

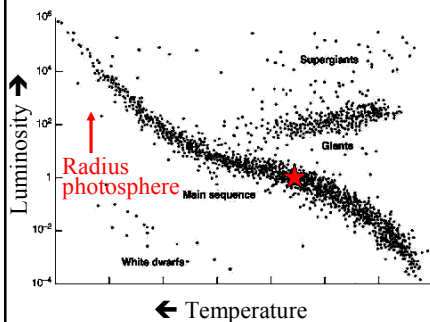


Life of the sun

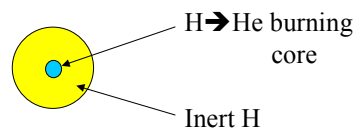


- Heat source moves closer to surface.
- Layers below surface swell up.
- Star becomes larger
- Surface becomes cooler

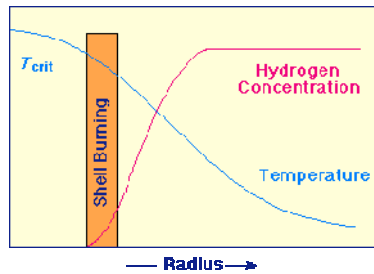
→ **Red giant.**



Present sun

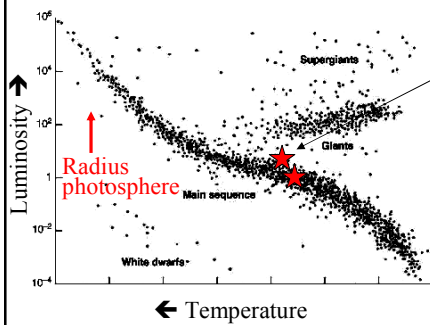


Life of the sun

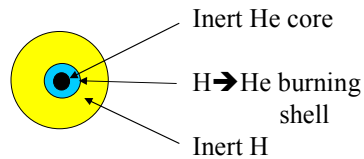


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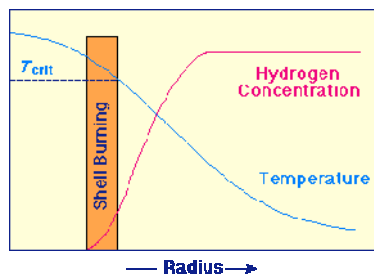
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5 Byr from now

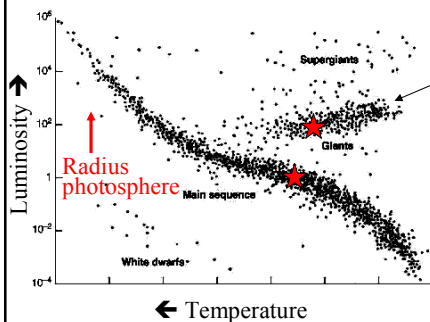


Life of the sun

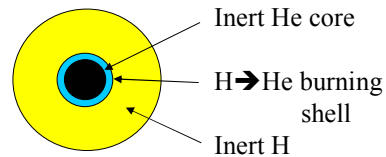


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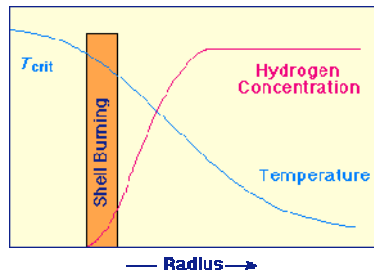
→ **Red giant.**



Few 100 Myr later

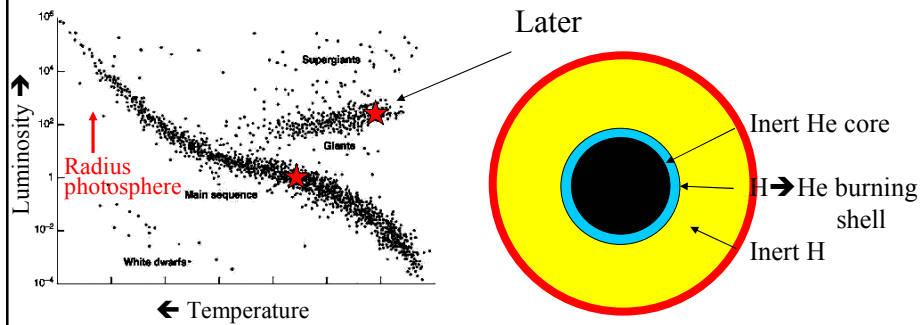


Life of the sun



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→ **Red giant.**

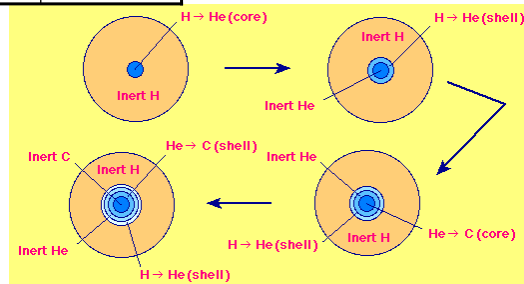


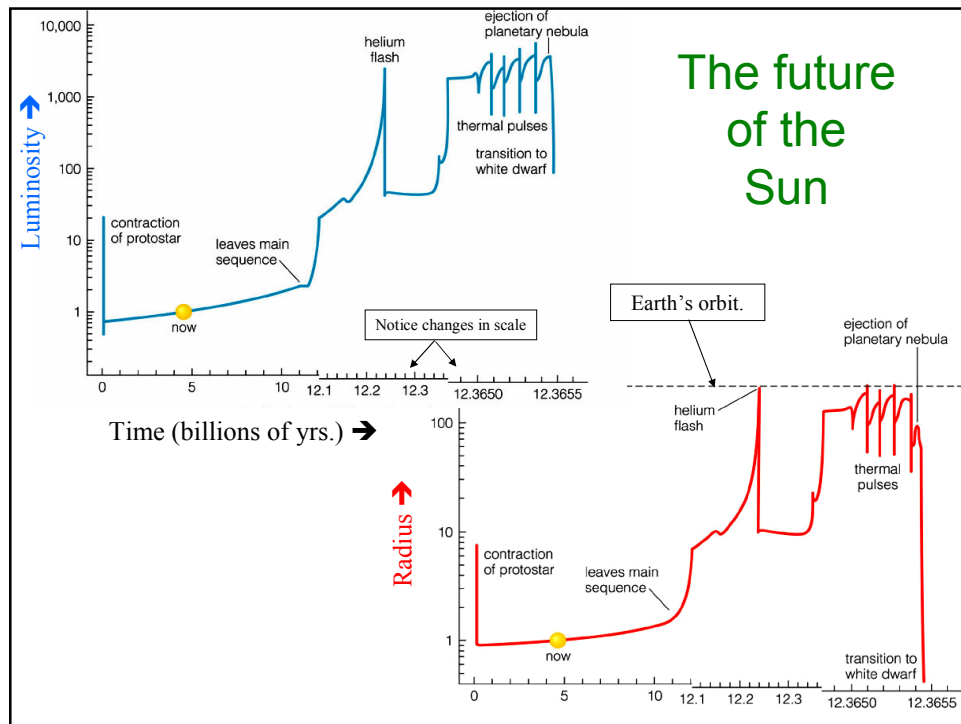
After helium is used up

Reaction	Min. Temp.
$4\ ^1\text{H} \rightarrow\ ^4\text{He}$	$10^7\ ^\circ\text{K}$
$3\ ^4\text{He} \rightarrow\ ^{12}\text{C}$	2×10^8
$^{12}\text{C} +\ ^4\text{He} \rightarrow\ ^{16}\text{O},\ \text{Ne},\ \text{Na},\ \text{Mg}$	8×10^8
$\text{Ne} \rightarrow\ \text{O},\ \text{Mg}$	1.5×10^9
$\text{O} \rightarrow\ \text{Mg},\ \text{S}$	2×10^9
$\text{Si} \rightarrow\ \text{Fe peak}$	3×10^9

Triple-alpha process

- Contraction heats center
- Helium starts to burn.





• Cat's Eye.

Harrington & Borkowski, (UMd) & NASA

- Helix nebula
- Gas & dust ejected by star in the middle.
- Ejection occurred several times.
- Wind blows gas into previous ejecta.
- Colors
 - Blue: O
 - Red: H & N



NASA, NOAO, ESA, Hubble Helix Nebula Team, M. Meixner (STScI), and T.A. Rector (NRAO).

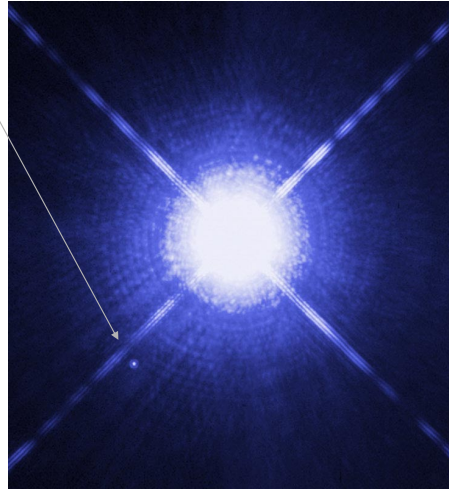
- NGC 6826
- Wind from hot star blows on material expelled by pulses.



Balick (U Wash), et al & NASA

The dead sun

- White dwarf Sirius B
- White dwarf is initially very hot.
- As it cools, the white dwarf grows redder and fainter.
- Q4 Put these in order:
MS, WD, giant, PN
 - a. MS, WD, G, PN
 - b. MS, WD, PN, G
 - c. MS, PN, G, WD
 - d. MS, G, PN, WD



NASA, H E Bond (STSCI) et al.