Outline of Solar System Formation

Formation Model Must Explain (ideally)
  SS motion
types and general location of planets and moons
belts of asteroids and comets
possible reasons for the exceptions

Interstellar Medium
  98% H and He
  enriched by giants, supernova and merging neutron star byproducts
  now about 2% other stuff

Solar Nebula Prehistory
  hot gas cools by expansion & radiation
  contraction under gravity (Jean's mass)
  not enough contraction to form a solar system

Formation of Molecular Cloud
  enough contraction concentrates the dust-the cloud is opaque to visible light
  microwave emission (thermal energy to radiation) occurs
  microwaves pass through dust opaque to light cooling the cloud more
  molecules form (H₂, H₂O, NH₃, CH₄, CO₂, and over 100 other molecules
  cloud temperature drops below 50 K.

Some Event Triggers Collapse
  nova or supernova explosion, collision of clouds or other events
  solar nebula is now like a ball rolling downhill

Compression, Heating, Rotation
  center grows denser as matter accumulates
  center heats up-gravitational potential energy to thermal energy
  cloud rotates faster as size shrinks
  cloud of gas and dust must collapse to a flat disk

Condensation Sequence
  four types of material available:
    1. H & He–can never condense (98% of the nebula)
    2. H compounds [ices]–can condense if colder than ~150 K (1.4% of the nebula)
    3. rock–can condense if colder than ~1300 K (0.4% of the nebula)
    4. metals–can condense if colder than ~1600 K (0.2% of the nebula)

  materials condensed to small solid particles according to the local temperature
  disk had additional kinds of material from the center outward

Growth of Proto-Planets
  small solid particles grew by accretion
  when larger we call the planetesimals (little bitty planet parts)
  planetesimals grew by collision and gravitational attraction
  largest ones became over 100 km in size and dominated the scene
  they are now protoplanets and grew by attracting the smaller objects

The Jovian Puzzle
  there is more than one good model here
  leading model has the icy planetesimals forming most of the initial protoplanets
  gravity was sufficient to attract and hold He & H
  these planets grew quite massive from
    more kinds of material
    larger volume of the disk at that distance from the protosun

The Jovian Moons
  like the solar nebula, each jovian nebula went through compression, heating, rotation, disk formation
the flat protoplanetary disk also had a condensation sequence
this situation resulted in moons of different composition

Clearing the Air
the protosun grew into our young Sun
its intense radiation and the solar wind drove off the H & He
young stars have strong solar winds and are hotter (with more intense radiation)
the young Sun ended planet formation

Slowing the Sun's Rotation
model predicts the Sun should rotate quickly
fast rotation means
1. a large strong magnetic field &
2. vigorous surface activity-large sunspots and many solar flares
flares would ionize the remaining gas (negative & positive ions)
magnetic fields trap ions, lock onto them in a sense
these ions were driven away by the solar wind and radiation
but they also carried away the Sun's angular momentum

Asteroids & Comets
asteroids are the remaining rocky planetesimals
asteroid belt is a region that has no planet to sweep up the planetesimals
planet could not form because of Jupiter's gravity
comets are the remaining icy planetesimals
theory says should be a belt of comets past where no planet could sweep them up
and there is the Kuiper belt predicted decades before its observation
originally should have been asteroids and comets among the jovians
but stable orbits are impossible and they were all perturbed by jovians
that action sent them
1. inward to crash into the Sun or terrestrial planets
creating the period of heavy bombardment or
2. outward to form the Oort cloud
migration of the jovians would have finished off the leftover planetesimals

Evidence
studies of gas and dust confirm the prehistory
we see molecular clouds in regions forming stars & we detect the microwave radiation from them
isotopes in meteorites (leftover planetesimals) indicate a nearby supernova-our trigger
well understood physics supports the ideas of compression, heating, rotation, disk formation, the condensation sequence, accretion & the growth of protoplanets
stars in formation have flat disks of gas and disks and polar jets of gas from a hot object hidden within
young stars rotate very quickly & have strong magnetic fields
asteroid belts have been seen around young stars
comets have been seen around young stars