EVOLUCION ESTELAR

$$T_{nuclear} = \frac{0.007 \times 0.1 \times (Masa) \times c^2}{L}$$

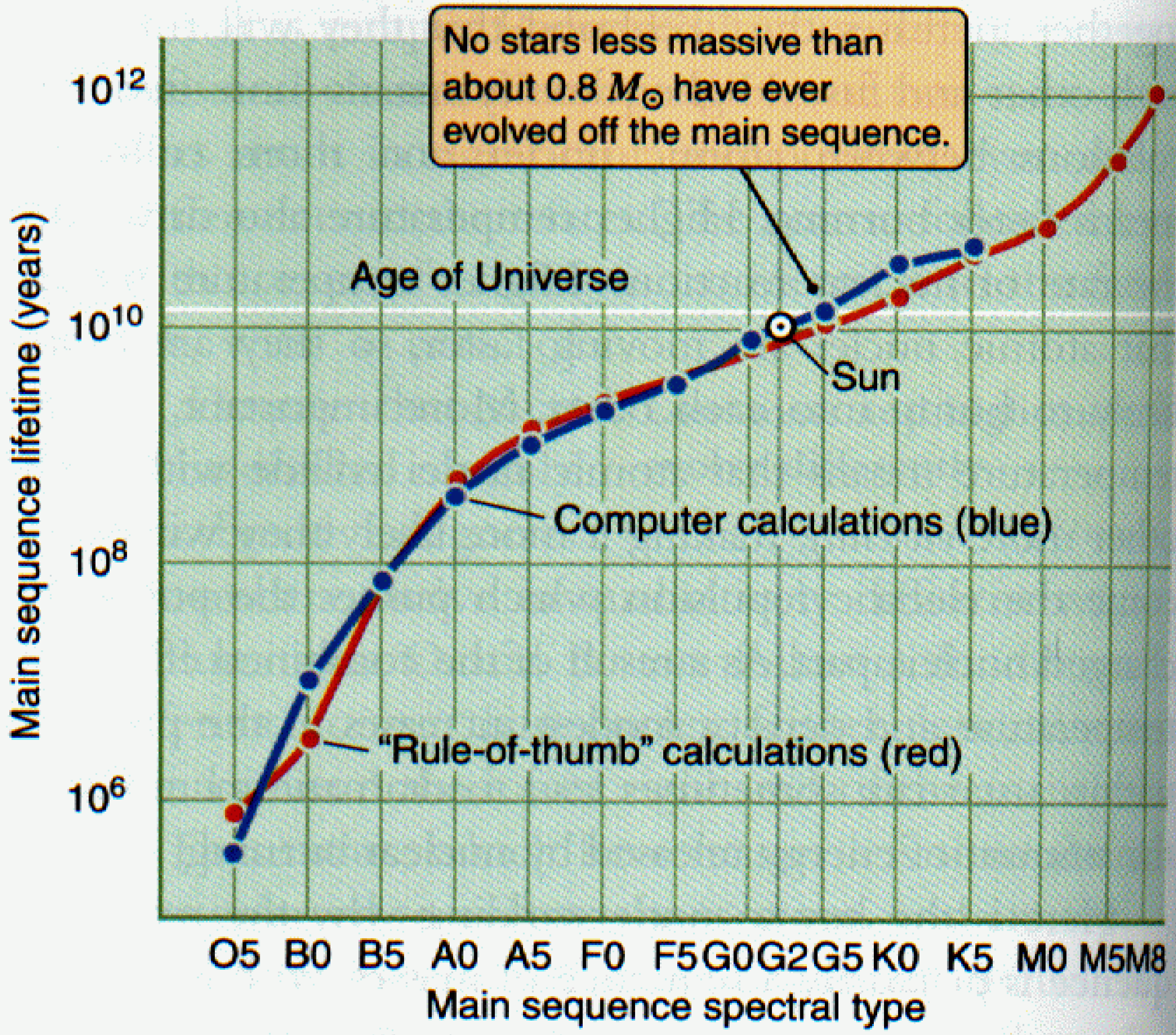


Figure 15.1 *The main sequence lifetimes of stars.*

Evolucion de la relacion H/He en el Sol

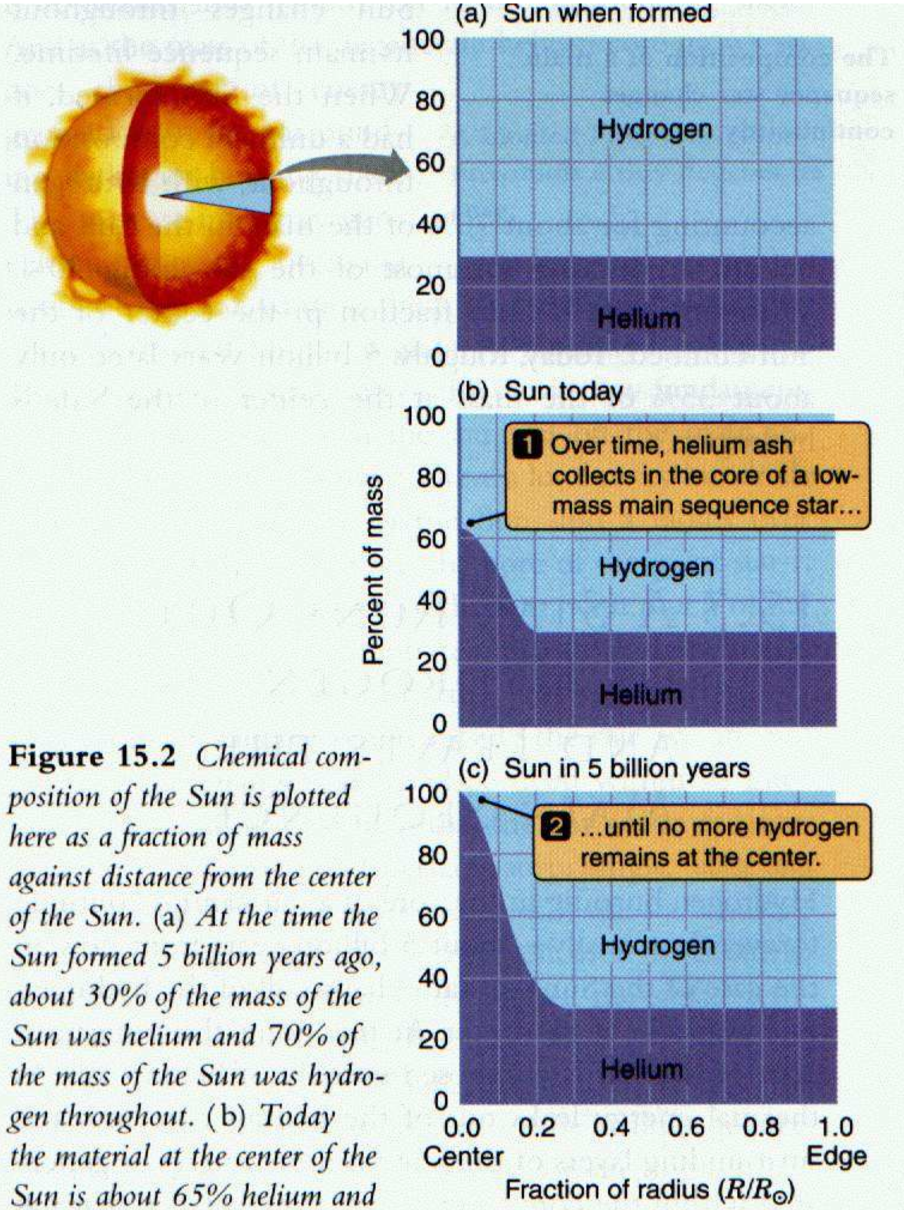


Figure 15.2 *Chemical composition of the Sun is plotted here as a fraction of mass against distance from the center of the Sun.* (a) *At the time the Sun formed 5 billion years ago, about 30% of the mass of the Sun was helium and 70% of the mass of the Sun was hydrogen throughout.* (b) *Today the material at the center of the Sun is about 65% helium and 30% hydrogen.* (c) *The Sun's main sequence life will end in about 5 billion years, when all of the hydrogen at the center of the Sun is gone.*

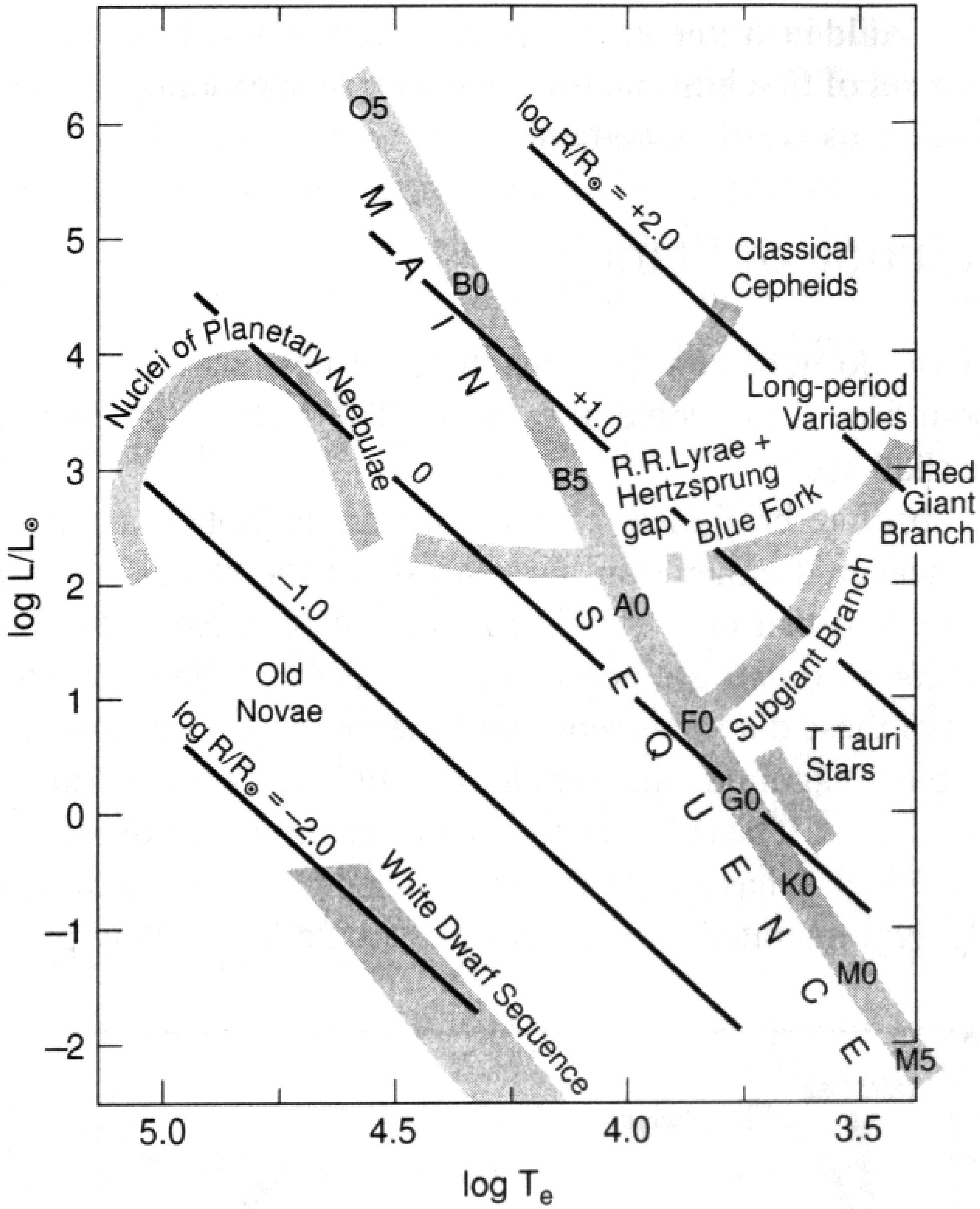
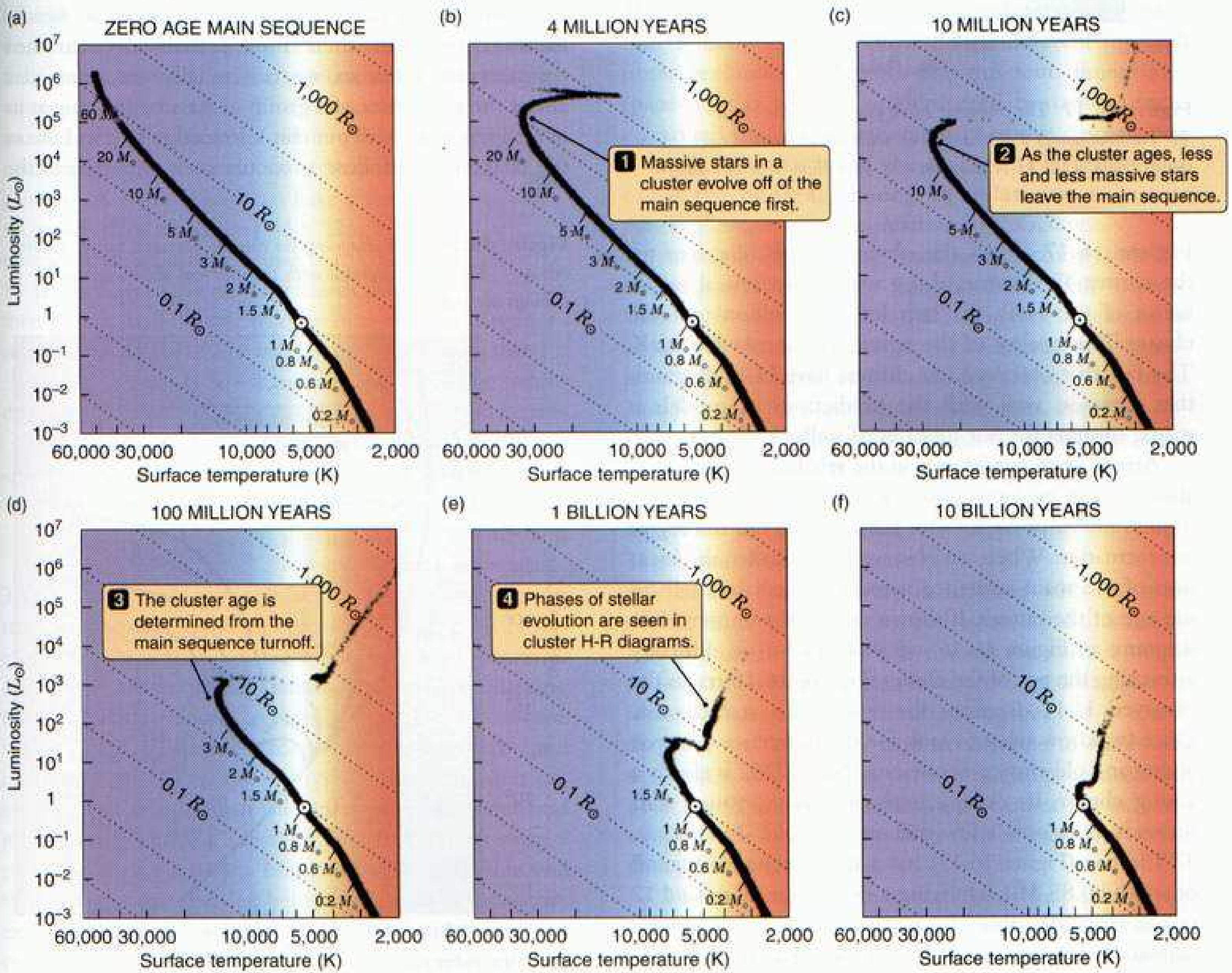


FIGURE 1.4. Schematic Hertzsprung–Russell diagram. The lines of constant slope represent stars having identical radii (see Section 4:13).

Figure 16.16 *H-R diagrams of star clusters are snapshots of stellar evolution. These are simulated H-R diagrams of a cluster of 40,000 stars of solar composition seen at different times following the birth of the cluster. Note the progression of the main sequence turnoff to lower and lower masses.*



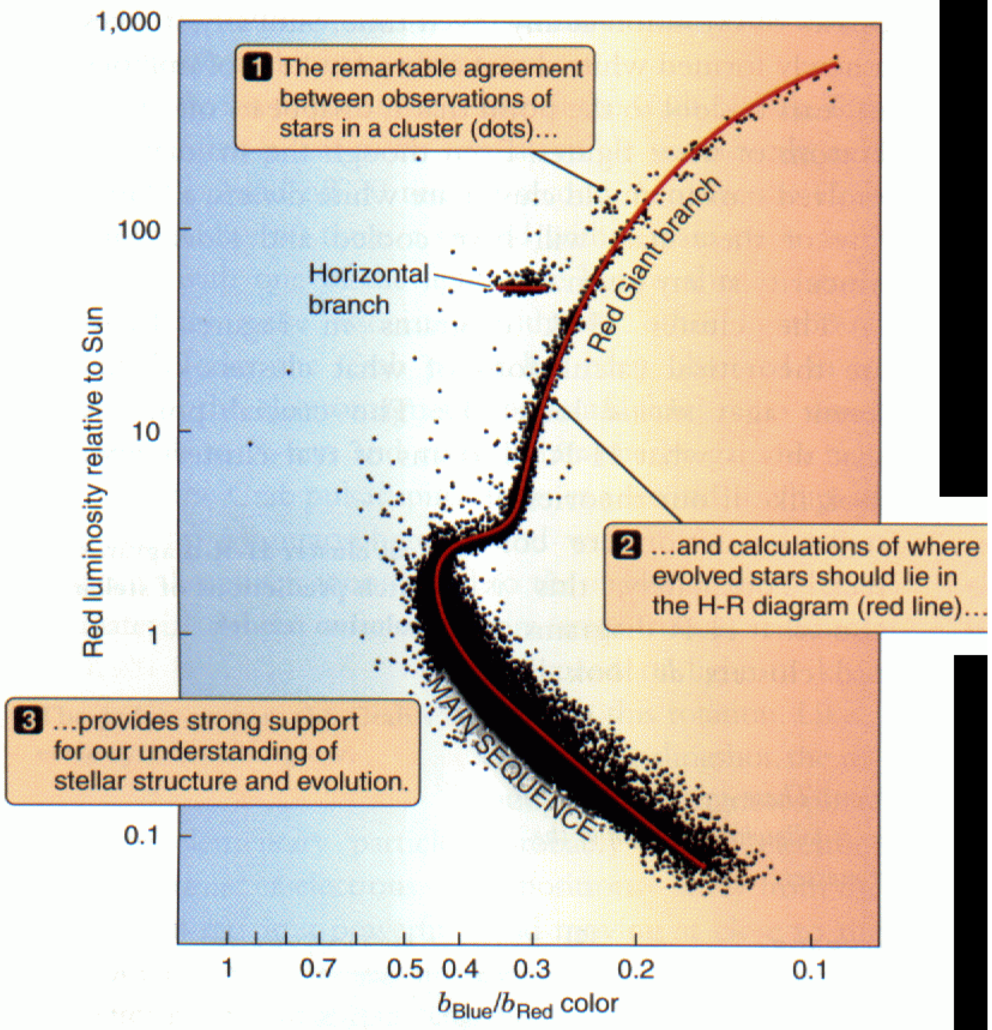
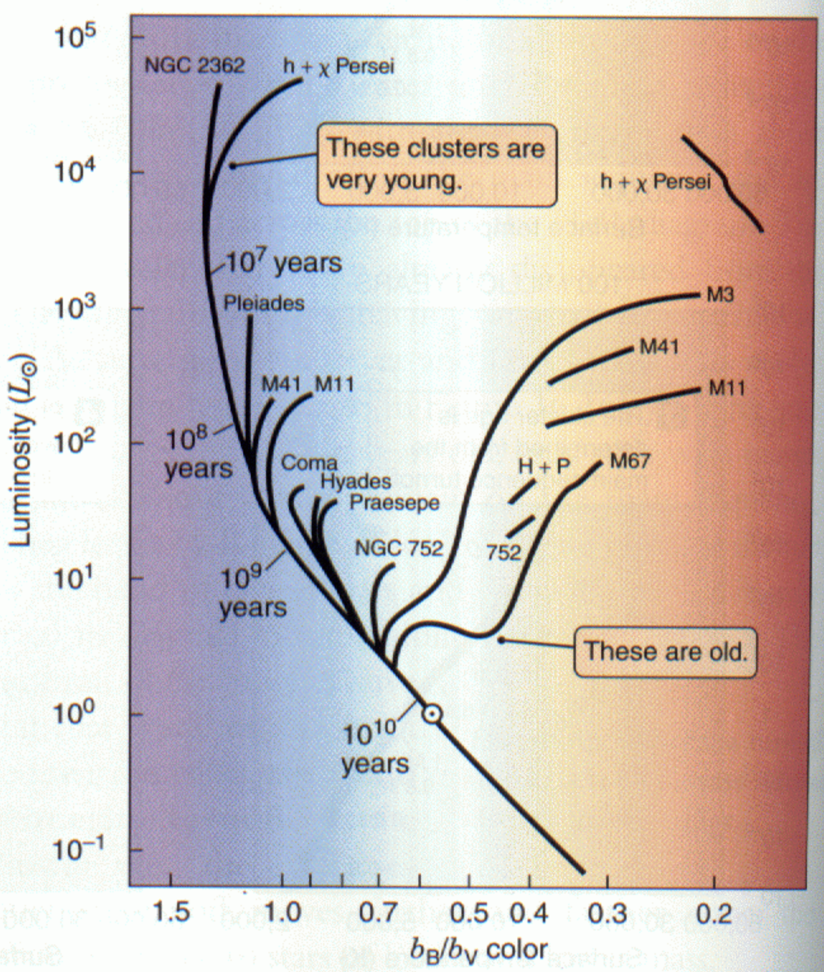


Figure 16.17 *The observed H-R diagram of the cluster 47 Tucanae agrees remarkably well with the theoretical calculation* (solid line) *of the H-R diagram of a 12-billion-year-old cluster.*

Figure 16.18 *H-R diagrams for clusters having a range of different ages. The ages associated with the different main sequence turnoffs are indicated.*



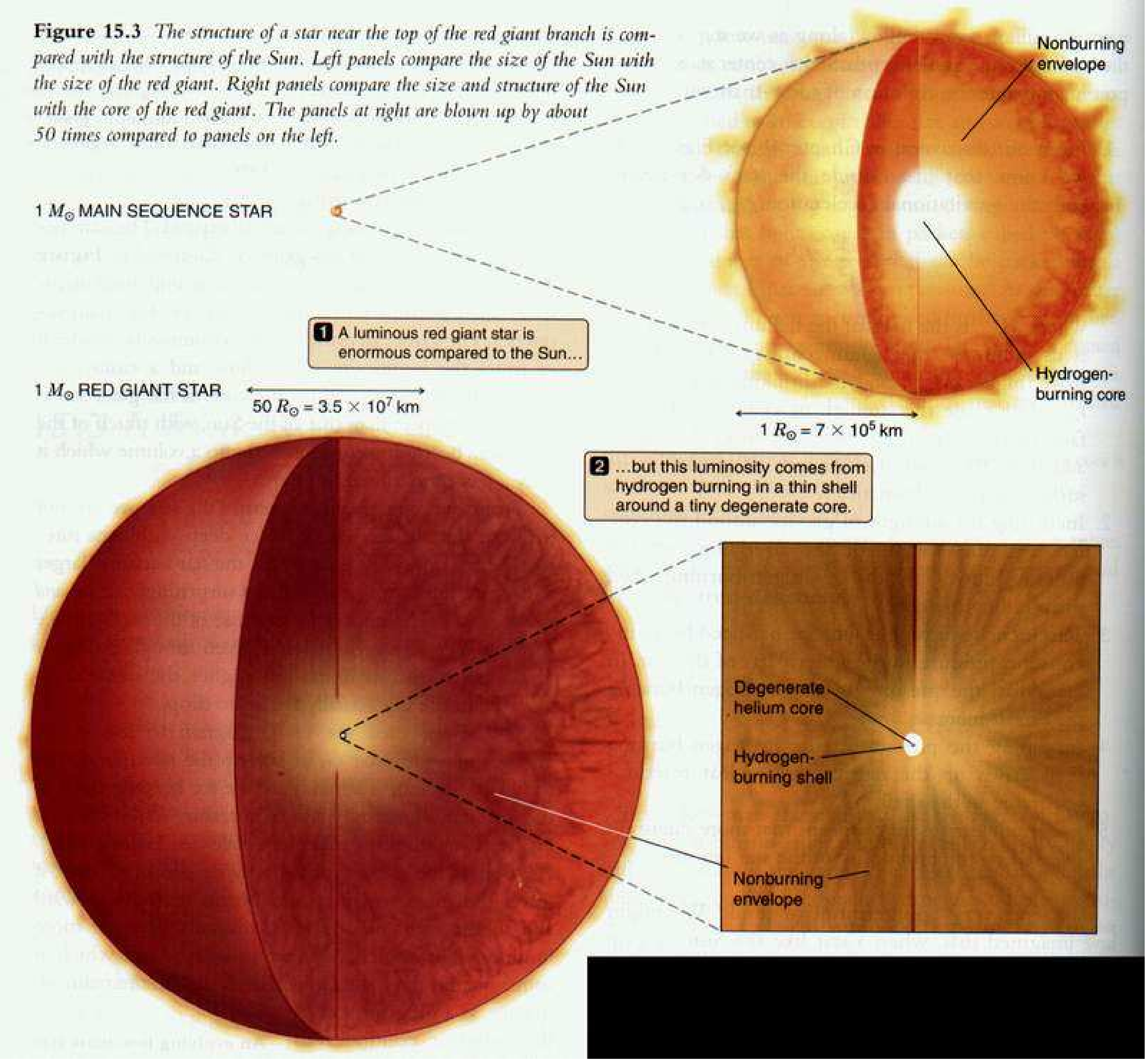


Figure 15.3 *The structure of a star near the top of the red giant branch is compared with the structure of the Sun. Left panels compare the size of the Sun with the size of the red giant. Right panels compare the size and structure of the Sun with the core of the red giant. The panels at right are blown up by about 50 times compared to panels on the left.*

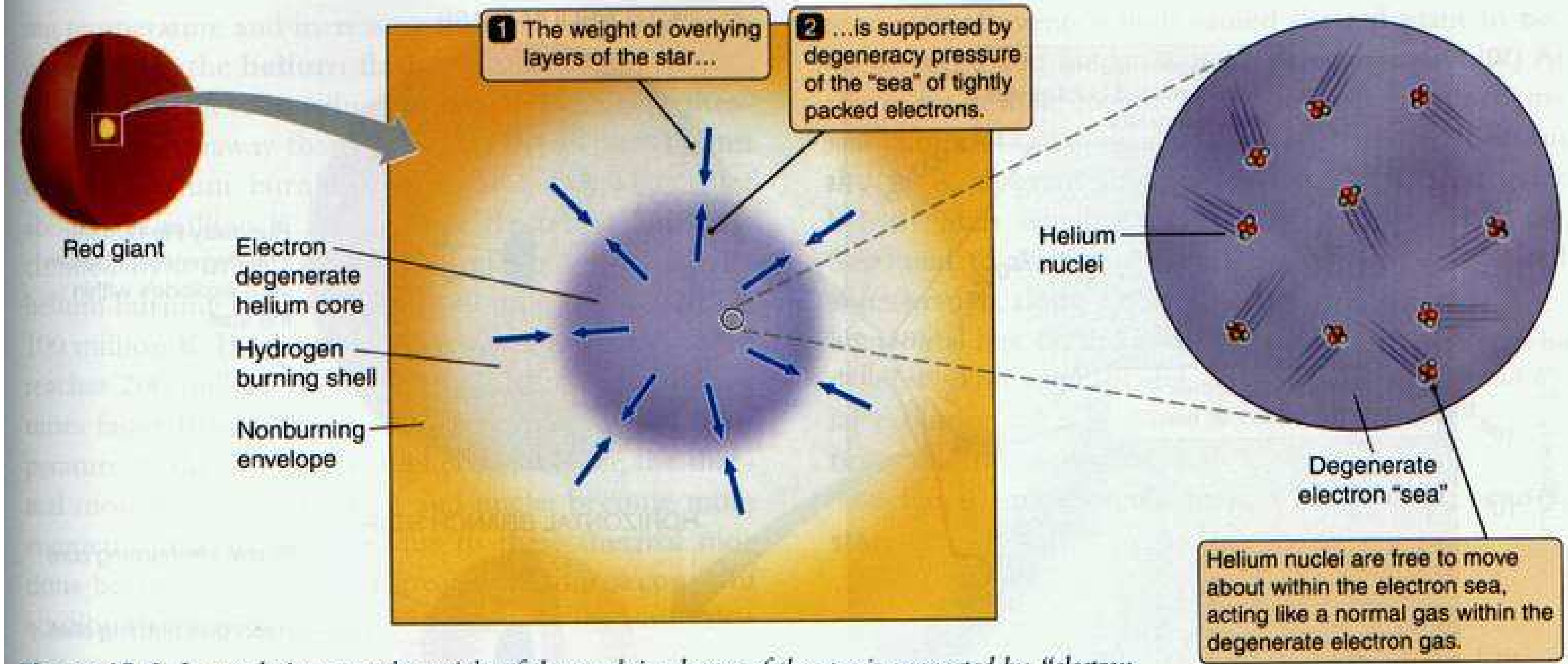


Figure 15.6 *In a red giant star the weight of the overlying layers of the star is supported by "electron degeneracy pressure" in the core arising from the fact that electrons are packed together as tightly as allowed by quantum mechanics. Even so, atomic nuclei in the core of the star are able to move freely about within the sea of degenerate electrons, and so behave as a normal gas.*

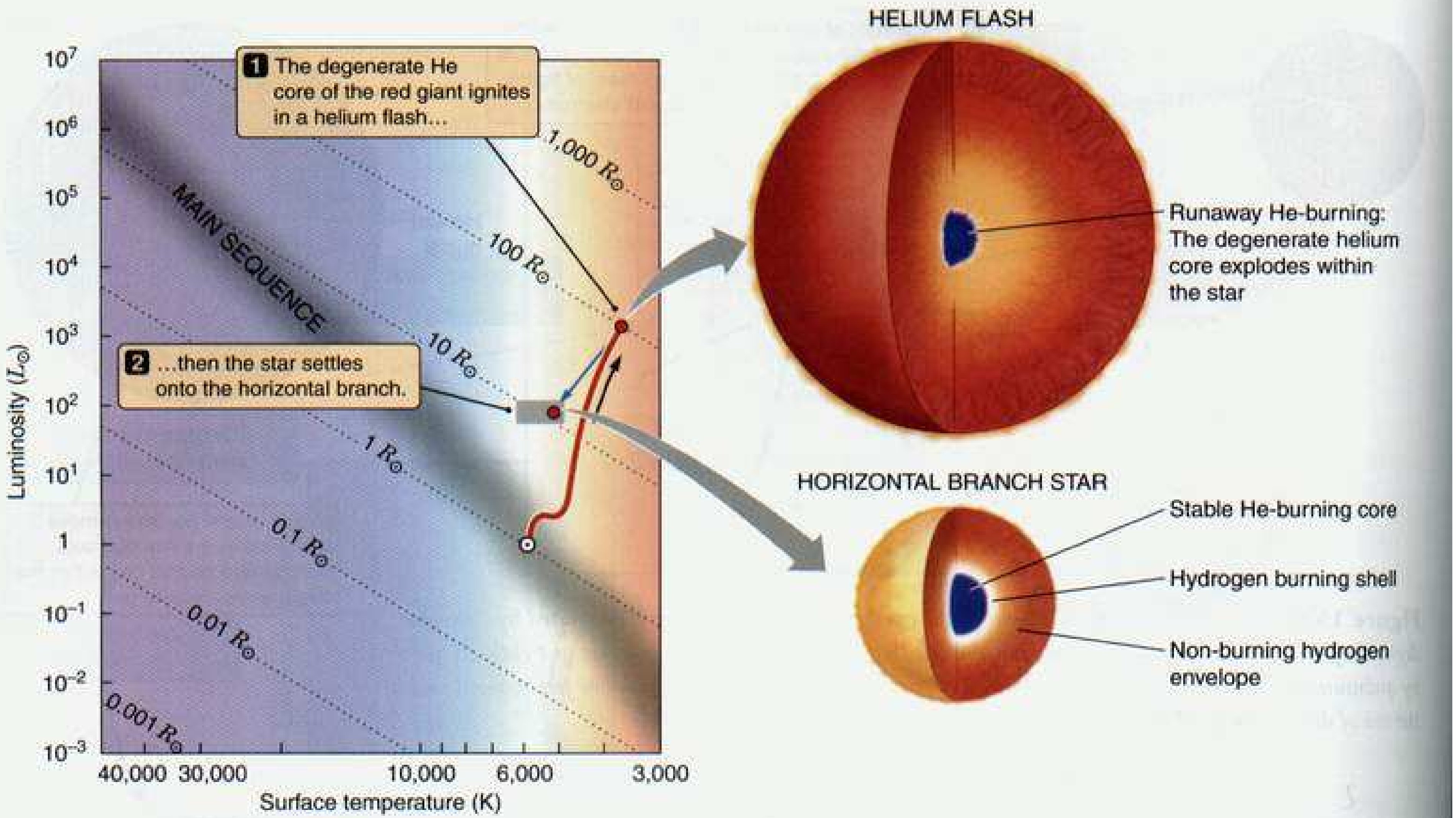


Figure 15.8 *When the core temperature of the red giant reaches about 10^8 K, He begins to burn explosively in the degenerate core, leading to the helium flash. After a few hours the core of the star begins to inflate, ending the helium flash. Over about the next 100,000 years (a relatively short time), the star settles onto the horizontal branch, where it burns He in its core and H in a surrounding shell.*

diagram as a cooling white dwarf star.

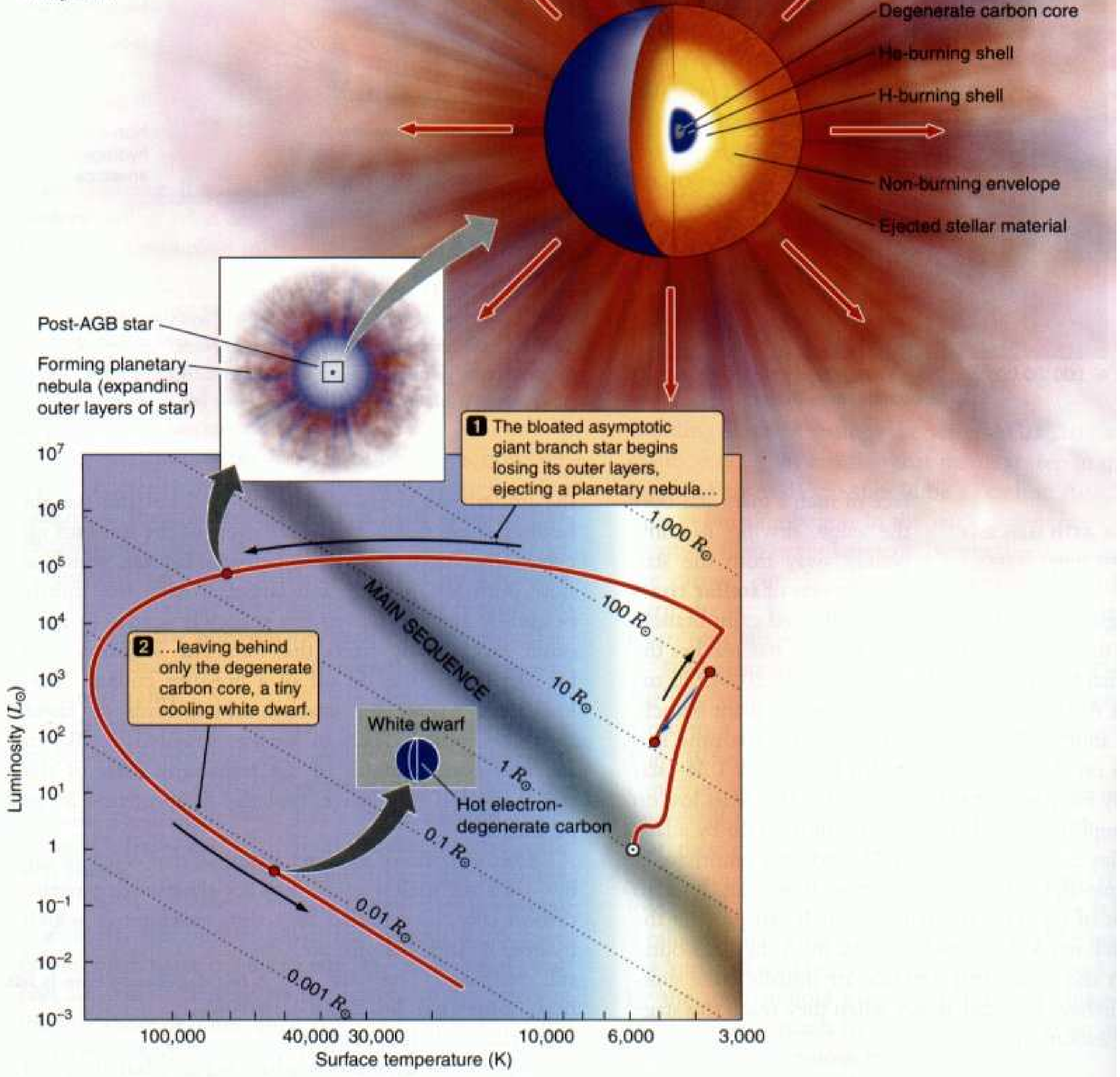
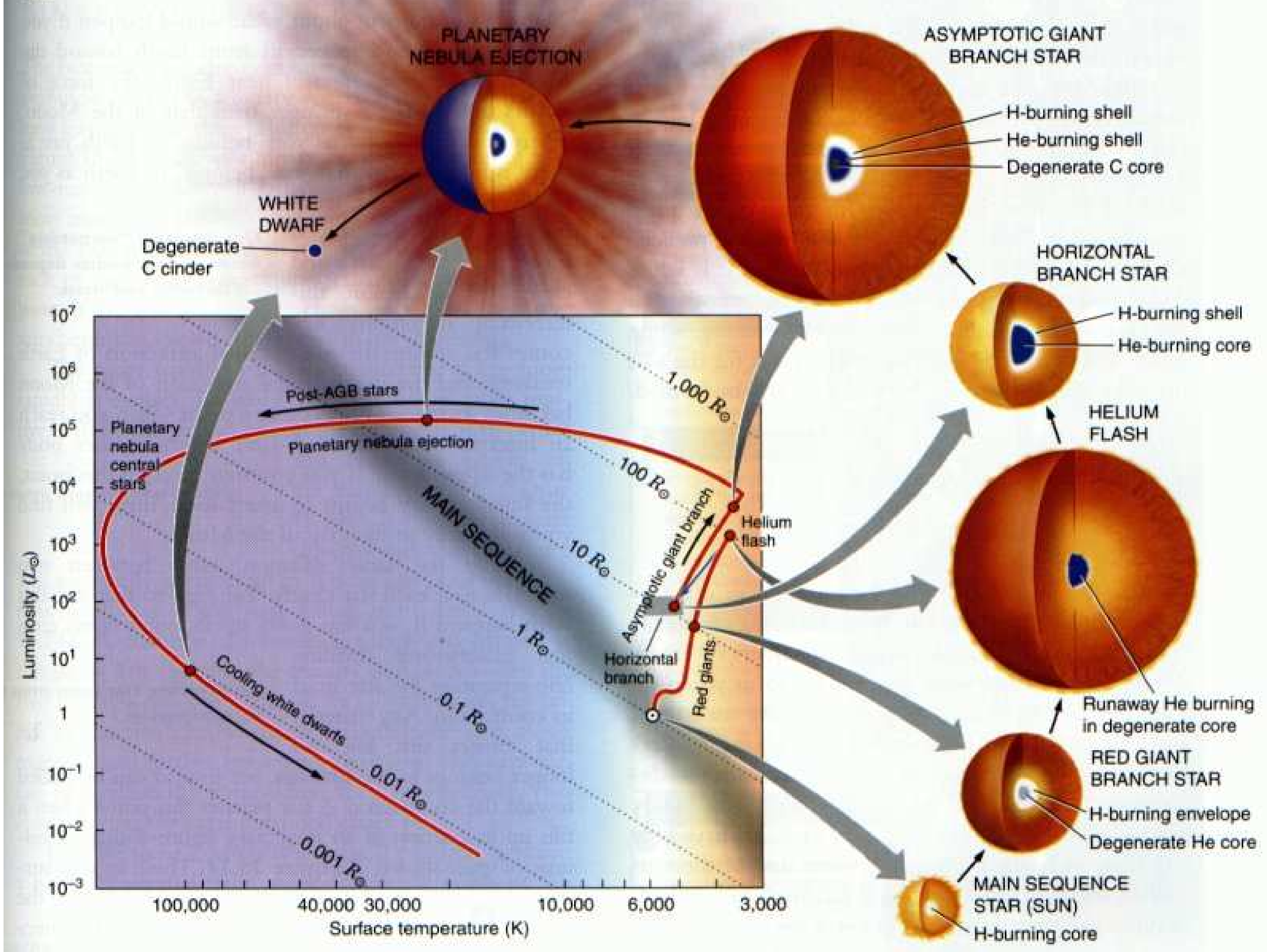


Figure 15.13 *This H-R diagram summarizes the stages in the post–main sequence evolution of a one-solar-mass star.*



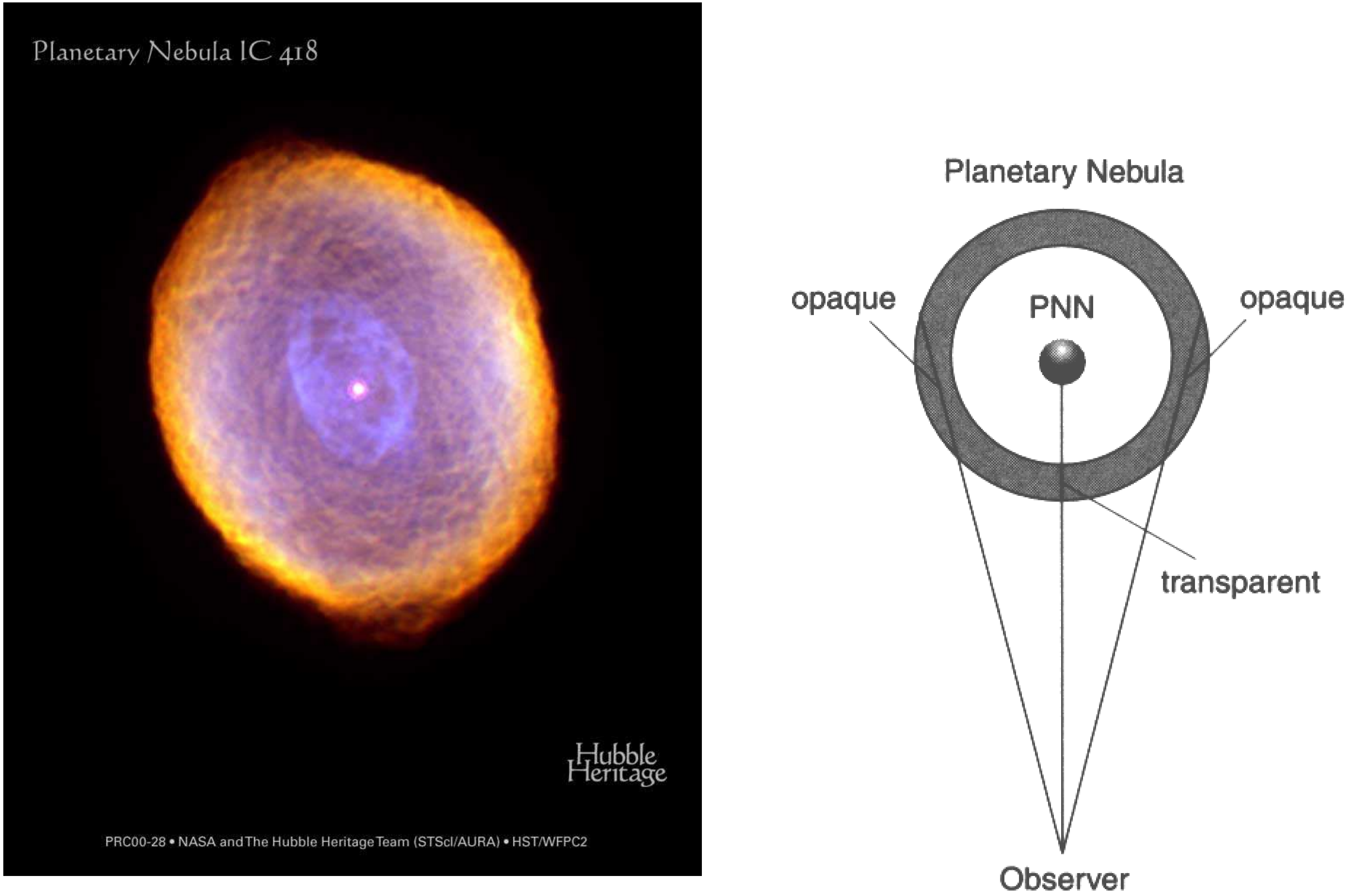
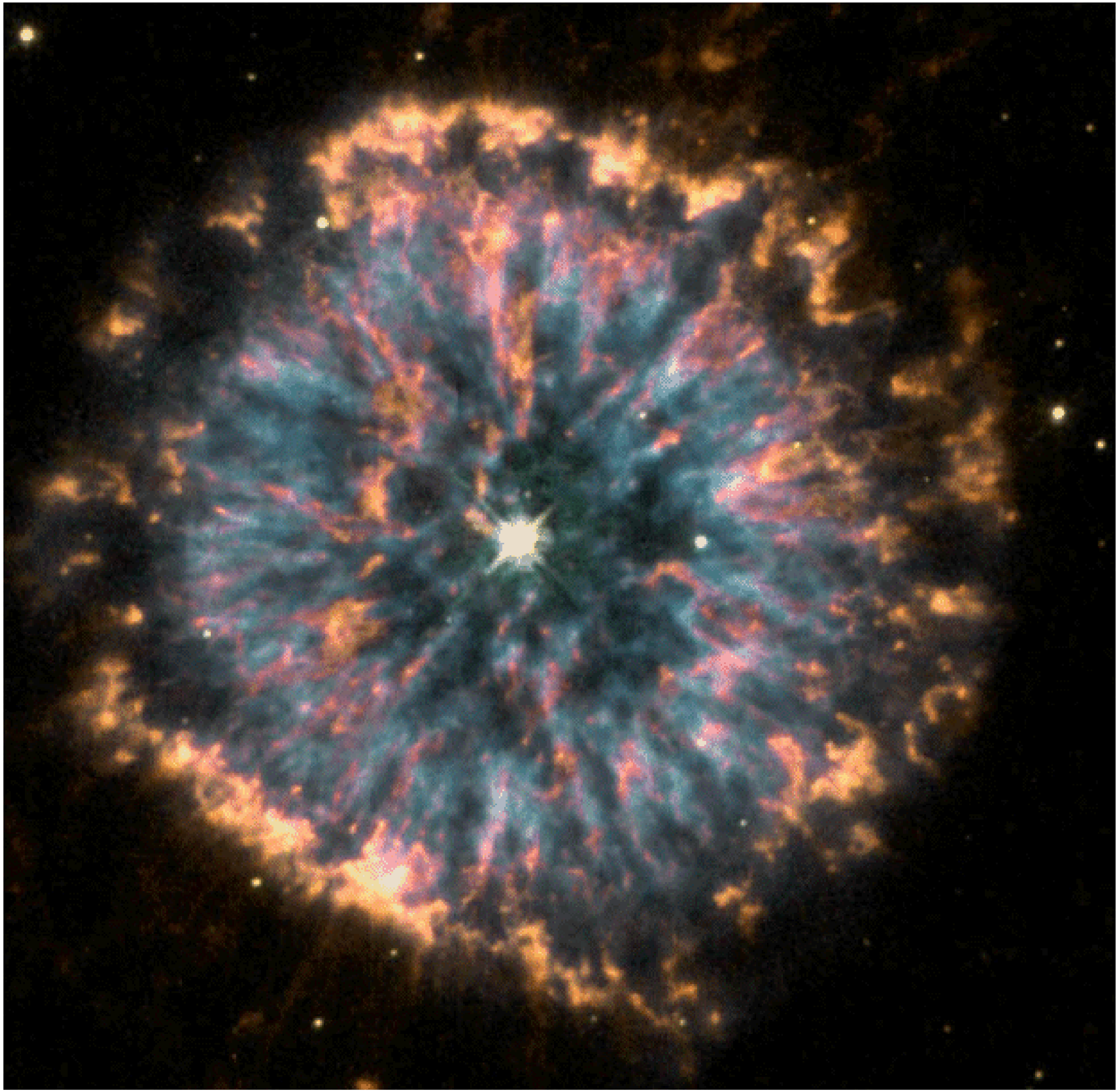
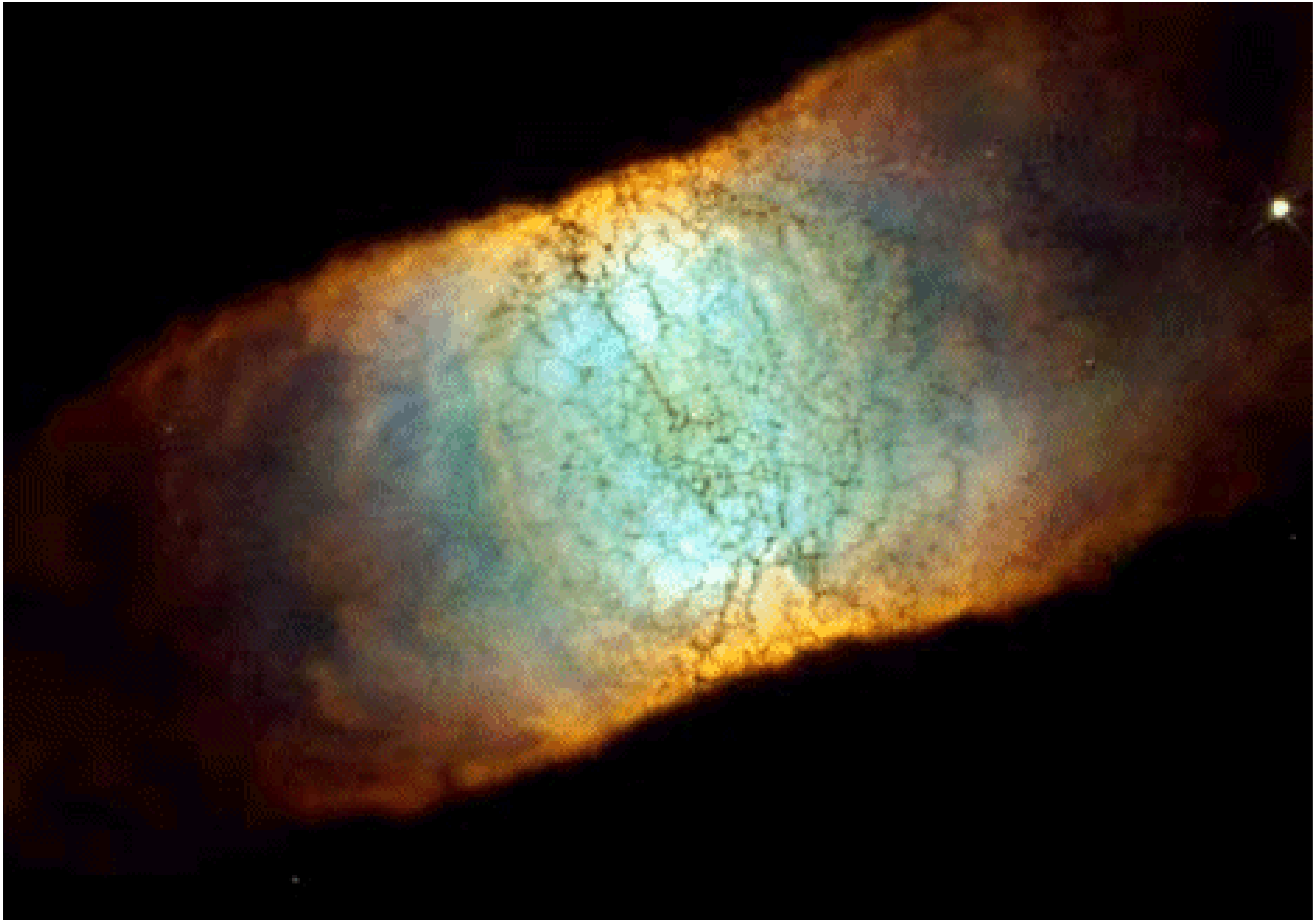
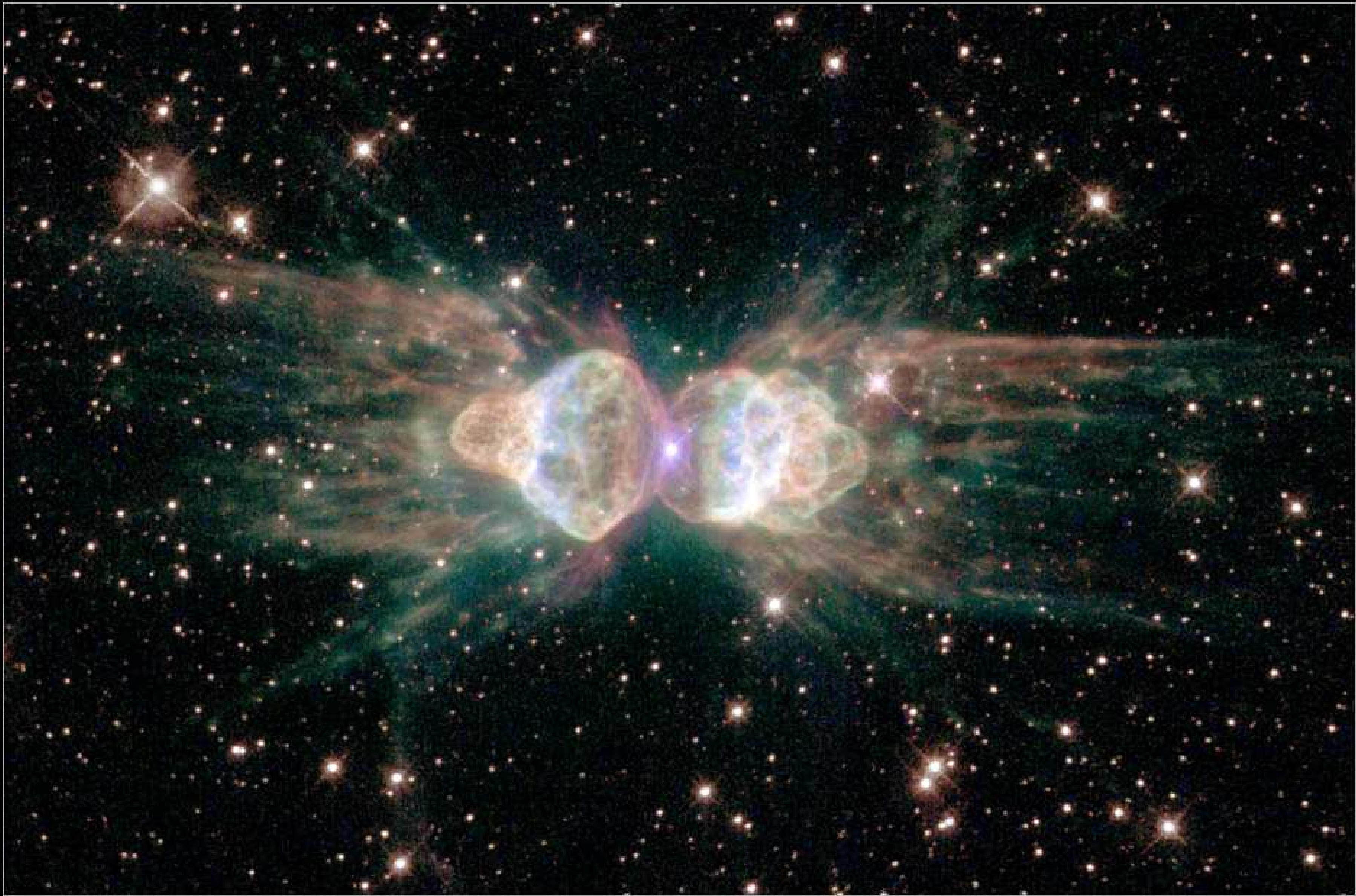


Figure 8.12 Sketch of a planetary nebula and its nucleus (PNN).





Planetary Nebula Mz 3



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The Dumbbell Nebula • M27

Hubble Heritage

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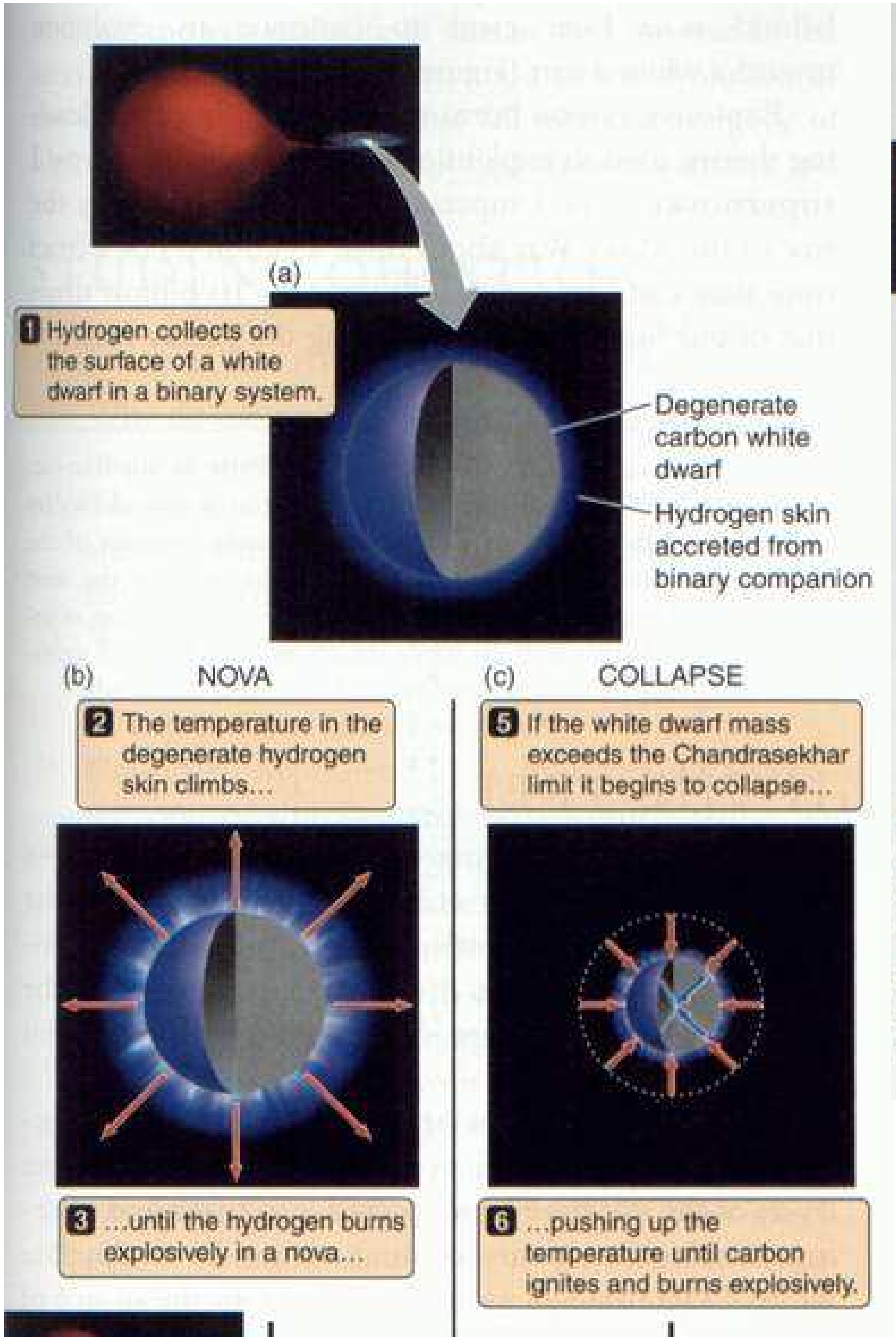


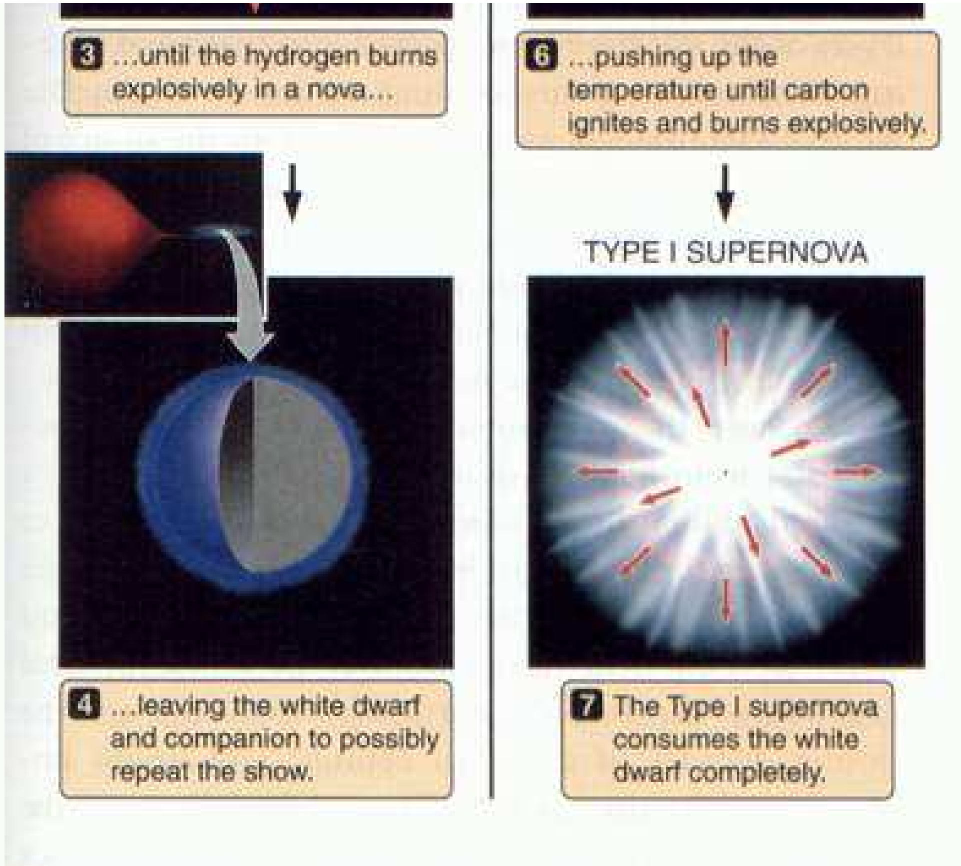


Figure 15.15 *In a binary system in which mass is transferred onto a white dwarf, a skin of hydrogen builds up on the surface of the degenerate white dwarf. If hydrogen burning ignites on the surface of the white dwarf, the result is a nova. If enough hydrogen accumulates to force the white dwarf to begin to collapse, carbon ignites and the result is a Type I supernova.*

Supernova

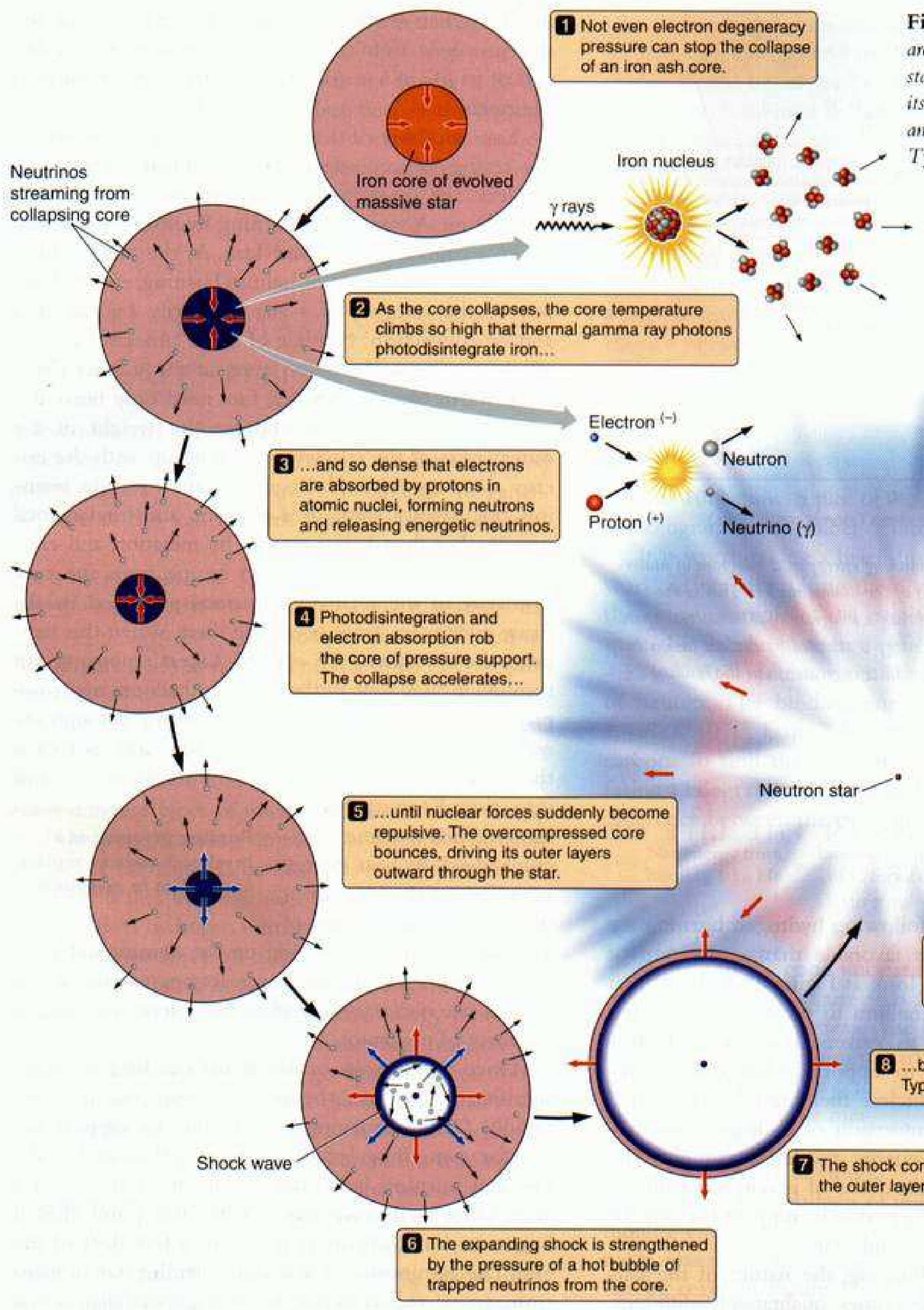
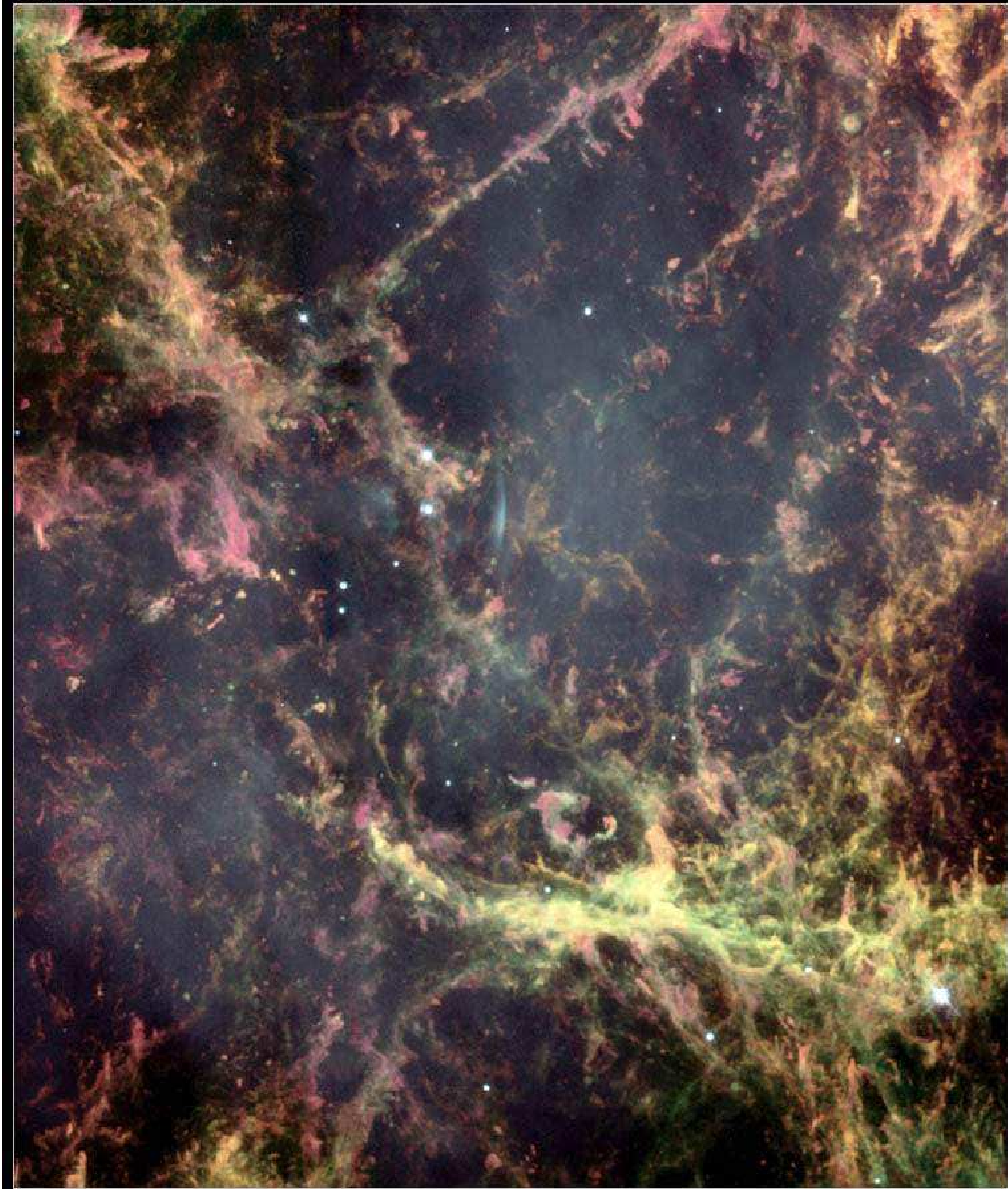


Figure 16.9 *Shown here are the stages that a high-mass star goes through at the end of its life as its core collapses, and the star explodes as a Type II supernova.*

Crab Nebula



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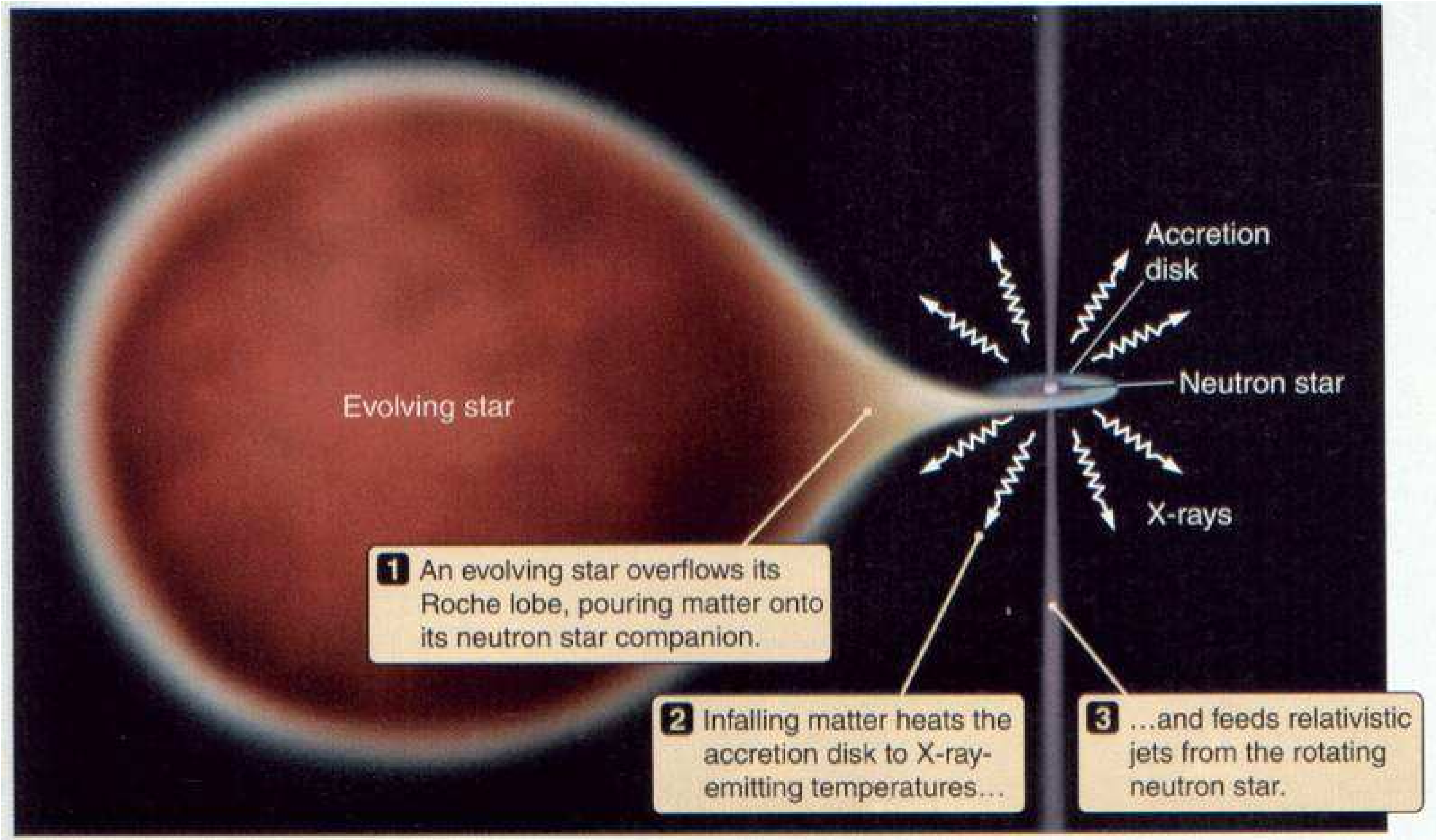
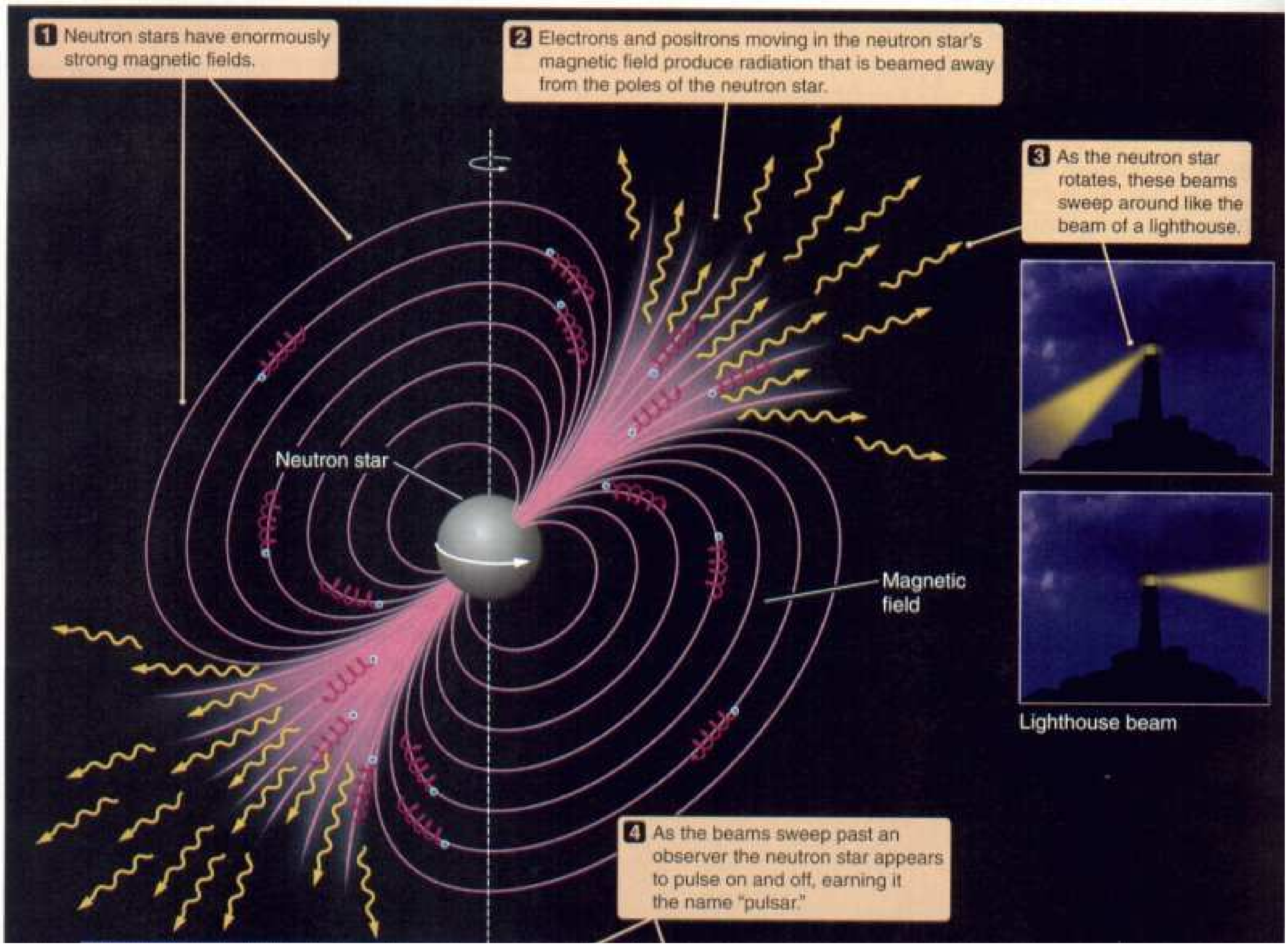
Estrella de rayos x





1 Neutron stars have enormously strong magnetic fields.
2 Electrons and positrons moving in the neutron star's magnetic field produce radiation that is beamed away from the poles of the neutron star.
3 As the neutron star rotates, these beams sweep around like the beam of a lighthouse.
Neutron star
Magnetic field
Lighthouse beam
4 As the beams sweep past an observer the neutron star appears to pulse on and off, earning it the name "pulsar."

OBJETOS COMPACTOS: NO HAY FUSION

ENANA BLANCA: sostenida por la presion del gas degenerado de electrones. Enrojecimiento gravitacional.

ENANA NEGRA: no emite nada.

Limite Chandrasekhar

ESTRELLA DE NEUTRONES: proceso URCA

$$(Z,A)+e \ = \ (Z-1,A) \ + \ \text{neutrino}$$

Sostenida por presion de gas degenerado de neutrones

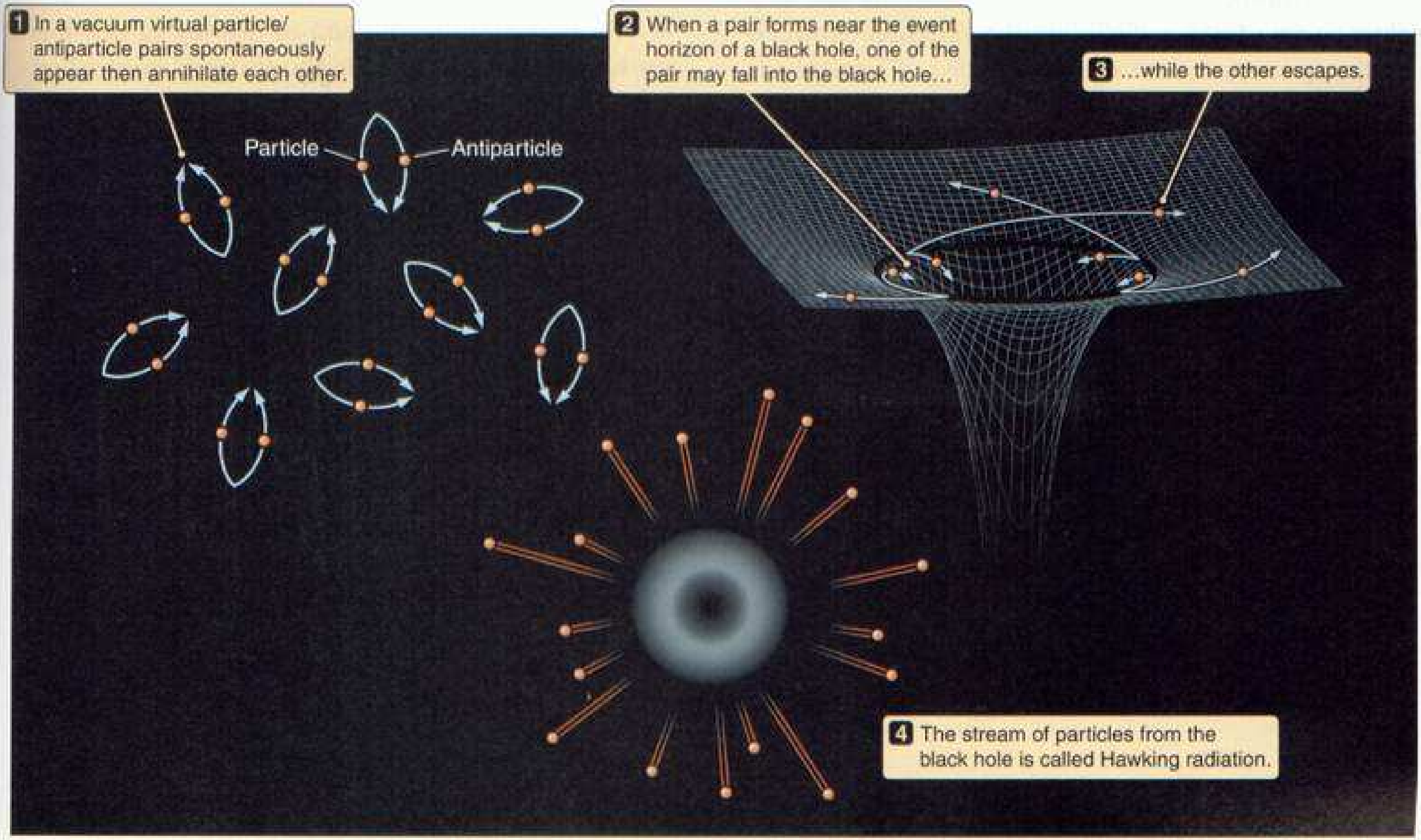
Limite Openheimer-Volkov

AGUJERO NEGRO: Vescape > c   (Gamma Ray Burst)

Radio de Schwarzchild

Radiacion de Hawking

Figure 16.26 *In the vacuum, particles and antiparticles are constantly being created and then annihilating each other. However, near the event horizon of a black hole, one particle may cross the horizon before it recombines with its partner. The remaining particle leaves the black hole as Hawking Radiation.*



VARIABLES

- Pulsantes (G, SG): Mira, Cefeidas, Lyra
- Eruptivas (binarias proximas): flares, TTauri, novas, supernovas
- Eclipsantes
- Rotantes: manchas, fuertes campos magneticos

TABLE A.5. Properties of Pulsating Variables.

Type	Range of Period, P	Spectral Type	Mean brightness M_υ and variation ΔM_υ	Remarks
RR Lyrae (Cluster Variables)	< 1 d	A4 to F4	$M_\upsilon = 0.6$ $\Delta M_\upsilon \sim 1.0$	Found in the halo of the Galaxy
Classical Cepheids	1–50	F to K	$M_\upsilon = -2.6$ to -5.3 M_υ, ΔM_υ depend on P $\Delta M_V \sim 0.4$ to 1.4	Found in the disk of the Galaxy
W Virginis Stars (Type II Cepheids)	> 10	F, G	$M_\upsilon =$ one or two mag. less luminous than Class. Ceph. of similar period. $\Delta M_\upsilon = 1.2$	Halo population
Mira Stars (Long Period Variables)	100–1000	Red giant	$M_\upsilon \sim$ from -2.2 to 0, $\Delta M_\upsilon =$ from 3 to 5 for increasing period	Intermediate between disk and halo
Semiregular Variables	40–150	Red giant	$M_\upsilon = 0$ to -1 $\Delta M_\upsilon \sim 1.6$	Disk population

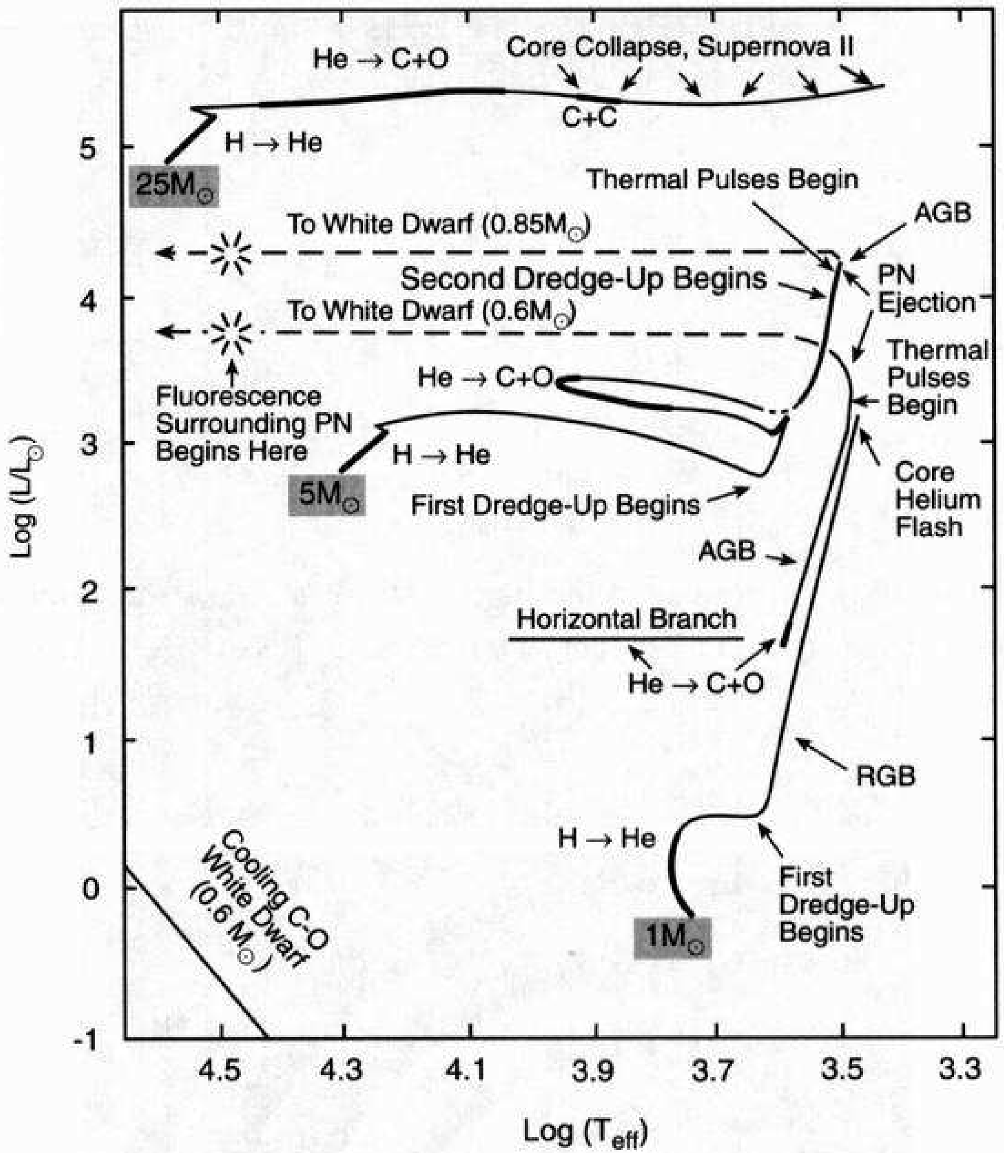


Figure 8.19 Evolutionary tracks of $1M_\odot$, $5M_\odot$, and $25M_\odot$ star models in the H–R diagram. Thick segments of the line denote long, nuclear burning, evolutionary phases. The turnoff points from the AGB are determined empirically [from I. Iben Jr. (1985), *Quart. J. Roy. Astron. Soc.*, 26].

FINAL DEL SOL