



Formation Theory:



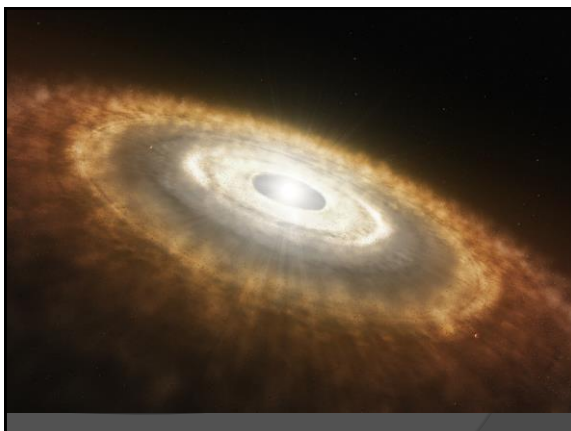
- Theories of the origin of the solar system rely on direct observation and data from probes.

Formation Theory:



- Scientific theories must explain **observed facts**, such as the shape of the solar system, differences among planets, and the nature of the oldest planetary surfaces- asteroids, meteorites, and comets.

FORMATION OF THE SOLAR SYSTEM – Solar Nebula Theory



The Solar Nebula Theory

- The Solar Nebula Theory is the theory most commonly held by scientists as to how our solar system formed.
- It explains that a planetary system forms from a huge cloud of gas and dust.

A Collapsing Interstellar Cloud:

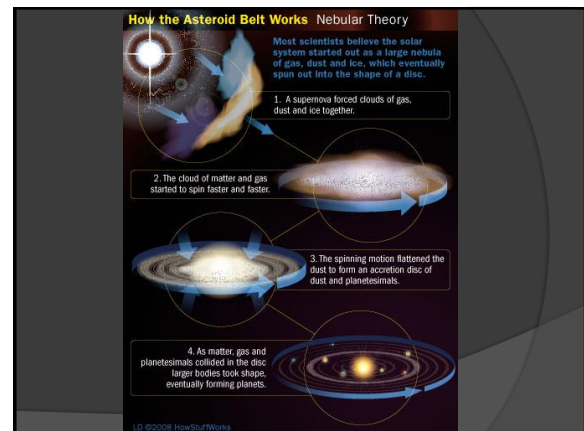
- Stars and planets form from interstellar clouds (**Nebula**), which exist in space between the stars.
- These clouds consist mostly of **hydrogen** and **helium** gas with traces of other elements and dust.

A Collapsing Interstellar Cloud:

- At first, the collapse of an interstellar cloud is **slow**, but it gradually accelerates and the cloud becomes much **denser** at its center.

A Collapsing Interstellar Cloud:

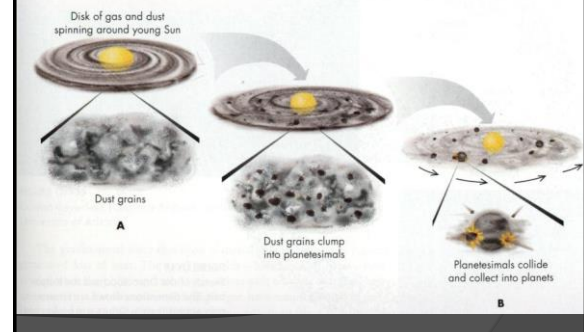
- If rotating, the cloud spins faster as it contracts, for the same reason an ice skater spins faster as they pull in their arms.



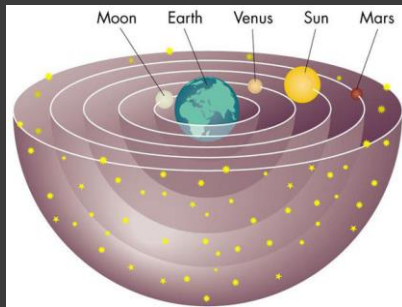
Planetesimals:

- Planetesimals** are objects hundreds of kilometers in diameter.
- Planetesimals are objects which collided together to form larger objects known as planets.

Planetesimals:

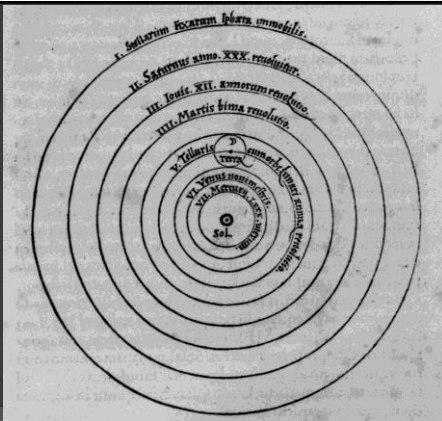


Geocentric Model



Nicholas Copernicus

- Polish scientist
- In 1543, suggested that the Sun was the center of the universe.
- The Earth and the other planets orbit around the Sun.
- "Heliocentric Model"**



Heliocentric Model



Tycho Brahe

- Danish Astronomer
- Designed and built accurate equipment to make accurate observations of planet' positions before the telescope was used in astronomy.



Tycho Brahe

- Lost his nose in a sword fight.
- Lived on his own island with a pet elk.
- Died of a ruptured bladder at a dinner party.



Johannes Kepler

- German Astronomer
- Used Brahe's data, he demonstrated that each planet orbits the Sun in an ellipse
- Kepler's first law of planetary motion.



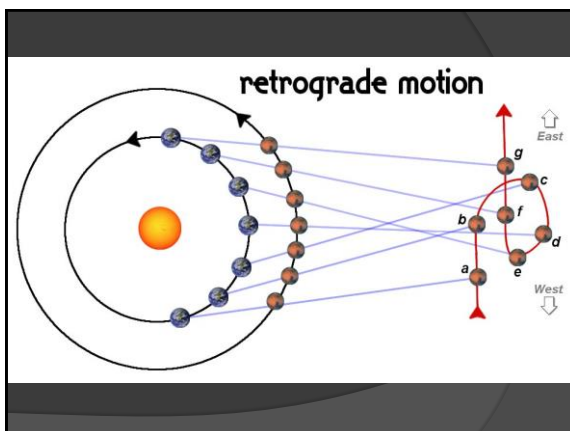
Kepler's Laws

- The length of time it takes a planet to make one complete orbit around the Sun is called the orbital period = P
- He noted that P was related to the distance of the planet to the Sun = a

$$P^2 = a^3$$

Retrograde Motion

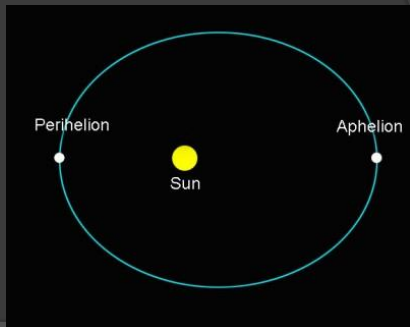
- Retrograde motion is the apparent backward movement of a planet.
- The search for an explanation of this motion motivated early astronomers for a better explanation for the design of the solar system.



Ellipse

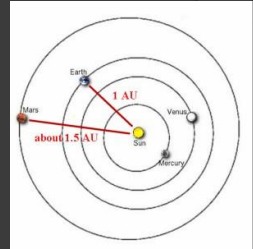
- An ellipse is an oval shape that is centered on two points instead of a single point.
- Kepler demonstrated that each planet orbits the sun with an elliptical orbit, not a circular orbit.

Elliptical orbit



Astronomical Unit

- An astronomical unit (AU) is a unit used to measure distance within the solar system. 1 AU is the distance from the Sun to the Earth.



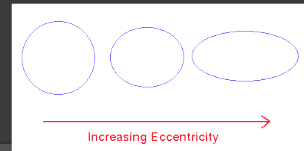
Astronomical Unit



Sun	-----
Mercury	0.4 A.U.
Venus	0.7 A.U.
Earth	1.0 A.U.
Mars	1.5 A.U.
Jupiter	5.2 A.U.
Saturn	9.5 A.U.
Uranus	19.2 A.U.

Eccentricity

- The shape of a planet's elliptical orbit is defined by eccentricity.
- Eccentricity is the ratio of the distance between the focal points and the diameter of the orbit.



Gravity:

- Newton first developed an understanding of gravity by observing falling objects.
- Newton's law of universal gravitation states that the mass of and the distance between two bodies determines the force between them.



Newton's Law of Universal Gravitation

$$F = \frac{Gm_1m_2}{r^2}$$

Universal Gravitation Equation

- ◉ F = Force of Gravity between two objects (in Newtons, N)
- ◉ G = Universal Gravitation Constant
 $G = 6.673 \times 10^{-11} \text{ N m}^2/\text{kg}^2$
- ◉ m_1 and m_2 are the masses of the two objects in kg
- ◉ r = the distance between the two objects centers in meters.

Multiplying in Scientific Notation

- ◉ To multiply two numbers expressed in scientific notation, simply multiply the numbers out front and add the exponents.
- ◉ $(n \times 10^a) \cdot (m \times 10^b) = (n \cdot m) \times 10^{a+b}$

Ex: $5.0 \times 10^4 \cdot 3.0 \times 10^3 = 15 \times 10^7 = 1.5 \times 10^8$

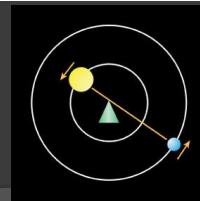
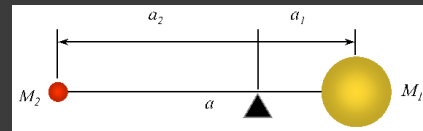
Dividing in Scientific Notation

- ◉ To divide two numbers expressed in scientific notation, simply divide the numbers out front and subtract the exponents.

$$\frac{n \times 10^a}{m \times 10^b} = \frac{n}{m} 10^{a-b}$$

$$\frac{6.2 \times 10^6}{3.1 \times 10^3} = \frac{6.2}{3.1} \times 10^{6-3} = 2.0 \times 10^3$$

Center of mass



Planetesimals:

- ◉ **Planetesimals** are objects hundreds of kilometers in diameter.
- ◉ Planetesimals are objects which collided together to form larger objects known as planets.

Gas Giants Form

- ◉ The first large planet to develop was Jupiter.
- ◉ Jupiter increased in size through the merging of icy planetesimals that contained lighter elements.
- ◉ Saturn and the other gas giants could not become as large because Jupiter collected so much material.

Terrestrial Planets Form

- Planets also formed by the merging of planetesimals in the inner part of the main disk, by the Sun.
- These were composed of elements that resist vaporization.
- This is why the inner planets are rocky and dense.
- The inner planets did not develop satellites.

Debris

- Material that remained after the formation of planets and satellites is called debris.
- Thousands of asteroids have been detected between the orbits of Mars and Jupiter.
- This is debris that never formed planets because of the gravitational effect of Jupiter.

Solar System Soup Lab

- We will be using vermiculite and water to model the solar nebula theory.
- Vermiculite is a mineral used in gardening and for insulation.
- Toxic: Do not consume!



What is a Planet?

- In August of 2007 the International Astronomical Union redefined what a planet is (no official scientific definition of a "planet" existed before). A planet:
 - Is a body that orbits the sun (this definition only applies to our Solar System)
 - Is large enough for its own gravity to make it round
 - And has "cleared its neighborhood" of smaller objects
- So a new the category of dwarf planet was created, which currently includes Pluto, Eris*, and Ceres**.

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The Inner Planets

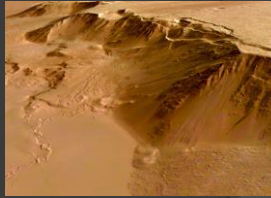
Terrestrial Planets

- Terrestrial planets are planets similar in distance from the sun as Earth that have a solid, rocky surface.



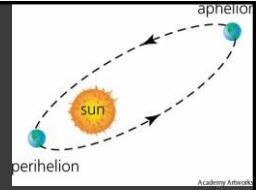
Scarps:

- **Scarps** are systems of cliffs, caused by the shrinking and cracking of a planet's crust



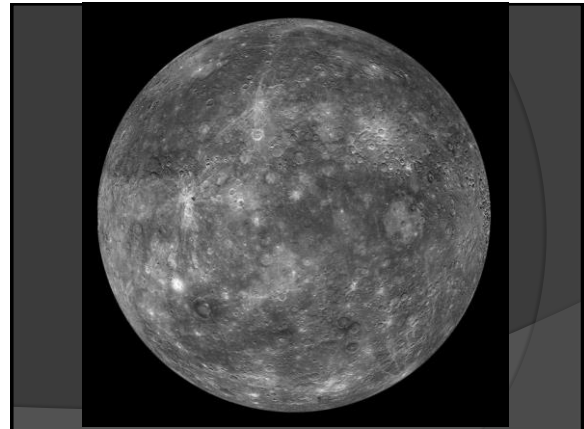
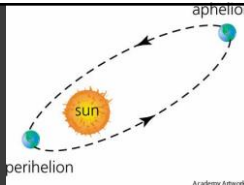
Mercury

- Orbit
 - highly eccentric
 - perihelion 46 million km
 - aphelion it is 70 million km
- Mercury only rotates 1 and a half times at the end of it's orbit around the sun.
- This means that two mercury years = three mercury days.



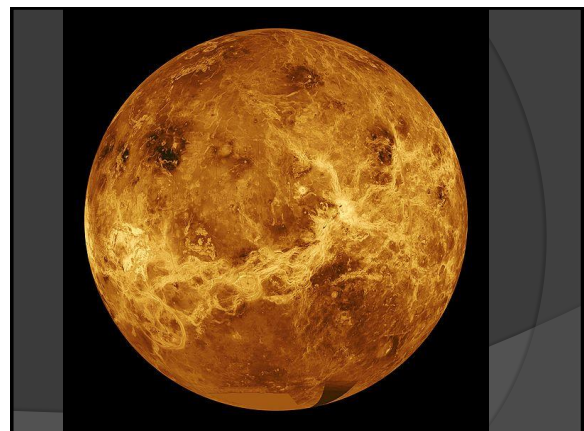
Mercury

- Closest to sun
- Appears to travel fastest
- 8th largest (smallest)
- Thin atmosphere of oxygen and sodium atoms.
- Daytime Temp = 427 degrees C
- Nighttime temp = -173 degrees C



Venus

- 2nd from Sun
- 6th largest
- brightest
- inferior planet
 - shows phases when viewed from Earth
 - Galileo's observed phases
 - Copernicus used data to develop heliocentric theory.



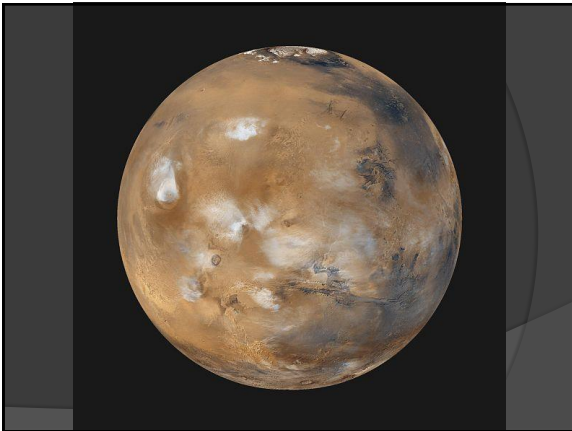
Earth

- ◉ 3rd from the Sun
- ◉ Moon is 1/6 mass of Earth
- ◉ period of rotation: 24 hours
- ◉ period of orbit: 365.25 days



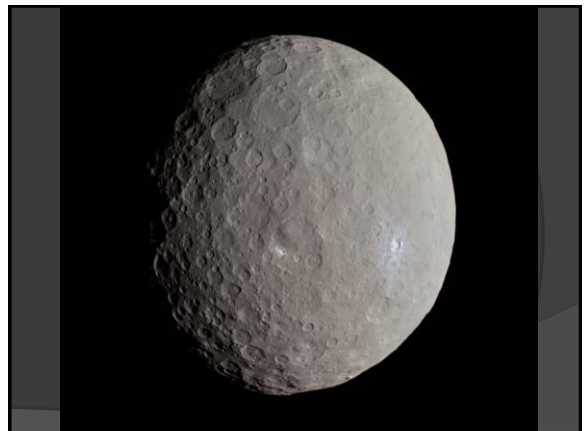
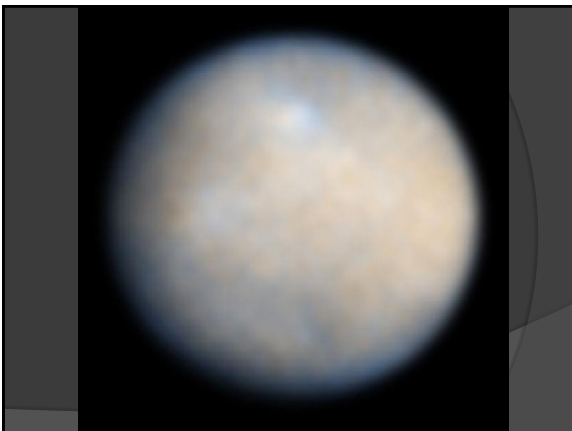
Mars:

- ◉ Mars is the 4th Planet from the Sun
- ◉ Solid carbon dioxide is found at the poles
- ◉ Mars is known as the Red Planet



Ceres (dwarf Planet)

- ◉ Largest known object in the asteroid belt
- ◉ Smallest of the 5 dwarf planets
- ◉ Ceres appears to have a rocky core and icy mantle, and may harbor an ocean of liquid water under its surface.





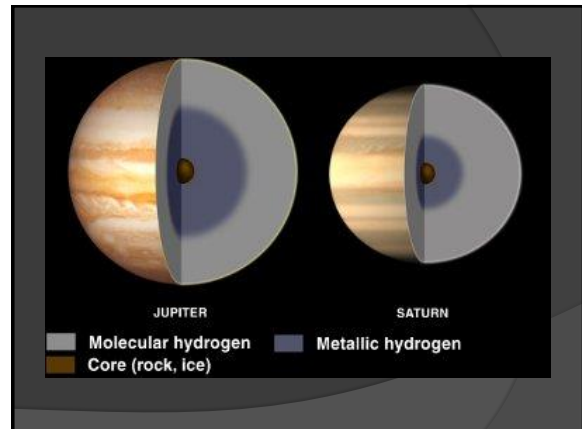
Gas Giant Planets:

- Very large planets made entirely of gas or liquid with a possible solid core.
- Jupiter, Saturn, Uranus, Neptune



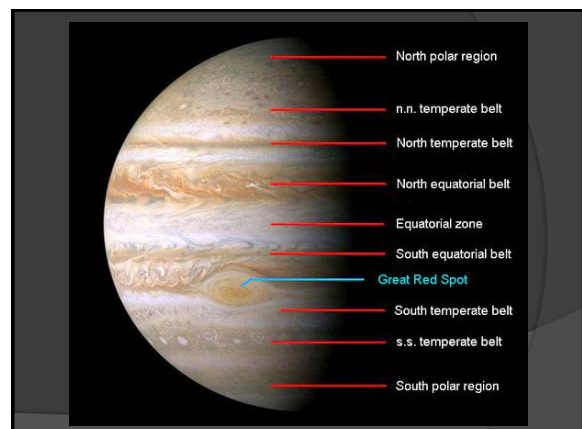
Liquid Metallic Hydrogen

- A form of hydrogen that has properties of both a liquid and a metal.
- Only exists under very high pressure.
- Liquid metallic hydrogen is found at the core of Jupiter and Saturn, generating a magnetic field.



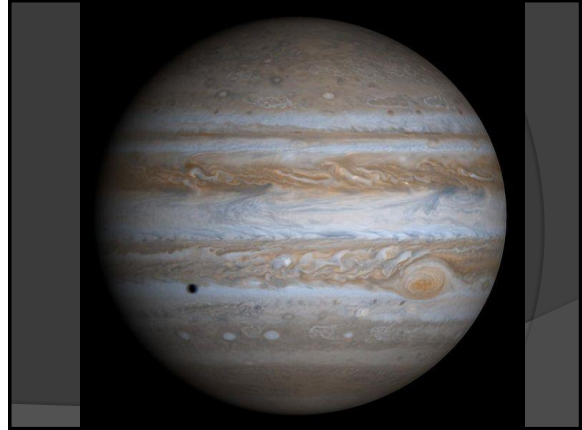
Belts and Zones

- Belts** are low, warm, dark-colored clouds that sink, and **zones** are high, cool, light colored clouds that rise.
- This is what give Jupiter and Saturn their bands of alternating dark and light colors.



Jupiter

- ◉ Jupiter contains over 70% of the mass in the solar system outside the Sun.
- ◉ It is about 11 times the radius and 330 times the mass of the earth.
- ◉ It is the first representative of the outer solar system.
- ◉ Unlike the inner planets, Jupiter is not a solid body, but instead is a ball of gas and liquid (mostly hydrogen and helium).

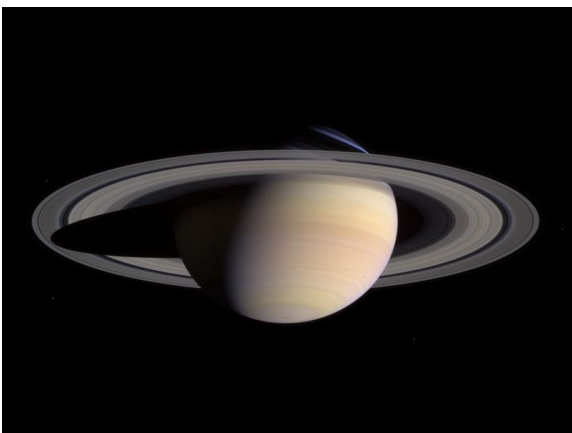


Saturn

- Saturn is a gas giant.
- It has strong surface winds (500 m/sec).
- Saturn is less dense than water.
- Saturn's magnetic field is 20x less than Jupiter's, but its core rotation period (10.5 hours) is similar.

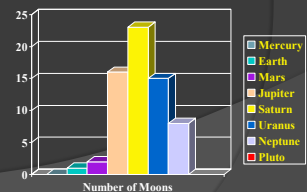
Saturn

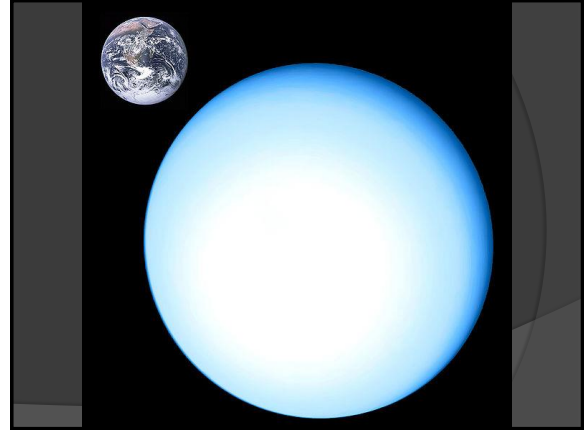
- ◉ Saturn's Moons:
 - Titan is the big one, and is larger than planet Mercury!
 - Mimas has a huge crater.
 - Epimetheus and Janus, just inside the orbit of Mimas, are continually exchanging orbits with one another in a "waltz" -- they are called the coorbital satellites.



Uranus

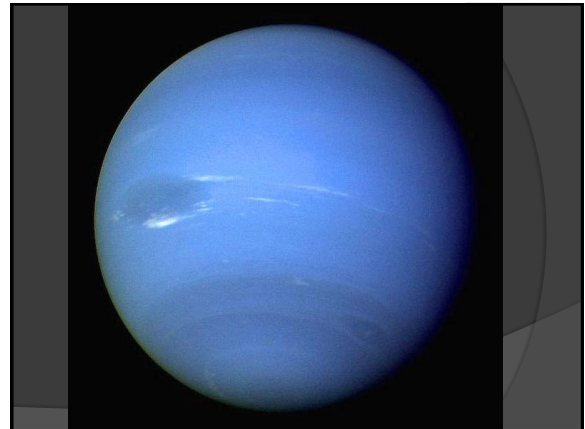
- ◉ Uranus has more moons (15) than any other planet except Jupiter (16) and Saturn (23)!
- ◉ Uranus rotates on its side.





Neptune

- ◉ The blue coloration of Neptune is probably due to the presence of methane
- ◉ Neptune has 13 moons

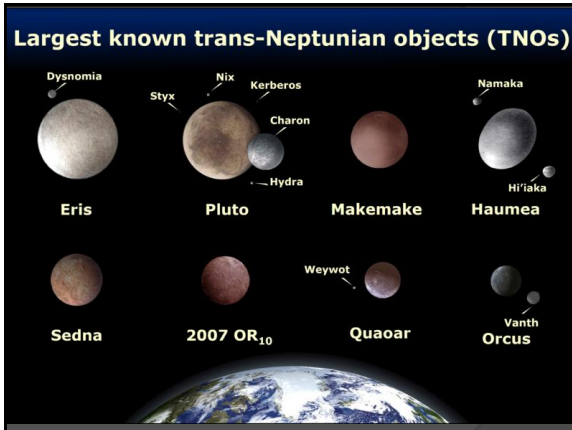


Pluto:

- ◉ Classified as a "Dwarf Planet".
- ◉ Has a long elliptical orbit.
- ◉ Made of rock and ice.
- ◉ Has an atmosphere of nitrogen, methane, and carbon monoxide.
- ◉ Smaller than Earth's moon.
- ◉ In synchronous orbit with its moon Charon.

Dwarf Planets

- ◉ A dwarf planet is an object that, due to its own gravity, is spherical in shape, orbits the Sun, is not a satellite, and has not cleared the area of its orbit of smaller debris.



United Nations Focuses on Asteroid Threat to Earth

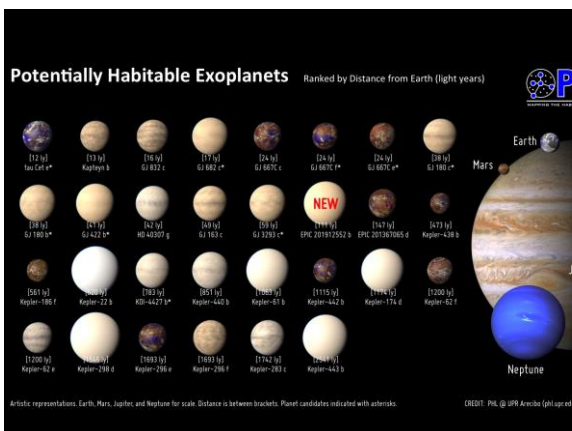
THE TORINO SCALE	
0	ZERO OR VIRTUALLY ZERO CHANCE OF IMPACT
1	IMPACT EXTREMELY UNLIKELY, MERIT MONITORING
2	IMPACT VERY UNLIKELY
3	CLOSE ENCOUNTER WITH AT LEAST 1% CHANCE OF LOCAL DESTRUCTION
4	CLOSE ENCOUNTER WITH AT LEAST 1% CHANCE OF REGIONAL DESTRUCTION
5	CLOSE ENCOUNTER WITH SIGNIFICANT THREAT OF REGIONAL DESTRUCTION
6	CLOSE ENCOUNTER WITH SIGNIFICANT THREAT OF GLOBAL CATASTROPHE
7	CLOSE ENCOUNTER WITH EXTREMELY SIGNIFICANT THREAT OF GLOBAL CATASTROPHE
8	CERTAIN COLLISION WITH LOCAL DESTRUCTION
9	CERTAIN COLLISION WITH REGIONAL DESTRUCTION
10	CERTAIN COLLISION CAUSING GLOBAL CLIMATIC CATASTROPHE

Exoplanets

- An exoplanet is a planet that orbits another star within the Milky Way galaxy.
- The first exoplanets were discovered in 1992.

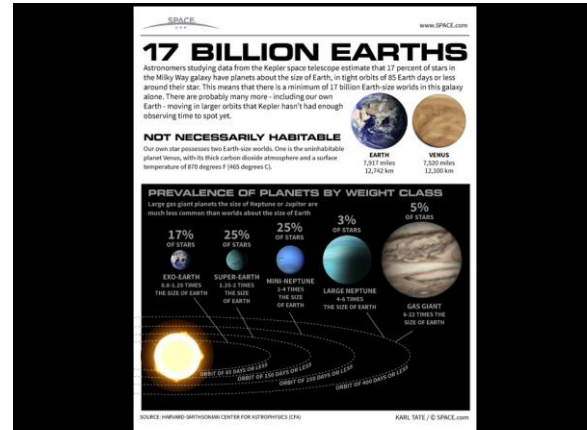
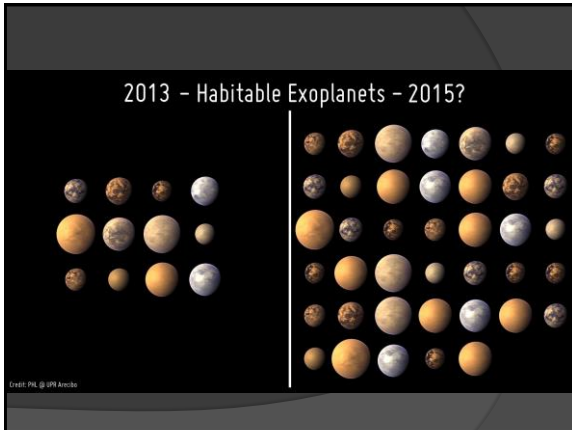
Exoplanets

- As of today, there are 1,827 confirmed exoplanets.
- There are 4,604 exoplanet candidates.
- 17% of stars are thought to have planets orbiting them.



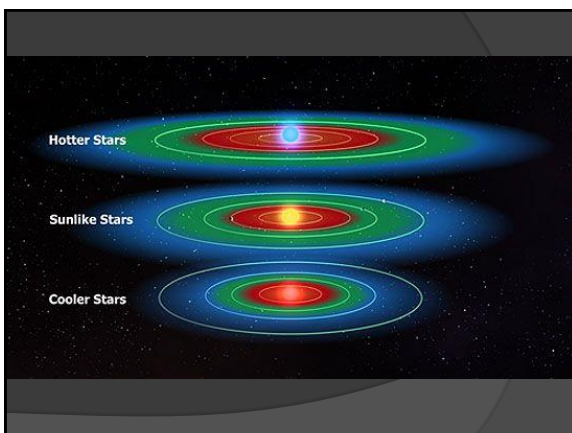
How Many Exoplanets?

- As of today, NASA has confirmed 1,827 exoplanets
- 4,604 Kepler Candidates



Habitable Zone (HZ)

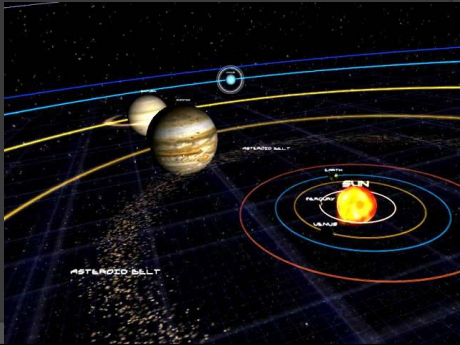
- The **Circumstellar Habitable Zone (CHZ)** is defined as the region around a star where water could exist on the surface of an Earth-like planet.
- The size and location of the CHZ change over time as a star evolves.



Smaller Solar System Bodies

- **Asteroids** – Rocky solid bodies that vary in diameter and have pitted, irregular surfaces.
- Some asteroids have satellites of their own.

Asteroid Belt



Meteoroids & Meteors

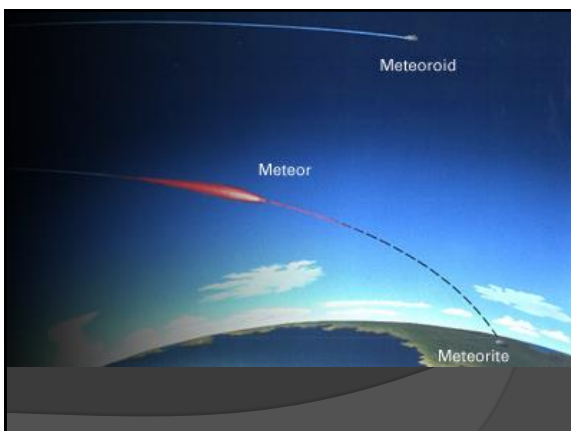
- When an asteroid fragment, or any other interplanetary material enters Earth's atmosphere it is called a **meteoroid**.

Meteoroids & Meteors

- As a **meteoroid** passes through the atmosphere, it is heated by friction and burns, producing a streak of light called a **meteor**.

Meteorite

- If the meteoroid does not burn up completely and part of it strikes the ground, the part that hits is called a **meteorite**.
- Large meteorites can produce **impact craters**.



Willamette Meteorite, Oregon



Barringer Crater, AZ



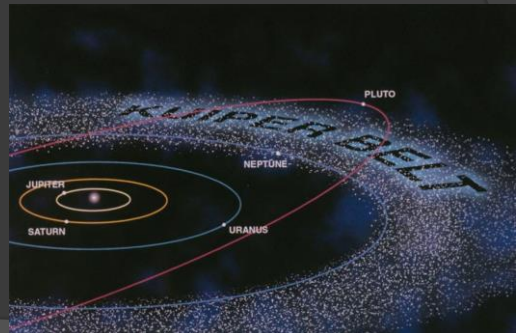
Barringer Crater, AZ



Kuiper Belt

- Like the rocky asteroid belt, another group of bodies mostly made up of ice and rock is found outside the orbit of Neptune.
- Eris and Pluto are two of many Kuiper belt objects.

Kuiper Belt



Comets:

- Comets come from the farthest limits of the solar system, the **Oort cloud**.
- Comets are small, icy bodies that have highly eccentric orbits.

Oort Cloud

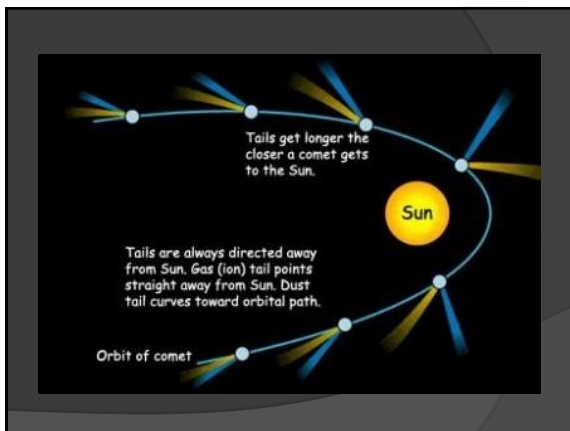


Comets:

- ◉ When a comet comes within 3 AU of the Sun, it begins to evaporate. It forms a head and one or more tails.
- ◉ The head is surrounded by glowing gasses with a solid core.

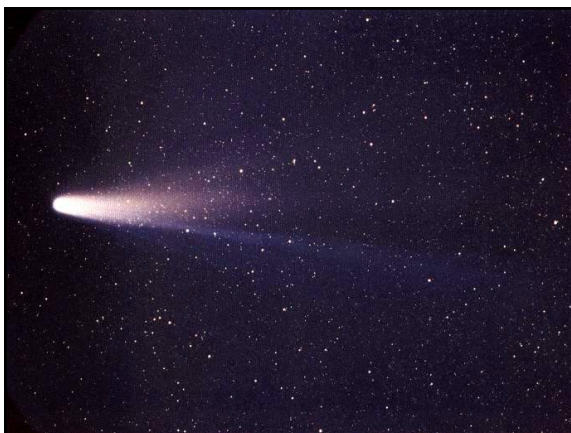
Comets:

- ◉ The tails form as gas and dust are pushed away from the comet by particles and radiation from the Sun.
- ◉ This is why comets' tails always point away from the sun.



Periodic Comets:

- ◉ Comets that repeatedly return to the inner solar system are called periodic comets.
- ◉ Halley's comet has a 76 year period. It appeared in 1985 and will return in 2061



Periodic Comets:

- ◉ Comet Hale-Bopp showed up in the year 1997.
- ◉ It is calculated to have an orbital period of 2520-2533 years.
- ◉ It will return around 4385



Science News:

- ◉ Lunar Eclipse
Saturday, April 4th
at 7:22 AM
Maximum View

Planet Project

- ◉ Where does the planet get its name?
- ◉ Orbital Period
- ◉ Rotational Period
- ◉ Distance from the Sun (Astronomical Units)
- ◉ Moons: Does this planet have any moons?
- ◉ Unique Features
- ◉ Composition (Atmosphere, Surface, Interior)
- ◉ Exploration: Probes, satellites, ect...
- ◉ Other Important Information

Test

- Formation of our solar system from collapsing interstellar cloud
- The current model of the solar system
- General information about each planet
- Galileo, Copernicus, and Kepler
- Dwarf planets, asteroids, and comets.

Solar System:

1. The four inner planets of our solar system are:

- A. Gas Giant Planets
- B. Interplanetary Asteroids
- C. Terrestrial Planets
- D. Meteorites

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Solar System:

2. The closest planet to the sun is:

- A.Venus
- B.Mercury
- C.Mars
- D.Earth

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Solar System:

3. Galileo discovered Jupiter's _____.

- A.rings
- B.12 smaller satellites
- C.4 major satellites
- D.the Great Red Spot

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Solar System:

4. The form of hydrogen that has properties of both a liquid and a metal is

- A.liquid metallic hydrogen.
- B.magnetic hydrogen
- C.liquid hydrogen
- D.electric hydrogen

Solar System:

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Solar System:

5. Low, warm, dark-colored, sinking clouds in Jupiter's atmosphere are known as:

- A.belts
- B.the Great Red Spot
- C.zones
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Solar System:

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Solar System:

6. The Astroid Belt is found between which two planets:

- A.Mercury and Venus
- B.Mars and Jupiter
- C.Saturn and Uranus
- D.Earth and Mars

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Solar System:

7. Which planet is furthest away from the sun?

- A.Uranus
- B.Jupiter
- C.Saturn
- D.Neptune

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- B.Jupiter
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Solar System:

8. Where do most of the comets that pass Earth originate?

- A. The Astroid Belt
- B. The Oort Cloud
- C. The Inner Solar System
- D. Black Holes

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Solar System:

9. Who first proposed the heliocentric view of the solar system?

- A. Copernicus
- B. Galileo
- C. Kepler
- D. Newton

Solar System:

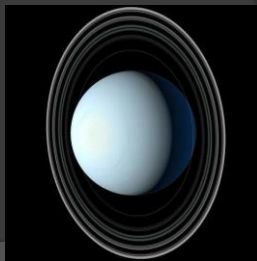
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Solar System:

10. Identify the following planet:

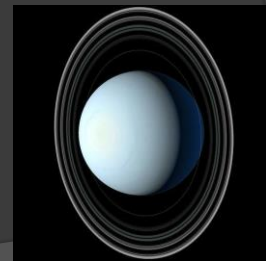
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 - C. icy, each planet
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