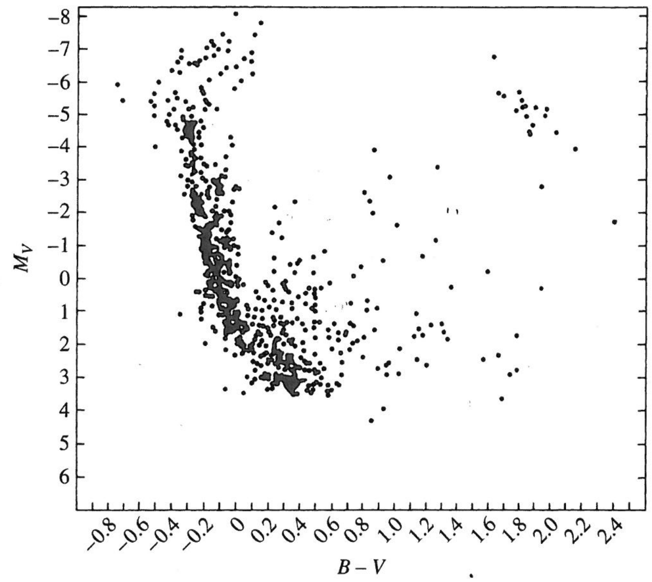

FIGURE 13.18 A color–magnitude diagram for the young double galactic cluster, h and χ Persei. Note that the most massive stars are pulling away from the main sequence while the low-mass stars in the middle of the diagram are still contracting onto the main sequence. Red giants are present in the upper right-hand corner of the diagram. (Figure adapted from Wildey, *Ap. J. Suppl.*, *8*, 439, 1964.)

in the cluster are currently leaving the main sequence, becomes redder and less luminous with time. Consequently, it is possible to estimate the age of a cluster by the location of the uppermost point of its main sequence. This fundamental technique is an important tool for determining ages of stars, clusters, our Milky Way Galaxy, and other galaxies with observable clusters, and even for establishing a lower limit on the age of the universe itself. A composite color–magnitude diagram of a number of clusters is shown in Fig. 13.19. Labeled vertically on the right-hand side is the age of the cluster corresponding to the location of the main-sequence turn-off point.

The Hertzsprung Gap

Another consequence of varying timescales can be seen in the color–magnitude diagram of h and χ Persei (Fig. 13.18). Apparent are red giants, together with low-mass pre-main-sequence stars. Also evident in the diagram is the complete absence of stars between the massive ones that are just leaving the main sequence and the few in the red giant region. It is unlikely that this represents an incomplete survey, since these stars are the brightest members of the cluster. Rather, it points out the very rapid evolution that occurs just after leaving the main sequence. This feature, known as the **Hertzsprung gap**, is a common characteristic of the color–magnitude diagrams of young, galactic clusters. The existence of the Hertzsprung gap is due to evolution on a Kelvin–Helmholtz timescale across the SGB, following the point when the hydrogen-depleted core exceeds the Schönberg–Chandrasekhar limit.

Notice in Fig. 13.19 that the cluster M67 does not show the existence of the Hertzsprung gap; the same can be said of M3 (Fig. 13.17). Recall that below about 1.25 $M_\odot$, the rapid