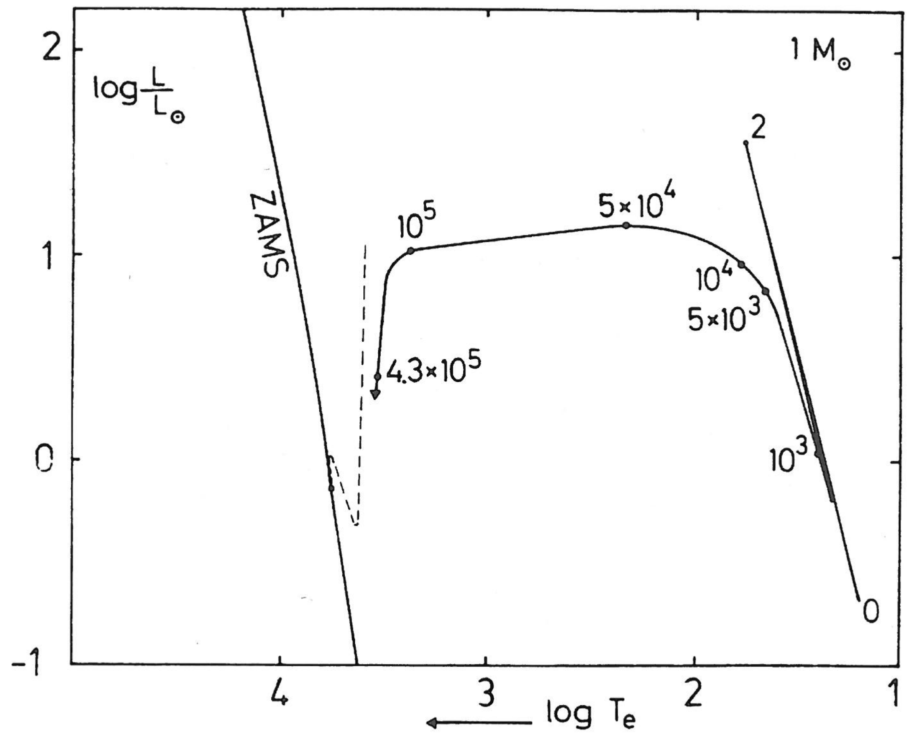

Figure 12.7 A theoretical evolutionary track of the gravitational collapse of a 1 $M_\odot$ cloud through the protostar phase (times are labeled in years since the development of a hydrostatic core). The dashed line shows the quasi-hydrostatic evolution of a pre-main-sequence star, beginning on the Hayashi track. Also shown is a portion of the zero-age main sequence (ZAMS). Both the Hayashi track and the ZAMS are discussed in Section 12.3. (Figure from Appenzeller and Tscharnuter, *Astron. Astrophys.*, *40*, 397, 1975.)

life histories of stars on the H–R diagram are known as **evolutionary tracks**. Figure 12.7 shows a theoretical evolutionary track of a 1 $M_\odot$ cloud during its collapse. As the collapse continues to accelerate, the luminosity of the cloud increases significantly while its effective temperature also increases.

Above the developing protostellar core, material is still in free-fall. When the infalling material meets the nearly hydrostatic core, a shock wave develops where the speed of the material exceeds the local sound speed (the material is supersonic). It is at this shock front that the infalling material loses a significant fraction of its kinetic energy in the form of heat that "powers" the cloud and produces much of its luminosity.

When the temperature reaches approximately 1000 K, the dust begins to vaporize and the opacity drops. This means that the radius where $\tau = 2/3$ is substantially reduced, approaching the surface of the hydrostatic core. Since the luminosity remains high during this phase, a corresponding increase in the effective temperature must occur.