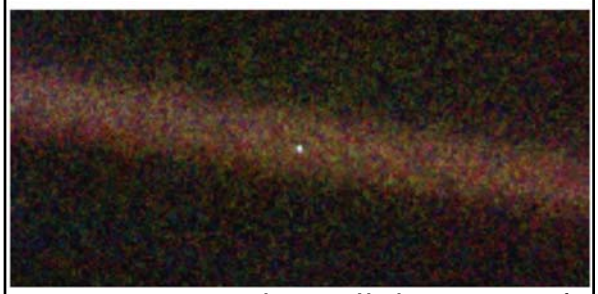
Chapter 7
Our Planetary System

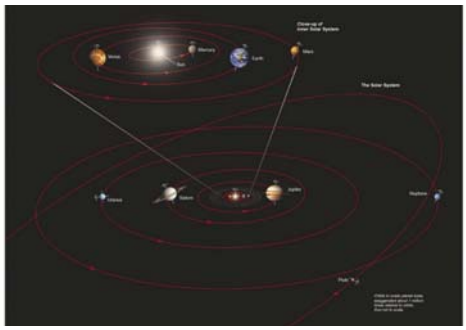


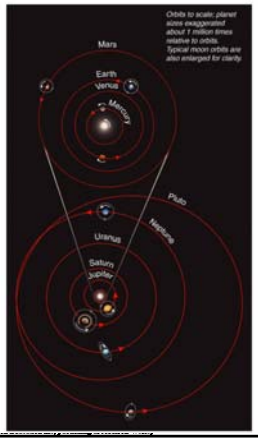
Earth, as viewed by the Voyager spacecraft

7.1 Studying the Solar System

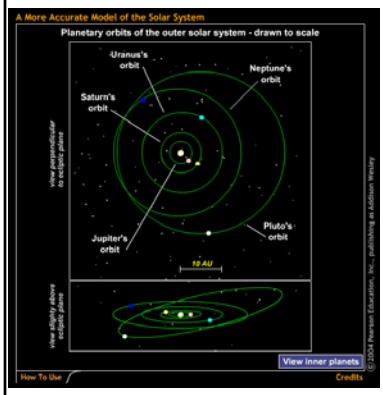
- Our goals for learning
- What does the solar system look like?
- What can we learn by comparing the planets to one another?
- What are the major features of the Sun and planets?

What does the solar system look like?



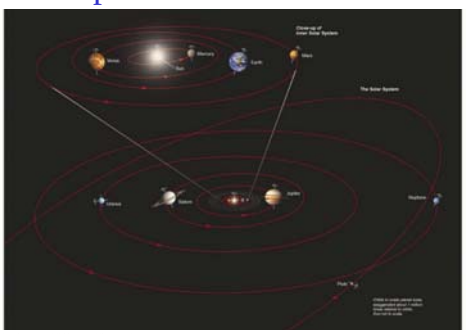


- Eight major planets with nearly circular orbits
- Pluto is smaller than the major planets and has a more elliptical orbit



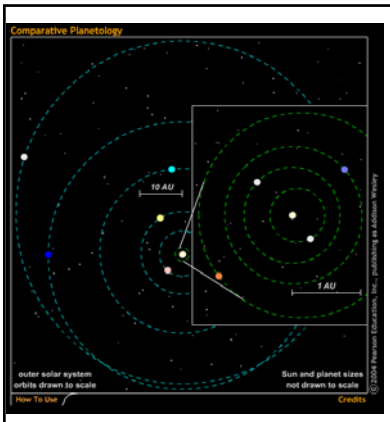
- Planets all orbit in same direction and nearly in same plane

What can we learn by comparing the planets to one another?



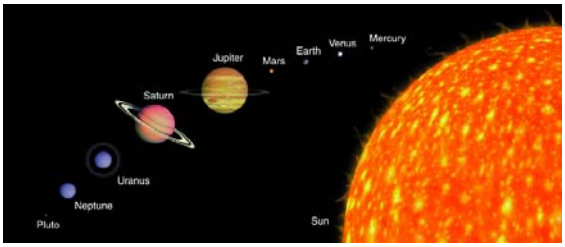
Comparative Planetology

- We can learn more about a world like our Earth by studying in context with other worlds in the solar system.
- Stay focused on *processes* common to multiple worlds instead of individual facts specific to a particular world.



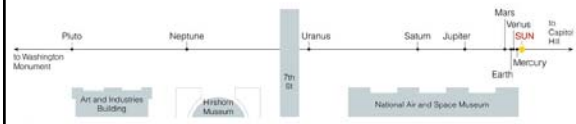
- Comparing the planets reveals patterns among them
- Those patterns provide insights that help us understand our own planet

What are the major features of the Sun and planets?

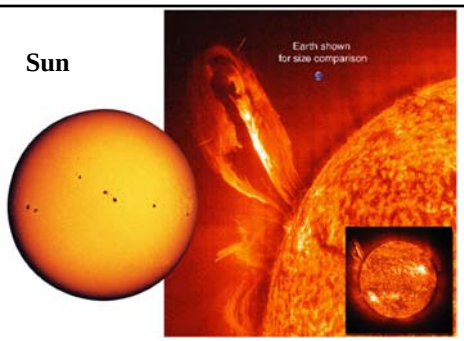


Sun and planets to scale

Planets are very tiny compared to distances between them.

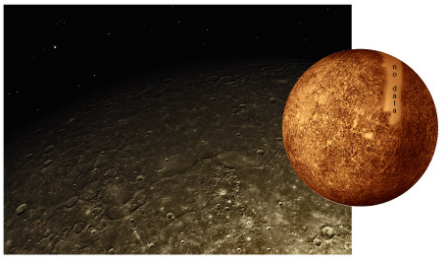


Sun



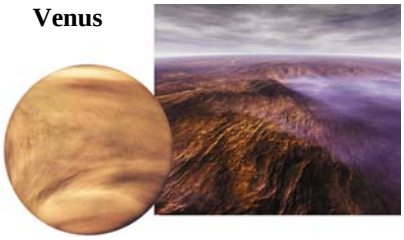
- Over 99.9% of solar system's mass
- Made mostly of H/He gas (plasma)
- Converts 4 million tons of mass into energy each second

Mercury



- Made of metal and rock; large iron core
- Desolate, cratered; long, tall, steep cliffs
- Very hot and very cold: 425°C (day), –170°C (night)

Venus



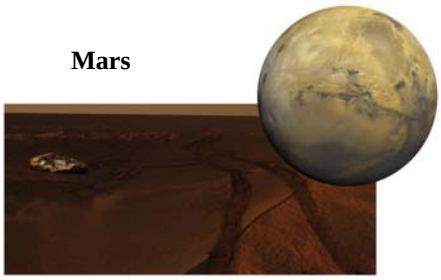
- Nearly identical in size to Earth; surface hidden by clouds
- Hellish conditions due to an extreme **greenhouse effect:**
- Even hotter than Mercury: 470°C, day and night

Earth

Earth and
Moon to scale

- An oasis of life
- The only surface liquid water in the solar system
- A surprisingly large moon

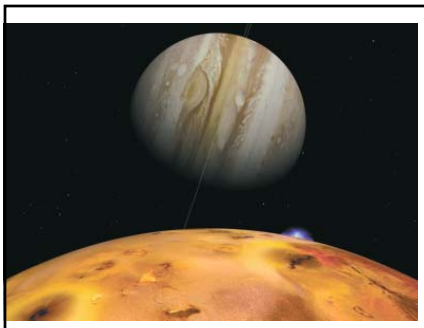
Mars



- Looks almost Earth-like, but don't go without a spacesuit!
- Giant volcanoes, a huge canyon, polar caps, more…
- Water flowed in the distant past; could there have been life?

Jupiter

- Much farther from Sun than inner planets
- Mostly H/He; no solid surface
- 300 times more massive than Earth
- Many moons, rings …

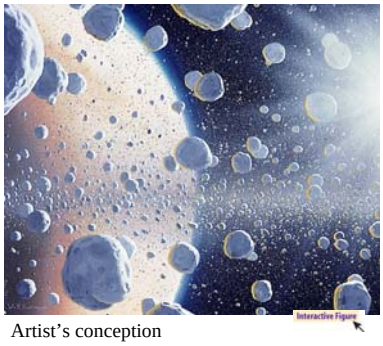


Jupiter's moons can be as interesting as planets themselves, especially Jupiter's four *Galilean moons*

- Io (shown here): Active volcanoes all over
- Europa: Possible subsurface ocean
- Ganymede: Largest moon in solar system
- Callisto: A large, cratered "ice ball"

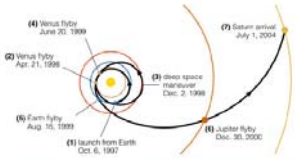
Saturn

- Giant and gaseous like Jupiter
- Spectacular rings
- Many moons, including cloudy Titan
- Cassini spacecraft currently studying it



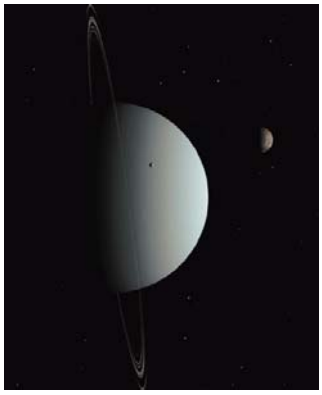
Artist's conception

Rings are NOT solid; they are made of countless small chunks of ice and rock, each orbiting like a tiny moon.



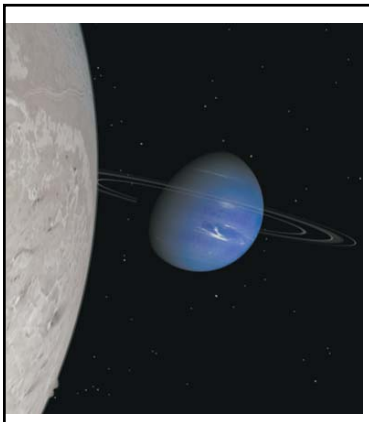
Cassini probe arrived July 2004

(Launched in 1997)



Uranus

- Smaller than Jupiter/Saturn; much larger than Earth
- Made of H/He gas & **hydrogen compounds** (H_2O, NH_3, CH_4)
- Extreme axis tilt
- Moons & rings



Neptune

- Similar to Uranus (except for axis tilt)
- Many moons (including Triton)

Pluto

- Much smaller than other planets
- Icy, comet-like composition
- Its moon Charon is similar in size

TABLE 6.1 *Planetary Data*[1]

Photo	*Planet*	*Relative Size*	*Average Distance from Sun (AU)*	*Average Equatorial Radius (km)*	*Mass (Earth = 1)*	*Average Density (g/cm³)*	*Orbital Period*	*Rotation Period*	*Axis Tilt*	*Average Surface Or Cloud Top Temperature*[2]	*Composition*	*Known Moons (2006)*	*Rings*[3]
	Mercury	•	0.387	2,440	0.055	5.43	87.9 days	58.6 days	0.0°	700 K (day) 100 K (night)	Rocks, metals	0	No
	Venus	•	0.723	6,051	0.82	5.24	225 days	243 days	177.3°	740 K	Rocks, metals	0	No
	Earth	•	1.00	6,378	1.00	5.52	1.00 year	23.93 hours	23.5°	200 K	Rocks, metals	1	No
	Mars	•	1.52	3,397	0.11	3.93	1.88 years	24.6 hours	25.2°	240 K	Rocks, metals	2	No
	Jupiter	●	5.20	71,492	318	1.33	11.9 years	9.93 hours	3.1°	125 K	H, He, hydrogen compounds[4]	61	Yes
	Saturn	●	9.54	60,268	95.2	0.70	29.4 years	10.6 hours	26.7°	95 K	H, He, hydrogen compounds[4]	31	Yes
	Uranus	●	19.2	25,559	14.5	1.32	83.8 years	17.2 hours	97.9°	60 K	H, He, hydrogen compounds[4]	24	Yes
	Neptune	●	30.1	24,764	17.1	1.64	165 years	16.1 hours	29.6°	60 K	H, He, hydrogen compounds[4]	13	Yes
	Pluto	·	39.5	1,160	0.0022	2.0	248 years	6.39 days	112.3°	40 K	Ices, rock	1	No

What have we learned?

- What does the solar system look like?
  - Planets orbit Sun in the same direction and in nearly the same plane.
- What can we learn by comparing the planets to one another?
  - Comparative planetology looks for patterns among the planets.
  - Those patterns give us insight into the general processes that govern planets
  - Studying other worlds in this way tells us about our own Earth

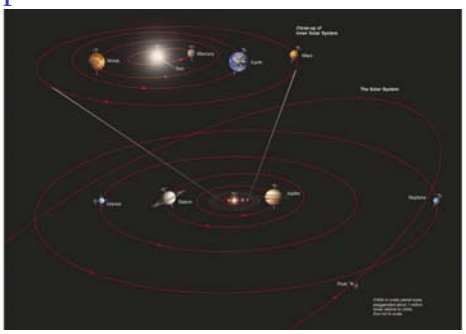
What have we learned?

- What are the major features of the Sun and planets?
  - Sun: Over 99.9% of the mass
  - Mercury: A hot rock
  - Venus: Same size as Earth but much hotter
  - Earth: Only planet with liquid water on surface
  - Mars: Could have had liquid water in past
  - Jupiter: A gaseous giant
  - Saturn: Gaseous with spectacular rings
  - Uranus: A gas giant with a highly tilted axis
  - Neptune: Similar to Uranus but with normal axis
  - Pluto: An icy "misfit" more like a comet than a planet

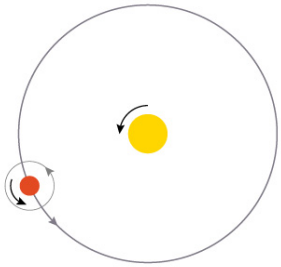
7.2 Patterns in the Solar System

- Our goals for learning
- What features of the solar system provide clues to how it formed?

What features of the solar system provide clues to how it formed?

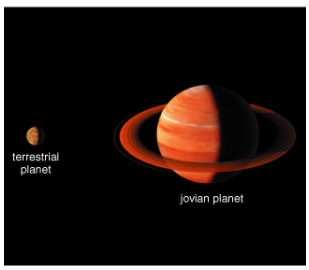


Motion of Large Bodies



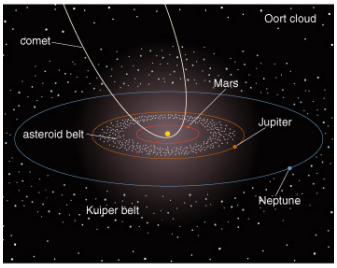
- All large bodies in the solar system orbit in the same direction and in nearly the same plane
- Most also rotate in that direction

Two Main Planet Types



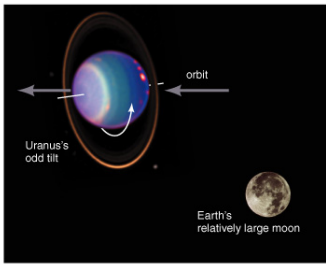
- Terrestrial planets are rocky, relatively small, and close to the Sun
- Jovian planets are gaseous, larger, and farther from Sun

Swarms of Smaller Bodies



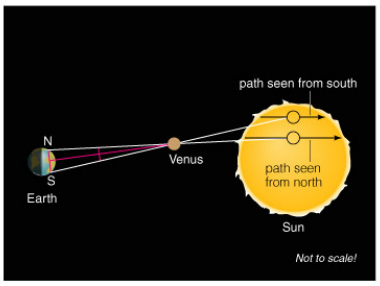
- Many rocky asteroids and icy comets populate the solar system

Notable Exceptions



- Several exceptions to the normal patterns need to be explained

Special Topic: How did we learn the scale of the solar system?

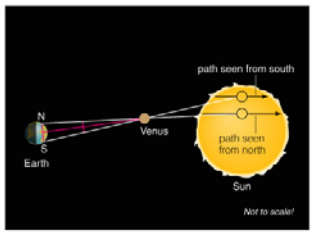


Transit of Venus

Transit of Venus: June 8, 2004

- Apparent position of Venus on Sun during transit depends on distances in solar system and your position on Earth

Measuring Distance to Venus



- Measure apparent position of Venus on Sun from two locations on Earth
- Use trigonometry to determine Venus' distance from the distance between the two locations on Earth

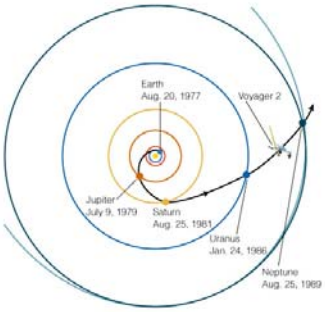
What have we learned?

- What features of the solar system provide clues to how it formed?
  - Motions of large bodies: All in same direction and plane
  - Two main planet types: Terrestrial and jovian
  - Swarms of small bodies: Asteroids and comets
  - Notable exceptions: Rotation of Uranus, Earth's large moon, etc.

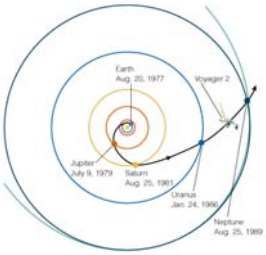
7.3 Spacecraft Exploration of the Solar System

- Our goals for learning
- How do robotic spacecraft work?

How do robotic spacecraft work?



Flybys



- A flyby mission flies by a planet just once
- Cheaper than other mission but have less time to gather data

Orbiters

- Go into orbit around another world
- More time to gather data but cannot obtain detailed information about world's surface

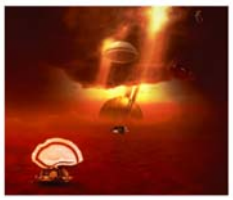
Probes or Landers

- Land on surface of another world
- Explore surface in detail

Sample Return Missions

- Land on surface of another world
- Gather samples
- Spacecraft designed to blast off other world and return to Earth
- Apollo missions to Moon are only sample return missions to date

Combination Spacecraft



- Cassini/Huygens mission contains both an orbiter (Cassini) and a lander (Huygens)

What have we learned?

- How do robotic spacecraft work?
  - Flyby: Flies by another world only once.
  - Orbiter: Goes into orbit around another world
  - Probe/Lander: Lands on surface
  - Sample Return Mission: Returns a sample of another world's surface to Earth