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FORMATION OF PLANETS IN SOLAR SYSTEM

SANIA SHARMA[1], Inamul Haq Wani[2]
Department of Physics, Govt. Maulana Azad Memorial College Jammu, Jammu and Kashmir, India

ABSTRACT:- The Solar System consists of the sun, nine planets, satellites of planets, asteroids and comets. The nine planets, are arranged according to their increasing distances from the sun, are : Mercury (Buddha), Venus (Shukra), Earth (Prithvi), Mars (Mangal), Jupiter (Brihaspati), Saturn (Shani), Uranus (Arun), Neptune (Varun) and Pluto (Yama).

The formation of planets in our Solar System is believed to have been formed from the same spinning disc of dust that formed from the sun. Planets are formed by particles colliding and sticking together as they orbit the star in a disc of gas and dust.

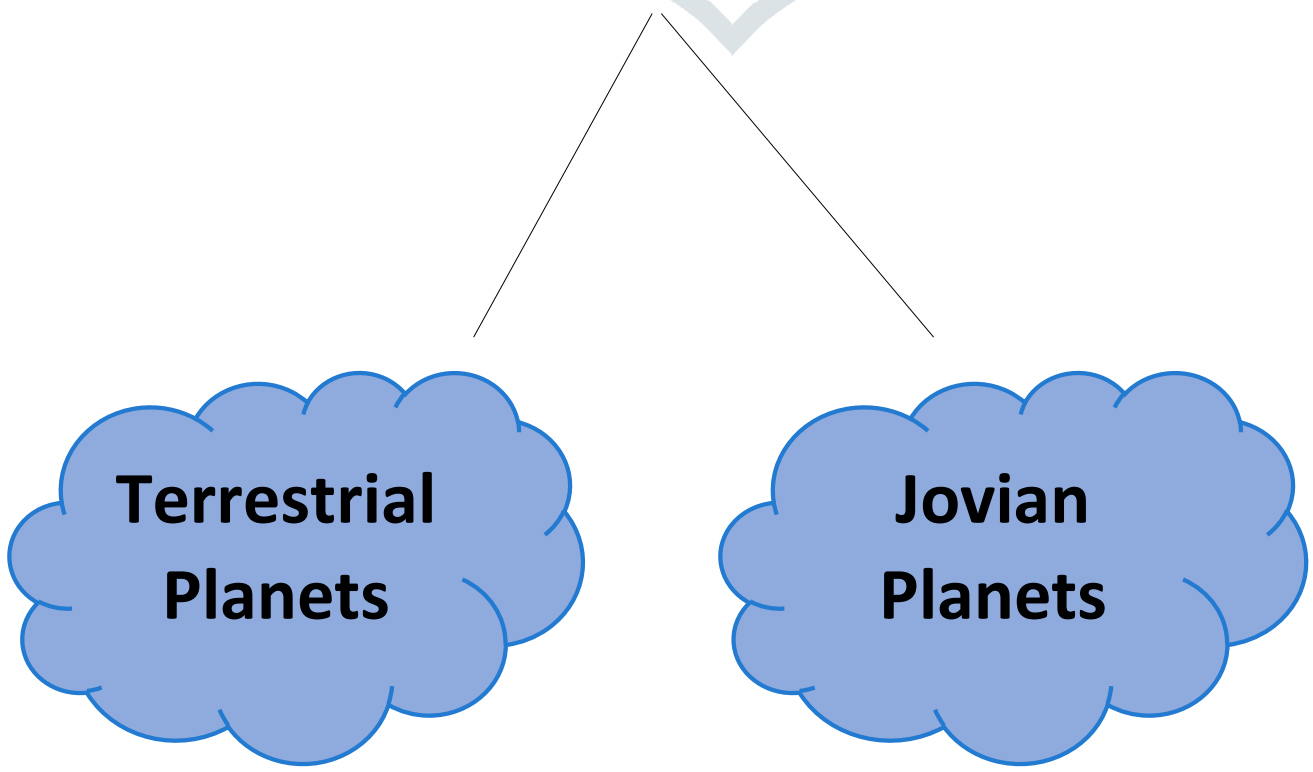
KEYWORDS:- Giant Planets, Terrestrial Planets, Planet Formation, Planetesimals and Protoplanetary Disk.

INTRODUCTION:-

What are planets exactly?

- A planet is a celestial body that revolves in an orbit around a certain star and receives all of its light from that star.
- Mercury, Venus, Mars, Jupiter and Saturn are the only five planets visible from Earth with the naked eye. Uranus and Neptune, on the other hand, were found after telescopes were constructed.
- Every planet, like the Earth, spins once every 24 hours around its axis. The period of revolution of a planet is how long it takes to rotate around the sun.

The planets can be categorized into 2 types

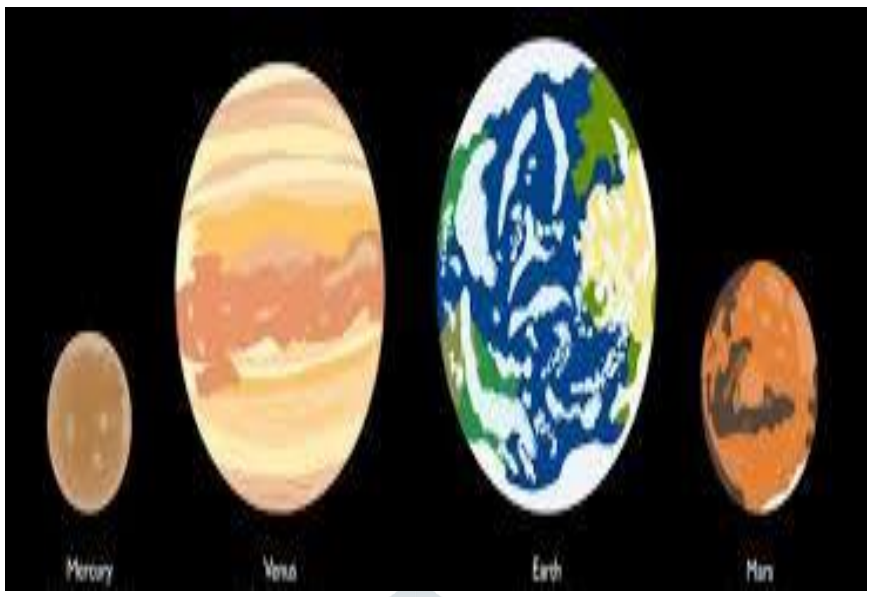


Terrestrial Planets / Inner Planets:- There are 4 terrestrial planets as:-

- Mercury
- Venus
- Earth and
- Mars

Terrestrial planets are Earth – like planets made up of rocks or metal with a hard surface. These planets are the closest to the sun. Terrestrial planets also have a molten heavy-metal core.

The planets that formed nearest the sun would have the greatest tendency to vaporize and would be strongly subject to the sweeping- away effect of the solar wind. Those nearby planets would therefore decrease in mass. The terrestrial planets like the Venus, Earth and Mars lost all of the hydrogen and helium and most of the other volatile matter. They, however, retained some of the heavier molecules like N_2 , H_2O, CO_2, NH_3, CH_4 etc.



Salient features of the terrestrial planets

Mercury	Venus	Earth	Mars
It can be seen near the horizon at sunset or sunrise.	It appears as the third brightest object in the sky after the Sun and the Moon, as it is nearest to the Earth.	Its crust, extending to 10 km deep under the oceans and up to 40 km under the continents, consists mainly of silicon (27.7%), and oxygen (47.3%). Elements like aluminium, iron, calcium, sodium etc. make the bulk of its matter and less than 2% is made of all other elements.	Though half in size of the Earth, this planet has various similarities with the Earth i) A day on Mars is 24h 40 minutes and a year lasts for 1.88 Earth year, ii) its rotation axis is tipped at 25° and thus has seasons and polar caps.
Like the Moon, it has no atmosphere and its surface is full of craters.	Its surface is dry, hot and volcanic. Its atmosphere contains about 96 percent carbon dioxide, 3.5 percent nitrogen and remaining half percent is water vapours, argon, sulphuric acid, hydrochloric acid etc.	Its rotation axis is tipped by ~ 23° causing various seasons and polar caps.	This is the most extensively probed planet and a few automated laboratories have also been landed. The atmosphere and geology of this planet has many features similar to the Earth.
It is, at the same time, the coldest and the hottest planet because its	The planet is covered by a thick cloud mainly consisting of sulphuric acid droplets.	Its atmosphere absorbs the harmful consists of distinct layers called	Martian surface has craters of all sizes and enormous volcanoes.

periods of revolution and rotation are almost equal which keeps its same surface face the Sun all the time.		troposphere, stratosphere and ionosphere. Troposphere comprises mainly of 78% nitrogen, 21% oxygen; stratosphere contains ozone which ultraviolet radiation from the Sun.	
Its surface temperature varies between + 340°C to -	Its surface temperature is very high (~ 470°C) which is perhaps caused due to the greenhouse effect: the infrared radiation emitted by the planet is not allowed to escape due to the presence of carbon dioxide in its atmosphere thus causing the heat received from the Sun to be trapped and raise its temperature.	Earth is the only planet known to have known life. Although life has not been found elsewhere in the solar system. Its surface temperature is -59 degree F .	Martian soil, like the Earth, is mostly made of silicates. However, due to the presence of 16 percent iron oxide in its soil, it has the characteristic red colour. It is also known as the Red Planet.

Jovian Planets /Outer Planets / Giant Planets:- There are 5 jovian planets as:-

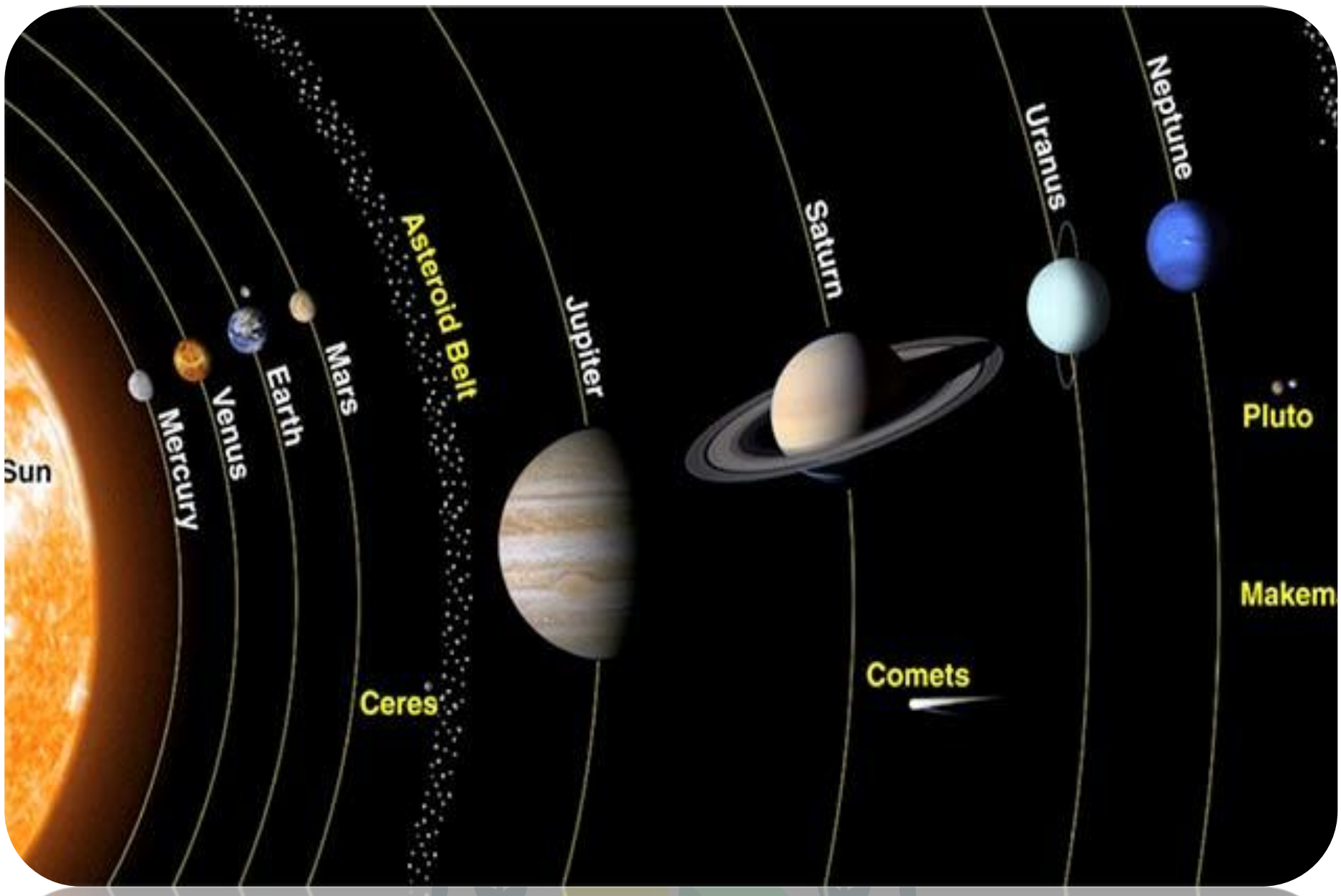
- Jupiter
- Saturn
- Uranus
- Neptune and
- Pluto

Jovian planets are massive, gaseous planets that extend far from the sun, do not have solid surfaces, have many moons and rings, undergo tremendous winds and storms, and have low densities. The gas giants are made up primarily of hydrogen and helium. These planets are also called Julian planets. The distant planets like Jupiter and Saturn were large and cold enough to retain all the substances in their atmosphere, including hydrogen and helium. They have small rocky core and very thick atmospheres composed mainly of hydrogen & helium. Uranus and Neptune also contain mainly hydrogen & helium with small quantities of the heavier elements. Therefore, these outer planets are called gas giants.

Salient features of the Jovian planets

Jupiter	Saturn	Uranus	Neptune	Pluto
It is the largest and the most massive planet (contains 71% of all the planetary mass).	It is the second largest planet exceeded in size and mass only by Jupiter. Like Jupiter, it consists mainly of hydrogen and helium.	This planet is smaller than Jupiter and four times farther from the Sun. In a telescope, it appears as a green disc	This planet was discovered in 1846 and it is so far away that, seen from this planet, the Sun would look like a bright spot!	This planet was predicted to exist theoretically to account for the observed irregularities in the orbits of Uranus and Neptune.
It is like a spinning ball of gas and liquids with no solid surface. In this regard, it is similar to the Sun. It has a large number of satellites.	It is the last (sixth) planet visible from the Earth. It has beautiful rings	The rings of this planet were discovered as late as 1977 and they comprise of very dark material, as black as coal.	Its cloud temperature is about – 237°C.	It is a very small (about one-fifth the size of the Earth), cold and dark planet.
It is covered by a turbulent, gaseous atmosphere comprising of hydrogen, helium and small traces of water vapour, ammonia, methane etc.	The temperature at its cloud tops is – 180°C. It is colder than Jupiter	It has a large number of Moons.	Like other jovian planets, this planet also has rings.	Unlike most planetary orbits, Pluto's orbit is quite elliptical and therefore it can come closer to the Sun than Neptune.
It has rings and it emits radio waves.	Its main satellite, Titan, is very large (diameter 5800 km) and	Its axis of rotation is tipped 97.9° from the perpendicular to its orbit. This	Two Moons of this planet are visible from the Earth.	Its mass is only 0.002 times the Earth mass.

	has atmosphere of its own as dense as ours.	causes its poles to nearly point towards the Sun.		



Forming of planets in the Solar System

Difference between Terrestrial and Jovian Planets

1. Size and Density: Terrestrial planets are small, rocky and have high density, while Jovian planets are large, gaseous and have low density.
2. Atmosphere: Terrestrial planets have thin atmospheres composed mainly of nitrogen, oxygen and carbon dioxide, while Jovian planets have thick atmosheres primarily composed of hydrogen and helium. This difference in atmosphere is due to their distance from the sun and their ability to hold onto gas molecules.
3. Distance from the Sun: Terrestrial planets are closer to the sun, and hence hotter, while Jovian planets are further from the sun and colder.

Characteristics of the terrestrial and jovian planets

Characteristics	Terrestrial	Jovian
Basic form	Rocky	Gas/ Liquid/ Ice
Mean orbital distance (AU)	0.39 - 1.52	5.2 - 30.1

Mean surface temperature (K)	200 - 700	75 - 170
Mass (relative to the Earth)	0.055 - 1.0	14.5 - 318
Equatorial radius (relative to the Earth)	0.38 - 1.0	3.88 - 11.2
Mean density (g cm^{-3})	3.96 - 5.42	0.68 - 2.30
Sidereal rotation period (equator	23.9 h - 243 h	9.8 h 0- 19.2 h
Number of known Moons	0-2	8 - 20
Ring systems	No	Yes

Theories on the formation of planets

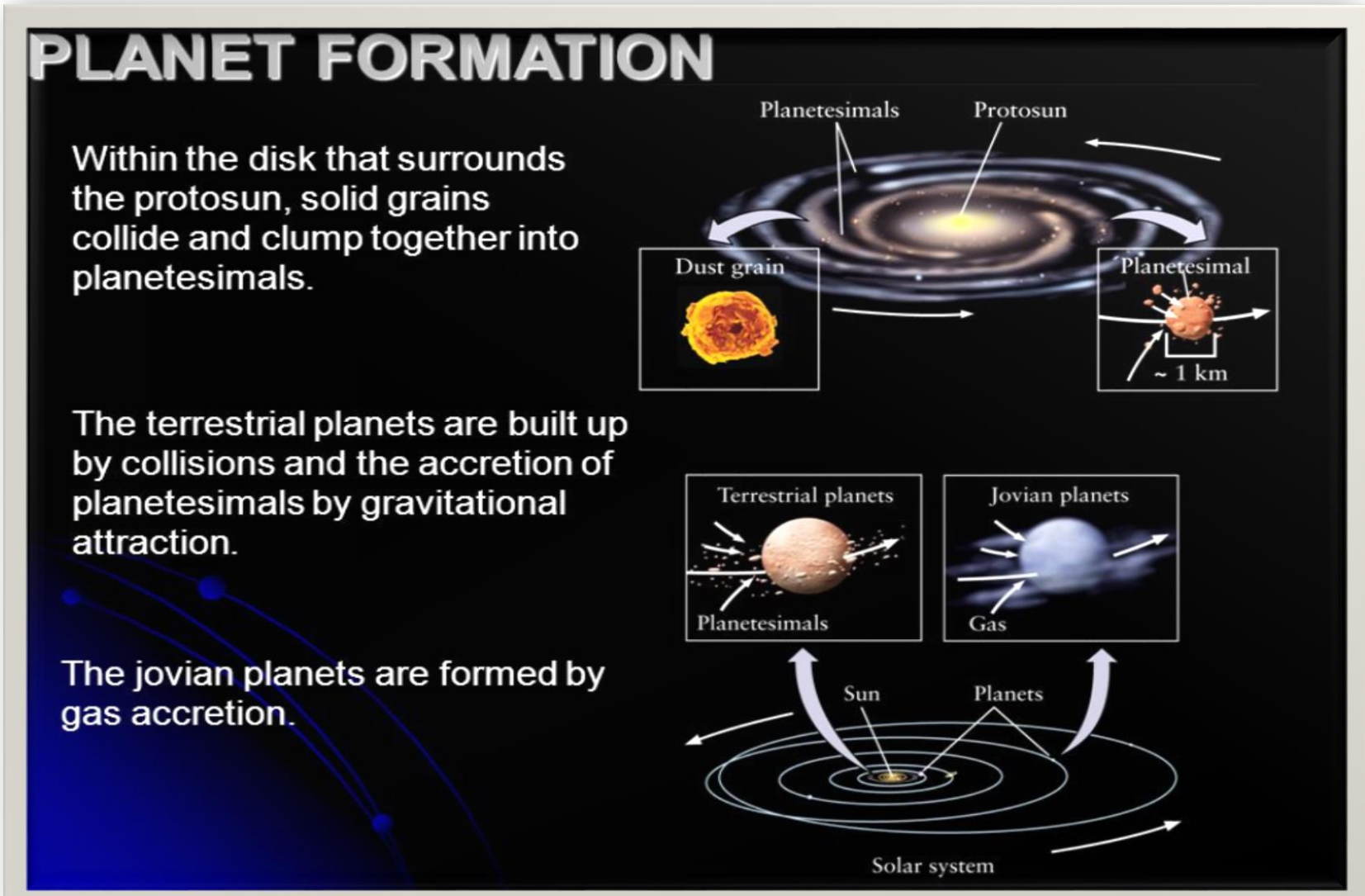
There are 2 types of theories on the formation of planets which include Early theories & Modern Theory.

Early theories include:-

Nebular Hypothesis: This hypothesis was given by Immanuel Kant which was revised by Laplace in 1796. It states that the sun was surrounded by solar nebula, composed most of hydrogen and helium along with dust. Friction and collision of particles lead to the formation of a disk-shaped cloud. Through the process of accretion, planets were formed out from material associated with the sun.

Binary Theory: Chamberlain and Moulton proposed the binary theory in 1900. According to this theory, another enigmatic wandering star approached the sun. As a result, the material's cigar-shaped extension was separated from the solar surface. As the passing star moved away, the separated material condensed into a planet, and the sun continued to revolve.

Modern Theory: In the context of scientific cosmology, the Sun and all other objects in the Solar System formed from material that had been swirling about in a nebula, an idea now known as the nebular theory or, more recently, as the condensation theory. According to the theory, the process of Solar System involved several stages. Such a process begins when tiny ice and dust particles condense in a nebula.



Stages of formation of planets

The following are stages in the development of planets:

- The first stage of formation – The first stage involves the growth of macroscopic grains of solid matter from the interstellar cloud. The size of these grains range from a few cm to a few km and they are called planetesimals. Planetesimals can grow through two processes: condensation and accretion. In the condensation process, grains grow by adding one atom at a time to a nucleus atom, from the surrounding gaseous cloud. This is similar to the growth of snowflakes in the Earth's atmosphere. In the accretion process, solid particles stick together. Further, the planetesimals would tend to rotate in the plane of the solar nebula.

- The second stage of formation - In the second stage, planetesimals coalesce and form protoplanets objects having planetary sizes and masses. Since all the planetesimals are moving along the same direction in the nebula, they collide with each other at a low relative velocity and stick together to form protoplanets. The growth of protoplanets is helped by gravity because the nebular matter is attracted by the protoplanets.

- The final stage of formation – At the third stage, hen a protoplanet grows into a stable planet, a large amount of heat is generated in its core due to the decay of short- lived radioactive elements. Heat is also generated due to collision of these planets with other objects. Due to high temperature, the planets segregate themselves according to their density. Therefore, the inner regions of the planets hold heavier elements and compounds and lighter elements are pushed to the surface.

Our solar system came into being 5 billion years ago. The solar system consists of nine planets, numerous satellites and asteroids, and one sun.

Conclusion:- In this article, we discussed the formation of planets and the process for the formation of planets. The terrestrial planets were produced by the slow accretion of small solid

bodies, and the principal volatiles in their atmosphere was introduced by captured solid bodies that originated at the greatest distance. At last, we also discussed the different kinds of planets and the existence of Dwarf planets.

The important fact to remember is that Pluto is considered to be a dwarf-planet and is not considered to be a planet. Pluto was considered to be a planet until 2006. There are 3 criteria that planets must meet in order to be considered a planet. Pluto only meets two of the three criteria . Many scientists believe that Pluto should still be considered a planet, but until the criteria are reconsidered, Pluto will remain a dwarf planet.

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