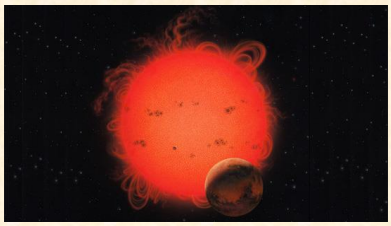
ASTR 1020: Stars & Galaxies

October 9, 2013

- Reading: Chapter 17, section 17.3-17.4.
- *Mastering Astronomy* Homework on Star Birth is due Oct. 11.



Astronomy Picture of the Day

Northern Lights over Prelude Lake,
located about 30 kilometers east of Yellowknife, Northwest Territories, Canada

Today's Topic: The Lives of Stars

First: Evolution of Low Mass Stars (less than 2x Sun's mass)

Protostars → Main sequence

Most of its life on Main Sequence (billions of years)

What happens when it runs out of hydrogen?

Reading Clicker Question

A star moves upwards and to the right on the HR diagram. What is probably happening in the core?

A) The core has just started to burn a new element
B) The inner core is collapsing and heating up; shell burning is increasing
C) All nuclear burning is slowing down
D) The inner core temperature is cooling

- **B) The core is collapsing and heating; shell burning is increasing**

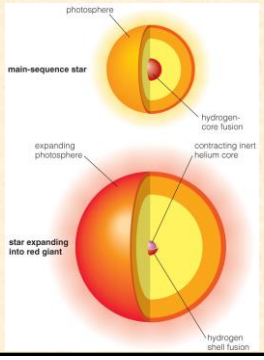
- Moving upwards on HR diagram means more luminosity → more nuclear fusion
- This is usually due to the inner core heating due to gravitational collapse
  potential → thermal

Red Giants

- Helium builds up in a non-burning core
- When hydrogen runs out, this core starts to collapse
- With no fusion, there is nothing to withstand gravity ← key theme

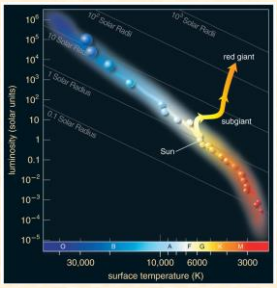
Red Giants

- CORE collapses…
- But layers just above core now also collapse and heat enough to fuse hydrogen
- Hydrogen SHELL burning over collapsing helium core



Red Giants

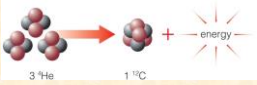
- As core collapses, hydrogen SHELL burns faster and faster– more energy created
- Luminosity increases, lifts outer parts of star
- Star becomes brighter, larger and cooler!!



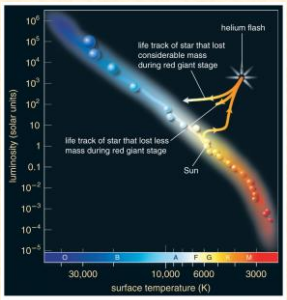
Helium burning

- When core contracts enough to heat to 100 million K,

helium starts to fuse into carbon



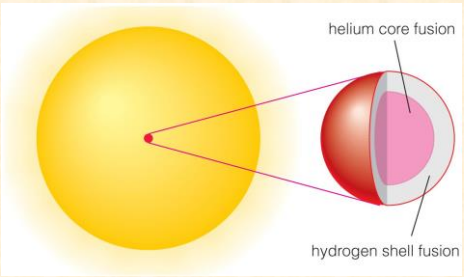
Helium "flash"



a Helium fusion begins with the helium flash, after which the star's surface shrinks and heats, making the star's life track move downward and to the left on the H-R diagram.

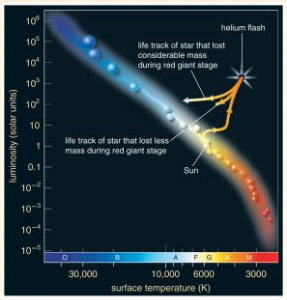
After the helium flash

- Helium burning into Carbon in the core - stable!
- Hydrogen still burning in a shell outside the core



On the HR Diagram

- Helium burning expands the core; Hydrogen shell also lifted and slightly cooled
- Energy output DECREASES slightly after helium flash (still brighter than main sequence)
- Outer layers fall and heat



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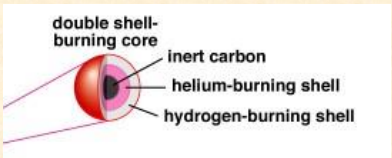
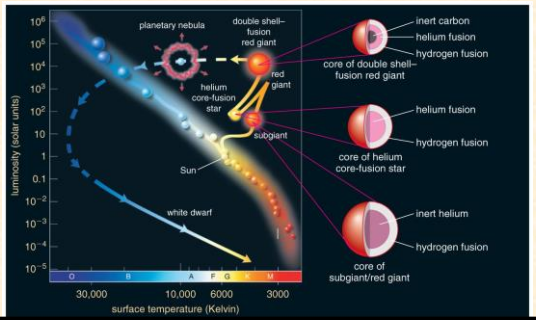
When helium runs out….

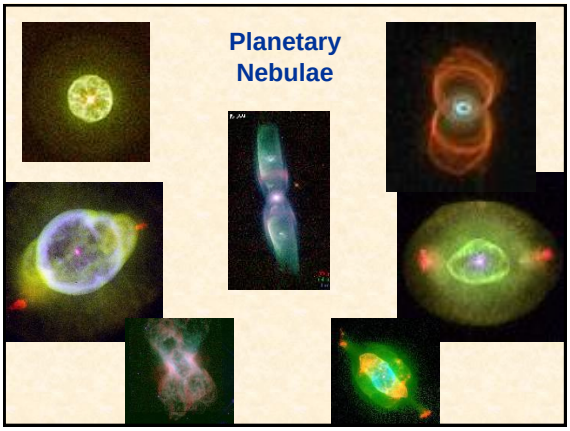
- Carbon core collapses and heats up
- Burning in helium AND hydrogen shells



- Energy generation becomes much higher again
- Outer layers lift and cool
- Star becomes very luminous red giant

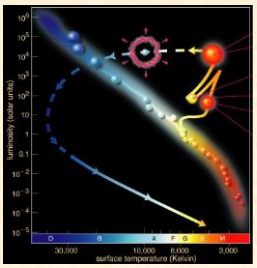


Planetary Nebulae

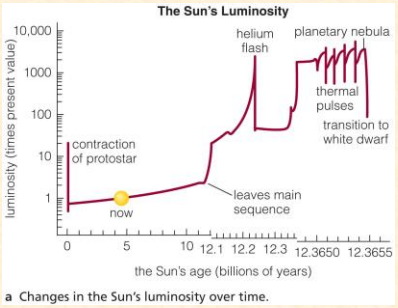


What's left inside?

- Nebula disperses
- Small, hot carbon "rock" left over = white dwarf (size of Earth)
- Supported by electron "degeneracy" pressure.
- Slowly cools and fades until it becomes a nearly invisible "black dwarf"



Earth's Fate



a Changes in the Sun's luminosity over time.

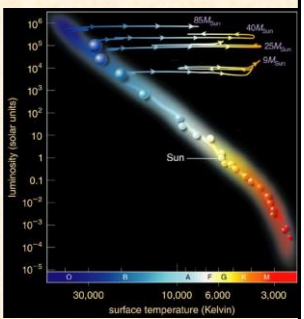
The Sun's luminosity will rise to 1000 times its current level—too hot for life on Earth.

Different Mass Stars

- Low mass: < 2 times the Sun
- Intermediate masses: 2-8 times the Sun
- High masses: > 8 times the Sun

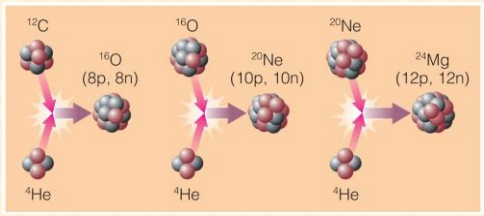
High Mass Stars

- Main sequence lifetimes- much shorter
- Early stages after main sequence- similar to a low mass star, but happen much faster



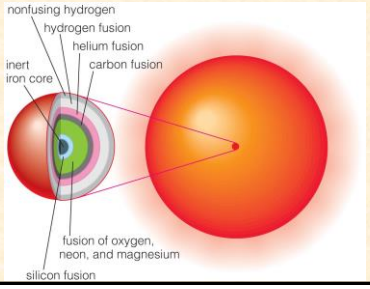
High Mass Stars

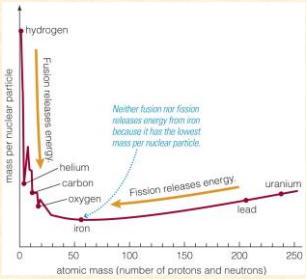
- Elements are formed via Helium Capture—
- A helium (2 protons) nucleus is absorbed, energy is released
- The elements are created going up the periodic table in steps of 2



Core structure keeps on building successive shells—

Lesser elements on the outside, heavier ones on the inside





Iron is a dead end for fusion because nuclear reactions involving iron do not release energy.

(This is because iron has lowest mass per nuclear particle.)

- The core of a high mass star accumulates iron as the layers above it burn
- Degeneracy pressure supports the core for awhile until the mass of iron gets too heavy