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Geography



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Introduction and Origin of the Earth

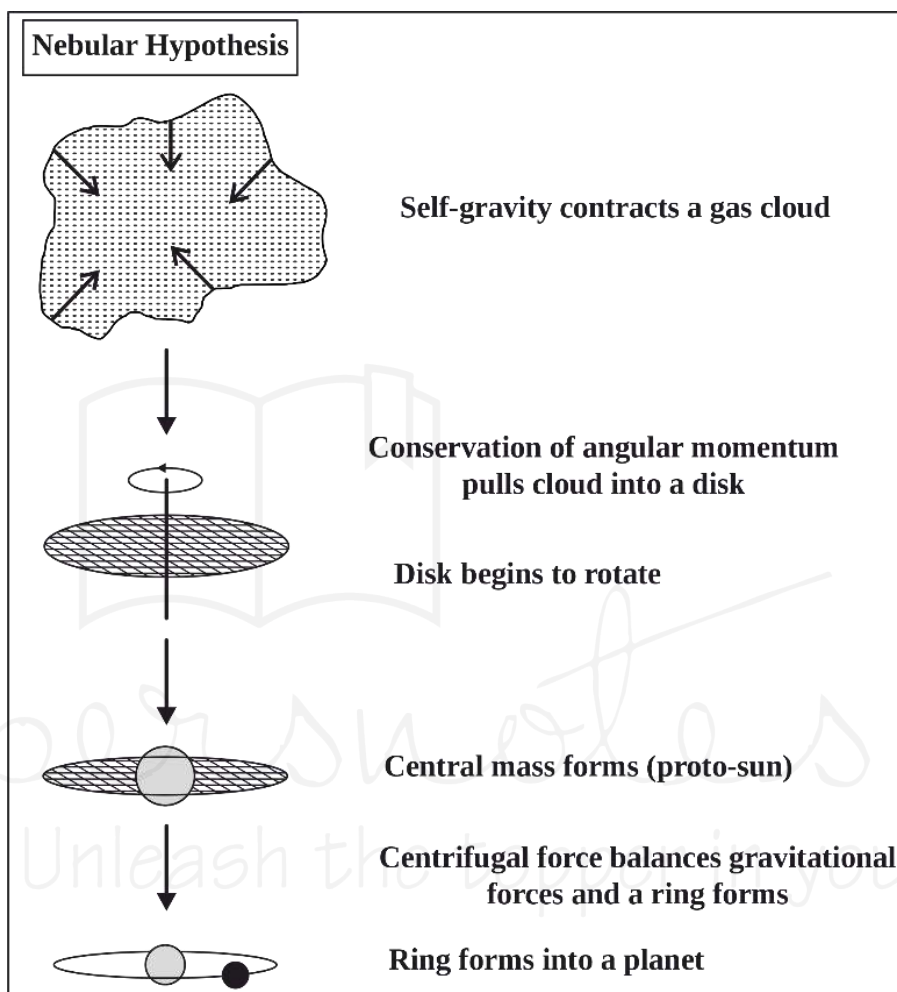


Earth formed about 4.6 billion years ago from dust and gas in the solar system. Over time, its surface and atmosphere developed, making life possible. Understanding Earth's origin helps us learn about its changes and evolution.

A. Origin of the Earth:

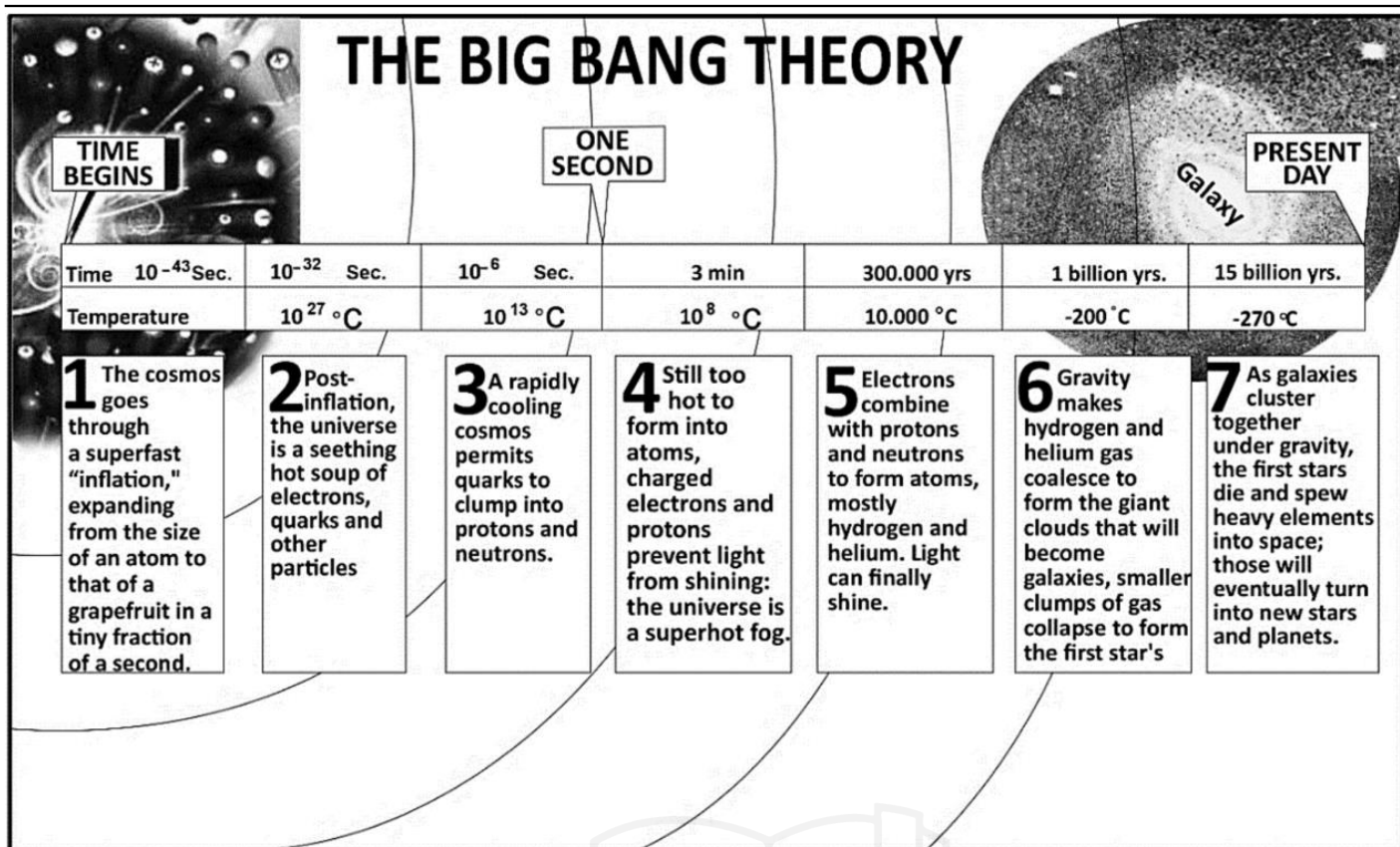
Nebular Hypothesis

- Propounded by: Immanuel Kant (revised by Pierre-Simon Laplace)
- The solar system evolved from a rotating cloud of gas & dust (solar nebula).
- Process:
 - ✓ Sun formed at the center of the nebula
 - ✓ Surrounding material formed a rotating disk.
 - ✓ Planets formed by accretion (gradual clumping of particles).
- Modified versions: Carl Weizsacker and Otto Schmidt
- Matter underwent friction & collision → disk-shaped cloud → gradual clumping into planets.



B. Origin of the Universe: Big Bang Theory

- Propounded by: Georges Lemaitre (1927) and strengthened by Edwin Hubble's observations (1929).
- The universe began 13.8 billion years ago from a dense, hot singularity.
- Key Concepts:
 - ✓ The universe is continuously expanding.
 - ✓ Galaxies move away from each other but do not expand themselves.



DID YOU KNOW?

Jayant Vishnu Narlikar co-developed the **Hoyle–Narlikar Theory of Gravity**, which supports the Steady-State Theory of Cosmology. This model proposes that as the universe expands, new matter is continuously created, maintaining a constant average density over time. This idea contradicts the Big Bang Theory.

C. Stages of Universe Development

1. All matter in a tiny dense ball.
2. Big Bang explosion → rapid expansion.
3. Within 300,000 years, temperature dropped to 4,500K → atomic matter formed.
4. The universe became transparent to radiation.

D. Galaxy

- A Galaxy is a vast system of billions of stars, which also contain a large number of gas clouds (mainly of hydrogen gas) and dust, isolated in space from similar systems.
- There are about 100 billion galaxies in the universe and each galaxy has on average 100 billion stars.
- The Milky Way Galaxy is the home of the Earth and our solar system & is spiral in shape.
- The latest known galaxy discovered is the Dwarf Galaxy.

E. Star Formation

- After the Big Bang, tiny density variations caused matter to clump under gravity, forming the seeds of large-scale structures.
- These matter concentrations grew into vast hydrogen-gas nebulae, the birthplaces of galaxies.
- Within a nebula, certain regions became especially dense and began gravitational collapse. As a clump contracted, its core temperature rose dramatically.

- Once the core reached roughly ten million K, hydrogen nuclei began to fuse. Nuclear fusion ignition marked the birth of a new star, shining steadily thereafter.
- Over millions of years, innumerable stars formed and came to illuminate their host galaxies.
- **Process Summary:** Irregular density distribution → gravity pulled matter into clumps → Nebula → localized clumps → gaseous bodies → stars.

F. Planet Formation

- Stars formed in nebulae → gas clouds around them began rotating.
- Gravitational attraction led to formation of gas cores and surrounding discs.
- Dust and particles coalesced → planetesimals development → continued to merge and accrete, eventually forming larger bodies → planets formation.

G. Formation of Moon

1. George Darwin's Fission Theory

- ✓ Earth and Moon were originally part of a single rotating mass.
- ✓ Rapid rotation caused the mass to become dumbbell-shaped, eventually leading to separation.
- ✓ The Moon split from Earth, forming a depression that later became the Pacific Ocean.

2. Modern Giant Impact Theory (Big Splat)

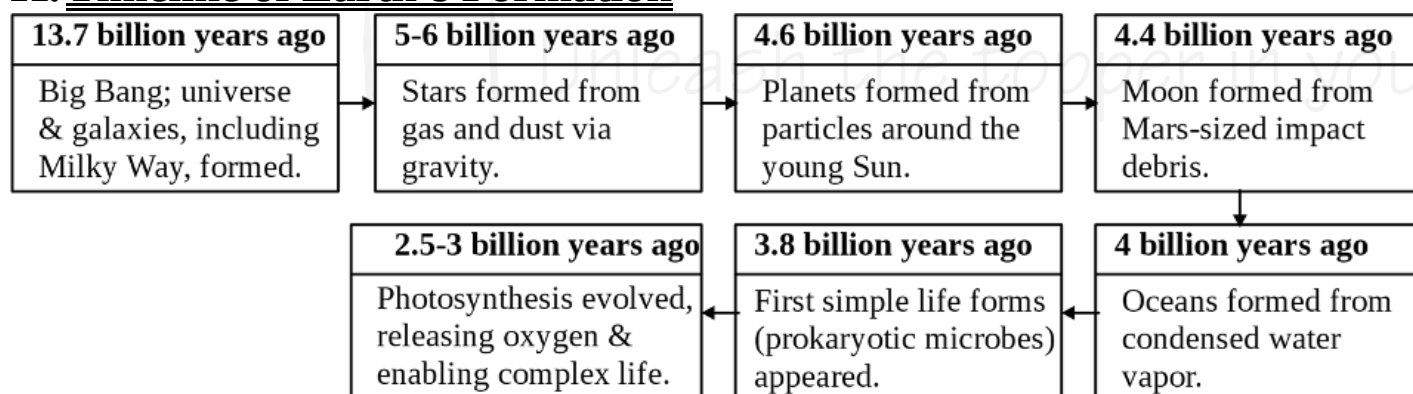
- ✓ Moon formed due to a collision between early Earth & a Mars-sized celestial body (3 times Mars' mass).
- ✓ The impact ejected material into orbit, which later accreted to form the Moon.
- ✓ The Earth experienced partial heating and differentiation, leading to layered internal structure during this process.

DID YOU KNOW?

The **Moon has no significant atmosphere** because it cannot retain gas molecules on its surface as its escape velocity is very low (about 2.38 km/s). On the other hand, the rms (root mean square) velocity of gas molecules at typical temperatures can be higher than the escape velocity. As a result, gas molecules escape into space, and the Moon fails to retain an atmosphere.



H. Timeline of Earth's Formation

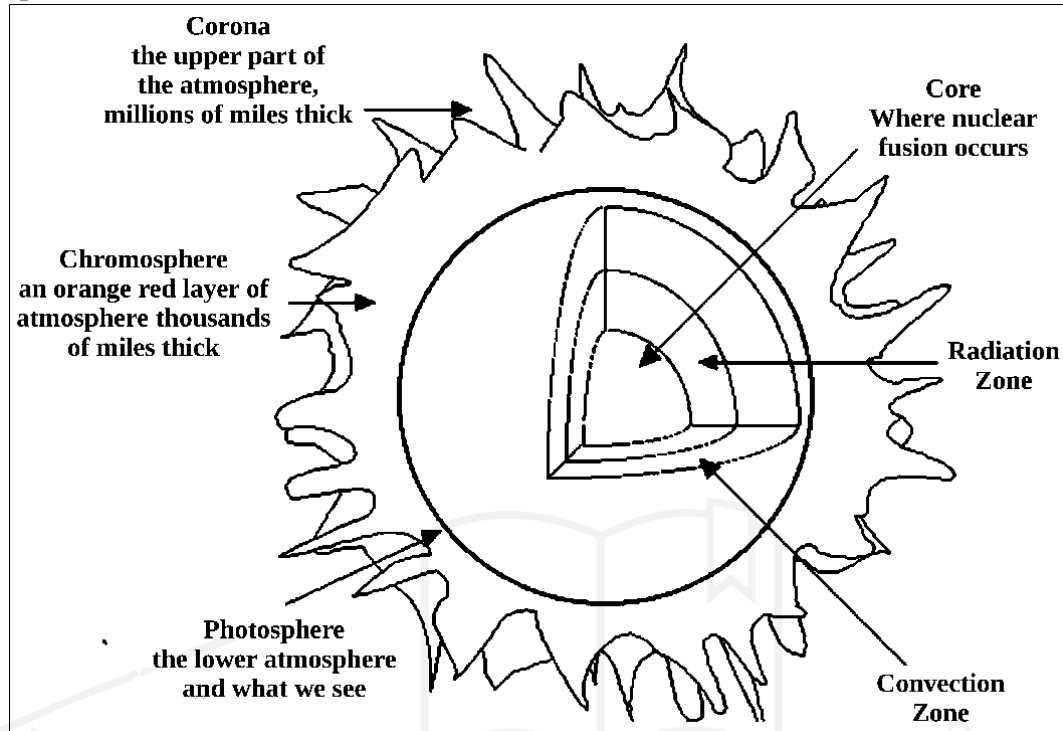


I. Solar System Overview

- Composed of: Sun, 8 planets, 200+ moons, asteroids, comets, dust, gas
- Inner Planets (Terrestrial): Mercury, Venus, Earth, Mars – solid, rocky
- Outer Planets (Jovian): Jupiter, Saturn, Uranus, Neptune – gaseous, large, ringed
- **Key Concept:** The gravitational pull of the sun keeps all the planets and other objects revolving around it. Thus the motion of all the members of the solar system is governed mainly by the gravitational force of the sun.

1. Structure of the Sun

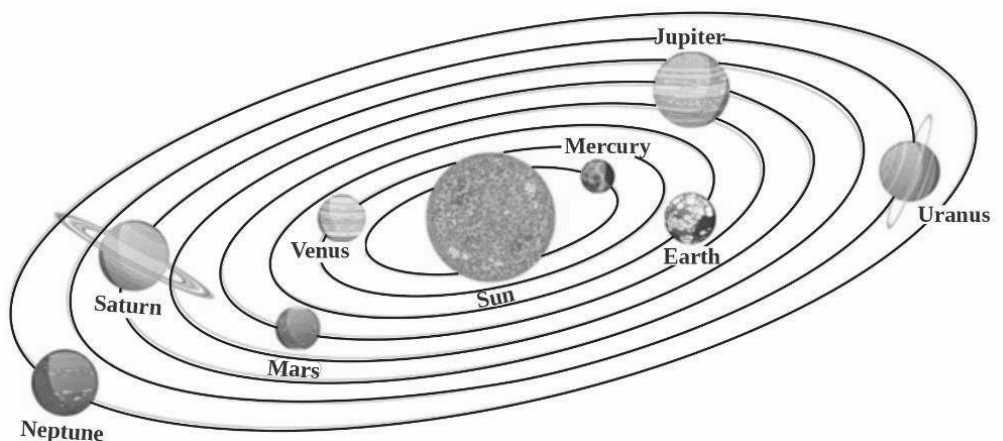
- ✓ The size of the sun is 13 lakh times that of the earth.
- ✓ It is composed of 71% hydrogen, 26.5% helium and 2.5% other elements.
- ✓ A storm of hot atoms which dissipates from the photosphere of the sun overcomes its gravity and goes into outer space, known as Solar flares.
- ✓ The regions from where the solar flares originate some dark spots are seen and these are called Sun spots.



Components	Description
Photosphere	Bright outer surface layer; emits most of the Sun's visible light
Chromosphere	Thin layer above photosphere; consists of burning gases
Corona	Outermost layer; hot plasma, visible during total solar eclipse
Sunspot	Cooler, darker patches on photosphere
Solar wind	Charged particles emitted from sun's upper atmosphere
Solar flares	Bright eruptions due to magnetic storms

2. Planets of the Solar System

- ✓ The planets are opaque bodies which continuously revolve around and are lighted by the sun.
- ✓ Planets are classified into the following two groups: inner and outer planets. These are separated by the asteroid belt.



2.1. Inner Planets (Terrestrial/rocky planets)

- ✓ **Mercury:** Closest to the sun, smallest and lightest, no moon, fastest revolution around the Sun, presence of magnetic field
- ✓ **Venus:** Earth's twin, retrograde rotation, no moon, hottest planet, morning star & evening star, slowest rotation. Surrounded by thick cloud cover so called Veiled planet
- ✓ **Earth:** Only planet supporting life, 1 moon, blue planet, average distance from the Sun is approximately 93 million miles, goldilocks zone (habitable zone).
- ✓ **Mars:** Red planet, 2 moons (Phobos & Deimos), cold & dry, home to largest volcano in the solar system (Olympus Mons), Partially in goldilocks zone .

2.2. Outer Planets (Jovian/gaseous planets)

- ✓ **Jupiter:** Largest and heaviest planet, 95 moons, faint rings composed of silicates, mostly hydrogen & helium, fastest rotation the solar system- Ganymede, largest moon in the Solar System.
- ✓ **Saturn:** Prominent rings, lightest density, 274 moons- Titan largest moon.
- ✓ **Uranus:** Rotates on side, 28 moons, methane atmosphere, green planet
- ✓ **Neptune:** Farthest, 16 moons, strongest winds, coldest planet, atmosphere made of hydrogen, helium and methane. Twin of uranus

3. Other Celestial Bodies

- ✓ **Asteroids (Planetoids):** Rocky bodies mainly between Mars and Jupiter (Asteroid Belt). It may be spherical, elongated or irregular in shape.
 - ✓ **Kuiper Belt:** It is a distant icy region of the outer solar system beyond Neptune (30–55 AU), containing dwarf planets like Pluto, Haumea, & Makemake etc. and composed mainly of frozen volatiles like methane and ammonia.
 - ✓ **Dwarf Planets:** Orbit the sun, roughly spherical, haven't cleared orbit path, less mass, less gravitational pull (e.g. Pluto, Ceres).
 - ✓ **Exoplanets:** It is a planet outside our solar system that orbits a star within the Milky Way galaxy. They are as gas giants, Neptunians, super-Earths & terrestrial planets. Notable ex: **Barnard's Star b**, a super-Earth at least 3.2 times the mass of Earth, which orbits a red dwarf & receives only 2% of the sunlight Earth gets.
 - ✓ **Comets:** Made of Ice & dust bodies with glowing tail when near the Sun (e.g. Halley's Comet- comes in approximately every 76 years). A comet becomes visible only when it travels close to the sun. The tail always points away from the Sun.
 - ✓ **Meteors:** Asteroids entering Earth's atmosphere; known as "shooting stars".
 - ✓ **Meteorites:** Meteor fragments that survive and hit Earth's surface.
 - ✓ **White Dwarfs:** Remnants of stars like the sun after exhausting their nuclear fuel.
 - ✓ **Nebulae:** Huge interstellar clouds of gas and dust that appear as faint, misty patches of light scattered all over the sky.
 - ✓ **Black Hole:** Regions of spacetime with gravitational forces so strong that even light cannot escape. Formed from collapsing massive stars beyond the Chandrasekhar Limit (1.4 solar masses).
 - ✓ **Pulsars:** Rapidly spinning neutron stars that emit regular pulses of radio waves & electromagnetic radiation.
 - ✓ **Quasars:** Extremely luminous active galactic nuclei powered by supermassive black holes, emitting enormous energy across the electromagnetic spectrum.
 - ✓ **Supernova:** A powerful & luminous explosion marking the death of a massive star.
-

- ✓ **Neutron stars:** Compact remnants of massive stars that exploded as supernovae. Composed mostly of neutrons.
- ✓ **Event horizon:** Boundary around a black hole beyond which nothing, not even light, can escape its gravity. It marks the **point of no return**, separating the black hole from the rest of the universe.
- ✓ **Singularity:** Central point of a black hole with zero volume but infinite density where gravity becomes infinite, and is hidden behind the event horizon.

Status of Pluto

- Discovered: 1930; once classified as the 9th planet of the solar system.
- Declassified: In 2006, the International Astronomical Union (IAU) redefined planetary criteria and revoked Pluto's planet status.

IAU Criteria for Planethood

- Must orbit the Sun independently.
- Must be massive enough to assume a nearly spherical shape (*hydrostatic equilibrium*).
- Must have cleared its orbit of other celestial bodies.

Why Pluto Fails?

- Pluto shares its orbit with other objects in the Kuiper Belt.
- It is only 0.07 times the mass of surrounding objects—not dominant enough gravitationally. Hence Pluto = Dwarf Planet.

J. Geological Time Scale of the Earth

Eon	Era	Period	Epoch	MYA	Life Forms	North American Events
Phanerozoic	Cenozoic	Quaternary (Q)	Holocene (H)	0.01	Extinction of large mammals and birds, Modern humans	Ice age glaciations, glacial outburst floods
			Pleistocene (PE)	2.6		Cascade volcanoes, Isthmus of Panama
		Neogene (N)	Pliocene (PL)	5.3	Spread of grassy ecosystems	Columbia River Basalt eruptions, Basin and Range extension (W)
			Miocene (MI)	23.0		
		Paleogene (PG)	Oligocene (OL)	33.9		
			Eocene (E)	56.0	Early primates	
			Paleocene (EP)	66.0	Mass extinction	Laramide Orogeny ends (W)
	Mesozoic	Cretaceous (K)		145.0	Placental mammals, Early flowering plants, Dinosaurs diverse and abundant	Laramide, Western Interior Seaway (W), Sevier Orogeny (W)

		Jurassic (J)		201.3	First dinosaurs, First mammals, Flying reptiles	Nevadan, Elko Orogeny (W)
		Triassic (TR)		251.9	Mass extinction, Breakup of Pangaea begins	Sonoma Orogeny (W)
	Paleozoic	Permian (P)		298.9	Mass extinction	Supercontinent Pangaea intact
		Pennsylvanian (PN)		323.2	Coal-forming swamps, Sharks abundant, First reptiles	Ouachita (S), Appalachian (E), Orogeny (E), Rocky Mts (W)
		Mississippian (M)		358.9	Mass extinction, First amphibians, First forests	Antler Orogeny (W), Acadian (E-NE)
		Devonian (D)		419.2	First land plants	
		Silurian (S)		443.8	Primitive fish	
		Ordovician (O)		485.4	Mass extinction, Trilobite maximum, Rise of corals	Taconic Orogeny (E-NE)
		Cambrian (C)		541.0	Early shelled organisms	Extensive oceans cover proto-North America (Laurentia)
	Proterozoic	Precambrian (PC, W, X, Y, Z)		2500	Complex to simple multicelled organisms	Supercontinent rifted, Grenville Orogeny (E), Iron deposits
	Archean			4000	Early bacteria and algae (stromatolites)	Oldest known Earth rocks
	Hadean			4600	Origin of life	Formation of Earth's crust, Formation of the Earth

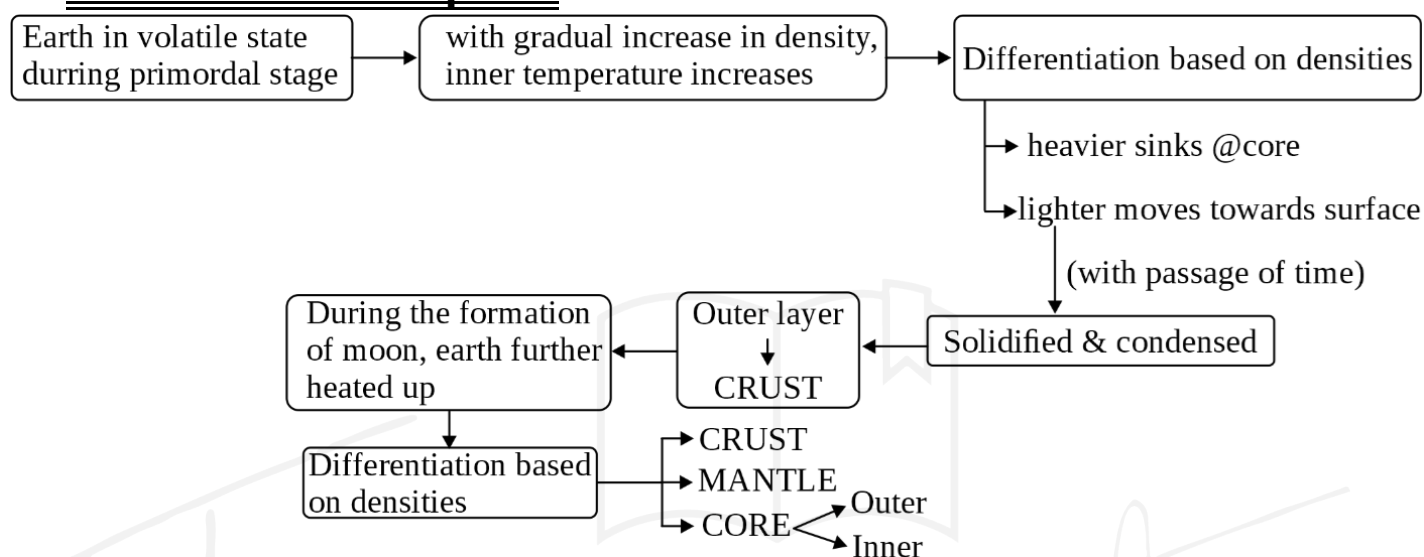
The Earth's origin marks the beginning of a dynamic and evolving planet shaped by complex geological and atmospheric processes. Understanding Earth's formation helps us appreciate the conditions that made life possible and provides insights into its continuous changes over billions of years.

Evolution of Earth



Earth formed about 4.5 billion years ago from cosmic dust & gas around the young Sun. Initially a hot, molten mass, it gradually cooled, forming a solid crust & oceans. Heavy elements sank to form the core, while lighter materials created the surface layers. Volcanic activity & gas emissions shaped the early atmosphere & hydrosphere. These processes laid the foundation for life & the planet's dynamic geology.

A. Evolution of Lithosphere



B. Evolution of Atmosphere

- Three stages of atmospheric evolution:
 - ✓ Loss of primordial atmosphere.
 - ✓ Hot Earth interior released gases (degassing), mainly water vapor, nitrogen, CO₂, methane, ammonia.
 - ✓ Photosynthesis by early life added free oxygen, changing atmospheric composition.
- Continuous volcanic eruptions contributed gases to the atmosphere.

DID YOU KNOW?

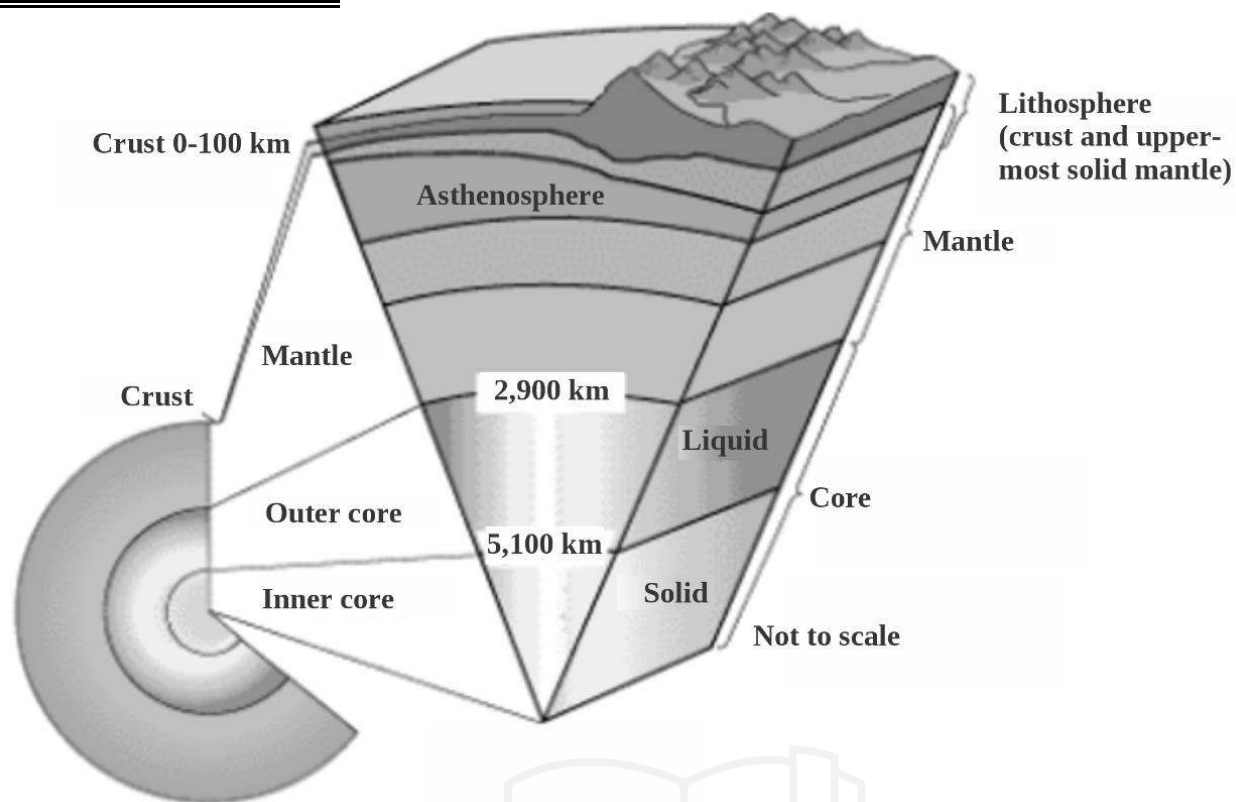
Early Earth's atmosphere was virtually oxygen-free and rich in CO₂, N₂ and other gases; O₂ only rose after photosynthetic life.



C. Evolution of Hydrosphere

- As the early Earth cooled, water vapor condensed, leading to the formation of liquid water bodies.
- This process began after volcanic outgassing released water vapor and gases into the atmosphere.
- CO₂ dissolved in rainwater, further cooling Earth and increasing rainfall.
- Oceans formed within 500 million years of Earth's formation.
- Early oceans were hot and acidic, but they acted as carbon sinks, helping stabilize temperatures.
- Photosynthesis in oceans led to oxygen saturation and later excess oxygen began accumulating in the atmosphere, triggering the Great Oxidation Event.

D. Structure of Earth



Layer	Thickness	Composition	State	Key features
Crust	5-70 km	Sial (Continents) Sima (Oceans)	Solid	Thin outer layer; divided into oceanic (dense) and continental (light) crust.
Mantle	2900 km	Solid rock, magma	Mostly Solid	83% of Earth's volume; includes plastic Asthenosphere (up to 400 km).
Core	2900-6400 km	Nickel and iron (NiFe layer)	Outer-liquid, Inner-solid	16% of Earth's volume; has metallic properties.

DID YOU KNOW?

1. Scientists aboard the US research vessel **JOIDES Resolution** set a new record by drilling 1.2 km below the seafloor at the Atlantis Massif, far surpassing the previous depth of 201 meters. This mission, part of the **International Ocean Discovery Program** with India as a funding partner, aimed to explore the Earth's mantle, which makes up over 80% of the planet's volume and is typically inaccessible except at mid-ocean ridges.
2. Researchers have uncovered a vast reservoir of water, dubbed the "**Ringwoodite Ocean**," concealed within the Earth's mantle, over 700 kms beneath the surface.

E. Composition of Earth's Crust

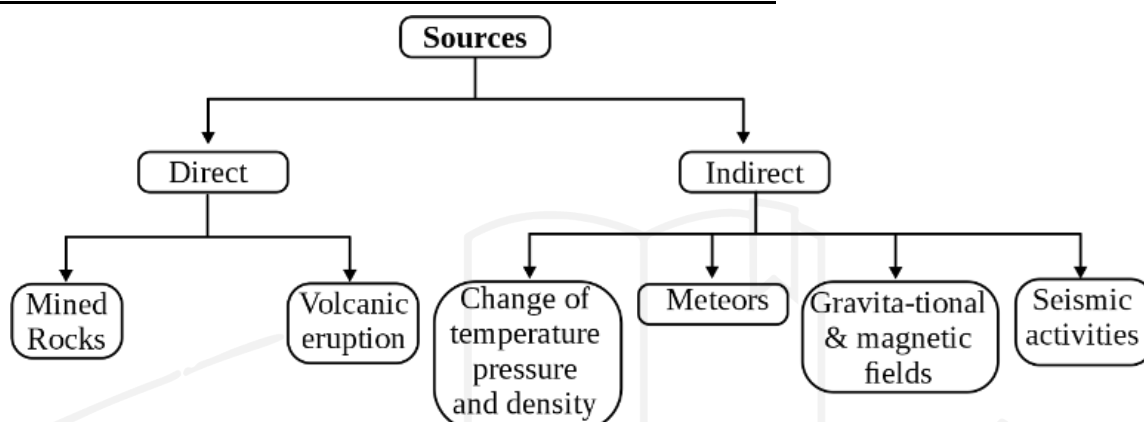
Element	Weight %
Oxygen	46.60
Silicon	27.72
Aluminium	8.13

Iron	5.00
Calcium	3.63
Sodium	2.83
Potassium	2.59
Magnesium	2.09
Others	1.41

F. Composition of Entire Earth

- Overall Chemical Composition: Iron (32.10%), oxygen (30.10%), silicon (15.10%), Magnesium (13.9%), sulfur (2.90 %), nickel (1.80 %), calcium (1.50%), aluminum (1.40 %), other elements(1.20 %).

G. Sources of Information on Earth's Interior



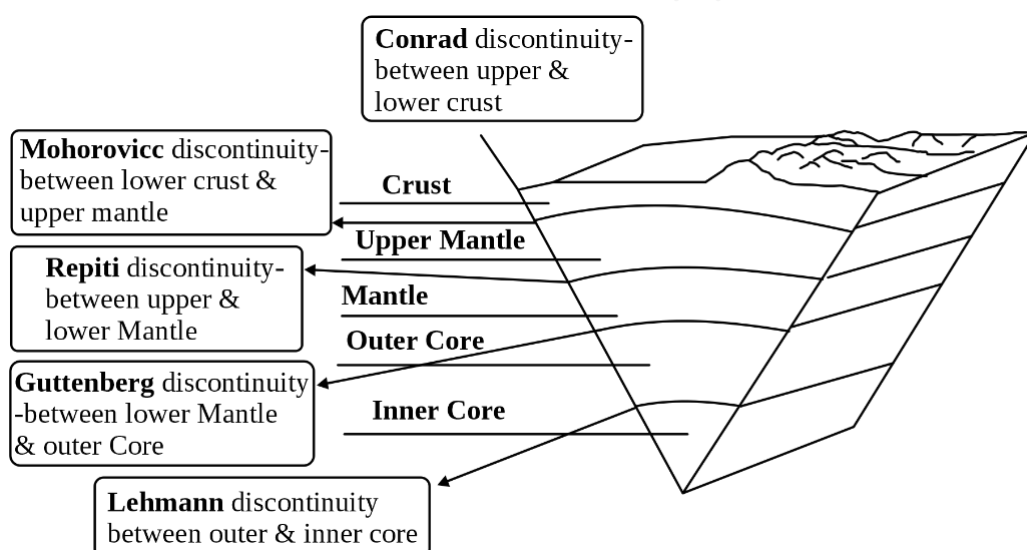
DID YOU KNOW?

Isostasy is a key geological concept stating that Earth's lighter crust "floats" on the denser mantle, much like icebergs in water. This explains varying topographic heights on the surface. In an ideal state, the crust and mantle remain in **isostatic equilibrium**, undisturbed by external forces. Natural processes like glaciation, erosion & volcanism disturb this balance, altering the lithosphere's structure. Understanding isostasy helps geologists study complex Earth processes like mountain formation, sedimentary basins, and continental drift.



H. Discontinuities

The Earth's interior is divided into distinct layers with unique physical and chemical properties. These layers differ in aspects like temperature and density. They are separated by transition zones called **discontinuities**, where sudden changes occur.

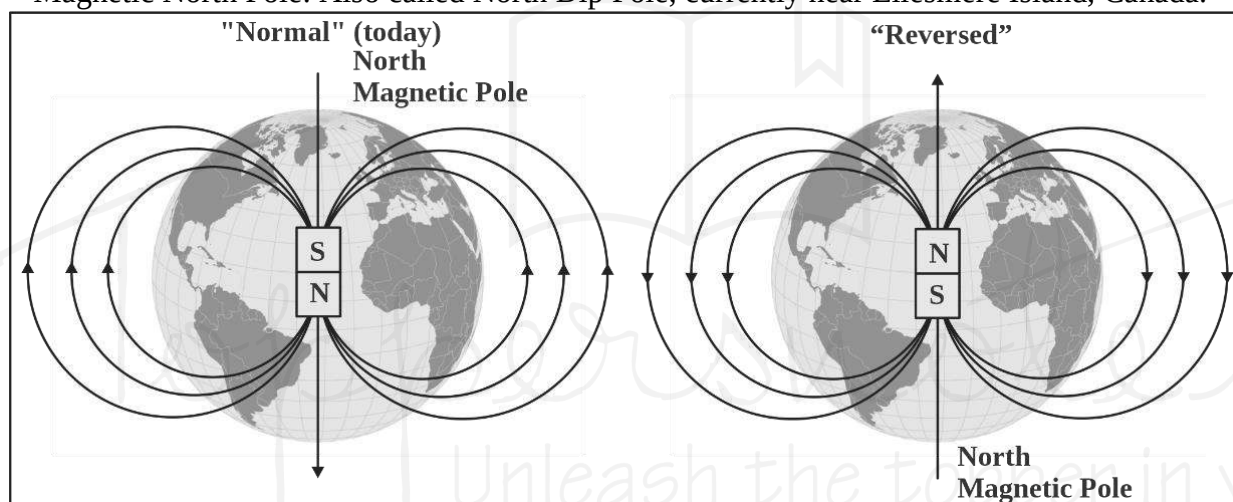


➤ List of Major Discontinuities

Discontinuity	Between	Key Features
Conrad Discontinuity	Upper Crust - Lower Crust	Present in continental crust only, at 15–20 km depth
Mohorovicc Discontinuity (Moho)	Crust - Mantle	Depth: ~35 km under continents, 8 km under oceans; abrupt P-wave jump
Repiti Discontinuity	Outer Mantle - Inner Mantle	Less well-defined; internal mantle boundary
Gutenberg Discontinuity	Mantle - Outer Core	At 2900 km; P-wave slows, S-wave vanishes (liquid outer core)
Lehmann Discontinuity	Outer Core - Inner Core	At ~5150 km; increase in P- and S-wave velocities

I. Earth's Magnetic Field

- **Generated by:** Convection currents of molten iron & nickel in Earth's outer core
- **Process:** The Geodynamo Effect, movement of conductive material produces electric currents, generating a magnetic field.
- **Region created:** Magnetosphere – protects Earth from solar wind.
- **Geographic Poles:** Fixed, based on Earth's rotational axis (Arctic & Antarctica).
- **Magnetic Poles:** Varying, based on magnetic field lines:
 - ✓ Magnetic North Pole: Also called North Dip Pole, currently near Ellesmere Island, Canada.



Magnetic Pole Reversal

- A phenomenon where Earth's magnetic north and south poles switch places.
- **Reason:** Caused by instabilities or fluctuations in the movement of molten metal in the outer core.
- **Frequency:** Occurs roughly every 300,000 years. The last full reversal, called the Brunhes–Matuyama reversal, occurred about 780,000 years ago.
- **Effects:**
 - ✓ The magnetic field weakens (up to 90%), but does not disappear.
 - ✓ May slightly increase exposure to solar radiation at Earth's surface.
 - ✓ No evidence of catastrophic biological or climatic effects.
- **Modern concern:** Potential disruption to satellites, power grids, and communication systems, but such effects would be gradual, not sudden.

DID YOU KNOW?

Recent research on ancient rocks from South Africa and Brazil suggests weakening of Earth's magnetic field during the Ediacaran period (635 - 541 mn years ago).



J. Motions of Earth

1. Rotation

- ✓ **Direction:** Earth rotates west to east (counterclockwise when viewed from above the North Pole).
- ✓ **Axis Tilt:** Tilted at 23.5° from the vertical relative to its orbital plane (**ecliptic**).
- ✓ One rotation = 24 hours → day and night cycle.
- ✓ Circle dividing day and night = circle of illumination.
 - Imaginary line dividing the sunlit (day) side and the dark (night) side.
 - Shifts slightly with the seasons due to axial tilt.
- ✓ **Effects of Rotation:**
 - **Day & Night:** Different parts of the Earth face the Sun & then rotate away.
 - **Coriolis Effect:** Deflects winds and ocean currents to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.
 - **Tidal effects** due to gravitational interaction with the Moon and Sun.
 - **Time zones:** Earth's rotation divides the globe into 24 time zones, each roughly 15° of longitude apart.

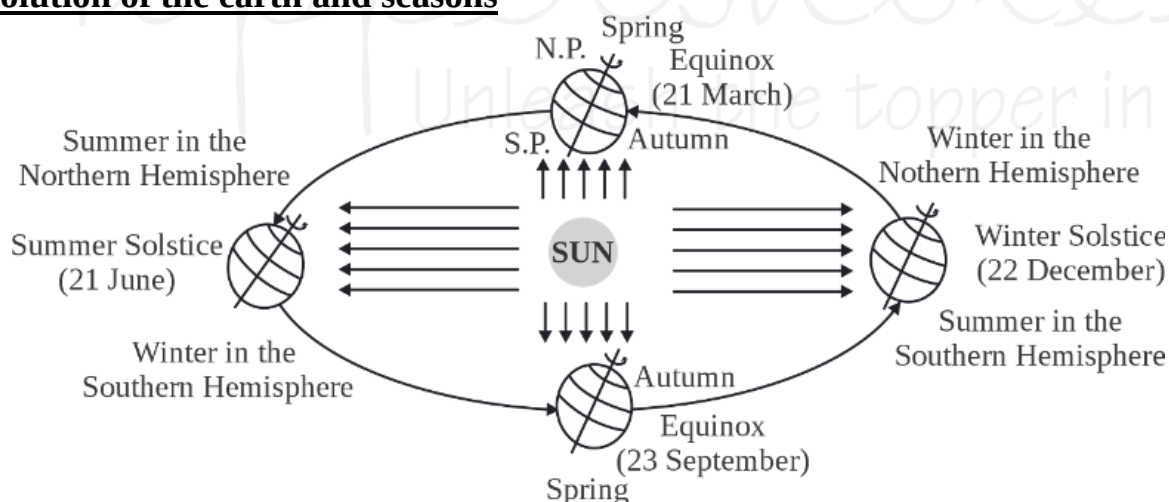
2. Revolution

- ✓ **Path:** Earth revolves around the Sun in an elliptical (oval-shaped) orbit.
- ✓ **Duration:** 365 $\frac{1}{4}$ days (365.2422 days) for 1 complete orbit → defines year.
- ✓ Leap year compensates for the extra $\frac{1}{4}$ day every year by adding 1 day every 4 years (Feb 29).
- ✓ **Effects of Revolution:**
 - Causes seasons due to axial tilt.
 - Changes in solar altitude and day length through the year.
 - Apparent movement of the Sun along the ecliptic path in the sky.

DID YOU KNOW?

- Melting polar ice redistributes mass toward the equator, changing Earth's moment of inertia & thus slightly shifting its rotation axis.
- Researchers have shown that increased ice melting may have delayed the need for adding negative leap seconds.

➤ Revolution of the earth and seasons

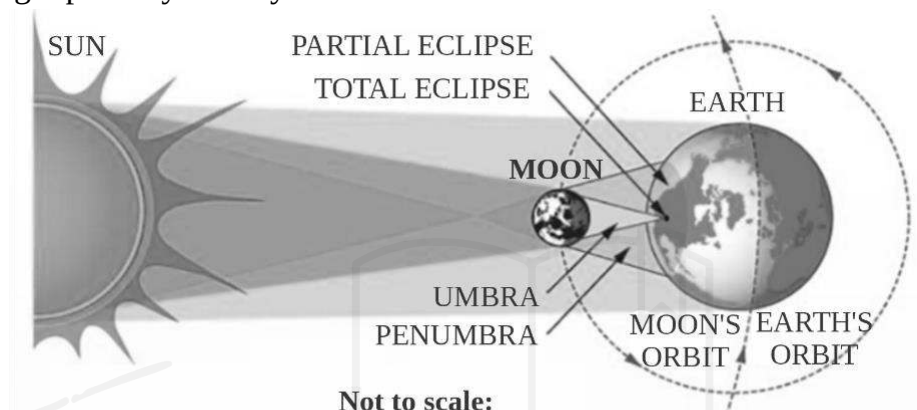


Event	Date	Description
Summer Solstice	21 June	Both Tropic of Cancer and Arctic Circle experience more than 12 hours of sunlight. Sun rays fall on the Tropic of Cancer; longest day & shortest night in the Northern Hemisphere; summer starts north of equator. Regions beyond the Arctic Circle experience 6 months of daylight.

Winter Solstice	22 December	Sun rays fall on the Tropic of Capricorn; summer in the Southern Hemisphere; winter in the Northern Hemisphere. Longest day & shortest night in the Southern Hemisphere.
Equinox	21 March 23 September	Sun rays fall directly on the equator; equal day and night globally; seasons change (spring/autumn). These are the only times when the Earth's axis is not tilted toward or away from the Sun. It occurs twice a year- on 21st March (Spring/Vernal Equinox) & 23rd September (Autumnal Equinox).

K. Solar and Lunar Eclipse

- Solar Eclipse (Surya Grahan):** Occurs when the Moon comes between the Earth & the Sun, blocking sunlight partially or fully.



Not to scale:

If drawn to scale, the moon would be 30 Earth diameters away from Earth. The sun would be 400 times that distance.

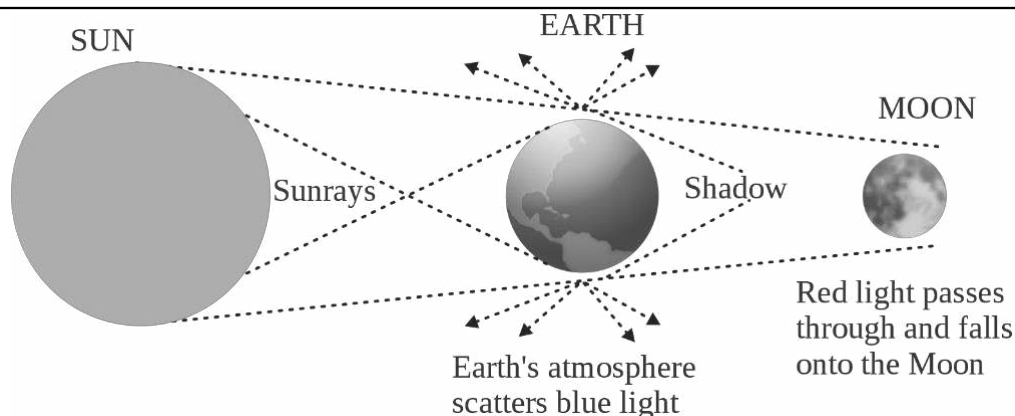
1.1. Types:

- ✓ **Total Solar Eclipse:**
 - The moon completely covers the Sun.
 - Seen from the umbra region (darkest part of the shadow).
 - Daylight temporarily turns into darkness.
- ✓ **Partial Solar Eclipse:**
 - The Moon covers only part of the Sun.
 - Seen from the penumbra region (lighter shadow).
 - Appears as a “bite” taken out of the Sun.
- ✓ **Annular Eclipse:**
 - Moon is farther from Earth, appears smaller
 - Doesn't cover the entire Sun.
 - Results in a glowing “Ring of Fire” around the Moon.

1.2. Conditions:

- ✓ Occurs only on Amavasya (New Moon).
- ✓ Requires perfect alignment in the order: Sun – Moon – Earth.
- ✓ **Visibility:** Only from specific regions on Earth within the eclipse path.
- ✓ Solar eclipses never last more than 7.5 minutes at any single location.

- Lunar Eclipse (Chandra Grahan):** Occurs when the Earth comes between the Sun & the Moon, casting its shadow on the Moon.



2.1. Types:

- ✓ **Total Lunar Eclipse:**
 - The entire Moon enters Earth's umbra.
 - The Moon appears reddish in color — often called a Blood Moon.
 - Caused by Rayleigh scattering and refraction of sunlight through Earth's atmosphere.
- ✓ **Partial Lunar Eclipse:**
 - Only a part of the Moon enters the umbra.
 - Appears as a visible dark “bite” taken out of the Moon.
- ✓ **Penumbral Eclipse:**
 - The moon passes through Earth's penumbra.
 - Very subtle dimming, often not noticeable to the naked eye.

2.2. Conditions:

- ✓ Occurs only on Purnima (Full Moon).
- ✓ Moon, Earth & Sun must be perfectly aligned (Sun–Earth–Moon).
- ✓ Visible from anywhere on Earth where the Moon is above the horizon.
- ✓ Lunar eclipses can last for several hours and are safe to view with the naked eye.

DID YOU KNOW?

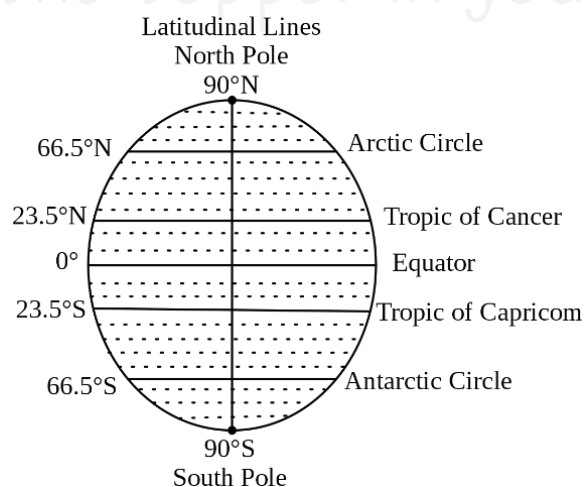
Bengaluru recently experienced a Zero Shadow Day, when the Sun was directly overhead and vertical objects cast no shadow. This phenomenon occurs twice a year, around the summer and winter solstices, in regions between the Tropic of Cancer and the Tropic of Capricorn, with the exact dates varying by location.



L. Latitudes and Longitudes

1. Latitude

- ✓ Angular distance north or south of the Equator (0° latitude), measured in degrees.
- ✓ Varies from 0° at equator to 90° at poles.
- ✓ **Lines of Latitude:** Also called parallels because they run east-west and are parallel to each other.
- ✓ Important latitudes:
 - **Tropic of Cancer (23.5°N):** Northern limit of the tropical zone.
 - **Tropic of Capricorn (23.5°S):** Southern limit of the tropical zone.
 - **Equator (0°):** Divides Earth into Northern and Southern Hemispheres.
 - **Arctic Circle (66.5°N):** Marks boundary of Northern Frigid Zone.
 - **Antarctic Circle (66.5°S):** Marks boundary of Southern Frigid Zone.



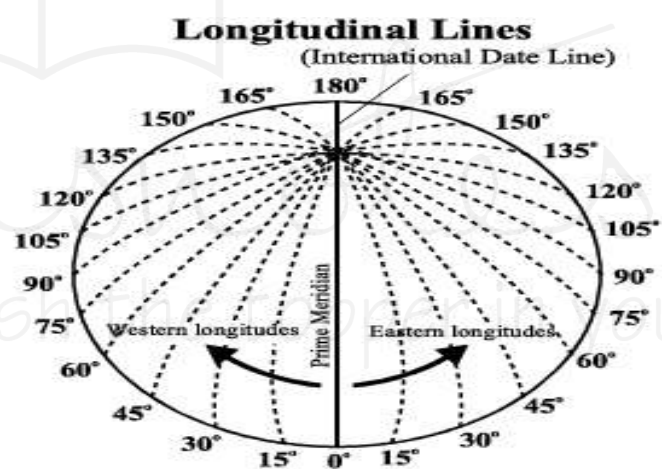
- ✓ Divides Earth into Torrid (tropical), Temperate & Frigid zones.
 - **Torrid Zone:** Between Tropic of Cancer and Tropic of Capricorn. The hottest zone which receives direct sun rays most of the year.
 - **Temperate Zones:** Between Tropics and Circles. Moderate climate and sun rays are slanting.
 - **Frigid Zones:** Within Arctic and Antarctic Circles. Very cold climate, receives indirect sunlight.

Major Latitudes of Earth

Latitude	Name	Countries
0°	Equator	Africa: Gabon, Republic of the Congo, Democratic Republic of the Congo, Uganda, Kenya, Somalia Asia: Indonesia, Maldives South America: Ecuador, Colombia, Brazil, São Tomé and Príncipe
23½° N	Tropic of Cancer	North America: Mexico, Bahamas Africa: Egypt, Libya, Niger, Algeria, Mali, Mauritania Asia: Taiwan, China, Myanmar, Bangladesh, India, Oman, UAE, Saudi Arabia
23½° S	Tropic of Capricorn	South America: Argentina, Brazil, Chile, Paraguay Africa: Namibia, Botswana, South Africa, Mozambique, Madagascar Australia: Australia
66½° N	Arctic Circle	Europe: Norway, Sweden, Finland Asia: Russia North America: United States (Alaska), Canada Oceania: Greenland (Denmark), Iceland
66½° S	Antarctic Circle	Antarctica: Antarctica

2. Longitude

- ✓ Angular distance east or west of the Prime Meridian (0° longitude).
- ✓ Varies from 0° to 180° east or west.
- ✓ **Prime Meridian:**
 - Passes through Greenwich, London.
 - Divides Earth into Eastern and Western Hemispheres.
 - Selected internationally in 1884 at the International Meridian Conference.
- ✓ Uses:
 - Determines local time: Every 15° of longitude = 1 hour difference.
 - Coordinates: Together with latitude, provides precise global locations.
 - Essential for navigation and mapping.
 - Vital for nautical charts, aircraft routing, and digital mapping systems.



DID YOU KNOW?

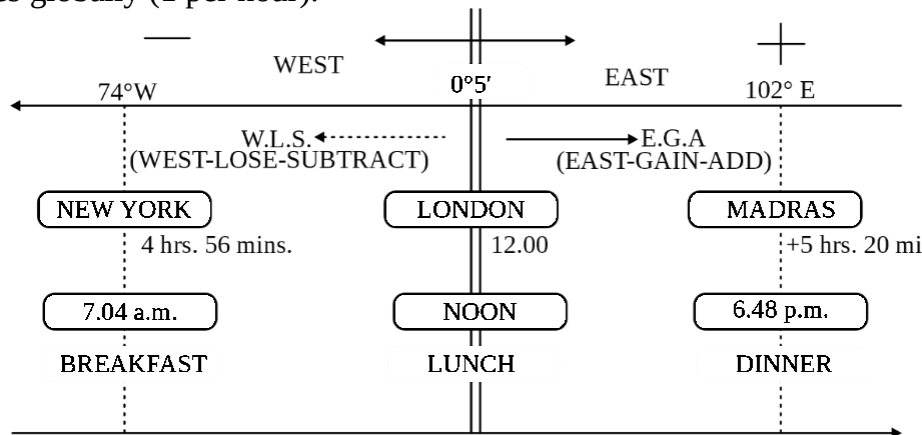
A light year is a unit of distance, not time. It represents the distance light travels in one year at a speed of 300,000 km per second, which equals approximately 9.461×10^{12} kilometers. The average distance from the Sun to Earth is about 149.6 million kilometers, which light covers in roughly 8.311 minutes.



M. Greenwich Meridian Time

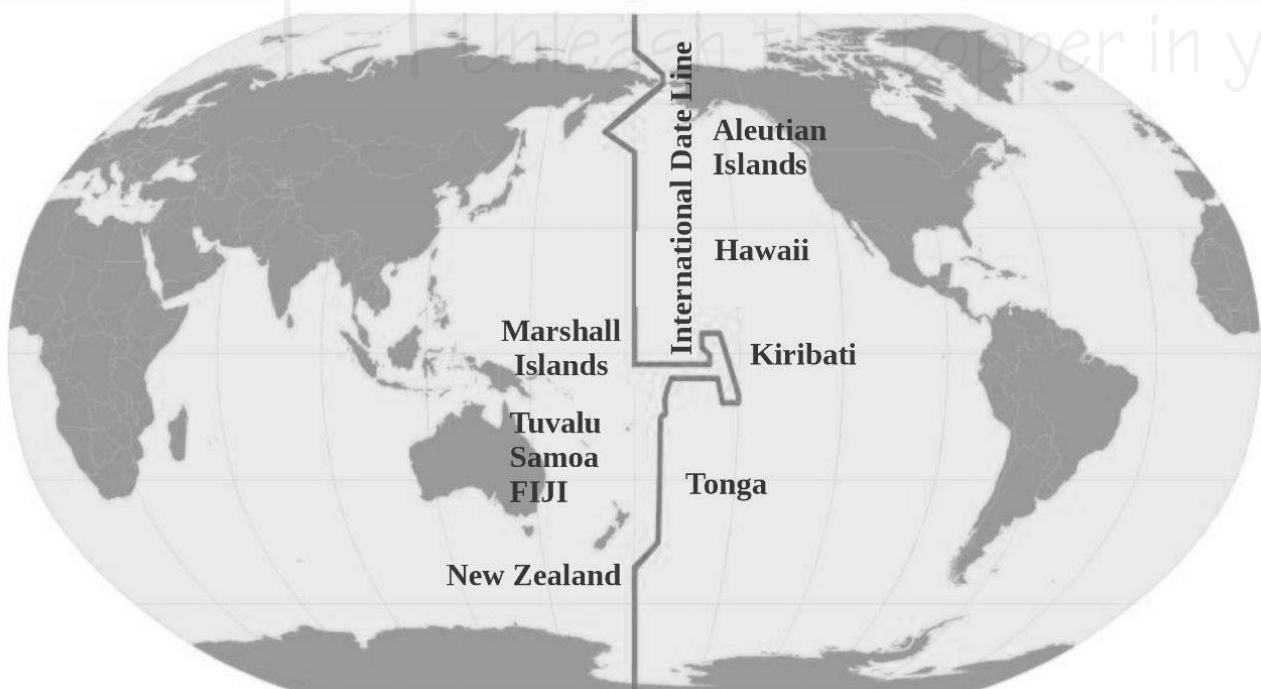
- The mean solar time at the Prime Meridian (0° longitude) in Greenwich, London.
- Established in 1884 as zero longitude.

- It serves as the global reference time from which all other time zones are calculated.
- Earth rotates 360° in 24 hours $\rightarrow 15^\circ$ per hour, 4 minutes per degree.
- Places east of Greenwich see sunrise earlier $\rightarrow (+)$ time; places west $\rightarrow (-)$ time.
- Prime Meridian (0°) is the reference for Greenwich Mean Time (GMT).
- 24 Time Zones globally (1 per hour).



N. International Date Line (IDL)

- The IDL is an imaginary line that runs roughly along 180° longitude in the Pacific Ocean, opposite the Prime Meridian (0°).
- Crossing it east to west $\rightarrow$ lose a day (e.g., Tuesday $\rightarrow$ Monday); west to east $\rightarrow$ gain a day (e.g., Monday $\rightarrow$ Tuesday).
- Separates two consecutive calendar dates.
- Prevents date confusion, mostly runs through oceans.
- Follows a zigzag pattern to accommodate political boundaries and island groups.
- Bering strait is nearest to the International date line
- Countries with large east–west extent (like Russia, USA, Canada) span multiple time zones.
- Countries with north–south alignment (like Chile, Norway) usually stay in one time zone.
- The Bering Strait (between Russia and Alaska) is the closest landmass to the IDL.
- Without the International Date Line, travelers circling the globe east or west would experience confusing date shifts without a clear way to adjust.
- The International Date Line is not an official law, but an agreed convention for timekeeping.



Countries with Multiple Time Zones

Country	Time Zones
France	13
Russia	11
United States	11
Australia	9
United Kingdom	9
Canada	6
Denmark	5
New Zealand	5
Brazil	4
Mexico	4

O. Indian Standard Time (IST)

- IST is based on 82.5°E longitude, which passes near Mirzapur (close to Allahabad/Prayagraj, Uttar Pradesh).
- This longitude was chosen to maintain a uniform time across the country.
- IST = GMT + 5 hours 30 minutes. So, when it is 12:00 noon in London, it is 5:30 PM in India.
- **Passes through:** UP, MP, Chhattisgarh, Odisha, Andhra Pradesh.
- **Earlier:** India had two time zones (including Chaibagaan Time in Assam).
 - ✓ It is still informally followed in some tea gardens for better use of daylight.

DID YOU KNOW?

Anadyr in Siberia and Nome in Alaska are a few kilometers from each other, but when people are waking up and getting set for breakfast in these cities, it would be different days.



P. Daylight Saving Time (DST)

- DST is the practice of moving clocks forward by 1 hour during the summer months.
- The goal is to make better use of daylight in the evenings and save energy by reducing artificial lighting.
- Practiced in parts of North America and Europe.
- Clocks are moved forward by 1 hour during summer to save energy.
- India does not observe DST but Northeast demands a separate time zone due to early sunrise and sunset.
- History and Adoption of Daylight Saving Time (DST):

Aspect	Details
Origins	➤ First suggested by Benjamin Franklin in 1784 in a whimsical essay.
Adoption	➤ Introduced during World War I by Australia, Great Britain, Germany , and the US to conserve fuel.
Current Practice	➤ DST is currently practiced in around 70 countries , including the European Union .
India's Case	➤ India does not observe DST due to minimal daylight variation near the Equator .

Problem Areas	➤ Can disrupt sleep patterns and circadian rhythms. ➤ Higher risks of sleep disorders, cognitive issues, and heart-related conditions. ➤ Not adopted universally, leading to confusion and inconsistencies across different time zones. ➤ In some regions, DST can increase energy use due to reliance on heating and cooling systems. ➤ Causes challenges for businesses, travel, and communication across regions with different observances.
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The Earth's evolution is a continuous process shaped by geological, climatic, and biological changes over billions of years. This dynamic history has transformed Earth from a molten mass to a life-supporting planet, highlighting the intricate connections between its physical environment and living organisms.

