

Solar system

Order of the Planets

Terrestrial Planets

Closest to Sun

Small Mass, Radius

Dense, rocky

Heavy molecules in atmospheres

Jovian Planets

Furthest

Large Mass, Radius

Gaseous, low density

Hydrogen, helium in atmosphere (+ methane, ammonia, water)

Formation of solar system

Current Characteristics that provide clues to process of formation

Mass mainly in the Sun

Planets in ecliptic

Orbits, rotations in same direction (generally)

Satellites orbit, rotate in the same direction (generally)

Density decreases with distance from Sun

Craters all over the place

Solar nebula

Chemical composition

Rotation

Temperature effect on composition

Formation of Planetismals - Condensation, accretion, collisions

Differentiation of planets – radioactive decay

Heavy Bombardment Era

Radioactive elements

Ages of solar system $1/2$ life

Supernova in the past

Other solar system

Method of detection

General characteristics of other systems

Earth

Interior studies –

Earthquakes

P-waves

S-waves

Focus

Epicenter

Shadow zones

Internal structure

Solid nickel-iron core

Liquid nickel-iron core

Magnetic Field – required conditions

Magnetosphere

Van Allen Belts

Aurora

Mantle

Lithosphere

Crust - types

Oceanic

Continental

Asthenosphere

convection

plate tectonics

sea floor spreading,

subduction,

Volcanoes - types

Basaltic

Composite – Andesitic Volcanoes

Hot spot volcanoes

Atmosphere

Composition

Primary Atmosphere

Secondary Atmosphere

Influences on Atmosphere composition

Volcanic gases

Formation of Oceans

Sedimentation

Biological processes

Greenhouse effect

Young vs Old planetary surface

The Moon

Surface features

No atmosphere

Craters

Mare

Highlands

Mountains

Volcanic features – volcanoes, rilles

Near side vs Far side

Tidal influences on Moon, Earth

Apollo exploration of the Moon

Moon Rocks

Basalt

Anorthosites,

Breccia

Origin of the Moon

Impact Theory

Support for Theory

Time line for Moon

Formation after the Earth
Heavy Bombardment
Formation of Mare
Human exploration

Mercury

Orbital period - Rotation Period relation
2 orbits = 3 rotations
Orbital Precession – General Relativity

Exploration

Mariner 10

MESSENGER (future mission)

Surface characteristics

No atmosphere

Craters,

Plains

Caloris Basin

Jumbled terrain

scarps

Internal structure

Venus

Slow retrograde rotation

General physical characteristics similar to the Earth

Mass, Radius, Composition

Atmosphere

Composition

Clouds – sulfuric acid

Pressure

Temperature

Greenhouse effect

Influences on atmosphere

Exploration

Venera Program

Pioneer, Magellan – radar mapping

Surface types

Lowlands

Rolling Plains

Continents

Aphrodite Terra – volcanos, large

Ishtar Terra - mountains, Maxwell Montes

Volcanic features

Volcanoes

Flow features

Arachnoids

Coronae

Pancakes

Mars

Features visible from Earth

Tilt of axis, length of day - like Earth

Ice caps

Atmosphere

Variation of surface features over time

Mars mistakes –

Giovanni Schiaparelli – canals

Percival Lowell's observations

Exploration

Viking 1, 2 – first successful landers

Pathfinder – first rover

Mars Global Surveyor (MGS)

2001 Mars Odyssey

Mars Express

Spirit & Opportunity

Ellipticity of Orbit

Seasonal variations

Dust storms

Atmosphere

Composition

Pressure

Temperatures

Internal Structure

Rocky

Poorly defined magnetic field

Surface Features

Craters – mainly in the south

Impact basins

Dry river channels – visible in the north

Volcanoes – mainly in the north

Rifts – Valles Marinaris

Ice caps – CO₂, H₂O

Desert dunes - sand

Tharsis Bulge

Olympus Mons and other volcanoes

Northern vs Southern Hemisphere features

Mars in the past

Thicker atmosphere

Water on the surface

Satellites of Mars –

Asaph Hall

Phobos, Deimos - characteristics

Jupiter

Largest Mass, Radius,

Composition – like the Sun

Exploration

Pioneer 10, 11

Voyager 1, 2,

Galileo – orbiter and probe

Visible Cloud layers

Haze

Ammonia

Ammonium Hydrosulfide

Water

Results from the *Galileo* probe

Hotter, denser

High speed winds

Chemically like Sun, minor differences

Differential Rotation

Great Red Spot

Lightning - cause

Internal Structure

Core

Liquid Metallic Hydrogen

Liquid Hydrogen

Visible cloud layers

Internal Heat source

Magnetic Field – source, strength

Ring

Galilean Satellites –

Io

Innermost

Tidal heating

Volcanoes

Sulfur

Rocky

Europa,

Icy

Water under ice

Less tidal heating

Ganymede

Largest satellite of all

Ice flow features

More craters

Callisto

Outermost

Craters

Icy

Saturn

Smaller version of Jupiter

Similar internal structure, composition, cloud layers

Less mass – lowest density
Less distinct cloud feature
Weaker magnetic field

Rings

Visible from the Earth
A, B, C rings
Cassini & Encke divisions
Tilted

Origin

Roche limit
Icy composition

Exploration

Pioneer 11, Voyager 1, 2
Cassini – current mission

Satellites – general characteristics

Titan

Largest of Saturn's
Atmosphere
Results from *Cassini-Huygens* probe

Enceladus

Results from *Cassini*

Uranus

Discovery by Herschel
Tilt of system – planet, satellite orbits, rings
Rings - discovery
Exploration – *Voyager 2*

Cloud features

Spots
Color of clouds - Methane

Internal Structure

Rock
Water, Methan, Ammonia “ocean”
Liquid H, He
Visible cloud layers

Magnetic field

Characteristics – off-axis, off-center
Source

Satellites – general characteristics

Miranda

Discoloration
Grooves
Cliffs
Cause?

Neptune

Discovery by Adams, Le Verrier (observed by Galle)
Exploration – *Voyager 2*

Similarities to Uranus

Similar size, radius, internal structure, composition

Cloud features

Great Dark Spot

Rings - ring arcs

Magnetic field

off-axis and off-center

Satellites – general characteristics

Triton

surface features

ice geysers

Pluto

Discovery by Tombaugh

Satellite: Charon

Discovery by Christy

Tidally locked system

Tilted system

Likely Composition

Atmosphere – nitrogen, methane, seasonal

Comets

Characteristics – Dirty Snowball

Ice – water, methane, ammonia, carbon dioxide

Dirt – carbon

Structure

Nucleus – core

Coma

Tails

Gas

Dust

Source of comets

Oort Cloud - long period comets

Kuiper Belt - short period comets

Other Objects

Quaoar – large Kuiper Belt object

Sedna(?) – inner Oort cloud?

Pluto – planet or Kuiper Belt object?

Famous comets

Halley's

Hale-Bopp

Comet exploration

Giotto – Halley's Comet

Stardust – Wild 2

Asteroids

Locations

Asteroid Belt

Trojan Asteroids

Near Earth Asteroids (NEA)
Potentially Hazardous Asteroids (PHA)

Exploration

Galileo images

NEAR spacecraft

Ceres – largest asteroid

Gaspra, Ida – observed by *Galileo*

Kirkwood gaps – influence of Jupiter

Types

S-types

Near Mars

Silicates (silicon) rich

C-types

Further out

Carbon rich

Most common

M-types

Metal

Least common

Meteors, Meteoroids, Meteorites

Difference of terms

Meteor Showers

Cause

Major Showers

Geminids

Leonids

Perseids

Meteorites

Stony -Most common

Silicon, Carbon

Carbonaceous chondrites – water, amino acids

Stony-Irons -rarest

Iron

Iron-nickel mix

Widmanstätten Figures

Martian Meteorites

Micro-meteorites

Impacts

Tunguska

Characteristics

Manson Iowa

Craters on the Earth

Impact on Jupiter

Shoemaker-Levy 9

Future impacts?