11-5. In what ways is the internal structure of a 1-M☉ main sequence star different from that of a 5-M☉ main sequence star? How is it different from a 0.5-M☉ main sequence star? What features are common to all these stars?

Compared with the more massive star, the sun-like star has a lower central temperature, relatively smaller radiative region and deeper convective zone; the dominant fusion reaction is the proton-proton chain, rather than the CNO cycle. Compared with the less massive star, the sun-like star has a higher central temperature, relatively larger radiative region and shallower convective zone. All three stars have a hydrogen-fusion principal energy source in which energy production is much higher at their centers than at shallower depths. All have a strong central mass concentration.

11-9. Why does helium fusion require much higher temperatures than hydrogen fusion.

Because helium has twice the positive charge on its nucleus that hydrogen has, two helium nuclei at the same separation as two hydrogen nuclei will have four times the electrical repulsive force acting on them as the hydrogen nuclei. Thus, getting the helium nuclei close enough to each other to react requires substantially higher collisional velocities, provided by substantially higher temperatures.

11-11. Explain how and why the turnoff point on the H-R diagram of a cluster is related to the cluster’s age.

In a star cluster the stars all form at roughly the same time and therefore are of the same age. Since the main sequence lifetime of a star decreases with stellar mass and therefore with luminosity, main sequence lifetime decreases monotonically from the bottom of the main sequence to the top. Thus we can think of a cluster forming with all of its stars on the main sequence, but as it ages, the point on the main sequence at which stars have just exhausted their central hydrogen and are beginning to evolve off the main sequence (the “turnoff point”) gradually shifts downward.

11-12. What is the difference between Population I and Population II stars? In what sense can the stars of one population be regarded as the “children” of the other population?

Population II stars formed earlier in the history of our Galaxy population I stars when, because they had had few predecessors, the available interstellar gas from which they formed was primarily hydrogen and helium with only a very low concentration of heavier elements. As the more massive members of population II quickly evolved through their late stages of mass loss including supernova explosions and other mass ejections, they enriched the interstellar medium in heavy elements, out of which enriched medium subsequent stars (population I) formed. Thus population I stars have greater heavy element concentrations than remaining population II stars and they are “children” of bygone population II stars in the sense that the heavier elements in them were synthesized in the cores of these bygone stars.