

Solar System

I. Origin of Solar System

- A. Nebular cloud of swirling gases and dust
- B. Composed mainly of hydrogen
- C. Gravitational collapse heated to fusion at center
 - 1. material with high melting temperatures
 - a. condensed in inner warm regions
 - b. silica, metal
 - c. accreted into inner rocky planets
 - 2. material with low melting temperatures
 - a. stayed melted in inner regions, condensed in outer regions
 - b. methane, water, ammonia, carbon dioxide
 - 1) lots of this stuff
 - 2) became primordial outer large planets
 - 3) large size has large gravitational field to hold light atoms
 - a) hydrogen and helium
 - b) gas giants

II. Overview of the solar system—Solar system includes

- A. Sun
 - 1. 99.85% of system mass
 - 2. Nuclear fusion of hydrogen into helium
- B. Objects in orbit around Sun
 - 1. Inner terrestrial planets
 - a. Mercury, Venus, Earth, Mars
 - b. Small, stony, Little atmosphere
 - 2. Outer gas planets
 - a. Jupiter, Saturn, Uranus, Neptune
 - b. Large, Gases (hydrogen and helium) and ices (methane, ammonia)
 - 3. Dwarf planets, asteroids, comets, meteoroids
 - a. Various compositions
 - 1) Terrestrial material,
 - 2) ices
 - b. various locations and orbits
 - 1) asteroid belt in planetary plane of orbit
 - c. highly eccentric and inclined orbits compared to eight planets

III. Composition of Solar System objects

- A. Gases—low melting temperature: about absolute zero
 - 1. hydrogen—most abundant gas in solar system
 - 2. helium
- B. Rocky and metallic material—high melting temperature: + 700° C
 - 1. silicate minerals—like igneous rocks
 - 2. pure metals and alloys—mostly iron and nickel

- C. Ices (of things besides water)—intermediate melting temperature
 - 1. Ammonia (NH_3)
 - 2. Methane (CH_4)
 - 3. Carbon dioxide (CO_2)
 - 4. Water (H_2O)

- D. Nebular cloud hypothesis of Solar System formation explains why inner planets and outer planets are different: temperatures and melting temperatures

IV. Planetary information

A. Mercury

- 1. Innermost planet
- 2. smallest planet 4880 km diameter
- 3. orbit
 - a. inclined 7° to Sun's equator
 - b. highly eccentric 45 million km to 70 million km
 - c. Revolves quickly Orbital period 88 Earth days
 - d. Rotates slowly 3 rotations in 2 orbits
 - 1) 179 Earth days for one Mercury mean solar day
 - 2) Table 21.1 says 59 days—that's a sidereal day WHAT'S THAT?
- 4. No atmosphere but trace of hydrogen and helium
- 5. Surface—
 - a. cratered highlands and vast, smooth terrains
 - b. scarps suggest crustal shortening
 - c. Extreme temperatures
 - 1) Cold nights (-173°C , -280°F)
 - 2) Hot days (427°C , 800°F)
- 6. Very dense—large iron core
- 7. Mariner 10 photo mosaic 1974 went to Venus first

B. Venus

- 1. motion
 - a. Orbit 225 days (text citation is in error)
 - b. Rotation is 243 Earth days, and retrograde (turns backwards)
 - c. Axial tilt 2° (178° retrograde)
- 2. Similar to Earth
 - a. Size 12000 km (c.f. 12756 km)
 - b. Density and composition
 - 1) 3000 km diameter iron core,
 - 2) partly molten rocky mantle
 - c. Location in the solar system
 - d. Has atmosphere—unlike Mars and Mercury
- 3. Shrouded in thick clouds
 - a. Impenetrable by visible light
 - b. Atmosphere is 97% carbon dioxide, 3% N_2 , trace H_2O
 - c. Surface atmospheric pressure is 90 times that of Earth's

4.Surface

- a. Mapped by radar by Magellan Project
- b. Features
 - 1) 80% of surface is subdued plains covered by volcanic flows
 - 2) Low density of impact craters
 - 3) Tectonic deformation active during the recent geologic past
 - 4) Thousands of volcanic structures

C. Mars

1.Called the "Red Planet"— "teleoscopic surface" close enough to view, and clear enough to see

2.Atmosphere

- a. 1% as dense as Earth's
- b. Primarily carbon dioxide 95%, 3% N₂, 1.6% Ar, trace H₂O
- c. Cold polar temperatures (-193 °F)
- d. Polar caps of water ice, covered by a thin layer of frozen carbon dioxide
- e. Extensive dust storms with winds up to 270 kilometers (170 miles) per hour
Mariner landed in a dust storm

3.Surface

- a. Less-abundant impact craters
- b. Numerous large volcanoes –largest is Mons Olympus, 75 km above mean surface (c. f. Everest, < 9 km above msl)
- c. Tectonically dead
- d. Several canyons
 - 1) Some larger than Earth's Grand Canyon
 - 2) Valles Marineras – the largest canyon
 - a) Almost 5000 km long
 - b) Formed from huge faults
- e. "Stream drainage" patterns
 - 1) Found in some valleys
 - 2) No bodies of surface water on the planet
 - 3) Possible origins
 - a) Past rainfall
 - b) Surface material collapses as the subsurface ice melts

4.Moons

- a. Two moons—Phobos 11 km, Deimos 6 km: close to surface
- b. Captured asteroids, probably

D. Jupiter

1.Largest planet, Very massive

- a. 2.5 more massive than combined mass of all other planets, satellites, and asteroids
- b. If it had been ten times larger, it would have been a small star
- c. 1/800 mass of Sun

2.Movement

- a. Rapid rotation-- Slightly less than 10 hours

- b. Orbital period—4332 Earthdays
- 3. Banded appearance
 - a. Multicolored Bands are aligned parallel to Jupiter's equator
 - b. Generated by wind systems
 - 1) Winds
 - a) to 200 mi./h at top of atmosphere (cloud tops)
 - b) measured to 400 mph inside
 - 2) Storms
 - a) Great Red Spot
 - i. In planet's southern hemisphere
 - ii. Counterclockwise rotating cyclonic storm
 - iii. Persistent over centuries—other storms survive a few days
 - b) move 7.5 degrees/day—48 days to circle planet
- 4. Structure—gas planet
 - a. atmosphere 90% H₂, 10% He
 - 1) density increases into depth of atmosphere until liquid mixture
 - 2) 'Surface' thought to be a gigantic ocean of liquid hydrogen
 - 3) Halfway into the interior, pressure causes liquid hydrogen to turn into liquid metallic hydrogen
 - b. Slightly bulged equatorial region—due to rapid rotation and lack of solid material
 - c. Rocky and metallic material probably exists in a central core
- 5. Moons
 - a. At least 63 moons—47 are less than 10 km diameter
 - b. Four largest moons
 - 1) Discovered by Galileo in 1610, Called Galilean satellites
 - a) He wanted to name them Medicean stars, after his patron Medici
 - b) But named by Marius in 1610 for figures in Zeus's life
 - 2) Each has its own character—very distinct from one another
 - a) Io
 - i. Innermost Galilean moon—slightly larger than Moon
 - ii. **Volcanically active**
 - a. heat source could be from tidal energy
 - b. internal stresses from Jupiter, and other Galilean moons
 - iii. Sulfurous/sodium-rich surface, iron (+/- sulfur) core, molten silica mantle
 - iv. Sulfur dioxide atmosphere
 - v. Magnetic field of its own imbedded within Jupiter's magnetic field

- b) Europa
 - i. Smallest Galilean moon
 - ii. Icy surface—
 - a. is there liquid water beneath it?
 - b. composition mostly rock (silicate minerals)
 - iii. Many linear surface features—what are these surface streaks?
 - iv. weak magnetic field, tenuous atmosphere of oxygen
 - c) Ganymede
 - i. Largest Jovian satellite—larger than Mercury
 - ii. Diverse terrains
 - a. Surface has numerous parallel grooves
 - b. areas of craters
 - iii. Magnetic field of its own imbedded within Jupiter's magnetic field
 - iv. Structure—inner iron +/- sulfur core, rocky mantle, ice crust
 - d) Callisto
 - i. Outermost Galilean moon—
 - ii. slightly smaller than Mercury, 1/3 Mercury's mass
 - iii. Densely cratered—most densely in solar system
 - iv. composed 40% ice, 60% rock/iron; CO₂ atmosphere
 - c. Ring system
 - 1) dark, composed of dust (not ice, like Saturn's)
 - 2) continually resupplied by micrometeor impacts with Metis,Adrastea, Amalthea, Thebe (four inner moons of Jupiter)
6. Interplanetary reach of Jupiter
- a. huge magnetic field reaches past Saturn—contains charged particles
 - b. intense radiation belt between ring and uppermost cloudtops
- E. Saturn
- 1. Smaller, but similar to Jupiter in its
 - a. Atmosphere
 - b. Composition
 - c. Internal structure
 - 2. Rings
 - a. Most prominent feature
 - b. Discovered by Galileo in 1610—but he didn't properly conceptualize them
 - c. Geometry correctly inferred by Huygens in 1659
 - d. Complex Composed of small particles (moonlets) that orbit it
 - 1) Most rings fall into two categories based on particle density
 - a) Main rings contain particles from a few centimeters to several meters in diameter

- b) Faintest rings are composed of very fine (smoke-size) particles
 - 2) Thought to be debris ejected from moons
 - 3) Origin is still being debated
 - 3. Other features
 - a. Dynamic atmosphere—10% polar flattening, equatorial bulge
 - b. Large cyclonic storms similar to Jupiter's Great Red Spot
 - c. Thirty named moons
 - 1) Titan – the largest Saturnian moon—larger than Mercury
 - a) Second largest moon in solar system (Ganymede)
 - b) substantial atmosphere—N₂, 6% argon, few % CH₄
 - c) surface very new—
 - i. tectonic, windblown, liquid methane, volcanic
 - ii. There is clear evidence for "precipitation, erosion, mechanical abrasion and other fluvial activity".
 - d) composed of water ice and rocky silicates
 - 2) Enceladus: shiniest object in solar system—new ice!
 - 3) other moons:
 - a) some are captured asteroids,
 - b) Phoebe has retrograde motion
- F. Uranus (ooRAINus)—discovered 1781, barely visible to naked eye
 - 1. rock, ices, atmosphere 83% H₂, 15% He, 2% methane
 - 2. Rotates "on its side"
 - 3. Rings—similar composition to Jupiter's rings
 - 4. Large moons w/ varied terrains—5 are 10-100x larger than others
 - a. 40-50% water ice, remainder is rock
 - b. Titania, Oberon, Umbriel, , Ariel, Miranda
 - 5. Uranus and Neptune are nearly twins--bluish in appearance
- G. Neptune
 - 1. Dynamic atmosphere--composed of methane
 - a. One of the windiest places in the solar system
 - b. Great Dark Spot disappeared, new one in N hemisphere
 - c. White cirrus-like clouds above the main cloud deck
 - 2. Eight named satellites, five others recently discovered
 - a. Triton – largest Neptune moon—nearly as big as Moon
 - 1) Orbit is opposite other planet's travel (retrograde rotation)
 - 2) Lowest surface temperature in the solar system (-391 °F)
 - 3) Atmosphere of mostly nitrogen with a little methane
 - 4) Volcanic-like activity—ice volcanoes
 - 5) Water ice, layers of solid nitrogen and methane
 - b. We know little about the other satellites of Neptune
 - 3. Has rings like Uranus, curiously oriented magnetic field generated by ? : water within planet
 - 4. Galileo saw Neptune in 1613, but thought it was a star