The Interstellar Medium
- Gas and dust lying between stars (10% of the mass of our galaxy)
- Hydrogen is the most abundant element
- Observe molecules too: H$_2$O, CO, Ammonia, Hydrocarbons, Amino Acids, Alcohols
- ISM is found in different states: hot, warm, & cold

Giant Molecular Clouds
- Very cold, "dense" gas/dust clouds
- Masses $\sim 10^6$ $M_\odot$
- $\sim$ 100 ly in diameter
- 74% H, 25% He, 1% other **

**"Heavy" elements, or "metals" = all elements heavier than H

- GMCs are important because they are what stars form from
- When they are compressed:
  1. By cloud-to-cloud collisions
  2. By supernova explosions

Cloud Collapse
1. Cold, dense cloud starts to collapse gravitationally
   - One cloud may form many stars ("open" cluster)
   - The dense core (protostar) collapses quickly as more material "accretes" onto it
2. After $10^7$ yrs, mass builds to $\sim 1$ $M_\odot$
   - Core heats through the release of gravitation potential energy
   - Radiation pressure stops accretion
   - Protostar $\rightarrow$ pre-main-sequence star which contracts due to gravity
Cloud Collapse

3. When the core reaches $T \sim 10^7$ K, fusion starts and radiation pressure halts contraction.

4. Outer shell of gas/dust is blown off and we have a new star.

Mass is Most Important Property

- The star’s mass places it on the H-R diagram.

- If $M \lesssim 0.08 M_\odot$: Core doesn’t heat enough to start fusion.
  - Brown Dwarf (slightly more massive than Jupiter)

- If $M \gtrsim 100 M_\odot$: Outer envelope is blown off, and star is disrupted.

Nebula

- Hot O & B stars have lots of ultraviolet radiation and they ionize the surrounding nebula.
- Recombination makes the nebula glow (emission nebula).
- Because they are made of ionized H, we also call them HII regions (for singly ionized H).

Star Clusters

- Ionization shell/Supernovae compress gas leading to star formation
- Strings of star clusters of increasing age in large star forming regions
- By plotting stars in clusters, can determine age (more later)

Star Formation

- Gas clouds collapse (100,000 yrs)
- Stars form all together - cluster
- Most massive ones use fuel fastest (1 million yrs)
- Least massive live longest (100 billion yrs)
Extrasolar Planetary Systems
- Newly formed stars everywhere with gas/dust clouds and disks
- Planets form everywhere
- 164 extrasolar planets found as of November 2005