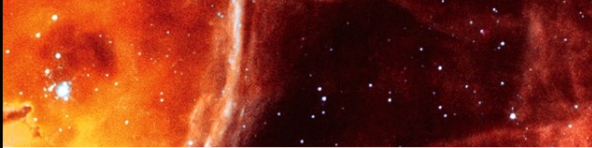


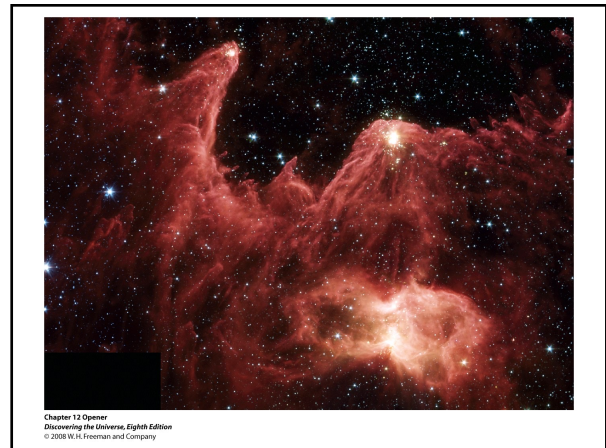
Discovering the Essential Universe



Neil F. Comins

CHAPTER 11 The Lives of Stars from Birth Through Middle Age

1



2

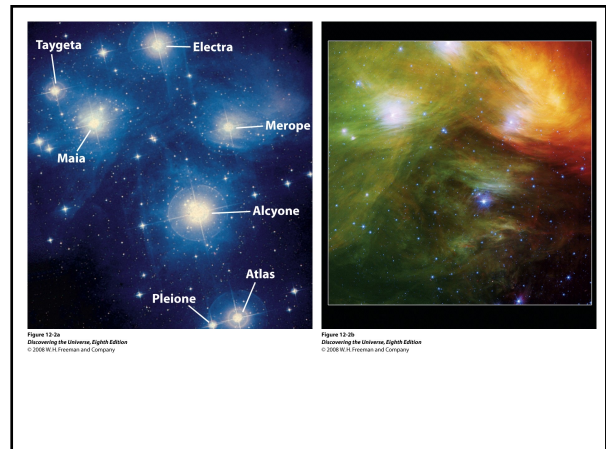
TABLE 12-1 Composition of the Interstellar Medium

| | Particle number (%) | Mass (%) |
|---------------------------------------|---------------------|-----------|
| Hydrogen (atoms and molecules) | 90 | 74 |
| Helium | 9 | 25 |
| Metals* | 1 | 1 |

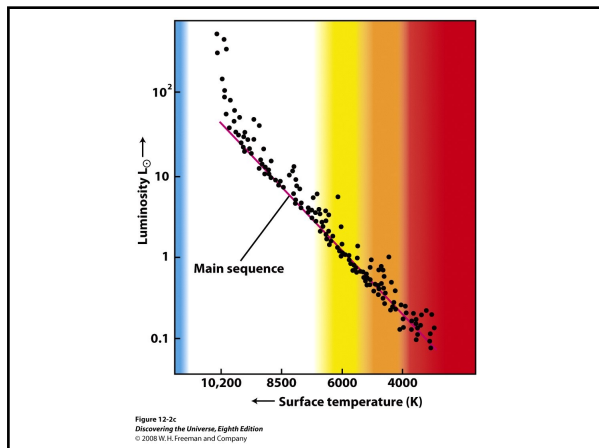
***Metals are all elements except hydrogen and helium.**

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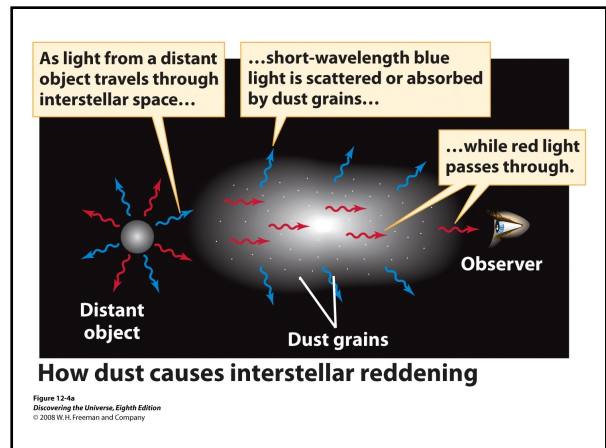
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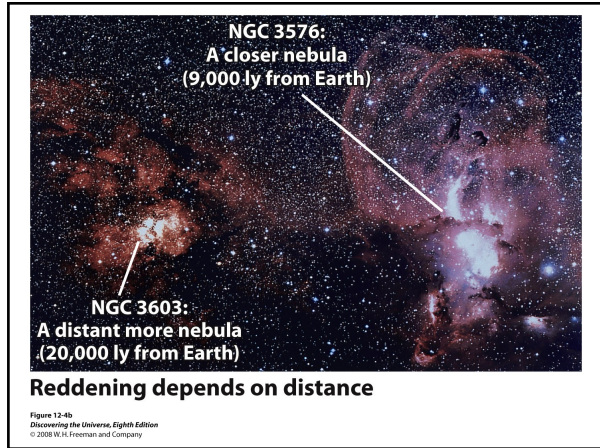
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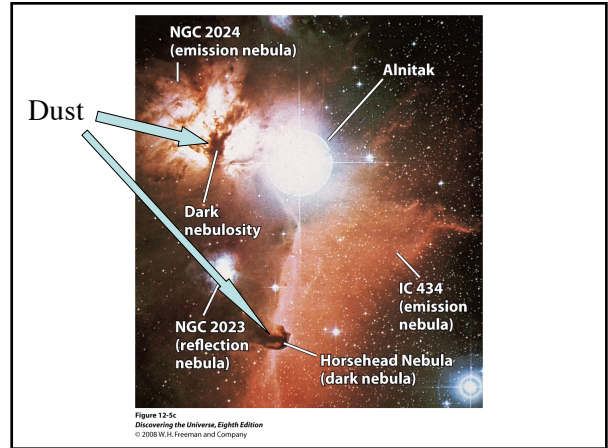
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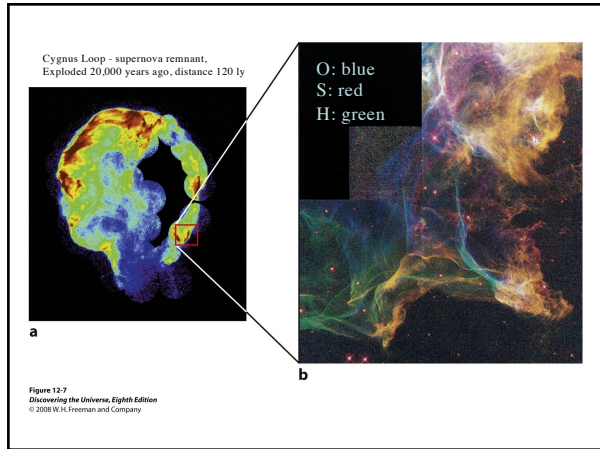
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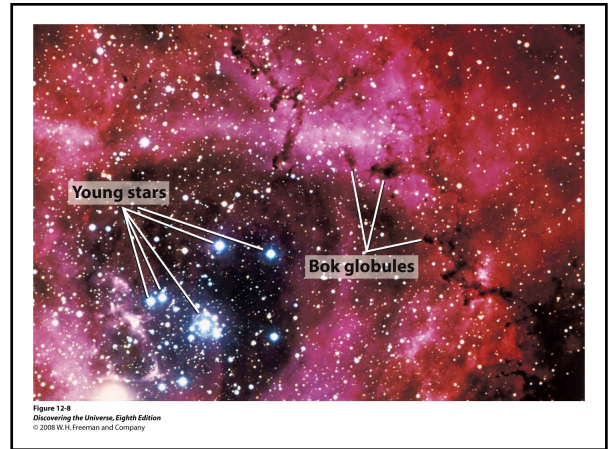
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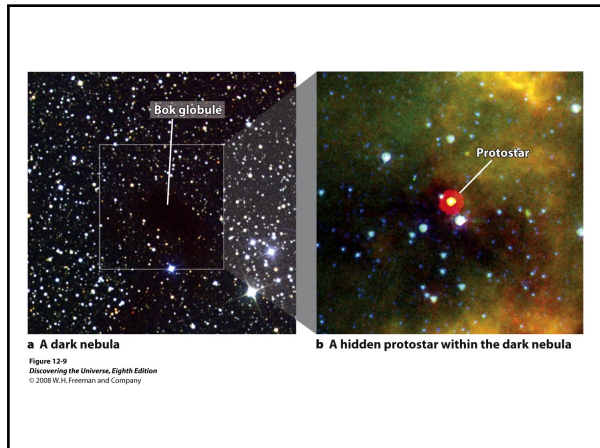
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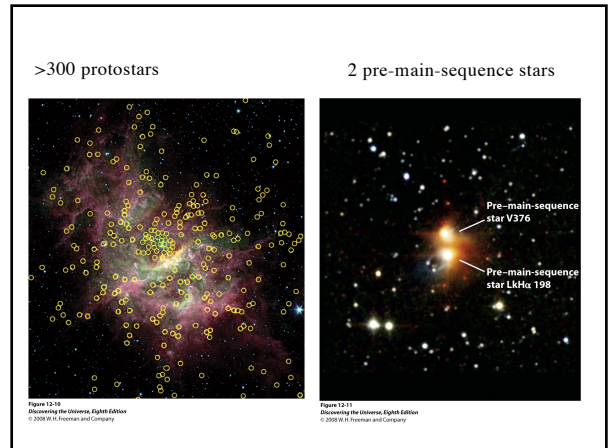
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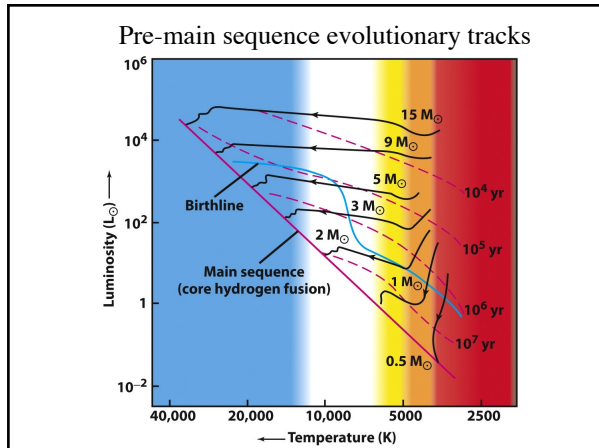
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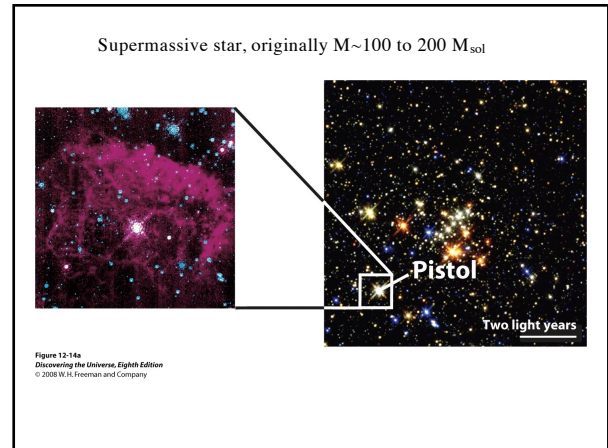


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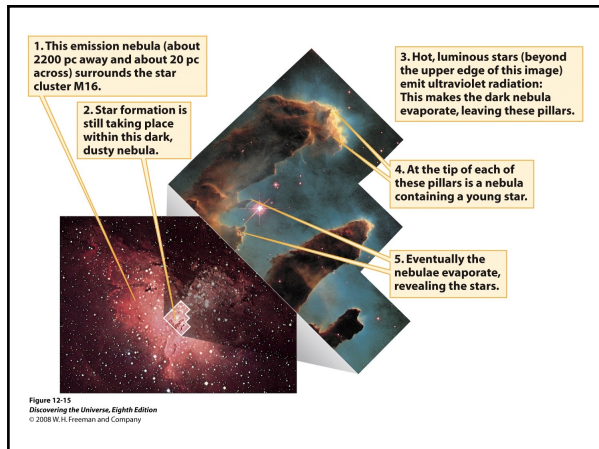


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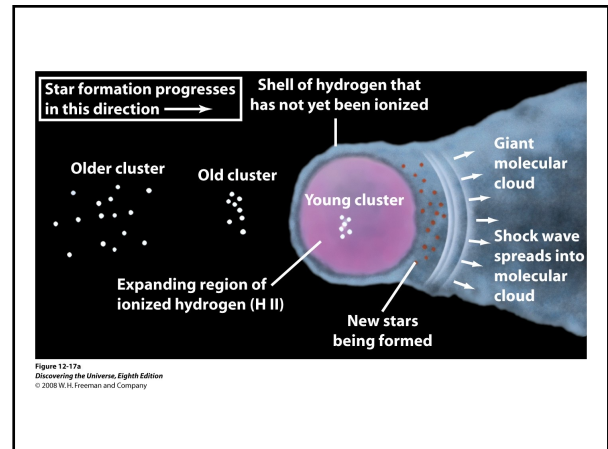


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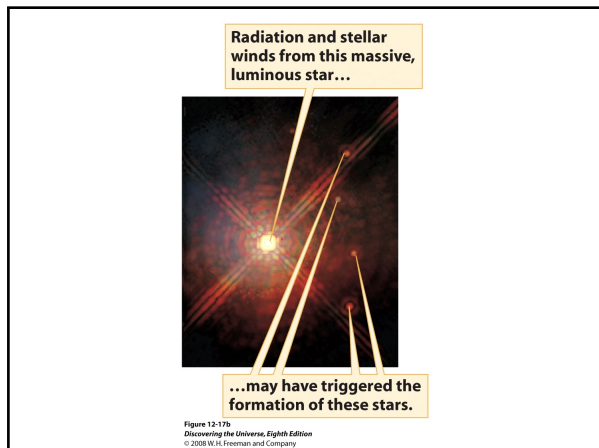


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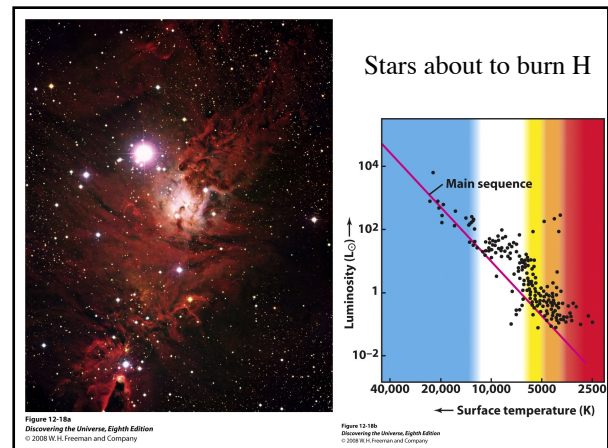
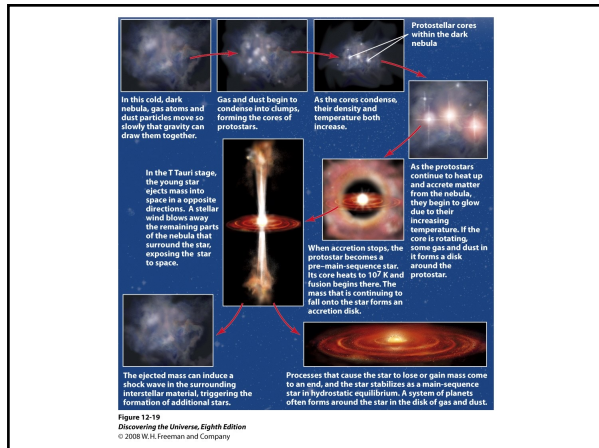


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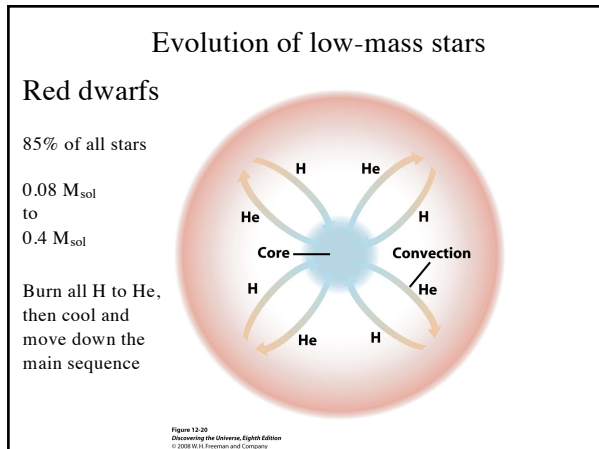
TABLE 12-2 Main-Sequence Lifetimes

| Mass (M_{\odot}) | Surface temperature (K) | Luminosity (L_{\odot}) | Time on main sequence (10^7 years) | Spectral class |
|----------------------|-------------------------|----------------------------|---------------------------------------|----------------|
| 25 | 35,000 | 80,000 | 3 | O |
| 15 | 30,000 | 10,000 | 15 | B |
| 3 | 11,000 | 60 | 500 | A |
| 1.5 | 7,000 | 5 | 3,000 | F |
| 1.0 (Sun) | 6,000 | 1 | 10,000 | G |
| 0.75 | 5,000 | 0.5 | 15,000 | K |
| 0.50 | 4,000 | 0.03 | 200,000 | M |

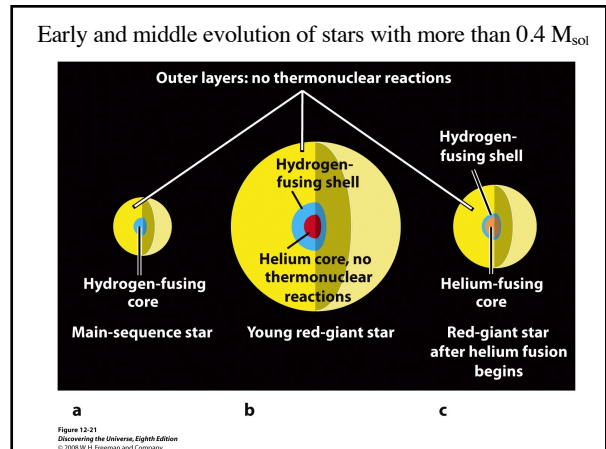
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$Lt = fMc^2$
 $t \propto Mc^2/L$ $L \propto M^{3.5}$
 $t \propto M^{-2.5}$

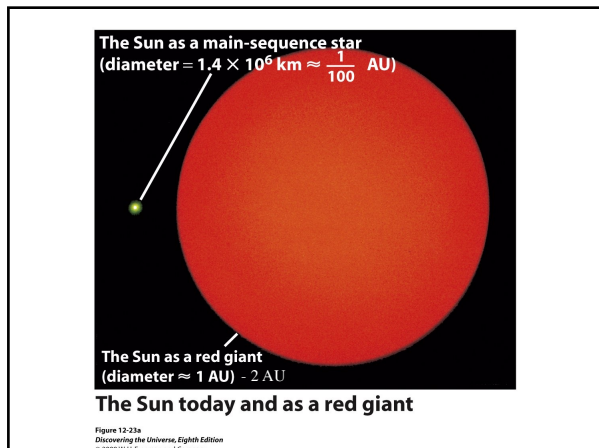
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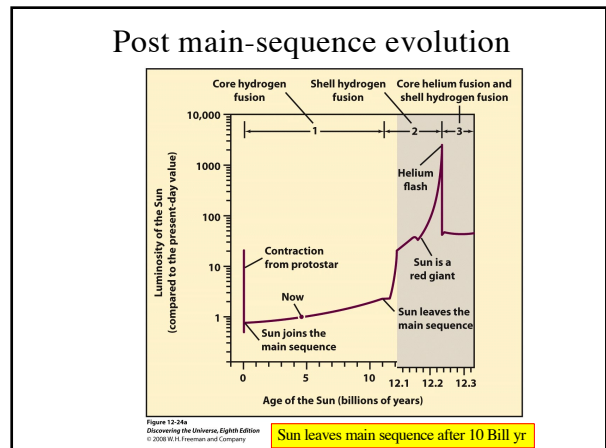
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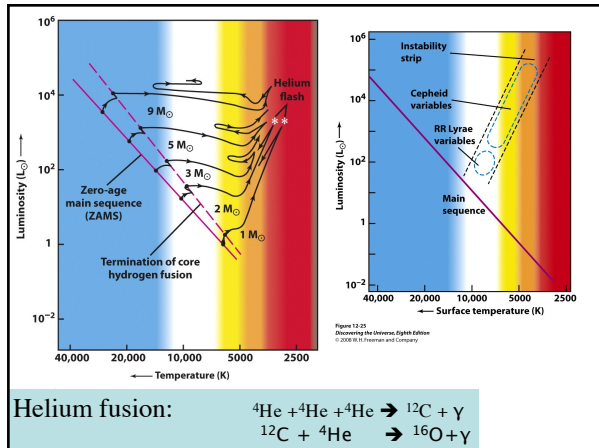
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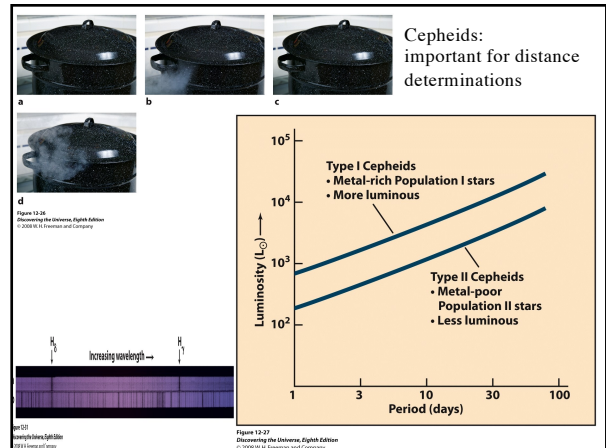
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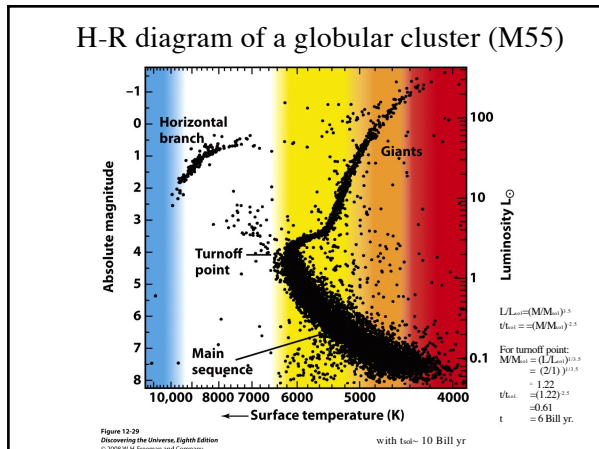
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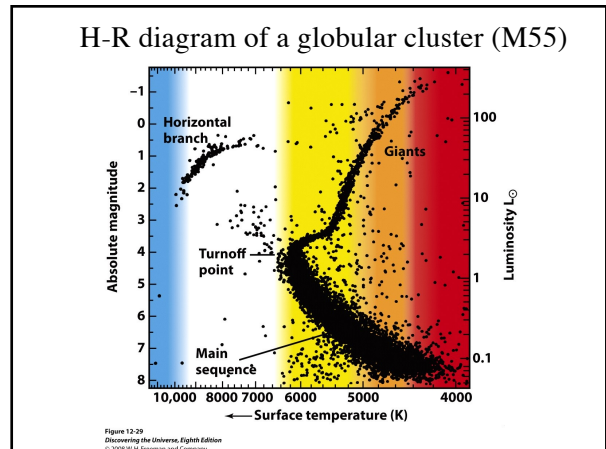
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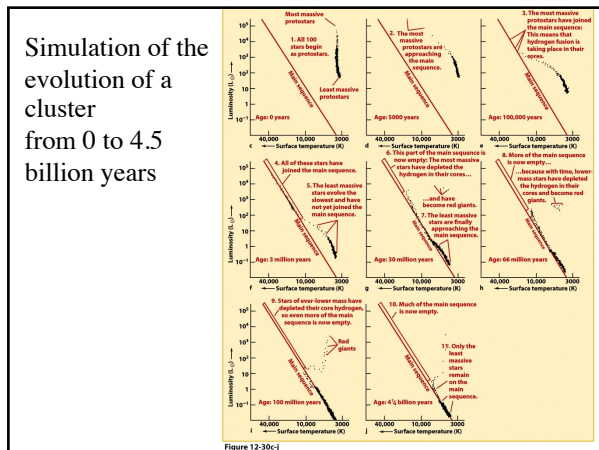
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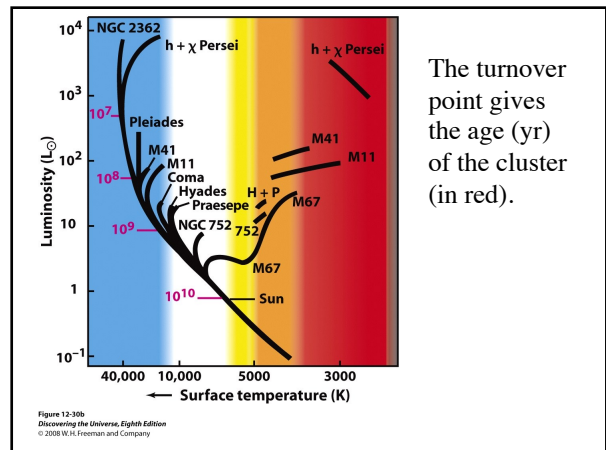
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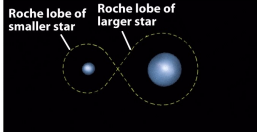


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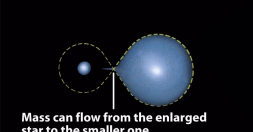
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Binaries



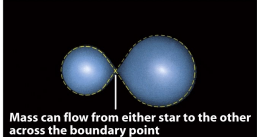
Roche lobe of smaller star Roche lobe of larger star

a Detached binary: Neither star fills its Roche lobe.



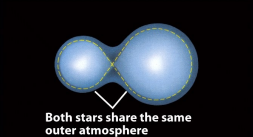
Mass can flow from the enlarged star to the smaller one

b Semi-detached binary: One star fills its Roche lobe.



Mass can flow from either star to the other across the boundary point

c Contact binary: Both stars fill their Roche lobes.



Both stars share the same outer atmosphere

d Overcontact binary: Both stars overflow their Roche lobes.

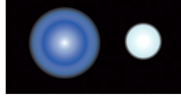
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Each star in a binary system has a Roche lobe. Within a Roche lobe, orbital material is bound to the star.

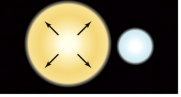
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A companion star can influence the evolution

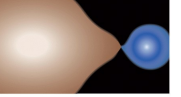
1 Held in a gravitational embrace, the pair of stars in Phi Persei has lived normal lives for the last 10 million years.




2 The duo's quiet lives end when the more massive star enters its twilight years. The aging star swells as it runs out of the fuel—hydrogen—which powers its thermonuclear furnace.



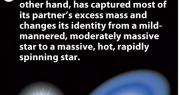
3 As the aging star expands, it begins dumping its mass onto its companion.



4 The once-massive star sheds practically all of its mass, leaving its hot, bright core exposed.



5 The smaller companion, on the other hand, has captured most of its partner's excess mass and changes its identity from a mild-mannered, moderately massive star to a massive, hot, rapidly spinning star.



6 In fact, the star is spinning so rapidly that its shape is distorted into a flattened spheroid. The rapid rotation also causes the star to dump hydrogen gas, which has settled into a broad ring—like the rings of Saturn—around the star.

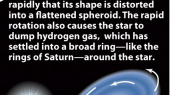


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