



# HR DIAGRAM

## Stellar Death Low Mass Stars





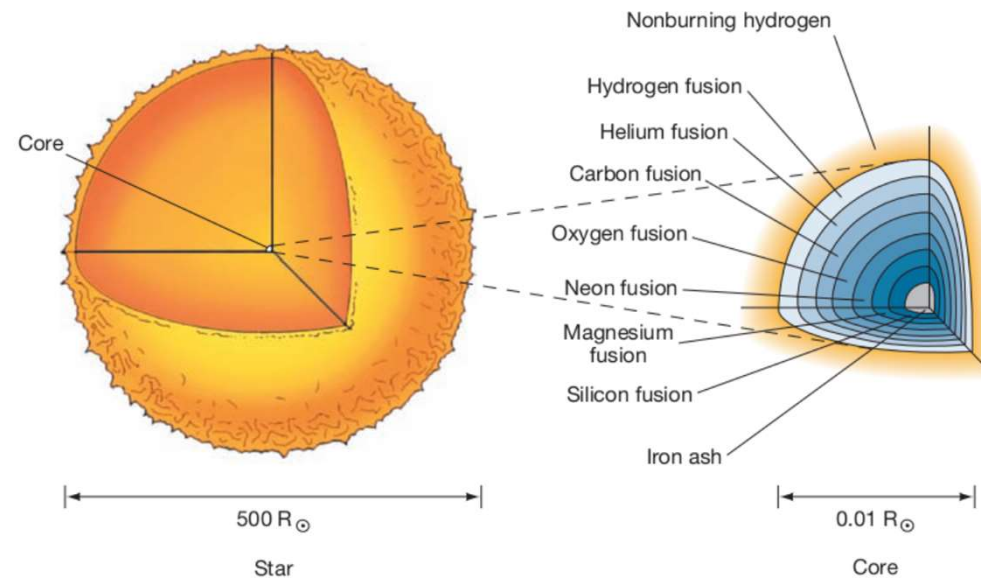
## HR DIAGRAM - Stellar Death Low Mass Stars

### Overview

Previous lessons have outlined stellar evolution to Helium fusion.

The lifecycle after Helium fusion depends on a star's mass.

The image to the right shows the varying layers of fusion that a star can attain depending on its mass.



NOTE: Many of today's images will come from the outstanding book *Astronomy Today* by Chaisson and McMillan (Pearson Prentice Hall, Inc).

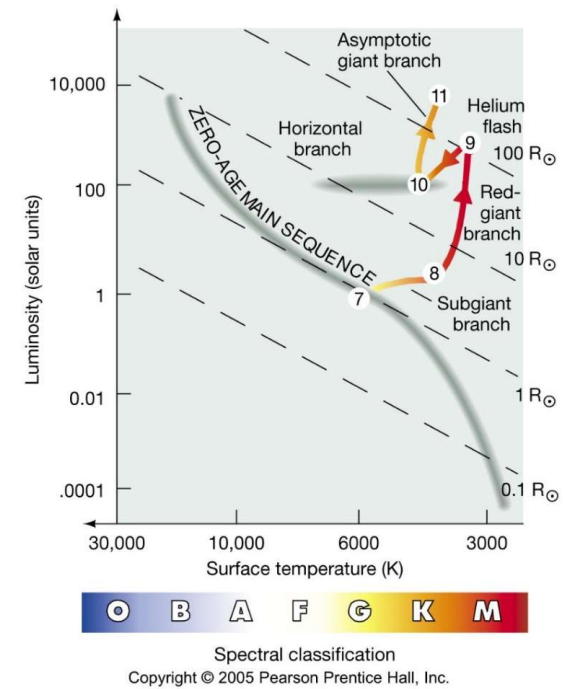
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## Review



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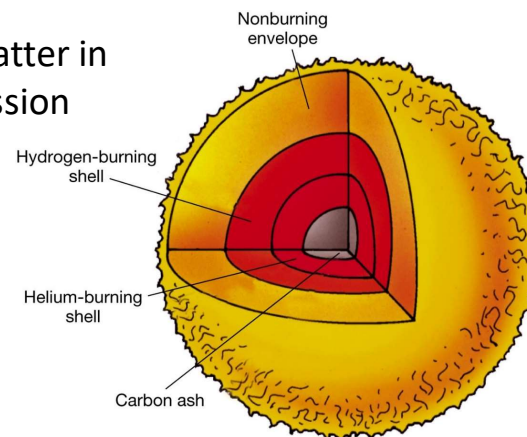




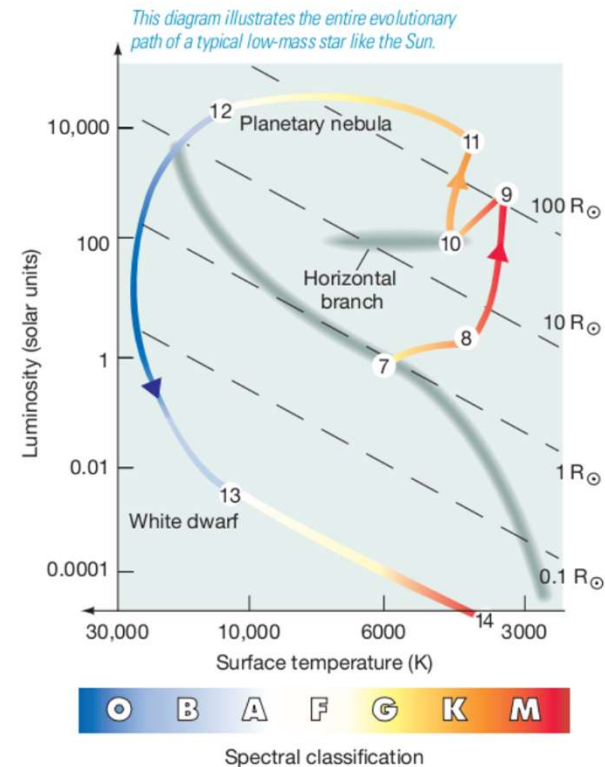
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### Approaching Stage 12 for Low Mass Stars

- As Helium burning continues it deposits Carbon ash in the core
- Pushes Helium to outer shells
- Temperature of 600M K needed for next level of Fusion
  - Before this temp is reached, Carbon, too, becomes degenerate
    - Contraction stops
    - Core temp stops rising
- Low mass stars do not have enough matter in overlying layers to force more compression



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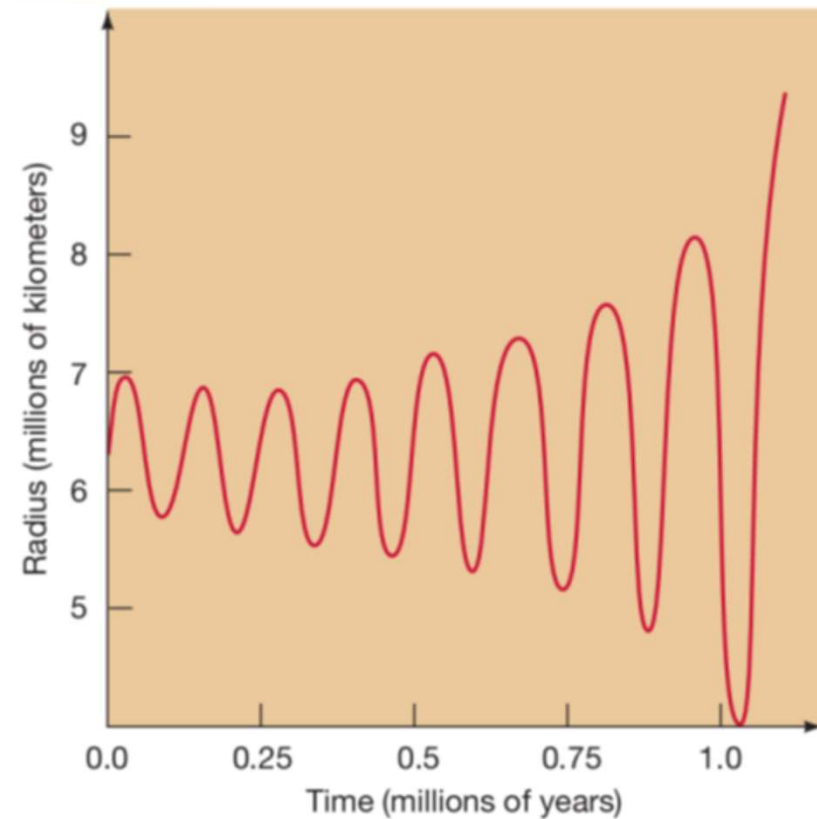
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### **Stage 12: Planetary Nebula**

- With no more outward fusion pressure being generated in the core it continues to contract.
- Outer layers of the star expand (~outside the orbit of Mars for the Sun)
  - Fluctuation occurs in these layers: Expansion, Contraction, Expansion, Contraction, etc
  - Begins to shed outer layers at speeds of 10s of km/second
  - Forms a planetary nebula:





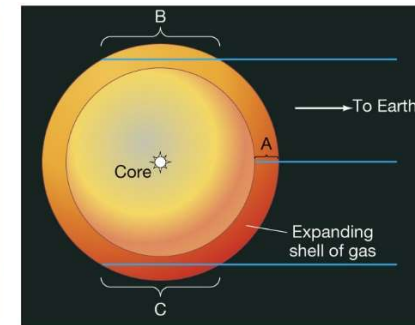
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### Stage 12: Planetary Nebula

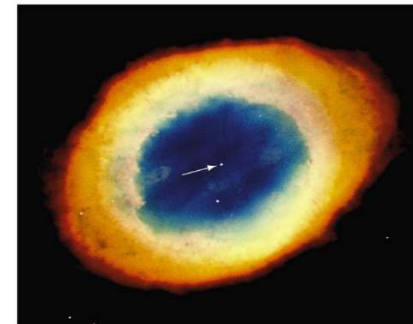
- The star now has two parts:
  - A small, extremely hot dense carbon core (White Dwarf)
  - An envelope about the size of our solar system.
- “Planetary nebula” coined in the 1700’s when astronomers viewing the fuzzy envelope thought it resembled a planetary system
  - Has nothing to do with a planet
- Ionizing radiation from carbon core causes illumination of the gases as they expand
- The following Elements have been found in these Planetary Nebula:
  - Helium
  - Carbon
  - Oxygen
  - A few heavier ones



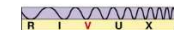
(a)



(b)



(c)



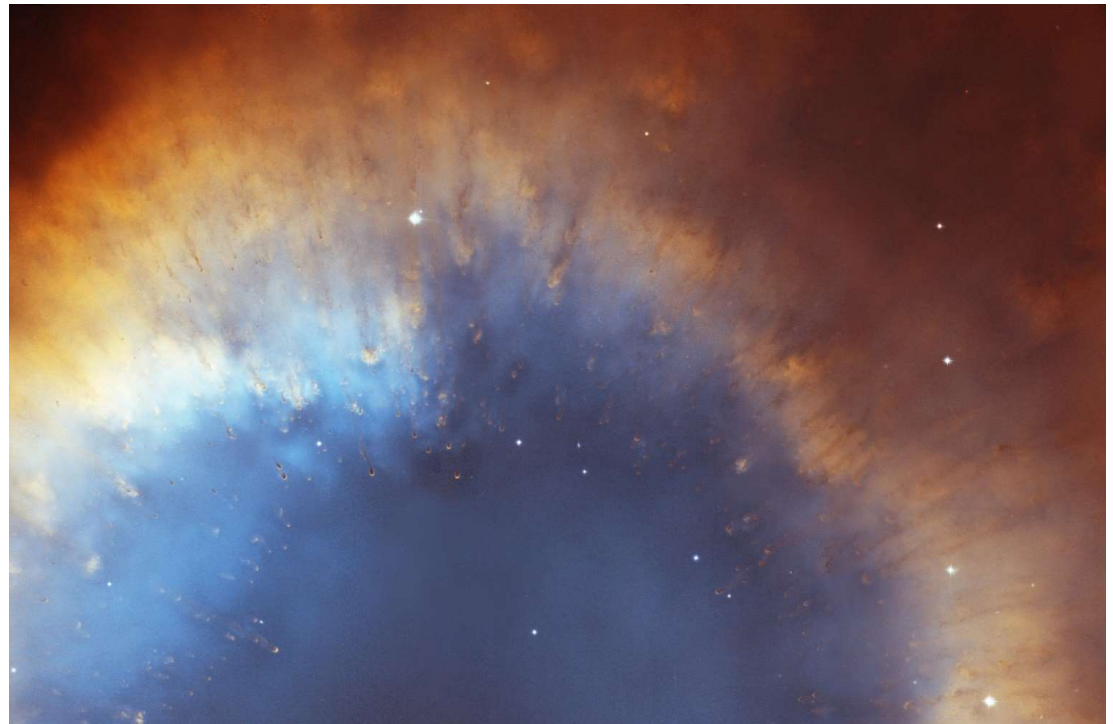
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### **Stage 12: Planetary Nebula**

- Planetary nebula examples:



Pasachoff\_Fig. 13.2a  
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# Stellar Death

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### Stage 13: White Dwarf

- Carbon core
- Continues to evolve and is visible as the gas cloud recedes
- Size of the Earth
- Very Hot
- In addition to Carbon White Dwarfs, there are also Helium White Dwarfs where Carbon fusion never occurred.

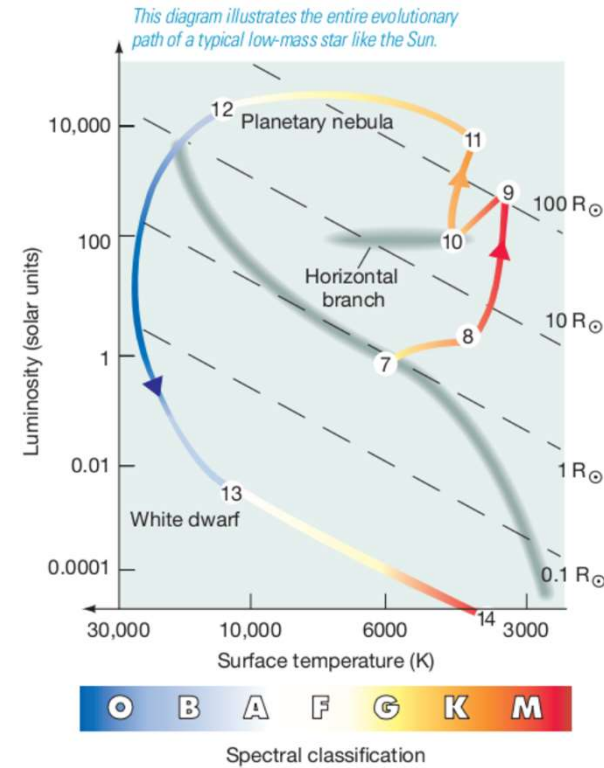


Pasachoff\_Fig. 13.2a

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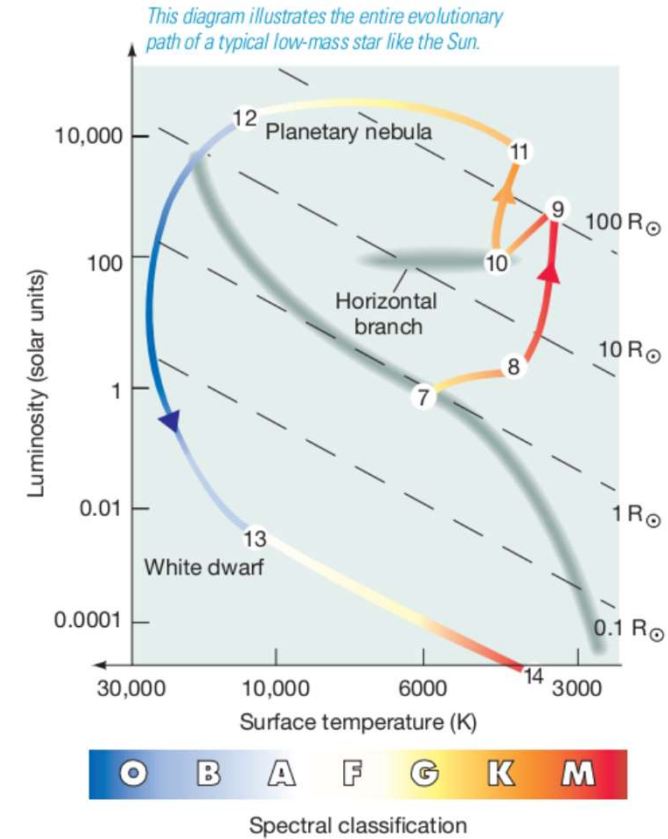




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### Stage 14: Black Dwarf

- Cold, dense, burnt out ember is space
- Doesn't shrink. Just cools and fades





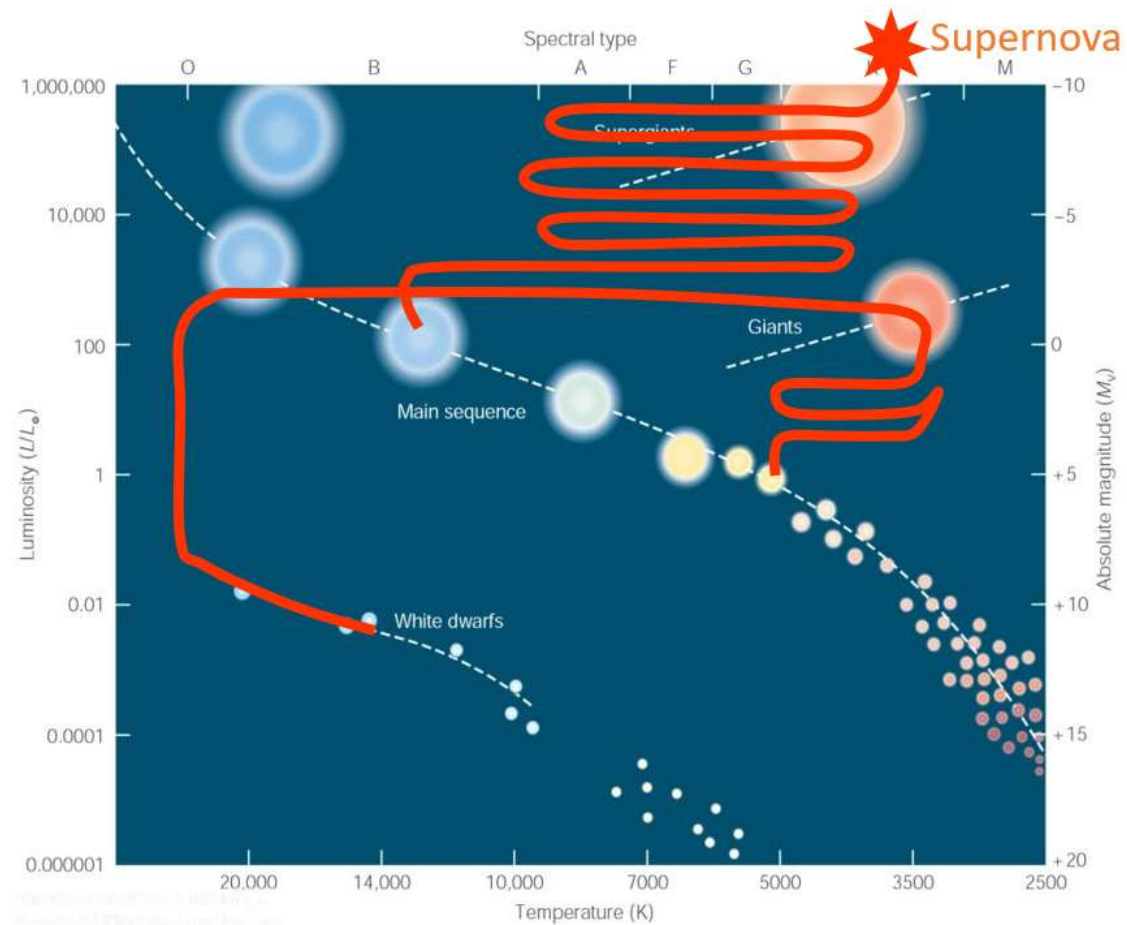
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### Summary

Low mass stars have a different evolutionary track based on mass.

Low mass stars do not have the pressures to raise the internal core temperatures enough to start heavier element fusion.

Therefore, they shed their outer layers into beautiful planetary nebula.



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# Questions?

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