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TELANGANA PUBLIC SERVICE COMMISSION (TSPSC) GROUP - 1, 2, 3 AND OTHER RELATED SERVICES

STUDYMATE NOTES

English

The Earth in our Solar System

The Earth in our Solar System

I. Universe and its Origin

Overview:

- In simple words, the universe is an expansive and boundless space. It encompasses galaxies, stars, planets, and various types of matter and energy.
- The universe originated from an energy-saturated state that later formed particles, assembling into light elements like hydrogen and helium. These combined together and resulted in formation of galaxies, stars, and other elements.
- Observable stars, planets, and galaxies constitute only 4 percent of the universe. The remaining 96 percent consists of substances that are not easily detectable or understood.

Key facts about Universe	
Feature	**Description**
Origin	Energy-saturated state → particles → light elements (hydrogen & helium) → galaxies, stars, elements
Composition	• 4% observable (stars, planets, galaxies) • vast majority of the universe remains unseen and mysterious • Unknown Matter: 96% dark matter and dark energy
Gravitational Lensing	It is a measurement technique that confirms the universe's age and the impact of dark energy, which is responsible for the universe's accelerating expansion.
Universe's Expansion	By studying light from a distant galaxy using gravitational lensing, scientists gained insights into the universe's expansion and properties of dark energy.
Big Bang Theory on expansion	• In the beginning, all matter forming the universe existed in one place in the form of a "tiny ball" (singular atom) with an unimaginably small volume, infinite temperature and infinite density. • At the Big Bang the "tiny ball" exploded violently. This led to a huge expansion. • It is now generally accepted that the event of big bang took place 13.7 billion years before the present. The expansion continues even to the present day.

Origin of the Universe and Origin Theory	
Feature	**Description**
Big Bang Theory	• The widely accepted explanation for the universe's origin is the Big Bang Theory. • It was proposed by **Abbe Georges Lemaitre** (a Belgian astronomer) in 1927. • Big Bang Theory describes the universe's formation around 13.75 billion years ago, rapidly expanding from a tiny size to its current vastness. • According to BBT, universe originated from a dense, hot Singularity and has been expanding ever since.
Hubble's Discovery (1929)	• **Edwin Hubble** provided evidence supporting an expanding universe. (Discovery of expansion) • Galaxies farther away have larger redshifts, indicating faster recession. • Hubble's observation supported Lemaitre's theory, providing crucial evidence for the Big Bang.
Nebular Hypothesis	• **German professor Immanuel Kant** proposed the Nebular Hypothesis, later revised by **Laplace** in 1796, suggesting the formation of planets from a slowly rotating cloud of material.
Accretion theory	• **Lyttleton** introduced the accretion theory, positing that 4.6 billion years ago, the **solar system originated from a dust and gas cloud called a solar nebula.** According to this theory, • As the solar nebula began to spin, the gravity collapsed the materials on itself and it formed the sun in the centre of the solar system. • When the sun formed, the remaining materials began to clump up. Small particles drew together, bound by the force of gravity, into larger particles. The solar wind swept away lighter elements, such as hydrogen and helium, from the closer regions. Only heavy rocky materials remained to form planets like

	Earth, while farther out, lighter elements coalesced into gas giants, moons, asteroids, and comets. ● Earth's rocky core formed initially from collisions of heavy elements, leading to the sinking of dense materials to the center and lighter materials forming the crust. ● The planet's magnetic field likely developed around this time, while gravity captured gases that composed the early atmosphere.
Hoyle's concept of steady state	● An alternative to this was Hoyle's concept of steady state. It considered the universe to be roughly the same at any point of time.

Note:

- Other theories formulating the origin of the Universe includes - **Theory of Mirage of a Black Hole, Plasma Theory of creation of Universe and White Hole Theory** etc. However, from the TSPSC Groups exam point of view, there is no need to go deep into these theories. Knowing the name of such theories is enough at this stage.

II. Galaxies and Stars

Formation of Galaxies and Stars

- As the universe expanded, matter scattered and galaxies were formed, including the Milky Way that houses our Solar System. Galaxies consist of stars, gas, dust, and dark matter.
- The term "galaxy" comes from the Greek "Galaxias," meaning "milky," a nod to our own galaxy, the Milky Way, which encompasses our Solar System.
- A galaxy starts to form by accumulation of hydrogen gas in the form of a very large cloud called **nebula**. Eventually, growing nebula develops localised clumps of gas. These clumps continue to grow into even denser gaseous bodies, giving rise to formation of stars.
- The formation of stars is believed to have taken place some 5-6 billion years ago.

Galaxies are in three major forms:

- **Spiral Galaxies:** Flat, rotating disks of stars, gas, and dust with a central bulge. Examples include the Milky Way and Andromeda.
- **Elliptical Galaxies:** Comprised of older stars and less gas. Messier 89 is an example of an elliptical galaxy.
- **Irregular Galaxies:** Youthful galaxies with higher dust and gas content, often very bright. The Large Magellanic Cloud is an example of an irregular galaxy.

Galaxy Types

Feature	Description	Examples	Key Features
Spiral	Flat, rotating disks with prominent arms, central bulge, diverse stellar populations.	Milky Way, Andromeda	Prominent spiral arms, active star formation.
Elliptical	Egg-shaped or spherical, older stars, less gas and dust.	Messier 89	Smooth appearance, dominated by older stars, less active star formation.
Irregular	No defined shape, high dust and gas content, often bright.	Large Magellanic Cloud	Unsymmetrical appearance, active star formation, vibrant colors due to dust and gas.

Do you know?

- The Milky Way has four main spiral arms: the Norma and Cygnus arm, Sagittarius, Scutum-Crux, and Perseus.

Stars and Constellations	
Feature	**Description**
Star	• A star is an astronomical object that emits its own light and heat. The nearest star to Earth is the Sun. • **Sirius is a brighter star** than the Sun, and **'Proxima Centauri' is the closest star to the Sun**. • Stars form from the clumping together of dust and gas due to gravitational forces. • Throughout their lifetimes, stars undergo various stages such as red giant, white dwarf, neutron star, and black hole, each representing different evolutionary phases.
Constellation	• A constellation is a **collection of stars** that form a recognizable pattern or shape in the sky. • The International Astronomical Union (IAU) established the official boundaries for 88 constellations in 1929, while Ptolemy listed 48 constellations in his book Almagest. • **Ursa Major** is a constellation visible in the northern and part of the southern hemisphere, named after the Latin phrase meaning **"Great Bear."**

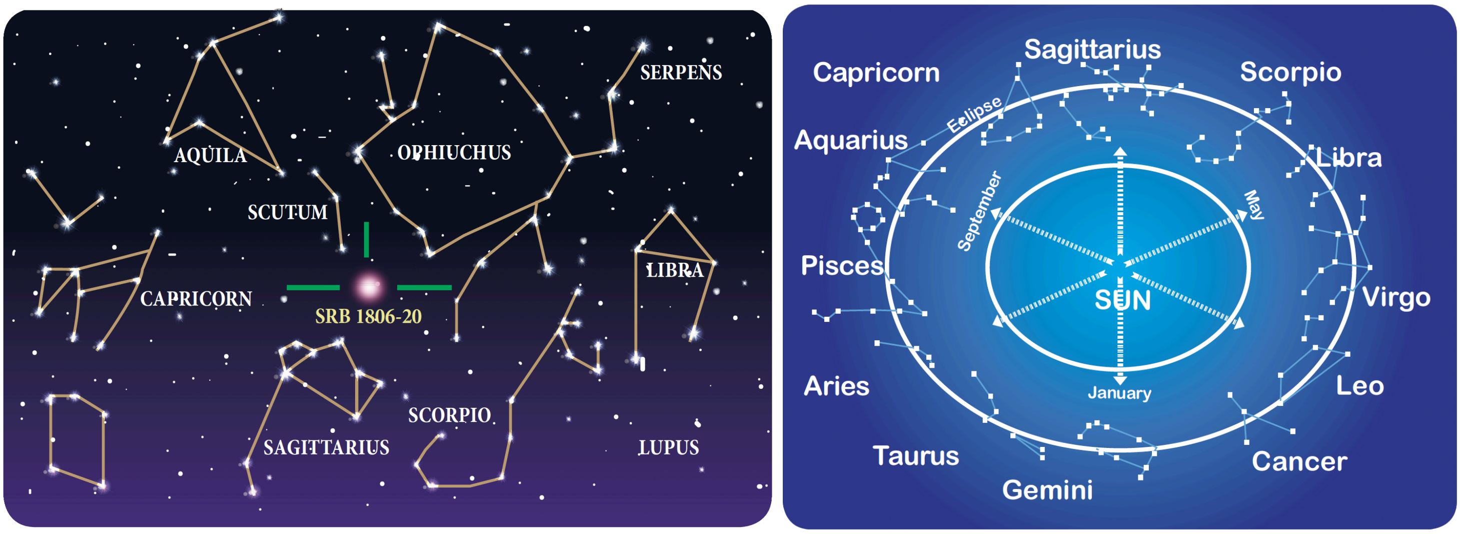


Fig: Constellation

Did you know about Sirius?

- Sirius, also known as the Dog Star, is the brightest star visible in our night sky.
- It is part of the "Greater Dog" constellation - Canis Major
- It is relatively close compared to other bright stars (8.6 light-years)
- It emits significantly more light than our Sun.

III. Solar system

Solar System	
Feature	**Description**
Structure	• **Central star:** Sun • **8 planets** orbiting in elliptical paths (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune) • **Other objects:** moons, asteroids, comets, meteoroids
Location	• Outer spiral arm of Milky Way galaxy • Orbits the Milky Way center at 828,000 km/h • Orbital period: 230 million years
Formation	• 4.6 billion years ago
Additional features	• **Kuiper Belt:** icy bodies beyond Neptune • **Oort Cloud:** spherical shell of icy debris beyond Kuiper Belt (1.6 light years away) • 163+ known natural satellites (moons) in the solar system • Jupiter and Saturn have the most moons
Key points	• Billions of possible solar systems in Milky Way alone • Some solar systems have multiple stars • Oort cloud marks the boundary of Sun's gravitational influence

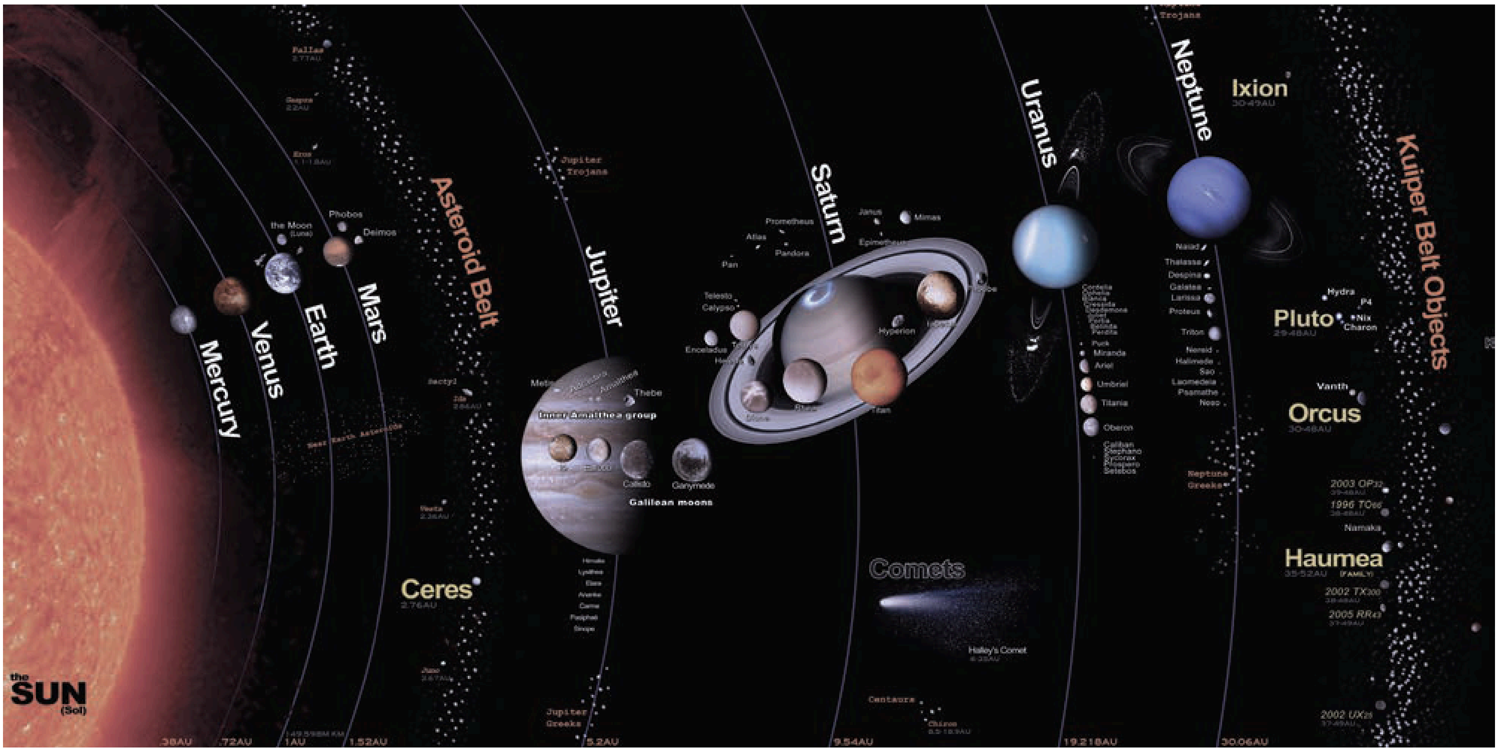


Fig: Solar System

The Sun	
Feature	**Description**
Key Points	• **Location:** Central star of our solar system. • **Type:** Yellow dwarf star, a hot ball of glowing gases. • **Gravity:** Holds the solar system together, keeping planets and particles in orbit. • **Magnetic Field:** Generated by electric currents, carried out by the solar wind. • **Significance:** Provides light, heat, and gravitational stability for the solar system.

Other key facts	• The Sun's temperature varies from around 5,500°C at the surface to millions of degrees at its core. • Its composition is mainly hydrogen (73.46%) and helium (24.85%), with trace amounts of other elements. • The solar wind is a stream of charged particles flowing out from the Sun, affecting planets and space weather. • The Sun's magnetic field interacts with Earth's magnetic field, causing auroras and other phenomena. • The Sun's life cycle is estimated to be around 10 billion years, with about 4.6 billion years already passed.
Radius of Sun	• 695,508 kilometers • Enormous compared to Earth (109 times wider).
Mass of Sun	• 332,946 times Earth's mass • Dominates the solar system, influencing gravity and orbits.
Volume of Sun	• 1.3 million Earths • Highlights the Sun's immense scale, dwarfing planets.
Distance from Earth	• 149.6 million kilometers (average) • Affects the intensity of sunlight and communication delays.

Structure of the Sun		
Layer	**Description**	**Key Features**
Core	Sun's center, hot and dense	Nuclear fusion occurs, generating energy (15 million °C).
Radiative Zone	Transfers energy outward through radiation (photons).	Hot gas, energy moves slowly.
Convective Zone	Energy transfer by rising and sinking hot gas bubbles (convection).	Cooler than radiative zone, turbulent.
Photosphere	Visible surface, emits light and heat (5,500-6,000 °C).	Appears as the Sun's "surface," granulation pattern visible.
Chromosphere	Lower atmosphere, thin layer, red color during eclipses.	Hotter than photosphere, turbulent.
Corona	Upper atmosphere, vast and hot (millions of °C).	Extends far beyond photosphere, source of solar wind.

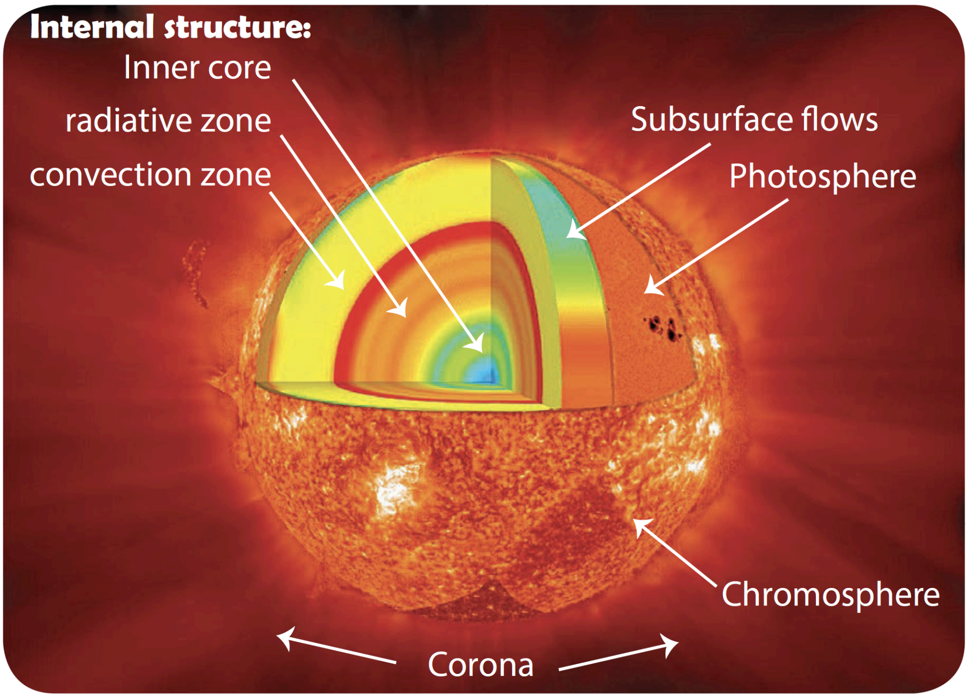


Fig: Structure of the sun

Orbit and Rotation of the Sun		
Feature	**Description**	**Significance**
Sun's Orbit	Around Milky Way center at 828,000 km/h	Influences the solar system's overall motion and timescale.
Orbital Period	230 million years	Provides context for galactic timescales and evolution.
Sun's Rotation	25 days at equator, 36 days at poles	Differential rotation due to non-solid nature.
Axial Tilt	7.25°	Affects seasonal variations on Earth and solar activity.
Mass Domination	Sun accounts for 99.8% of solar system mass	Crucial for gravitational influence and stability.
Sun's Future	Will exhaust fuel and expand, engulfing inner planets.	Understanding stellar lifespans and potential consequences.
White Dwarf Stage	Sun's final state after 6.5 billion years	Prediction of the solar system's ultimate fate.

The Planets

The Planets	
Feature	**Description**
Definition and Characteristics	• **Planet definition:** Greek for "wanderer," a celestial body orbiting the Sun without its own light or heat, with specific characteristics: ○ Orbits the Sun ○ Not a satellite of another planet ○ Spherical shape due to gravity ○ No other major body crossing its orbit
Classification	• **Inner Planets (Terrestrial):** Mercury, Venus, Earth, Mars - rocky, closer to the Sun • **Outer Planets (Jovian/Gas Giants):** Jupiter, Saturn, Uranus, Neptune - gaseous, farther from the Sun
Movement	• **Rotation:** spinning on its axis (one rotation = one planet day) • **Revolution:** orbiting the Sun (one revolution = one planet year)

Planets in the Solar System	
Feature	**Description**
Mercury	• **Smallest planet in our solar system:** No moons or liquid water. • **Extreme rotation and revolution:** Rotates every 58.65 Earth days (slow) but revolves around the Sun every 88 Earth days (fast). • **Proximity to Sun:** 0.4 astronomical units away, receiving intense solar radiation. • **Surprising temperature:** Second hottest planet despite being closest to the Sun due to lack of atmosphere to retain heat. • **Sunlight travel time:** 3.2 minutes for sunlight to reach Mercury from the Sun. Did you know? • Mercury has a heavily cratered surface due to its lack of atmosphere and ancient asteroid bombardment. • It experiences extreme temperature swings, ranging from scorching hot during the day to frigid cold at night. • Mercury's thin atmosphere cannot trap heat effectively, leading to drastic temperature changes.
Venus	• **Second closest planet** to the Sun. • **Nickname:** "Earth's Sister" due to similar size and mass. • **Hottest planet:** Mean surface temperature of 462°C. • **Nicknames**: "Morning star" and "Evening star" for visibility before sunrise and after sunset. • **Unusual rotation:** Clockwise (east to west), one rotation takes 243 Earth days (longest day).

	• **Orbit:** 224.7 Earth days, no natural satellites. • **Distance from Sun:** 0.7 astronomical units, sunlight takes 6 minutes to reach Venus. Did you know? • Venus has a thick, toxic atmosphere composed mainly of carbon dioxide, trapping heat and creating a runaway greenhouse effect. • Its surface is mostly flat, with vast plains and volcanic features. • Clouds on Venus are made of sulfuric acid, making it highly corrosive.
Earth	• **Third planet from the Sun:** Ideal distance for liquid water and potential life. • **Fifth largest planet:** Moderate size with diverse surface features. • **Rotation and Revolution:** 23h 56m 4s rotation, 365.25 days revolution. • **Temperatures:** Varies from -88°C to 58°C, supporting various life forms. • **Unique features:** Oxygen atmosphere, abundant water, moderate temperature, and one natural satellite (Moon). • **Nickname:** "Blue Planet" due to extensive oceans. • **Sunlight travel time**: 8.2 minutes. Did you know? • Earth's dynamic atmosphere protects us from harmful solar radiation and regulates climate. • Plate tectonics on Earth create diverse landscapes and contribute to the planet's dynamism. • The Moon plays a crucial role in stabilizing Earth's axis and influencing tides.
Mars	• **Fourth nearest planet to the Sun**, second smallest in the solar system. • **Nickname:** "Red planet" due to iron oxide-rich surface. • **Landmass:** Similar to Earth, though Mars is smaller overall. • **Rotation and Revolution**: 24h 37m rotation, 687 days revolution. • **Temperature extremes:** -153°C to 20°C, hinting at potential for liquid water. • **Habitability potential:** Considered Mars, after Earth, most likely to harbor life. • **Surface features**: Seasons, polar ice caps, volcanoes, canyons, and weather patterns. • **Moons:** Two natural satellites, Phobos and Deimos. Did you know? • Mars's thin atmosphere and lack of a strong magnetic field pose challenges for life as we know it. • Ongoing research explores the possibility of past and present water on Mars, crucial for potential life.
Jupiter	• **Largest planet in the solar system:** Fifth from the Sun, dwarfing other planets in size and mass. • **Gas giant:** Primarily composed of hydrogen and helium, lacking a solid surface. • **Fast rotation:** Shortest day in the solar system, completing one rotation in 9 hours, 55 minutes. • **Long orbital period:** Takes 11.86 years to complete one revolution around the Sun. • **Ring system:** Faint rings made mostly of dust particles, discovered in the 17th century. • **Numerous moons:** 67 confirmed satellites, including Ganymede, the largest natural satellite in the solar system. Did you know? • Jupiter's immense gravity influences the orbits of other planets and asteroids. • Its atmosphere is turbulent, with storms like the Great Red Spot raging for centuries. • Jupiter has a strong magnetic field, protecting it from harmful solar radiation.
Saturn	• **Second largest planet in the solar system:** Sixth from the Sun, known for its majestic size and beauty. • **Nickname:** "Ringed Planet" due to its extensive and iconic ring system. • **Rings:** Composed mainly of ice and dust particles, with a total of 30 confirmed rings. • **Density:** Unique distinction of having an average density less than water. • **Moons:** 53 confirmed natural satellites, including Titan, the second largest moon in the solar system. • **Rotation and revolution:** Rotates in 10 hours 34 minutes, takes 29.4 years to orbit the Sun.

	Did you know? ● Saturn's rings are diverse in size, composition, and reflectivity, offering a mesmerizing spectacle. ● Its atmosphere is turbulent, with storms and winds reaching high speeds. ● Titan, Saturn's largest moon, has a thick atmosphere and lakes of liquid methane, making it a potential candidate for harboring life.
Uranus	● **Seventh planet from the Sun:** Not visible to the naked eye due to distance. ● **Unique rotation:** Rotates east to west, like Venus, but on its side with a 98-degree axial tilt. ● **Sunlight distribution:** Polar areas receive most sunlight due to the tilt. ● **Composition:** Atmosphere dominated by hydrogen, helium, and methane, contributing to a bluish-green hue. ● **Temperature:** Very cold due to its great distance from the Sun. ● **Name:** Derived from the ancient Greek god of the sky. ● **Additional features:** Rings and 27 known moons. Did you know? ● Uranus's extreme tilt creates unique seasonal patterns, with long periods of daylight and darkness at the poles. ● Its rings are faint and composed of dust and ice particles, unlike the vibrant rings of Saturn. ● Some of Uranus's moons, like Titania and Miranda, show geological activity and intriguing features.
Neptune	● **Eighth planet from the Sun:** Farthest planet, shrouded in darkness and mystery. ● **Extreme rotation and revolution:** Rotates in 16 hours, orbits the Sun in 165 years (longest in the solar system). ● **Moons and rings:** 13 moons, including Triton, and 5 faint rings. ● **Coldest planet:** Receives minimal sunlight due to distance, with temperatures reaching -214°C. ● **Mathematical discovery:** Neptune's existence was predicted through calculations before its visual observation, a triumph of scientific reasoning. ● **Windy giant:** Possesses the fastest winds in the solar system, exceeding 2,000 km/h. Did you know? ● Neptune's atmosphere is turbulent, with storms and winds raging at immense speeds. ● Triton, its largest moon, is geologically active with geysers and ice volcanoes.

Distance of the planets from the sun

Name Of The Planet	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Diameter (km)	4,879	12,104	12,756	6,794	1,42,984	1,20,536	51,118	49,528
Density (kg/m^3)	5,427	5,243	5,514	3,933	1,326	687	1,271	1,638
Rotation Period (hours)	1,407.60	5,832.50	23.9	24.6	9.9	10.7	17.2	16.1
Length of Day (hours)	4,222.60	2,802	24	24.7	9.9	10.7	17.2	16.1
The Average distance from the sun (10^6 km)	57.9	108.2	149.6	227.9	778.6	1,433.50	2,872.50	4,495.10
Orbital Period (days)	88	224.7	365.3	687	4331	10,747	30,589	59,800
Number of Satellites	0	0	1	2	67	53	27	13

Dwarf Planets	
Feature	**Description**
Definition	• Smaller than planets but larger than asteroids, dwarf planets are celestial bodies orbiting the Sun with sufficient mass for self-gravity and a nearly round shape. They are not satellites of any planet.
Number	• Five officially recognized dwarf planets: Ceres, Pluto, Haumea, Makemake, and Eris.
Pluto's Reclassification	• In 2006, Pluto's status was reclassified from planet to dwarf planet because it did not meet the newly defined criteria, specifically, not clearing its orbital neighborhood.
Unique characteristics	• Each dwarf planet has distinct features: ○ **Ceres:** Largest dwarf planet, located in the asteroid belt. ○ **Pluto:** Iconic dwarf planet with five moons, including Charon. ○ **Haumea:** Ellipsoidal shape, rapid rotation. ○ **Makemake:** Large dwarf planet with a methane atmosphere. ○ **Eris:** Most massive dwarf planet, highly reflective surface.

Satellites	
Feature	**Description**
Meaning	• "Satellite" comes from Latin, literally meaning "companion," reflecting their relationship to planets.
Early History	• Until Galileo's discovery of Jupiter's moons in 1610, the Moon was the only known satellite.
Abundance	• Today, there are over 163 known satellites in our solar system, orbiting planets and dwarf planets.
Orbital Direction	• Most satellites, including the Moon, orbit their planets from west to east.
Reflected Light	• Satellites lack their own light source and shine by reflecting sunlight.
Physical Characteristics	• Generally lack atmospheres and liquid water, though some exceptions exist (e.g., Titan, Europa). • The diversity of satellites is vast, ranging from tiny moons like Phobos (Mars) to massive giants like Ganymede (Jupiter).

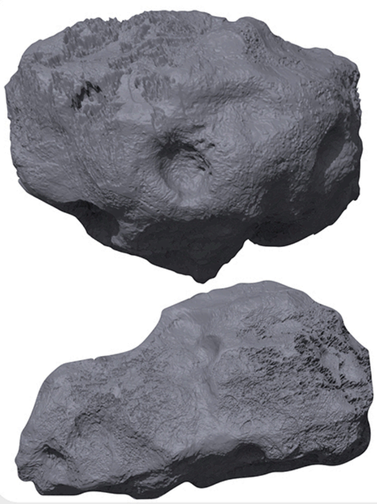
The Moon	
Feature	**Description**
Distance	• 384,401 km from Earth (average).
Orbital period	• 27 days, 7 hours, 43 minutes (rotation and revolution).
One side visible	• Due to tidal locking, Earth sees only one side of the Moon.
Fifth largest moon	• In our solar system, behind Ganymede, Callisto, Io, and Europa (all Jupiter's moons).
Formation	• Likely from a collision between Earth and a Mars-sized body.
Surface features	• Craters, high mountains, and vast plains, casting dramatic shadows.
Reflected light	• Sunlight takes 1.25 seconds to reach Earth from the Moon.
Gravity	• 1/6 that of Earth, leading to lighter weight on the Moon.
Moon & Earth	• The Moon plays a crucial role in tides, stabilizing Earth's axis, and influencing our climate.

Asteroids	
Feature	**Description**
Small, rocky bodies	• Asteroids are significantly smaller than planets and lack their atmospheres and round shapes.
Solar orbit	• They revolve around the Sun, similar to planets, but often in irregular or elliptical orbits.
Nickname	• "Minor planets" due to their smaller size compared to planets.
Abundance	• Millions of asteroids exist in our solar system, with the majority concentrated in the asteroid belt between Mars and Jupiter.
Size range	• Varies greatly, from large planetoids hundreds of kilometers across to tiny pebbles.
Origins	• Theories suggest asteroids could be remnants of a planet's destruction or leftover material from the solar system's formation.
New discoveries	• Asteroids are still being discovered, with ongoing surveys and missions revealing more about their populations and characteristics.

Did you know?

- Asteroids pose potential threats to Earth if they collide with our planet, but monitoring and deflection technologies are being developed.
- Studying asteroids can provide valuable insights into the formation and evolution of our solar system and the potential for resources like water ice.
- Missions to asteroids, like Hayabusa and OSIRIS-REx, have returned samples to Earth for further study and analysis.

WHAT IS AN ASTEROID?



An asteroid is <u>a rocky object, smaller than a planet and bigger than a meteroid, that orbits the Sun</u>.

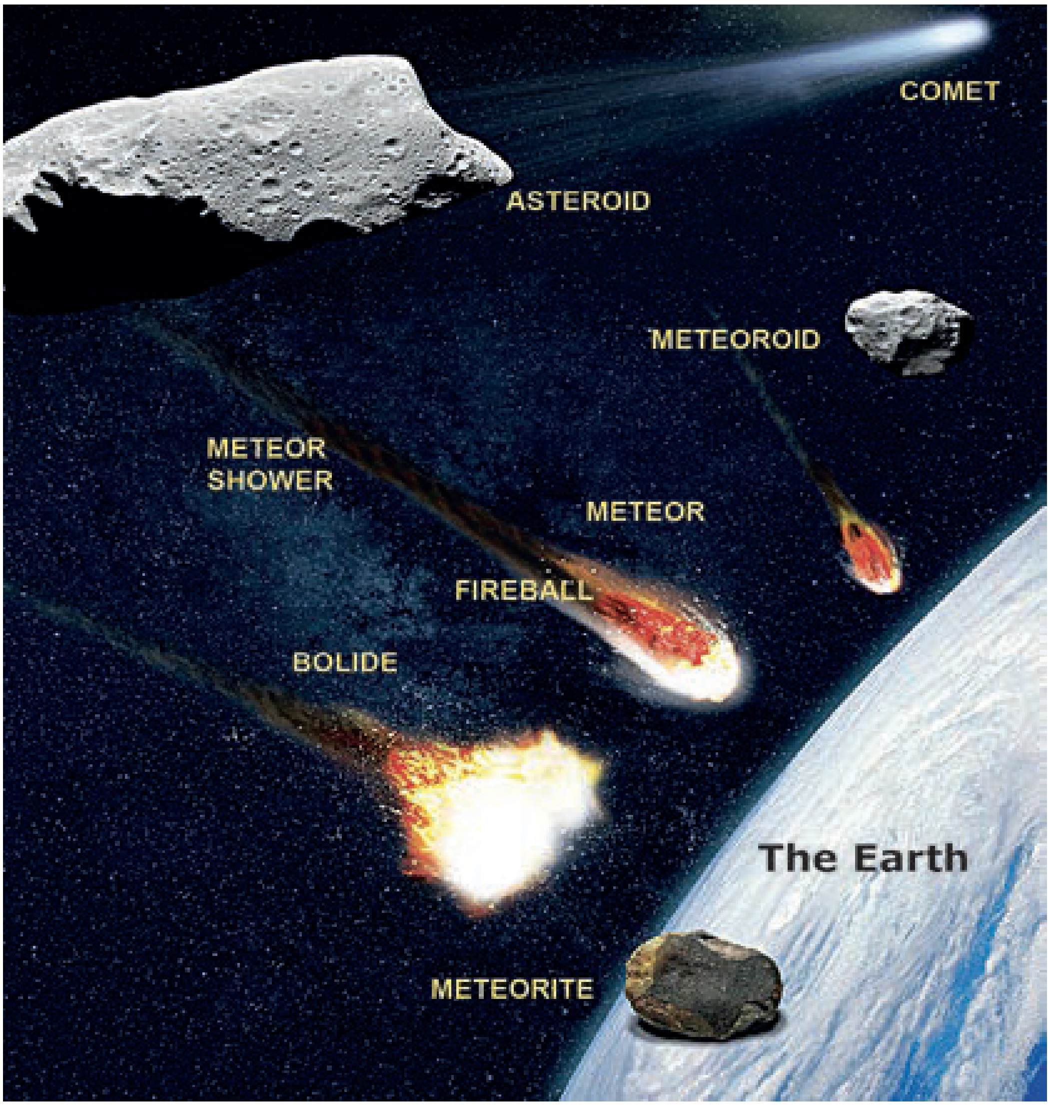
Most asteroids are **irregularly shaped**, though a few are nearly spherical, and they are often **pitted or cratered** because of the impacts with other asteroids.

Scientists have identified **30,039 near-Earth** asteroids in the **Solar System.** Most of them are located in the main asteroid belt; a region between the orbits of Mars and Jupiter.

Comets	
Feature	**Description**
Mesmerizing objects:	● Comets have captured human imagination for centuries, sparking curiosity and even fear.
Greek origin	● Their name, "Kometes," means "long-haired star" in Greek, reflecting their characteristic tails.
Composition	● Made of ice particles, dust, and rocky fragments, often referred to as "dirty snowballs."
Solar orbits	● Travel around the Sun, but unlike planets, their orbits are highly elliptical, taking them close and far.
Perihelion and Aphelion	● Closest point to the Sun is called perihelion, farthest point is aphelion.
Tail formation	● As comets approach the Sun, heat and radiation vaporize ice, creating a visible tail of dust and gas.
Types of tails	● Comets have two main tails: a dust tail and an ion tail, each with distinct properties.

Did you know?

- Comets come in various sizes, ranging from small, short-lived objects to massive ones like Hale-Bopp.
- Their orbits can take them from the inner solar system to the distant reaches beyond Neptune.
- Missions like Rosetta and Deep Impact have provided close-up views of comets and valuable scientific data.
- The best known Comet, Halley's Comet, appears once in every 76 years. The Halley's Comet was seen last in 1986 and it will be seen again on 28th July 2061.



Meteors, Meteoroids, and Meteorites	
Feature	**Description**
Shooting stars	• The bright streaks of light seen in the night sky are called meteors.
Origins	• Meteors are remnants of asteroids or comets, known as meteoroids, that enter Earth's atmosphere at high speeds.
Burning and falling	• Most meteoroids burn up due to friction with Earth's atmosphere, creating the spectacular meteor streaks.
Meteorites	• If any part of the meteoroid survives and reaches Earth's surface, it's called a meteorite.
Craters	• The impact of large meteorites can create craters like Meteor Crater in Arizona and Lonar Lake in India.

Did you know?

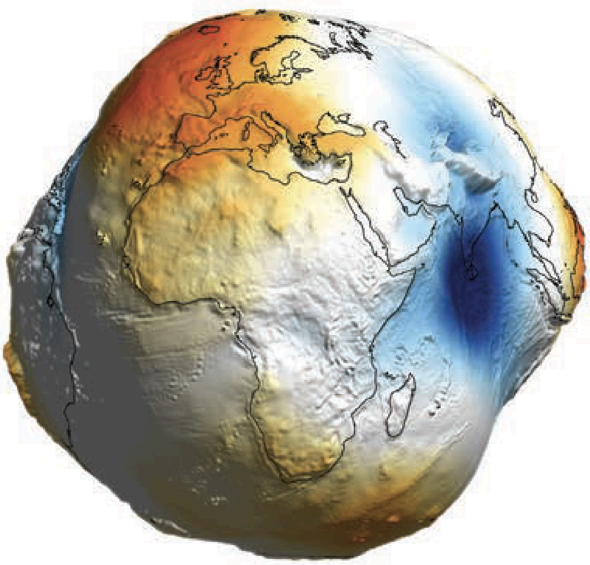
- Meteors come in various sizes, from tiny dust particles to objects as large as cars.
- Meteor showers occur when Earth passes through the debris field of a comet, resulting in many meteors within a short timeframe.
- Meteorite research has revealed the presence of organic molecules and potential water ice, raising questions about the origins of life.

IV. Earth's Shape and Size

Feature	Description
Early misconceptions	• The belief in a flat Earth persisted for centuries, even hindering exploration efforts like Columbus's voyage.
Greek philosophies	• Early Greek thinkers proposed various models, from Anaximander's cylindrical Earth to Pythagoras's spherical Earth.
Aristotle's observations	• He noted the circular lunar shadow and changing constellation visibility as evidence for a spherical Earth.
Eratosthenes's measurement	• He accurately estimated Earth's circumference based on sun elevation differences at different locations.
Modern understanding	• Earth is not a perfect sphere but an oblate spheroid, bulging at the equator and flattened at the poles.
Terminology	• This shape is called "geoid," meaning "earth-shaped," and results from the centrifugal force of Earth's rotation.
Gravity variations	• Gravity is strongest at the poles and weakens towards the equator due to the bulge.
Sun's pull	• The Sun's gravitational pull differs at the poles, influencing Earth's axial tilt.
Axial tilt and seasons	• If Earth weren't tilted, days and nights would be equal throughout the year, causing no seasonal variations.

Did you know?

- Understanding Earth's shape is crucial for navigation, satellite technology, and studying its dynamics, such as plate tectonics.
- Technological advancements like spaceflight have provided visual proof of Earth's spherical shape.
- The geoid is not perfectly smooth but has variations due to mountains, ocean trenches, and other geological features.



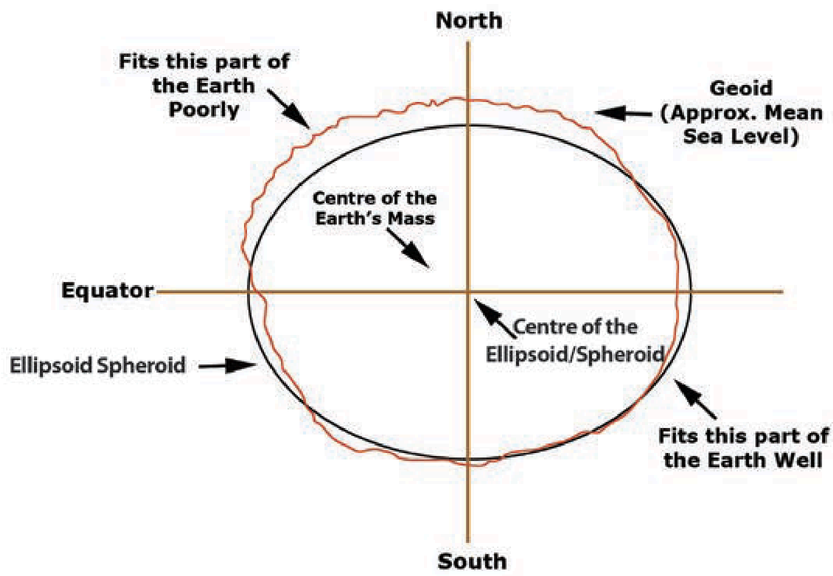


Fig: Geoid : Shape of the earth

V. Earth's Motions: Rotation and Revolution

Earth has two main movements:

1. **Rotation** on its axis (spinning) and
2. **Revolution** around the Sun.

Earth's Rotation	
Feature	**Description**
Rotation	• Earth rotates eastward on its axis, completing one revolution every 23 hours, 56 minutes, and 4.09 seconds.
Axis and tilt	• Earth's axis is tilted at 23.5° to the orbital plane, causing seasonal variations.
Rotational velocity	• Velocity varies with distance from the equator, with the equator having the highest (1,670 km/h) and the poles having the least (near zero).
Effects of rotation	
Day and night	• Earth's rotation causes the apparent rising and setting of the Sun, creating day and night cycles.
Time zones	• Differences in rotation speed across longitudes lead to different times in different places (4 minutes per degree).
Apparent movement	• Objects like the Sun and stars appear to move west to east due to Earth's rotation.
Coriolis force	• Earth's rotation deflects winds and ocean currents from their straight paths.
Tides	• Rotation, along with gravity from the Sun and Moon, influences tides.
Earth's shape	• Rotation causes Earth to bulge at the equator and flatten at the poles.
Did you know? • Earth's rotation is crucial for many phenomena, from day-night cycles to weather patterns. • The tilt of its axis causes the seasonal variations we experience throughout the year.	

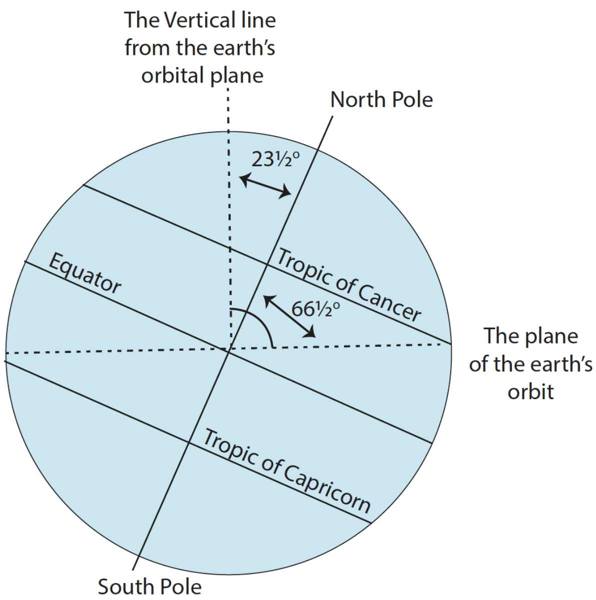


Fig: Tilt of the Earth's axis

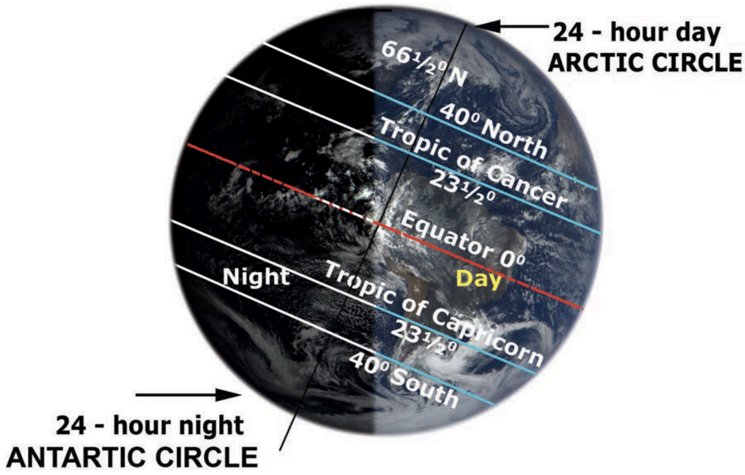


Fig: Circle of Illumination

Circle of Illumination: The Line Between Day and Night	
Feature	**Description**
Circle of illumination	• The line separating the lit and dark sides of Earth, visible from space and changing with seasons.
Definition	• An imaginary line separating the Earth's sunlit (day) and unlit (night) sides. • Visible from space as a dynamic boundary constantly shifting due to Earth's rotation and orbit.
Appearance	• **From space:** A sharp, curved line, not perfectly circular due to Earth's tilt and elliptical orbit. • **From Earth:** Indirectly observed through sunrise/sunset, twilight caused by gradual transition across the line.
Movement	• **Rotational dependent:** Fastest at equator (24-hour rotation), slowing towards poles (0 rotation). • **Latitude dependent:** Movement speed decreases with increasing latitude.
Seasonal Changes	Due to Earth's axial tilt (23.5°): • Equinoxes (spring/autumn): Circle cuts evenly across latitudes, resulting in ~12 hours of day/night everywhere. • Solstices (summer/winter): Circle's tilt leads to longer days in one hemisphere, longer nights in the other.
Significance	• Defines day/night duration and sunlight angle at different locations. • Influences climate, weather patterns, and biological rhythms.

Earth's Revolution	
Feature	**Description**
Movement around the Sun	• Earth revolves around the Sun in an anti-clockwise direction (west to east) in an elliptical orbit.
Orbital distance	• The average distance is 150 million km, but it varies throughout the year ○ Perihelion: Closest point to the Sun (147 million km) around January 3rd. ○ Aphelion: Farthest point from the Sun (152 million km) around July 4th.
Revolution period	• Earth completes one revolution in 365 days and 6 hours (365.25 days), slightly longer than our calendar year.

Revolution speed	• Earth travels at an average of 107,000 km per hour (30 km per second), much faster than a speeding bullet.
Leap year	• To account for the extra quarter day in Earth's revolution, we add a leap day (February 29th) every four years.
Effects of revolution	• **Seasons:** Earth's tilt causes seasonal variations in temperature and daylight hours. • **Day and night lengths:** Days and nights vary in length throughout the year due to the tilt and elliptical orbit. • **Solar energy distribution:** The amount of solar energy received varies by latitude, influencing temperature zones.

Did you know?

- Understanding Earth's revolution is crucial for predicting weather patterns, agricultural practices, and seasonal celebrations.
- The elliptical orbit and Earth's tilt combine to create complex seasonal variations across different parts of the planet.

Difference between Rotation and Revolution

Rotation	Revolution
• Spinning of the earth from west to east on its axis.	• Movement of the earth around the sun in its elliptical orbit.
• It takes 24 hours to complete a rotation (or a day)	• It takes 365¼ days to complete one revolution (or a year)
• It is known as the daily or diurnal movement.	• It is known as the annual movement of the earth.
• Rotation causes days and nights to alternate, tides, deflection of winds and ocean currents and also gives the earth its shape.	• Revolution results in the varying lengths of day and night, changes in the altitude of the midday sun and change of seasons.

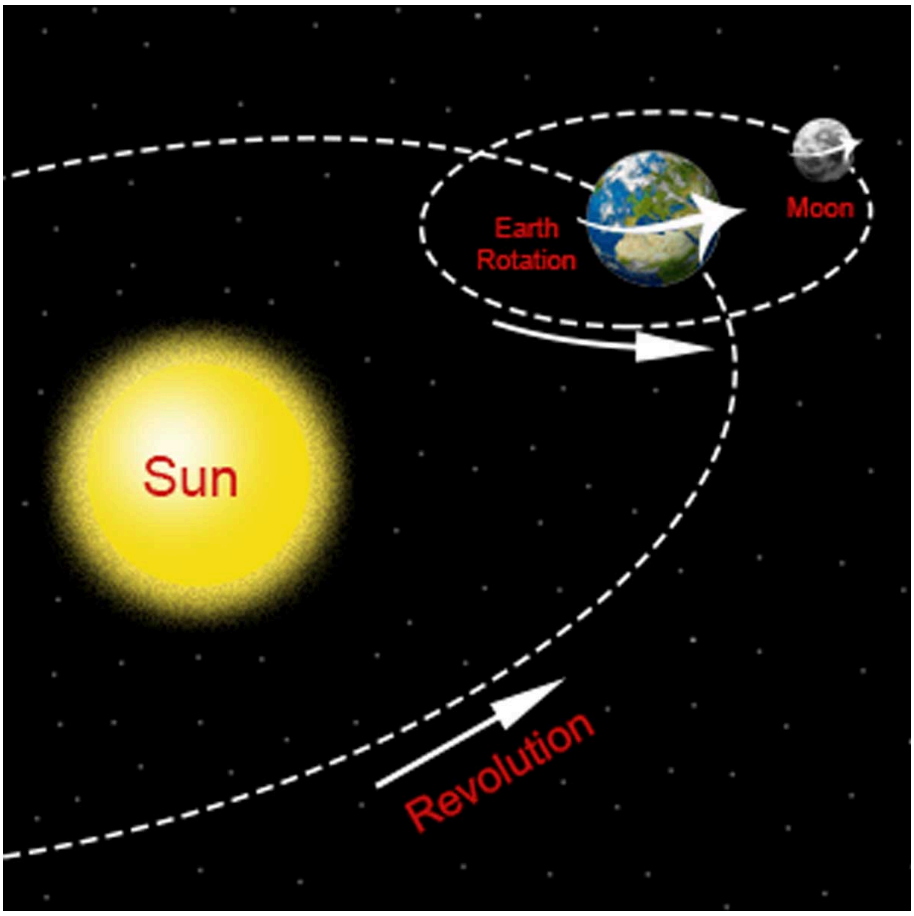


Fig: Earth's Rotation and Revolution

Earth's revolution and the Seasons	
Feature	**Description**
Season's origin	• The interplay of Earth's revolution around the Sun and its 23.5° axial tilt creates the four seasons: spring, summer, autumn, and winter.
Sun's apparent movement	• As Earth orbits, the Sun appears to move north and south in the sky, swinging above and below the equator.
Misconception	• This apparent movement is not the Sun shifting, but rather Earth's tilted axis causing different parts of the planet to receive varying amounts of sunlight throughout the year.
Equinoxes	• On March 21st and September 23rd (equinoxes), the Sun rises due east and sets due west, and day and night lengths are roughly equal everywhere on Earth.
Latitude and sunshine	• The latitude of a location determines the amount and angle of sunlight it receives, influencing seasonal variations in temperature and daylight hours.
Did you know? • The tilt angle and elliptical orbit combine to create complex seasonal patterns with variations in temperature, precipitation, and daylight hours across different latitudes.	

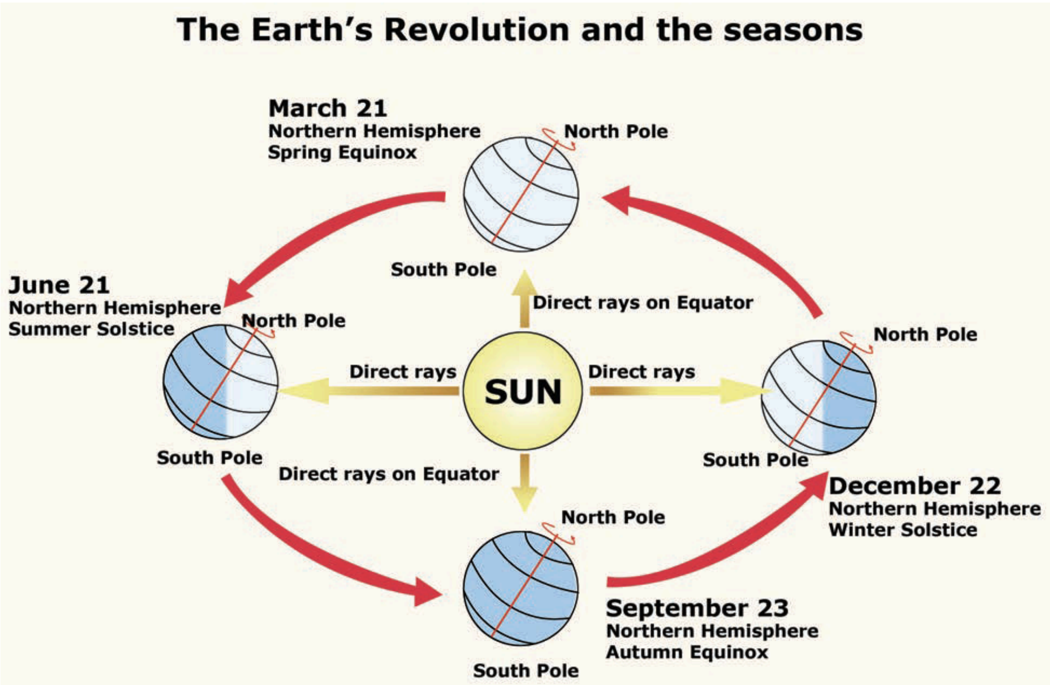


Fig: Earth's revolution and the seasons

Equinoxes and solstices

Equinoxes	
Feature	**Description**
Sunlight intensity	• When the sun's rays are vertical at noon, they fall on a smaller area, concentrating the heat and contributing to warmer temperatures.
Equinoxes	• These occur twice a year when Earth's tilt aligns the equator directly with the Sun, causing the sun's rays to fall vertically at the equator.
21 March (Spring Equinox)	• On this day, all places on Earth experience roughly equal hours of daylight and darkness due to the sun's position. This marks the beginning of spring in the Northern Hemisphere and autumn in the Southern Hemisphere.

23 September (Autumn Equinox)	• Similar to the March equinox, the sun is directly overhead at the equator, leading to equal day and night lengths worldwide. This marks the beginning of autumn in the Northern Hemisphere and spring in the Southern Hemisphere.

Did you know?
- Equinoxes represent a state of balance where the tilt of Earth's axis doesn't favor either hemisphere for sunlight exposure.
- The equal day and night lengths during equinoxes are not perfectly precise but very close.

Solstices

Feature	Description
Definition	• These occur twice a year when Earth's tilt reaches its maximum, causing the sun's rays to fall vertically at one of the Tropic lines (Cancer in the north, Capricorn in the south).
21 June (Summer Solstice)	• The North Pole is tilted towards the sun, experiencing continuous daylight for 24 hours (midnight sun), while the South Pole faces darkness. • The Northern Hemisphere has its longest day and shortest night of the year, marking the start of summer.
22 December (Winter Solstice)	• The South Pole tilts towards the sun, receiving continuous daylight, while the North Pole experiences 24 hours of darkness. • The Southern Hemisphere enjoys its longest day and shortest night, marking the start of summer.
Sunlight angle and temperature	• The angle at which sunlight strikes Earth determines the intensity and duration of daylight, influencing temperature variations across the globe.
Unequal day and night lengths	• During solstices, the day and night lengths in one hemisphere are significantly longer than in the other, creating extreme sunlight conditions.

Did you know?
- Solstices play a crucial role in shaping seasonal patterns, influencing temperature, precipitation, and daylight hours in different regions.

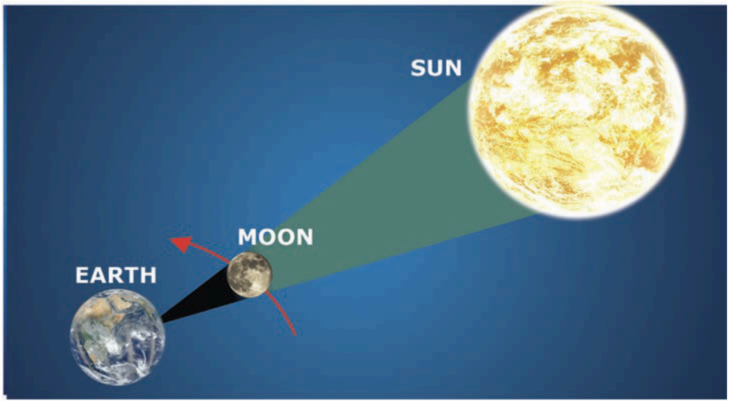
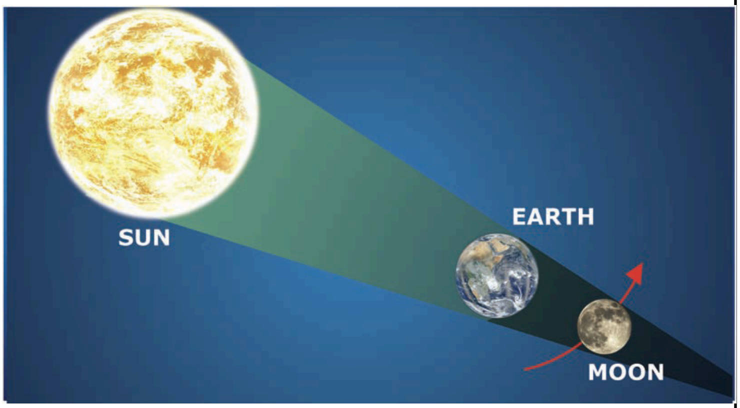
Variation in the length of day time

Latitude	Summer Solstice	Winter Solstice	Equinoxes
0º	12 hrs	12 hrs	12hrs
10º	12hrs 35 min	11hrs 25 min	12hrs
20º	13hrs 12min	10hrs 48min	12hrs
30º	13hrs 56min	10hrs 4 min	12hrs
40º	14hrs 52 min	9 hrs 8 min	12hrs
50º	16hrs 18min	7 hrs 42 min	12hrs
60º	18hrs 27min	5 hrs 33min	12hrs
70º	24 hrs (for 2 months)	0 hrs 00 min	12hrs
80º	24 hrs (for 4 months)	0 hrs 00 min	12hrs
90º	24 hrs (for 6 months)	0 hrs 00 min	12hrs

Eclipses

- These are celestial events where one heavenly body casts a shadow on another, temporarily obscuring it from our view.
- Eclipses are rare celestial phenomena, requiring precise alignment of the Sun, Earth, and Moon.

Types of Eclipses

Solar Eclipses	Lunar Eclipses
Occur on New Moon days when the Moon passes between the Sun and Earth, blocking part or all of the Sun's light from reaching us. • **Partial:** The Moon covers only a portion of the Sun. • **Annular:** The Moon completely covers the central part of the Sun, leaving a bright ring visible around it. • **Total:** The Moon completely covers the Sun, plunging the area in darkness for a few minutes. 	Occur on Full Moon days when the Earth passes between the Sun and the Moon, casting its shadow onto the Moon. • **Partial:** Earth's shadow partially covers the Moon's surface. • **Penumbral:** The Moon passes through the faint outer part of Earth's shadow, causing a subtle dimming of its brightness. • **Total:** Earth's full shadow engulfs the Moon, turning it a deep red or orange due to scattered sunlight. 

Phases of the Moon

Feature	Description
Moon phases • The changing appearance of the Moon throughout the month is due to its position relative to the Sun and Earth, and the varying angles of sunlight hitting its surface.	
New Moon	• The Moon is between the Sun and Earth, completely hidden in Earth's shadow, and invisible from Earth.
Waxing Crescent	• As the Moon orbits Earth, it gradually emerges from Earth's shadow, appearing as a thin crescent.
First Quarter	• Half of the Moon's illuminated side is visible, resembling a right angle.
Waxing Gibbous	• The Moon appears more than half illuminated, increasing in brightness until it reaches.
Full Moon	• The Moon is directly opposite the Sun from Earth, fully illuminated and appearing as a bright disk.
Waning Gibbous	• The Moon's illuminated area starts to shrink, becoming less than full but still more than half lit.
Last Quarter	• Again, half of the Moon is visible, but this time the left side is illuminated.
Waning Crescent	• The Moon further dims as it approaches Earth's shadow, appearing as a thin crescent again.
Cycle repeats • This cycle of phases repeats every approximately 29.5 days, marking a lunar month.	
Did you know? • Understanding Moon phases is crucial for various phenomena like tides, lunar calendars, and even myths and folklore in different cultures. • Observing Moon phases can help us track the Moon's position in its orbit around Earth.	

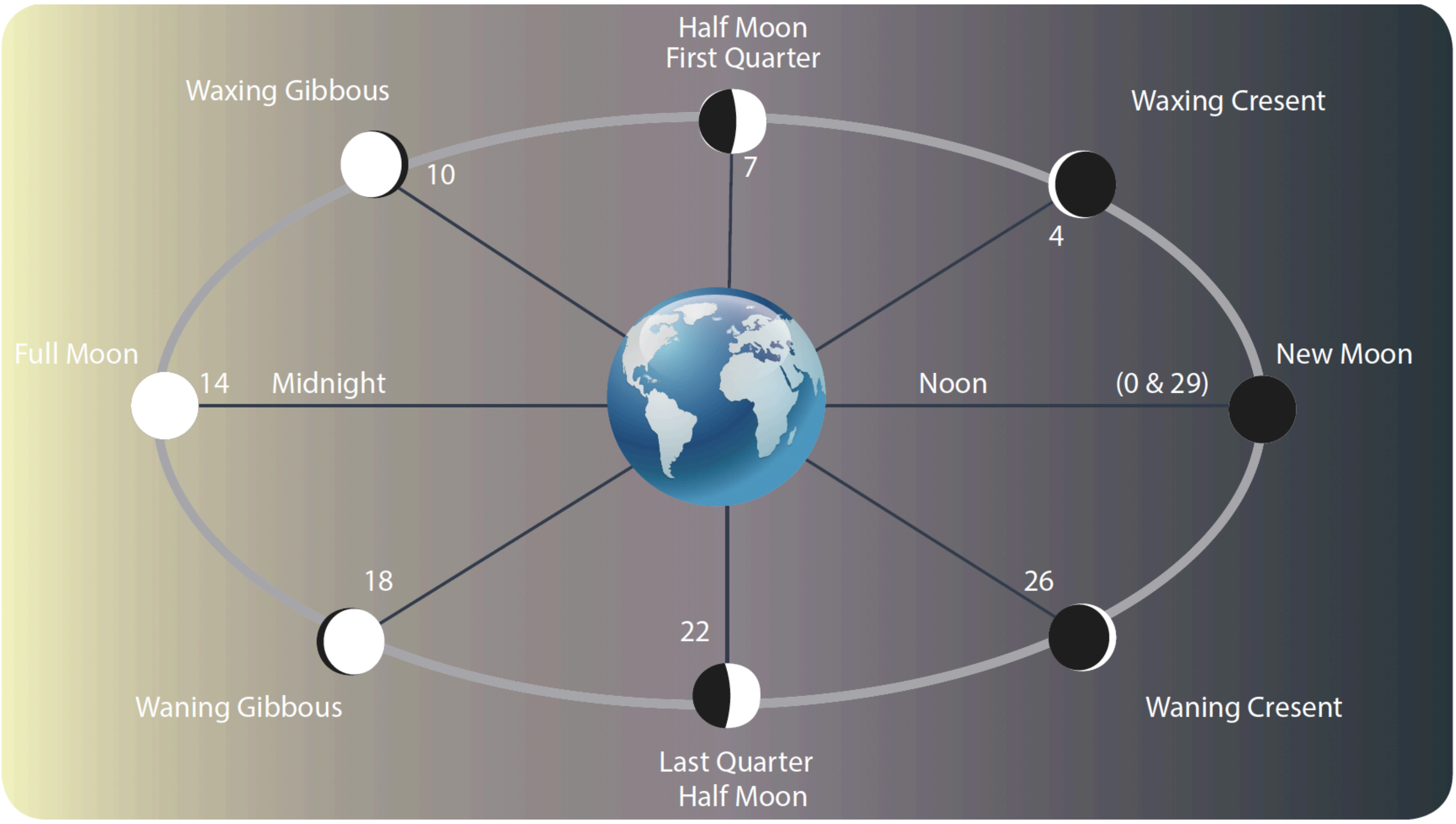


Fig: Phases of the Moon

Factors influencing daylight length	
Feature	**Description**
Earth's tilt	• The 23.5° tilt of Earth's axis plays a crucial role. As Earth orbits the Sun, different parts of the planet receive varying amounts of direct sunlight depending on their tilt towards or away from the Sun.
Latitude	• The further away from the equator, the greater the seasonal variations in daylight hours. This is because the Sun's rays hit the Earth at a more oblique angle at higher latitudes, leading to shorter days and longer nights in winter and longer days and shorter nights in summer.
Examples and observations	
Equator	• At the equator, the Sun's rays are nearly perpendicular throughout the year, resulting in consistent 12-hour days and nights.
Mid-latitudes	• Places like India or Europe experience moderate seasonal variations in daylight. Summer days are longer than nights, and winter days are shorter than nights.
Polar regions	• At the poles, the extreme tilt causes dramatic changes in daylight hours. During summer, the Sun can remain above the horizon for months, creating "midnight sun." Conversely, winter brings continuous darkness for months.

Did you know?

- Variations in daylight hours influence temperature patterns, plant and animal behavior, and human activities like agriculture and recreation.
- Understanding these variations helps us predict weather patterns, plan outdoor activities, and adapt to seasonal changes.

Effects of the spherical shape of the earth	
Feature	**Description**
Variation in Solar Radiation Received	On a flat Earth, all places would receive the same amount of sunlight, leading to uniform temperatures. However, Earth's spherical shape creates a complex distribution of solar energy. ● **Sun angles:** Only places at a specific latitude receive vertical sunrays on any given day. As you move away from this "hot spot," the sun's rays strike the Earth at decreasing angles. ● **Seasonal changes:** Earth's tilt and its orbit around the Sun further influence the angle of sunlight received at different locations, leading to seasonal variations in temperature and daylight hours. ● **Temperature zones:** This variation in solar energy creates distinct temperature zones on Earth, ranging from scorching deserts near the equator to frigid polar regions.
Angle of Sun Rays and Temperature	Slanting sunlight spreads over a larger area, diluting its intensity and reducing heating compared to direct rays. ● **Atmospheric effects:** As sunlight travels through the atmosphere at lower angles, it encounters more air molecules, leading to greater reflection and absorption, further reducing its intensity. ● **Latitude and temperature:** The lower the latitude (closer to the equator), the higher the angle of sunlight and hence, the higher the temperature. This is why the equator experiences the hottest temperatures.
Did you know? ● The spherical shape also contributes to the formation of wind patterns and ocean currents, influencing global climate patterns.	

Heat Zones	
Feature	**Description**
Definition	● The interplay of Earth's spherical shape and its movement around the Sun leads to the formation of three distinct heat zones, each with its own characteristics.
Torrid Zone:	● Located between the Tropic of Cancer (23.5° N) and the Tropic of Capricorn (23.5° S). ● Receives direct sunlight throughout the year due to Earth's tilt and orbital position. ● Experiences consistently high temperatures, with minimal seasonal variations. ● Examples: Amazon rainforest, Sahara Desert.
Temperate Zone:	● Lies between the Tropic of Cancer/Capricorn and the Arctic/Antarctic Circles (66.5° N/S). ● Receives sunlight at varying angles throughout the year, leading to distinct seasons. ● Experiences moderate temperatures with warm summers and cold winters, with the intensity varying based on latitude. ● Examples: Europe, North America, parts of Asia and South America.
Frigid Zone:	● Encompasses the regions beyond the Arctic and Antarctic Circles. ● Receives sunlight at very low angles for most of the year, except for brief periods during summer. ● Experiences extremely cold temperatures and long periods of darkness in winter. ● Examples: Greenland, Antarctica, parts of Canada and Russia.
Did you know? ● The distribution of heat within each zone can be further influenced by factors like altitude, proximity to oceans, and local topography.	