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Paper 1 – Volume 5

Geography of World



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GEOGRAPHY OF WORLD

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1 CHAPTER

Universe and the Solar System



Origin of the Universe

- **Universe:** Everything that exists, including distant stars, planets, and satellites, as well as our own planet and all of its people.



Theories about origin of Universe:

1. Big Bang theory

THE BIG BANG THEORY

Time	10 ⁻⁴³ sec.	10 ⁻³² sec.	10 ⁻⁶ sec.	3 mln.	300,000 yrs.	1 billion yrs.	15 billion yrs.
Temperature		10 ²⁷ °C	10 ¹³ °C	10 ⁸ °C	10,000°C	-200°C	-270°C

- 1** The cosmos goes through a superfast "inflation," expanding from the size of an atom to that of a grapefruit in a tiny fraction of a second.
- 2** Post-inflation, the universe is a seething, hot soup of electrons, quarks and other particles.
- 3** A rapidly cooling cosmos permits quarks to clump into protons and neutrons.
- 4** Still too hot to form into atoms, charged electrons and protons prevent light from shining: the universe is a superhot fog.
- 5** Electrons combine with protons and neutrons to form atoms, mostly hydrogen and helium. Light can finally shine.
- 6** Gravity makes hydrogen and helium gas coalesce to form the giant clouds that will become galaxies; smaller clumps of gas collapse to form the first stars.
- 7** As galaxies cluster together under gravity, the first stars die and spew heavy elements into space; those will eventually turn into new stars and planets.

Labels in the infographic: Electron, Galaxy, Quarks, Neutron, Proton, Hydrogen nucleus, Helium atom, Hydrogen atom.



- The **most popular argument** regarding the origin of the universe .
- aka **expanding universe hypothesis**.
- **Edwin Hubble in 1920 proved** that the universe is expanding .
- **Took place 13.7 billion years** before the present.
- **Galaxies move further and further apart with time** and thereby, the **universe is considered to be expanding**.
- Scientists believe that though the space between the galaxies is increasing, observations do not support the expansion of galaxies.
- **Stages** in the development of the universe:

- **Beginning-** All matter forming the universe **existed in one place** as a **“tiny ball”** (singular atom) with an **unimaginably small volume, infinite temperature and infinite density.**
- **Big Bang-** **“Tiny ball” explodes violently** which led to a huge expansion.
 - The expansion **continues even to the present day.**
 - As it grew, **some energy was converted into matter.**
 - **Rapid expansion within fractions of a second after the bang-** later, it slowed down.
 - **Within the first 3 minutes** from the Big Bang event, the **first atom began to form.**
 - **Within 300,000 years from the Big Bang,** temperature **dropped to 4,500K** and gave rise to atomic matter.
 - The **universe became transparent.**
- **Common misconception:**
 - Gives the complete origin of the universe but it **does not describe the energy, time and space involved in the creation of the universe.**
 - **Only explains how the universe emerged** from its initial high-temperature state.
 - **Only describes the size of the observable universe** and not the universe as a whole
- **Evidences of Big Bang**
 - **Expanding galaxies:**
 - **Hubble in 1929 noted that galaxies outside our own Milky Way were all moving away from us,** at a speed proportional to its distance from us.
 - **Realized that there must have been an instant** in time (now known to be about 14 billion years ago) **when the entire Universe was contained in a single point in space.**
 - The **Universe must have been born in this single violent event** which came to be k/a **“Big Bang.”**
 - **Cosmic Background radiation:**
 - **Early photons ,the afterglow of the Big Bang** k/a **cosmic background radiation (CBR) can be observed even today.**

2. Pulsating theory

- Universe is believed to be **pulsing, expanding and shrinking alternately,**
- According to this theory, the **universe's expansion may be halted by gravitational attraction at some point in the future, causing it to compress again.**
- **After it has been constricted to a particular size, it will explode again, and the universe will begin to expand.**
- The **pulsating universe is created by the universe’s parallel expansion and contraction.**



Components of the Universe

Galaxy

- **Collection of millions or billions of stars, gas and dust,** bound together by gravity.
- Mainly divided into **four types viz. elliptical, normal spirals, barred spirals and irregular.**



Milky Way Galaxy

- Shape- spiral.
- **Has a disk-shaped structure** - diameter of roughly 100000 light years.
- Around its centre, the Milky Way galaxy **rotates gently in a counter-clockwise manner**.
- **Centre- All stars** (including the sun and the solar system) **rotate**.
- **Appears like a river of light flowing from one corner to the other** in the night sky, therefore k/a Akash Ganga.

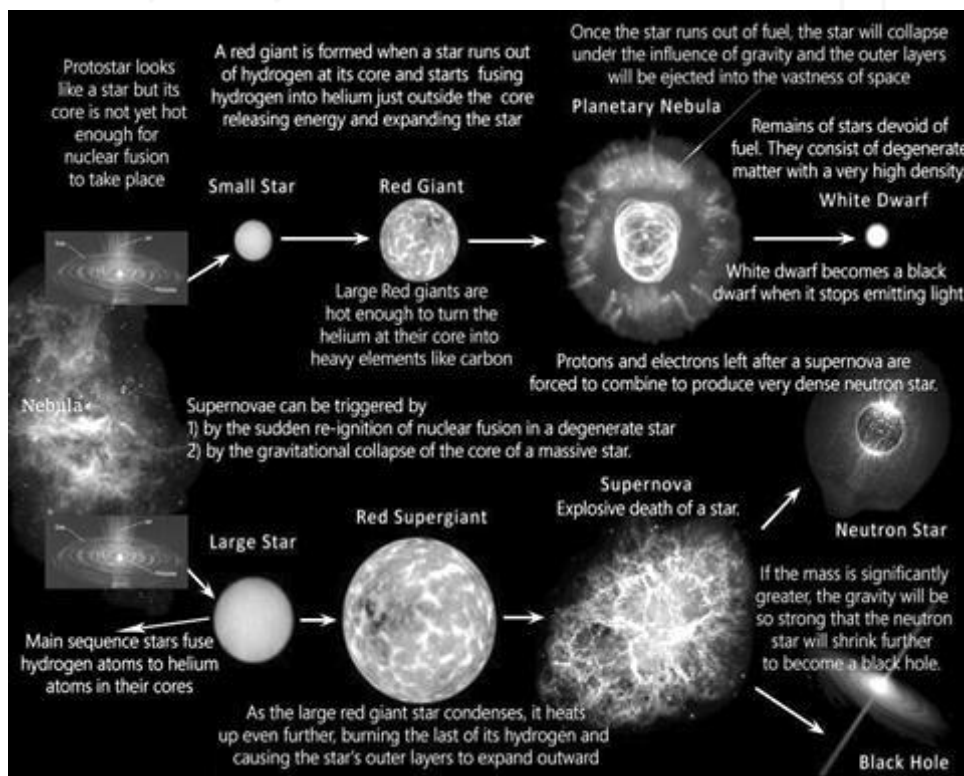
Stars

- Incredibly **hot celestial beings** that generate their **own light**.
- Massive **clouds of hydrogen gas, helium, and dust**.
- **3 types** as per their colour and temperature:
 - **Red: low surface temperatures**
 - **White: high surface temperatures**
 - **Blue: very high surface temperatures**
- In the night sky, all **stars** (save the pole star) **appear to travel from east to west**- caused by the **earth's rotation** on its axis.
- The **monthly locations of the stars fluctuate**- due to interaction between the **rotation of the earth around its axis and the orbit of the earth around the sun**.



Birth and Evolution of a Star

- **Raw material** for star formation- **Hydrogen**.
- **Beginning of a star's life cycle**- **formation of thick clouds of hydrogen and helium gas (i.e. Nebula)** in galaxies.
- **Birth** - caused by the **gravitational collapse** of these too thick **clouds of gases** in the galaxy.



ProtoStar

- **Resembles a star, but core not heated enough for nuclear fusion to occur- occurs only when the initial temperatures are very high - hard to achieve and control.**
- **Difficult to view** - frequently **covered by dust**, which filters the light they emit.

T Tauri Star

- **Young (< 10 million years old) , light star experiencing gravitational contraction .**
- **Intermediate stage** between a **Protostar** and a low-mass **main sequence star**.

Main sequence stars of fusion ignition

- **Hydrogen + helium.**
- **Make up the vast majority of stars** in the universe (**about 90%**).
- **A star like the Sun swells up to become a red giant** at the end of its life, **before shedding its outer layers** as a planetary nebula and finally decreasing to become a white dwarf.

Final Stages of a Star's Life

- Enters **red-giant phase-** becomes a **red-giant star**.
- Can then **die out** by becoming a **white dwarf star** or exploding as a **supernova star** → development of **neutron stars and black holes, depending on its mass.**
- **White dwarf** - **tiny hot star** that is **at the end of its life cycle** - **leftovers of regular stars** that have exhausted their nuclear energy reserves.

NOVA

- Occurs on the **surface of a white dwarf**.
- **If two stars in the system are close enough** together, **material (hydrogen) from the partner star's surface can be transferred onto the white dwarf.**
- When enough material accumulates on the surface of a white dwarf, **nuclear fusion occurs**, resulting in a **dramatic brightening of the star.**



Supernova

- **Star's rapid death causes it to brighten to the brightness of 100 million suns** for a brief period of time.
- **The very bright burst of radiation disperses most or all of a star's material at a high velocity, causing a shock wave to propagate into the interstellar medium.**
- These shock waves **cause condensation in a nebula, opening the way for the formation of a new star.**
- **Responsible for a large amount of primary cosmic rays.**

Black Dwarf

- **Last stage** of star development.
- It is a **white dwarf that has cooled** to the point that **no substantial heat or light is emitted.**
- **No black dwarfs are projected to exist** in the universe yet since the time necessary for a white dwarf to achieve this condition is calculated to be greater than the universe's current age.



Brown Dwarfs

- Objects that are **too big to be planets** but **not big enough to be stars**.
- Considered to **develop** from a collapsing cloud of gas and dust in the **same manner as stars do**.
- The **centre** of the cloud, however, is **not thick enough to start nuclear fusion** when the cloud falls.



Neutron Stars

- Stars that **emit neutrons**.
- Mostly **made up of neutrons**.
- **Formed during supernova** pushing protons and electrons to combine to form a neutron star.
- **High density stars** (A sphere with a diameter of merely 20 kilometres can hold three times the mass of the Sun).
- If it has a **larger mass**, and **intensely high gravity** shrinking it even further, eventually becoming a black hole.



Black Holes

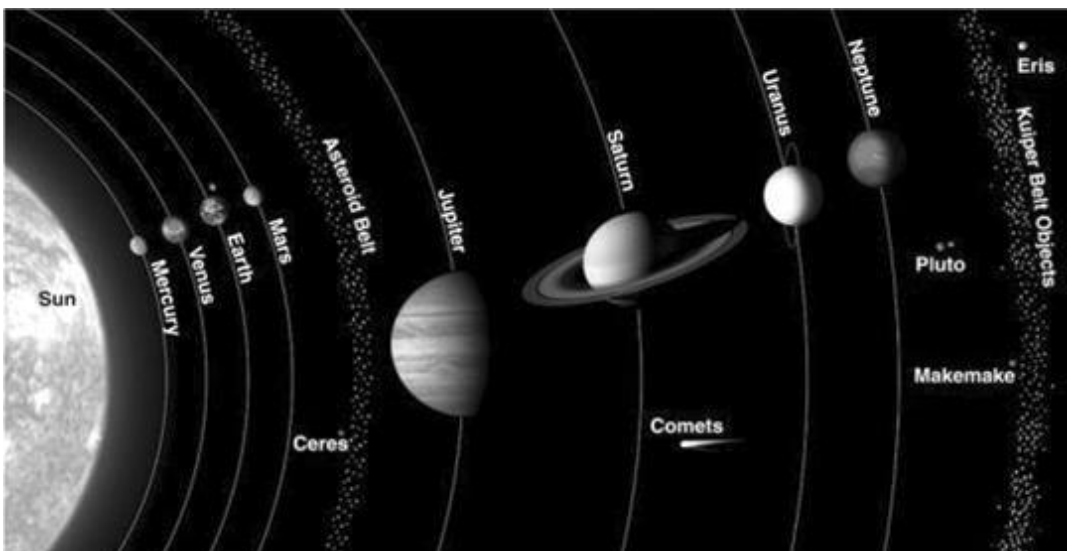
- At the end of their lives, **big stars are believed to create black holes**.
- **Gravitational pull is so strong** that nothing, **not even light, can escape it**.
- A black hole's **matter density can't be measured** (it's infinite!).
- **Warp space around them** and can pull nearby objects, including stars, into them.



Dark matter

- A kind of matter hypothesised in astronomy and cosmology to account for a significant amount of the **universe's mass that appears to be absent**.
- **Invisible to telescopes**- does not emit or absorb significant amounts of light or other electromagnetic energy.
- **A black hole is not the same as dark matter**.
- **Unknown elements** of dark matter.
- Might be a swarm of black holes, a dwarf, or a whole new particle.

Solar System



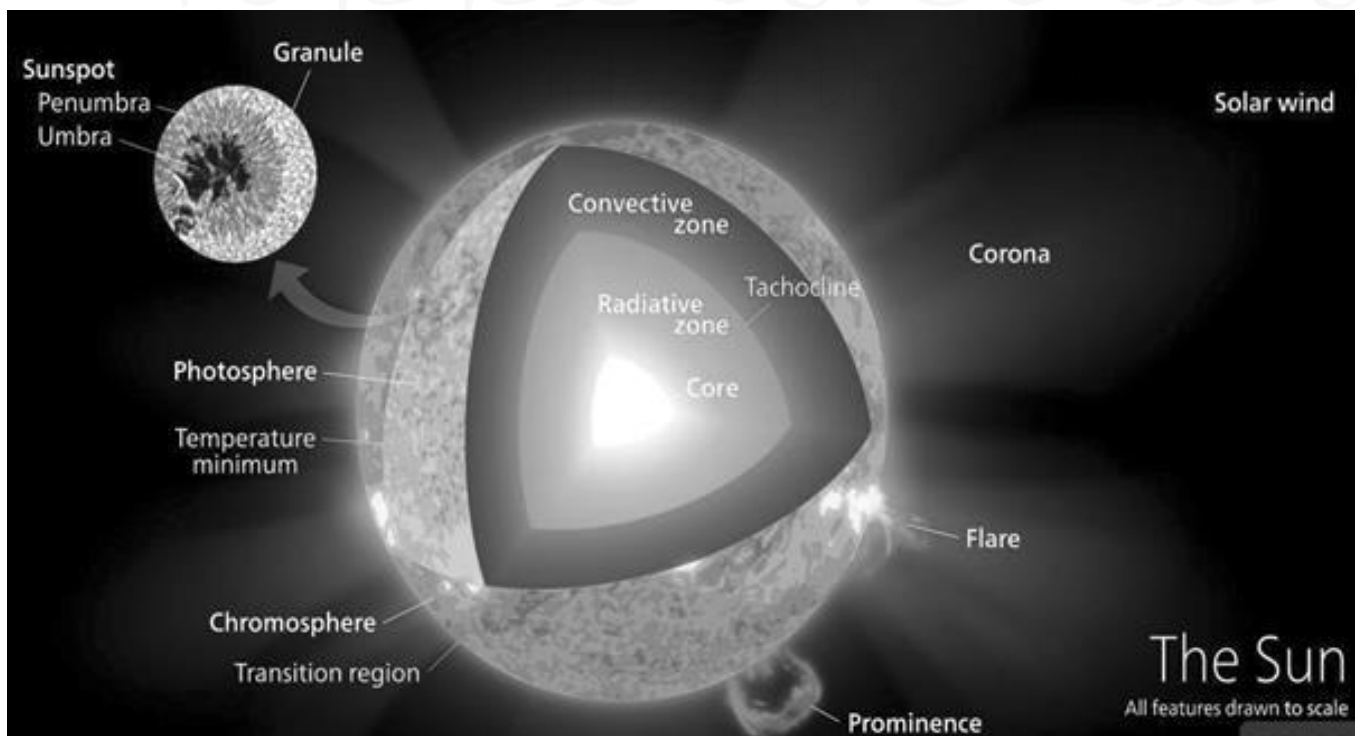
- **Age:** 4.6 billion years old
- **Distance:** 27,000 light years from the Milky Way's centre.
- **Components** - sun, eight planets and their satellites + asteroids, comets, and meteors.
- **Sun-** centre of the solar system.
- The sun's **gravitational influence maintains** the whole **solar system** rotating around it → sun's **gravitational pull determines velocity** of all solar system **components**.
- ~ **99.9% of the matter in the solar system** - from the sun.

Sun

- **Age:** 4.6 billion years.
- **Diameter:** 1.39 million km.
- **Temperature:**
 - **Surface-** 6000 °C on surface
 - **Core:** 16 million °C
- **Density:** 1.41 times that of water.
- **Rotation time:** 25 days and 9 hours.
- **Rotational speed:** 7179.73 km/h. (rotates **counter-clockwise**)
 - The **earth's rotational velocity** is 1675 kilometres per hour.
- **Mass:** 3,32,900 times of Earth masses.
- **Distance:** 150 million kilometres away from Earth
- **Time taken by light to reach earth:** 8 minutes and 20 seconds.



Time taken by light to reach Earth from the closest star, proxima centauri : 4.3 light years.



Internal Structure and Atmosphere of the Sun

- **Solar interior** - core, radiative zone and the convective zone.

- **Solar atmosphere - photosphere, chromosphere, and the corona** (solar wind is an outflow of gas from the corona).
- **Photosphere**
 - **Bright outer layer of the Sun** emits most radiation.
 - Extremely **uneven surface**.
 - **Effective temperature** on the outer side of the photosphere- **6000°C**.
- **Chromosphere**
 - **Just above the photosphere** is the chromosphere.
 - **Relatively thin layer** of burning gases.
 - The chromosphere is a **bit cooler — 4,320° C**.
- **Corona**
 - **Atmosphere of plasma** that **surrounds the Sun** and other celestial bodies.
 - **Stretches millions of kilometres into space** and may be **viewed best during a total solar eclipse**.

Plasma

- **Ionised gas** (atoms and molecules are converted into ions typically by removing one or more electrons from the outer shell)
- **Eg. Lightning and electric sparks** -made from plasma.
- **Neon lights - 'plasma lights'**- light comes from the plasma inside of them.

- **Sunspot**
 - **Dark patch on the surface of the Sun**.
 - **Appear as dark areas** - as **about 500-1500°C cooler than the surrounding chromosphere**.
 - **Has a lifetime** ranging from a few days to a few months.
 - **Each spot has a black centre or umbra**, and a **lighter region or penumbra**, surrounding it.
 - **Sun - 1% cooler when it has no sunspot** and that this variation in solar radiation might affect the climates of the Earth.
- **Solar prominence**
 - **An arc of gas that erupts from the surface of the Sun**.
 - Can loop **hundreds of thousands of miles into space**.
 - **Held above the Sun's surface by strong magnetic fields** and can last for many months.
 - Later they **erupt, spewing enormous amounts of solar material into space**.
- **Solar Wind**
 - **Stream of energised, charged particles**, primarily electrons and protons, **flowing outward from the Sun**.
 - **Speeds upto 900 km/s** and at a **temperature of 1 million degrees** (Celsius).
 - **Made of plasma** (ionised atoms).
- **Solar Flares:**
 - **Magnetic anomalies cause solar flares to form** on the sun's surface.
 - **Magnetic storms that seem like brilliant spots** with a **gaseous explosion on the surface**.

Impact of Solar winds:

1. Aurora

- **A natural light show in the sky** - commonly observed in **high latitudes** (Arctic and Antarctic).
(This is due to the earth's magnetic field lines and the solar wind.)

- **Caused by Charged particles (electrons and protons),** entering the atmosphere from above, creating ionisation and excitation of atmospheric elements, as well as **visual emissions.**

2. Some planets have atmospheres, while others don't.

- **Solar wind particles have a well-developed magnetic field - reach the planet - deflected.**
- **Magnetosphere -**
 - **Region around a planet dominated by the planet's magnetic field-** Earth has the **strongest magnetosphere** of all the rocky planets.
 - **Overall shape** is determined by the **solar wind.**
 - **Planets with a weak / non-existent magnetosphere** - prone to solar wind atmospheric stripping.
 - **Side facing the Sun-** magnetosphere is generally shaped like a hemisphere,
 - **Opposite side-** extends in a lengthy trail.
- **Magnetopause -**
 - **Abrupt boundary between a magnetosphere and the surrounding plasma.**
 - **Boundary between the planet's magnetic field and the solar wind.**

Planets

- A celestial body that orbits a star in an elliptical path.
- **2 groups:**
 - **Terrestrial Planets-**
 - **Inner planets** (as they lie between the sun and the belt of asteroids)
 - Have **smaller and denser bodies**
 - **Composition-** silicates and metals.
 - **Dense, rocky compositions, few or no moons, and no ring systems.**
- **Mercury (Buddh):**
 - **Smallest** and **closest** to the sun.
 - **Distance from Sun:** 57.91 million km
 - **Orbital period:** 87.97 Earth days,(Shortest)
 - **Length of day:** 58d 15h 30m
- **Venus (shukr):**
 - **Brightest planet** in the solar system (**morning/ evening star**)
 - Rotates in **anticlockwise direction**
 - The **hottest** planet in the Solar System- high concentration of CO₂ and thick atmosphere.
 - **Distance from Sun:** 108.2 million km
 - **Orbital period:** 225 days
 - **Length of day:** 116d 18h 0m
- **Earth (Prithvi):**
 - Only known planet to **sustain life.**
 - **Distance from Sun:** 149.6 million km
 - **Age:** 4.543 billion years
 - **Orbital period:** 365 days
 - **Natural Satellite:** MOON



- **Mars (Mangal):**

- **Red Planet:** Presence of **iron oxide on surface**
- **Length of day:** 1d 0h 37m
- **Distance from Sun:** 227.9 million km
- **Orbital period:** 687 days
- **Natural satellites:** Phobos, Deimos
- **Jovian planets / Gas Giants -**
 - **planets of outer circle**
 - Have a **greater size and less dense** materials.
 - They usually have a **thick atmosphere**, consisting of **helium and hydrogen**.

- **Jupiter(Brhaspati):**

- **Largest planet of the solar system**
- **Length of day:** 0d 9h 56m
- **Distance from Sun:** 778.5 million km
- **Age:** 4.603 billion years
- **Orbital period:** 12 years
- **Natural satellites:** Io, Europa, Ganymede, and Callisto(called the Galilean satellites because Galileo discovered them.)

- **Saturn(shani)**

- ☞ **Saturn's rings** are probably made up of **billions of particles of ice and ice-covered rocks**.
- ☞ **Length of day:** 0d 10h 42m
- ☞ **Distance from Sun:** 1.434 billion km
- ☞ **Orbital period:** 29 years
- ☞ **Moons:** Titan, Enceladus, Mimas, Tethys, etc.
- ☞ **Titan - second-largest moon** in the Solar System (larger than Mercury)
- ☞ **Only satellite in the Solar System with a substantial atmosphere (nitrogen-rich).**

- **Uranus(arun)**

- ☞ Rotates in **clockwise direction** i.e opposite of the sun's rotation.
- ☞ **Length of day:** 0d 17h 14m
- ☞ **Distance from Sun:** 2.871 billion km
- ☞ **Orbital period:** 84 Years
- ☞ **Natural satellites:** Miranda, Ariel, Umbriel, Titania, and Oberon.

- **Neptune(Varun)**

- ☞ **Farthest known planet**
- ☞ **Uranus and Neptune - Twin planets.**
- ☞ **Strongest sustained winds** (2,100 km/h) of any planet in the Solar System found here.
- ☞ **Length of day:** 0d 16h 6m
- ☞ **Distance from Sun:** 4.495 billion km
- ☞ **Orbital period:** 165 years
- ☞ **Natural satellites:** Triton, Hippocamp, Proteus, Nereid, etc.

Asteroids

- **Rocky remains** left over from the formation of the solar system.
- These remains failed to consolidate due to **Jupiter's gravitational influence**.
- **Composition** - refractory stony and metallic materials, with some ice.
- **Size**- microscopic to hundreds of kilometres.
- **Ceres** - largest asteroid (946 km in diameter), a protoplanet, and a dwarf planet.
- **All other asteroids** are considered as **tiny** Solar System bodies.



Kuiper Belt:

- A **circumstellar disc** in the **outer Solar System**.
- Spans 30 AU from Neptune's orbit to around 50 AU from the Sun.
- **Pluto (39 AU)**- largest known object in the Kuiper belt.

Oort cloud

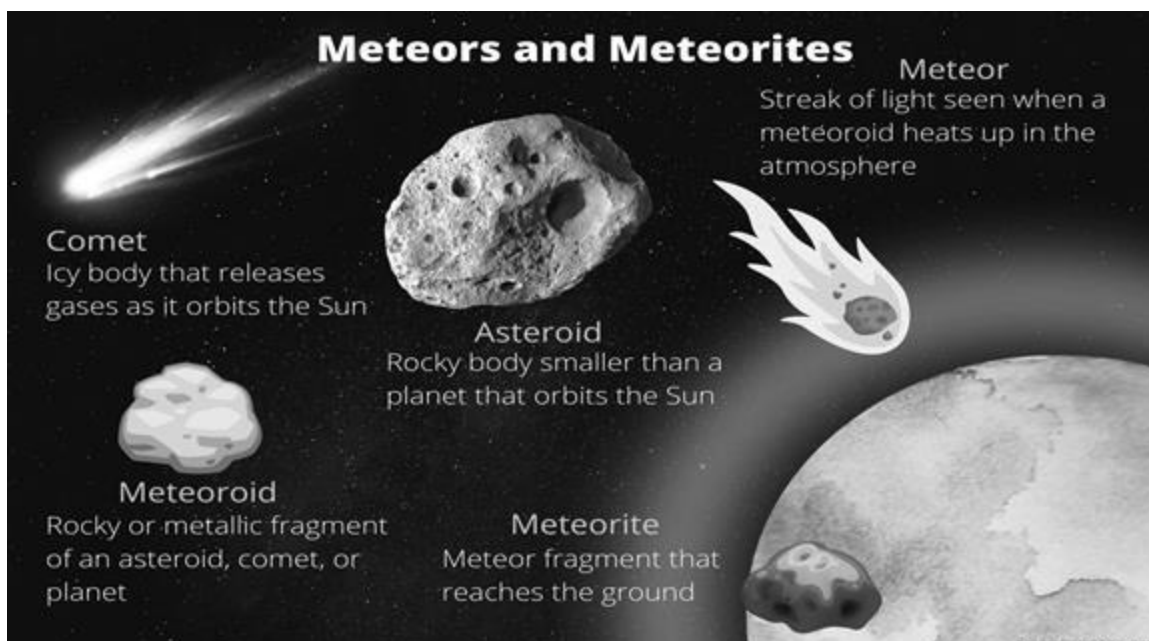
A **giant shell of icy bodies** that **encircle the solar system** occupying space at a **distance between 5,000 and 100,000 AU**.

Comets

- An **icy small solar system body**- **heats up** (when passing close to the Sun) due to **solar radiation** and the **solar wind** - begins to **outgas (release gases)** - atmosphere and sometimes a tail visible .
- Have highly **elliptical orbits**.
- **Composition**- **Stony and metallic minerals** held together **by frozen gases** (water, ammonia, methane, and carbon dioxide).
- **Types:**
- **Short-period comets** - orbital period - **100 years**- generally **originate** in the **Kuiper belt**.
- **Long period comets** - orbital period - **thousands of years**, come from the more distant **Oort Cloud**.



Meteoroid, Meteor and Meteorite



- **Meteoroid:** Any solid debris originating from asteroids, comets, or other astronomical objects that drifts across interplanetary space.
- **Meteor:** A flash of light that emerges in the sky when a meteoroid hits the atmosphere (mesosphere) at a high speed and **burns up due to friction**. Sometimes known as a 'shooting star' or a 'falling star.'
- **Meteorite:** When a meteoroid does not burn entirely and lands on the surface of the Earth.

Meteorite crater:

- A circular depression generated on the earth's surface as a result of a meteorite impact.
- Most visible meteorite craters - Moon and Mercury's surfaces (because they are geologically inactive due to a negligible atmosphere).
- **World's Largest Meteor Crater:** 1,300 metres deep **Arizona(US)**.
- **Chicxulub crater (Mexico's Yucatan Peninsula)** - caused by a meteor impact that is **believed to have wiped out the dinosaurs** (mass extinction at the end of the Cretaceous 65 million years ago).
- **Meteorite craters in India**
 - **Lonar Lake (1.8 km in diameter)** in Buldhana District of **Maharashtra**.
 - **Dhala crater (14 km in diameter)** in Shivpuri district, **Madhya Pradesh**.
 - **Ramgarh crater (3.5 km in diameter)** is a potential meteorite crater in **Kota plateau** in **Rajasthan**.

Meteor Showers

- Occurs when Earth encounters many meteoroids at once.
- Comets also orbit the sun.
- As a comet gets closer to the sun, some of its icy surface boils off, releasing lots of particles of dust and rock (meteoroids).
- This comet debris gets scattered along the comet's path, especially in the inner solar system (including planets Mercury, Venus, Earth and Mars).
- When Earth makes its journey around the sun, its orbit crosses the orbit of a comet i.e. Earth encounters a bunch of comet debris.
- These meteoroids when enter the earth's atmosphere burn up and cause continued lighting of sky for some time k/a meteor shower.
- Named for the constellation where the meteors appear to be coming from.
- Eg. **Orionids Meteor Shower** appears to be originating near the constellation 'Orion the Hunter'.

Moon

- **Diameter** - one-quarter of earth.
- **Distance from earth**- **3,84,400 km**.
- Light takes only a second to reach us from the moon.
- **Tidally locked to the earth**, meaning that the moon revolves around the earth in about 27 days which is the same time it takes to complete one spin.
- Hence, **only one side of the moon is visible from earth**.
- **Without moon, Earth's tilt could vary as much as 85 degrees** (at present the Earth's axis of rotation is tilted at an angle of 23.5° relative to our orbital plane).



Tidal locking - Object's orbital period = rotational period.

Formation of Moon:

- Formation is an **outcome of 'giant impact'** aka **'the big splat'**.
- A **body of the size 2-3x of mars collided into the earth** shortly after the earth was formed- **blasted a large part of the earth into space.**
- **Part of blasted material** - continued to orbit the earth - **formed into present moon** about 4.44 billion years ago.
- **Moon used to revolve much closer to Earth than today.**
- **Earth rotates -> Moon's gravity causes tides.**
- **Little friction between the tides and the turning Earth-** earth's rotation slows down just a little (1.4 milliseconds in 100 years).
- As Earth slows- **Moon drifts away a little** (four centimetres per year).

Types of Moon:

1. Blood Moon/ Copper Moon

- **Total lunar eclipses aka blood moons** because of the **reddish orange glow the moon takes on.**
- **Total lunar eclipse** - Earth moves **between the Sun and the Moon** - **cuts off the Moon's light supply.**
- **Surface of the Moon takes on a reddish glow** instead of going completely dark.
- Reddish color during totality **due to Rayleigh scattering.**

Rayleigh scattering

Same mechanism **responsible for causing colorful sunrises and sunsets**, and for the **sky to look blue.**

2. Blue Moon

- **Appearance: two and a half years** on average.
- Blue moon **does not mean blue coloured moon.** It is just **second full moon of any calendar month.**

3. Super moon

- **Full moon occurs at its perigee.**
- **Rare event.**
- Has to satisfy **two conditions**
 - **Moon must be closest** to the earth
 - Should be a **full moon.**
- Moon- **30 % brighter** and **14 % larger.**
- **Difference cannot be seen with naked eye.**

Dawn and Twilight

- **Dawn:**The period between **sunrise** and full **daylight.**
 - **Twilight:** The period between **sunset** and complete **darkness.**
 - **Occurrence-** Earth receives **scattered or refracted light** from the sun **when** it is still **below the horizon** during **dawn and twilight.**
 - **Poles-** **winter darkness** is much **longer-** mostly **merely twilight.**
-

Eclipse

- **Occurrence:** When the **Sun, the Earth, and the Moon** are in a **straight line**.
- **Types :**



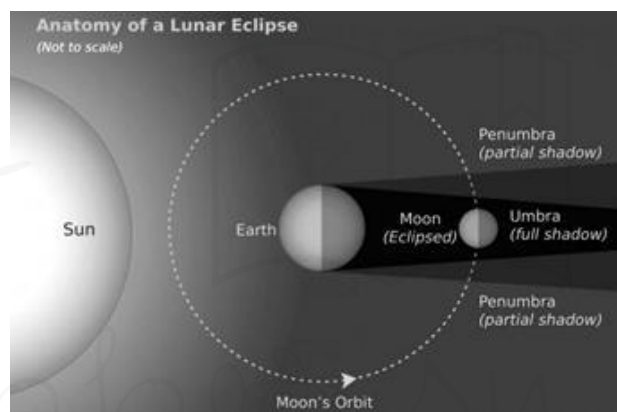
1. Lunar Eclipse

- **Ideal Position:** Only when the Sun, the Earth, and the Moon are in a straight line, and the **Earth is between the Sun and the Moon**,
- Possible only on a **Full Moon day**. However, since these **three bodies must be in the same plane as the ecliptic**, a **lunar eclipse does not occur on every Full Moon day**.

Total lunar eclipse: Moon exactly in the plane of the ecliptic.

Partial lunar eclipse: Moon close to the ecliptic plane.

No eclipse: Moon much above or far below the ecliptic plane.



2. Solar Eclipse

- **Ideal Position:** Only when the Sun, the Earth, and the Moon are all in a straight line, and the **Moon is between the Sun and the Earth**.
- Possible on a **New Moon day** -But **does not occur on every New Moon day**.

Total Solar Eclipse: Moon is **exactly in the plane of the ecliptic**.

Partial solar eclipse: Moon is **close to the ecliptic plane**.

No Eclipse : Moon is **much above or far below** the ecliptic plane.

Annular Eclipse: Moon **covers the sun but** the sun can be seen around the edges of the moon.

- **Diamond Ring Effect:** A visual phenomena **can be seen from Earth** when standing in the **umbra** of the moon's shadow.

