

6. Our Solar System

- Sun:
 - Over 99.9% of the mass of the solar system
 - Mostly made out of H/He and converts 4 million tons of mass into energy every second

- **Terrestrial planets are made of rock and metal (high density), are small and closer to the Sun (higher surface temps):**
 - Mercury → large iron core; the side that faces the sun (day) is very hot (425°C) and the other side (night) is very cold (-170°C)
 - Venus → **similar in size to Earth** but very dense atmosphere that hides the surface; very extreme conditions due to extreme greenhouse effect which also makes it very hot (470°C day and night)
 - Earth → **only planet with surface liquid water** to accommodate life and a **surprisingly large moon**
 - Mars → similar to Earth with giant volcanoes, huge canyons and polar caps; thought to have had flowing water in the distant past

- **Jovian planets are gaseous giants (lower density than terrestrials) with many moons and rings that sit farther away from the Sun (lower surface temps)** and are considered “miniature solar systems”:
 - Jupiter → mostly H/He with no solid surface; its Galilean moons (Io, Callisto, Europa and Ganymede) have solid surfaces and have similarities to planets
 - Saturn → known for its rings which are NOT solid, they are made of countless very small chunks of ice and rock; the Cassini satellite went through them with practically no damage which shows their non-solidity
 - Uranus → made of H/He but also larger quantities of other hydrogen compounds and it has a very unusual axis tilt almost parallel to its orbit
 - Neptune → similar to Uranus but a much more perpendicular tilt

- Dwarf planets are much smaller than normal planets, with icy and rocky composition and also have moons e.g. Pluto and Eris (5 dwarf planets known to date)

- Smaller bodies like asteroids and comets also populate the Solar System:
 - **Asteroid Belt** → flat shape and found between the orbits of Mars and Jupiter
 - There are **small gaps in the Belt due to orbital resonance with Jupiter**, i.e. asteroids’ orbits in the gaps lined up with Jupiter’s orbit creating gravitational tugs that pulled them closer, creating gaps
 - It is hypothesised that Jupiter’s tidal forces impeded the formation of a planet there
 - **Kuiper Belt** → flat shape and found on the outskirts of the Solar System, after the orbit of Neptune

- **Oort Cloud** → spherically shaped and found in the far end of the Solar System; can't be seen but we can see comets moving with unbound orbits coming from all directions so its hypothesised to be spherical in shape
- Formation of the Solar System:
 - The nebular theory states that a solar system is formed from the **gravitational collapse of a massive interstellar gas cloud** (solar nebula)
 - Interstellar gas is recycled throughout a star's lifetime: they are born from the collapse of the gas, form heavier elements during its lifetime thanks to fusion and they return the material (gas) to space when they die in an explosion
 - The next star to be born from the new gas cloud now has even heavier elements
 - From the heavy elements found on Earth, it is thought that our Solar System was formed after a number of these cycles
 - As a nebular cloud begins to collapse the **conservation of angular momentum and energy cause it to speed up** (potential energy → kinetic energy)
 - The **kinetic energy is then converted to thermal energy**, so it also heats up (with the inner parts spinning faster i.e. getting hotter than the outer parts)
 - **Collision between newly formed particles in the cloud also causes it to flatten**
 - Due to the different temperatures in the disk, the **frost line** becomes important (to understand the differences between Terrestrial and Jovian planets)
 - Inside the frost line of the disk the temperature is too high for ices to stay solid (i.e. they melt)
 - This is where Terrestrial planets form from small particles of rock and metal (which are solid even at high temps) stick together getting bigger and heavier and transforming from planetesimals to planets
 - Outside the frost line the temperature is much lower, so ices stay solid
 - This is where Jovian planets form because ice is now a solid too, so they can become **larger and heavier**, obtaining a **large gravity which is able to draw in gases** like H/He to their surface, becoming even bigger (process of accretion)
 - Once the star/Sun is formed, light and '**solar wind**' (charged particles exhaled by the new star travelling at very high speeds) blew away most particles which were not accreted onto a planet due to gravity
 - According to the nebular theory, the young Sun was much faster than it is now
 - This is due to the '**loss**' of **angular momentum from the exhale of solar wind** → the small charged particles latched onto the magnetic field of the sun, rotating with it but getting further away until they are far enough to be out of the field's influence
 - With their increasing radius from the Sun, they increased their angular momentum which means the Sun's angular momentum must have gone down (conservation laws)
 - Formation of planets in any solar system would be inevitable (although they would differ widely)