**Chapter 12: Evolution of Low-Mass Stars**

**12.1: The Life of a Main-Sequence Star Follows a Predictable Path**

**Changes in Structure**

* Evolutionary track
  + The path a star takes along an H-R diagram throughout its life
  + Stars of all masses grow smaller and hotter until they reach their positions as stars on the main sequence
* Mass related to luminosity
  + The more massive a star is, the more luminous it is because mass governs the rate of nuclear fusion in a star
  + Thus, mass is the main factor in how long a star will be on the main sequence, with less massive stars being their longer

**Helium Ash in the Center of the Star**

* Helium ash builds up in the center of the star
  + Ash = product of fusion, which collect at the core of the star
* As stars get older, they lose overall percentage of hydrogen and gain overall percentage of helium

**12.2: A Star Runs out of Hydrogen and Leaves the Main Sequence**

**Electron-Degenerate Matter in the Helium Core**

* Most of the volume of a star is made up of empty space, with hydrogen and helium gas spread throughout it
* These atoms are so small, however, that the space is virtually empty space
* As helium builds up in the core, gravity pulls these atoms closer and closer to the point that the electrons, which have been stripped from the nucleus, are smashed as close as they physically can be together
  + This is called electron-degenerate matter

**Hydrogen Shell Burning**

* Once a star has burned all hydrogen from its center, it starts to burn hydrogen from around the center
  + Called hydrogen shell burning
* Electron-degenerate matter gets smaller the more massive it is
  + As stars lose hydrogen in their core and more helium ash builds up, the core gets smaller yet more massive
  + The outer parts of the star expand rapidly, forming them into red giants
    - These red giants are huge, yet redder and cooler than other stars due to their surface area
    - Luminosity goes up

**The Evolution of the Star on the H-R Diagram**

* As all of this happens, the star leaves the main sequence in what is called a red giant branch, moving along it exponentially in speed
* Overall it leads to a snowball effect in terms of growing luminosity and energy output

**12.3: Helium Begins to Burn in the Degenerate Core**

**Helium Burning and the Triple-Alpha Process**

* Eventually the now-helium core gets so hot that the helium atoms collide with enough force to start helium fusion (helium burning)
* This process is known as the triple-alpha process
  + 2 helium atoms collide forming an unstable beryllium atom, which then if collided with another helium atom forms a stable carbon atom

**A Helium Flash**

* Helium burning throughout a star occurs fully within hours of starting, due to another snowball effect caused by the degenerate material in the core