Chapter 6b
The Birth of the Solar System

1. The Solar Nebula
   Clues for the Model
   Summary of steps
   Composition

2. The collapse
   Start of Collapse
   Stages of Collapse
   Angular momentum

3. Proto Stars
   Proto Stars
   Stellar Disk
   T-Tauri Winds
   Inner Planets
   Outer Planets

Nebular theory
Early attempt: A cloud of gas broke into rings and condensed to form planets. There were doubts about the stability of such rings!

Catastrophic theories
Scientists then considered accidental or unlikely celestial events such as close encounter of the sun with a star? Such encounters are quite rare and the hot gases would dissipate rather than condense to planets

Condensation theory
Added effects of interstellar dust to the nebular theory. The dust help cool the nebula and acts to allow the condensation of particles

BIRTH PLACE OF STARS
Giant molecular clouds
The Orion Nebula is at the edge of an immense interstellar molecular cloud only 1,500 light-years away—the nearest large star-forming region.

The cloud is roughly
90 % hydrogen,
9 % helium
small amounts of everything else (like iron, carbon, oxygen, ...).
This large swirling cloud that formed the Solar System is referred to as the Solar Nebula.

Supernova creates a shock wave that pushes on nearby nebula.

Cloud of gas and dust contracts due to gravity;

As the cloud collapses, it heats up and compresses in the center.

Collapsing gas and dust heats through collisions to around 3000 K so everything in gaseous form

Conservation of angular momentum
The cloud flattens to a disk due to rotation

The initial collapse takes less than 100,000 years.
The protostar is likely to be surrounded by a remnant of the cloud from which it formed. -- ultimately creating the comet-shaped clouds of glowing gas.

Ultraviolet radiation from the star and nearby hot stars rapidly destroys the cloud.

Proto star (T Tauri Phase)
The star is bursting out of its dusty shell driven by the central heat and strong T Tauri Winds.

Gas molecules and dust grains in circular orbits --- those on noncircular orbits collide with particles and eventually dampen noncircular motion.

Eventually the star completes its contraction, where it begins to burn hydrogen.

Formation of Terrestrial and Jovian

- Rocks and metals condense, hydrogen compounds stay vaporized.
- Hydrogen compounds, rocks, and metals condense.

Small dust grains in the disk collide and coalesce. This process continues until the clumps are a few hundred kilometers across. At this time the objects are referred to as planetesimals.

- outer gas cooler than the inner gas
- metal stuff can condense (freeze) at high temperatures while volatile stuff condenses at lower temps
- at Jupiter temperature cool enough to freeze water further out ammonia and methane freezing out
The gravity of the planetesimals is large enough to start attracting other planetesimals and so form larger bodies.

Asteroid belt: remains of rocky planetesimals. There could have been a planet but it never formed due to the effect of Jupiter.

Jupiter can capture comets or eject comets from the solar system.

Kuiper Belt

Oort Cloud
End of Chapter 6b
The Solar System

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