Our Solar System

Components

Sun

Ball of hot gas which generates light and heat through nuclear reactions in its core.

1000 times the mass of all other bodies put together.

Its gravitational pull holds the Solar system together.

Composition (by Mass):

71% Hydrogen

27% Helium

2% (Carbon, Oxygen, Nitrogen, etc)

Planets

9 Planets in all. In order of increasing distance they are:

Mercury, Venus, Earth, Mars

Jupiter, Saturn, Uranus, Neptune, Pluto

Planets move around Sun in nearly circular orbits, and all are nearly in the same plane (i.e. Solar system is pancake shaped).

Planets rotate around the Sun COUNTER CLOCKWISE as viewed from above the Earths North Pole.

Planets generally rotate on their own axis, in same direction as they orbit about the Sun. The inclination of the rotation axis to the orbital plane is generally small(less than 30 degrees)

Exceptions

Venus: Spins backward --- Retrograde rotation

Uranus and Pluto: Rotation axes lie nearly in their orbital plane.

Two distinct types of planets:

Inner (or Terrestrial) Planets:

Mercury, Venus, Earth, Mars

Small rocky planets with little or no atmosphere.

Rock: Mixture of Silicon, Oxygen, and heavy elements such as Aluminum, Magnesium, Sulphur, and Iron.

Density: 3.9 to 5.5 gm/cm^3

Outer (or Jovian) Planets

Jupiter, Saturn, Uranus., Neptune, (Pluto)

Gaseous, liquid, or icy

Larger than inner planets (except for Pluto)

Ice: Frozen liquids and gases:

Water H_2O

Ammonia NH_3

Methane CH_4

No solid surface between the gaseous outer regions and the liquid interior.

Density : 0.71 to 1.67 gm/cm^3

Satellites

Most planets have their own set of bodies (or satellites) that orbit them (except Mercury and Venus).

Mercury: 0 Venus: 0

Earth: 1

Mars: 2 Jupiter : 16

Saturn: 20 Uranus: 15

Neptune: 8 Pluto: 1

Moons generally orbit in circular paths, and have their orbit in approximately the same plane as their orbit about the Sun.

Exceptions: Uranus and Neptune

Asteroids

Rocky bodies with diameters from a few meters to 1000km.

Most asteroids circle the Sun in a large gap between Mars and Jupiter.

Probably remnant material that failed to aggregate into a planet (possibly due to disturbance by Jupiter's gravity).

Meteoroid

A chunk of rock in space. Similar to asteroid.Term asteroid generally only used for rocks greater than a few hundred meters across**.**

Meteor

Flash of light, visible at night, caused by a meteorite entering the Earth's atmosphere. The light is generated because the meteoroid heats up due to frictional heating caused by its passage through the Earth's atmosphere.

Meteorite

Piece of rock that has survived its decent from space.

Classified as stony, stony irons, and irons as determined by their chemical composition.

Comets

Icy bodies (Giant dirty snowballs?) 10 km across (or smaller).

They may grow huge tails as they approach the Sun.

At a distance of 3 to 5AU the Sun's heat is sufficient to vaporize the ices.

Material gets pushed, by **radiation pressure** and the **Solar Wind,** into a tail that points **AWAY** from Sun **.**

Two tails - ion tail and a curved dust tail.

Oort Cloud: Spherical region beyond Pluto (40,000 to 100,1000 AU) where majority of comets are believed to reside. Occasional collisions send a few bodies into the inner Solar System.

Origin of the Solar System

Any theory must explain:

1. Flatness of Solar System
2. The 2 types of Planets.
3. Similarity in composition of the Outer planets with the Sun.
4. The common age of about 4.5 billion years (i.e. 4.5×10^9) for objects in the Solar System.

Sun formed from collapse of an Interstellar gas cloud.

Interstellar gas cloud

Same composition as present Sun.

Composed mainly of gases (Hydrogen, Helium, Oxygen) and Interstellar grains (dirt).

Interstellar grains:

Mixture of silicates, iron compounds, carbon compounds, and water frozen into ice.

Cloud became unstable due to gravity and collapses. Gravitational collapse may have been triggered by a cloud collision or supernova explosion.

Because the cloud was rotating, collapse was impeded in directions perpendicular to the cloud's rotation axis. Cloud was therefore flattened.

Solar Nebula

After a few million years, cloud collapsed to become a rotating disk with a bulge in its center.

Disk: 200 AU in diameter [Pluto 40 AU]

10 AU thick

Condensation in the Solar Nebula

As a gas cools, its molecules combine (condense) to form liquid or solid particles.

The temperature at which condensation occurs depends on:

1. The substance condensing
2. The pressure

When a material cools, the substance with the highest vaporization temperature condenses first.

eg Iron condenses at 1300K

Silicon condenses at 1200K

Water at a few hundred K

Condensation process can be halted if the temperature stops decreasing.

Thus

Inside Jupiters Orbit:

Only silicate/iron particles.

Too hot for “ices” to condense.

Water, hydrogen present as gases.

Jupiters orbit and beyond.

Silicate/iron particles.

Ice particles.

Accretion:

The sticking of small pieces together to make larger pieces.

Small pieces held together by electrostatic forces.

Subsequent collisions allowed objects to form with sizes from millimeters to kilometers.

Kilometer objects are called **planetesimals.**

Planetesimals in the disk collide with one another, forming planets.

Some collisions lead to fragmentation.

Gentle collisions lead to merging.

Planetary orbits tends to become circular.

Growth is aided by gravitational attraction.

In outer solar system, Planet growth was more rapid because of the abundance of ice condensates.

The large gravitational attraction of the outer bodies allowed hydrogen and helium to be captured enhancing their growth still farther. Jupiter probably started out as a rock/ice core, somewhat larger than the Earth.

Small (and warmer) inner bodies (eg Earth) were too small to capture hydrogen, which was swept away.

The violent impact of planetesimals on a Planets surface liberated energy, melting the planet. This allowed DIFFERENTIATION to occur, with iron sinking to the core.

Formation of Moons.

Gravitational force of large planets drew in additional material, becoming ringed in material. Miniature solar system.

Moons mainly composed of rock, since too small to have captured much hydrogen.

The cratered surfaces of the Moon and Mercury bear vivid testimony to the final stages of planetary formation.

Collision with large bodies may have had HUGE effects.

- Collision of Mars sized body with Earth may have produced Moon.
- Collision of bodies with Uranus and Pluto may have produced the extreme tilt of their rotation axes.

Origin of Moon

1. Capture of small planet

2. Twins

Earth and Moon formed side by side.

3. Fission theory.

Earth spun very much faster in past. Moon broke off.

4. Impact Theory.

Impact of Mars sized body with Earth 4.5 billion years ago.

Collision occurred as Earth was forming.

Ejected material condensed to form Moon.

Moon contains material from Earth, and Impact body

NB: Density of Moon = 3.3 gm/cm^3

(c.f. with Earth = 5.5 gm/cm^3)

Formation of Atmospheres.

Jovian Planets were massive enough to capture their own atmospheres from the Solar Nebula. Therefore rich in Hydrogen

Inner Planets (eg Venus and Earth):

Atmosphere formed from volcanic eruptions.

Clearing of Solar System

Formation of planets took about 1 million years.

Sun became hot, blowing out a tenuous stream of gas from its surface. This pushed the remnant gas and dust into the outer Solar System.