UnderStand UPSC
What we UnderStand, We Conquer

SUCCESS

The TRUE Foundation Program

UPSC 2027 & 2028

PHYSICAL GEOGRAPHY

ONE STOP SOLUTION

Satyam Jain

(3 UPSC CSE Interviews,
Mentor to 300+ Rankers Including AIR-1,
Published Author)

Call For More Info
8377072252

Ground floor, 11B, Bada Bazar Road, Old Rajender Nagar, New Delhi – 110060

understand.upsc | UnderStandUPSC.com | : UnderStand UPSC

INDEX

Nature And Subject Matter Of Geography

Derived from the Greek words ***geo* (earth)** and ***graphos* (description)**, Geography means **"description of the earth."** It draws data from **both natural and social sciences** and seeks to synthesize this information. **Geography** studies areal differentiation, exploring why phenomena differ across regions by analyzing factors like **soil, climate, market demands, and human capacity,** creating **cause-effect relationships.**

Geography answers three key questions:

What exists on earth's surface? Where is it found? and why is it ***located there?***

It interprets spatial patterns and examines interactions between nature and humans.

> **What is Geography?**
>
> Geography is concerned with the description and explanation of the areal differentiation of the earth's surface.
>
> *Richard Hartshorne*
>
> Geography studies the differences of phenomena usually related in different parts of the earth's surface.
>
> *Hettner*

Geography is a discipline of synthesis

- It integrates knowledge from both natural and social sciences.
- Focuses on spatial synthesis, unlike history which emphasizes temporal synthesis.

Geography has a holistic approach

- It recognizes the interdependence of various systems **(Natural, Social, Economic, Cultural).**
- Views the world as a unified system **(global village).**

Interconnected with other sciences

- **Natural sciences:** Geology, Meteorology, Botany, Zoology, etc.
- **Social sciences:** History, Economics, Political Science, Sociology, etc.
- Helps understand the spatial variation of phenomena studied in other disciplines.

Geography explains historical events spatially

- Geographic factors like mountains, rivers, and coasts have influenced **migration, trade, wars, and colonization.**
- **Example:** Himalayas protected India; sea routes enabled European colonization.

Geographical phenomena are dynamic

- Landforms, climate, vegetation, and cultures change over time.
- Geography studies these changes by linking them to **specific historical and spatial contexts.**

Time is the fourth dimension in geography

- Other **three dimensions: Length, Breadth, and Height (Depth)**.
- Time and space are interconnected (e.g., distance can be measured in hours).

Technology enhances geographical studies

- Use of GIS, remote sensing, and data from **audio-visual media** improves analysis and monitoring of spatial patterns.

Branches of Geography

- Geography, an **interdisciplinary subject**, is studied through **two approaches**: the systematic approach **(Humboldt)** that analyzes global phenomena and patterns, and the regional approach **(Ritter)** that studies regions holistically.
- It also reflects a dualism between physical geography **(Natural processes)** and human geography **(human activities)**, both essential to understanding the Earth's surface.

Branches of Geography (based on systemic approach)

Physical Geography: Focuses on natural features and	• **Geomorphology**: Studies landforms, their origin, evolution, and the processes shaping them. • **Climatology**: Focuses on atmospheric structure, weather patterns, climatic types, and regions.

processes of the Earth.	• **Oceanography and Hydrology**: Examines water bodies like oceans, rivers, lakes, and their impact on life and human activities. • **Soil and Pedology Geography**: Analyzes soil formation, types, fertility, distribution, and utilization.
Human Geography: Explores human activities, society, and their spatial interactions.	• **Social/Cultural Geography**: Studies societal structure, spatial behavior, and cultural expressions across regions. • **Population and Settlement Geography**: Deals with population dynamics (growth, distribution, migration) and the nature of rural and urban settlements. • **Economic Geography**: Examines economic activities like agriculture, industry, transport, trade, tourism, and infrastructure. • **Historical Geography**: Explores how historical events and processes have shaped geographical spaces over time. • **Political Geography**: Investigates political boundaries, interrelations between political units, elections, and political behavior within spatial contexts.
Biogeography: A bridge between physical and human geography, focusing on living organisms in spatial contexts.	• **Phytogeography (Plant Geography)**: Studies the spatial distribution of natural vegetation and ecosystems. • **Zoogeography**: Focuses on the distribution and habitat characteristics of animal species. • **Ecology/Ecosystem Studies**: Analyzes relationships between organisms and their environments. • **Environmental Geography**: Addresses environmental issues like pollution, land degradation, and promotes sustainable development and conservation.

Branches of Geography Based on Regional Approach

1. Regional Studies / Area Studies

- Focus on studying **geographical phenomena** within specific regions.
- Divided into **Macro (large), Meso (medium), and Micro (small)** level regional studies.

2. Regional Planning

- Involves planning for balanced development.
- Includes rural/country planning and urban/town planning.

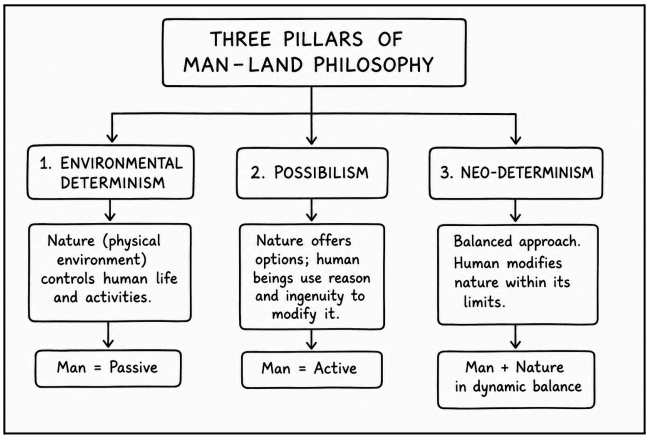
3. Regional Development: Concerned with strategies and actions to improve regional economies and quality of life.

4. Regional Analysis: Uses spatial data and techniques to evaluate regional characteristics, disparities, and development potential.

Common Aspects Across Branches of Geography

A. Philosophy of Geography

- **Geographical Thought**: Explores the evolution of geographical knowledge and ideas.
- **Human Ecology**: Studies the relationship between humans and their environment (land and people interaction).
- The **Three Pillars of Man-Land Philosophy:**
  - **Environmental Determinism:** Nature dictates and controls human actions and culture.



- **Possibilism:** Nature offers choices, while **human technology and culture** actively shape the environment.
- **Neo-Determinism:** A middle path where humans navigate nature's choices like a traffic controller, bound by **ecological limits.**

B. Methods and Techniques

- **Cartography**: Art and science of map-making, now includes **Computer Cartography**.
- **Quantitative Techniques**: Use of mathematical/statistical tools for spatial analysis.
- **Field Survey Methods**: Collection of first-hand data through fieldwork.
- **Geo-informatics**:
  - **Remote Sensing**: Observation of Earth through **satellites or aerial imagery.**
  - **GIS (Geographic Information System)**: Tools for mapping and spatial analysis.
  - **GPS (Global Positioning System)**: Satellite-based system for accurate location identification.

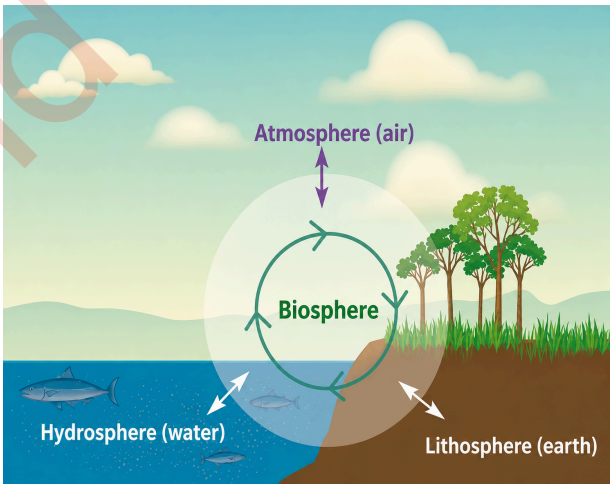
Physical Geography

Scope of Physical Geography

- Physical geography focuses on studying the natural environment of the Earth.
- It includes the study of the **lithosphere, atmosphere, hydrosphere, biosphere, and soils.**

Key Components of Physical Geography

- **Lithosphere**
  - Studies landforms, relief, drainage, and physiography.
  - Landforms like **plains, plateaus, and mountains** influence human settlement and activities.
- **Atmosphere**
  - **Covers weather and climate:** temperature, pressure, wind, precipitation, and climatic types.
  - Climate impacts **Human life (housing, clothing, food)** and agriculture.



- **Hydrosphere**
  - Involves study of oceans, seas, lakes, and other water bodies.
  - Oceans provide marine resources including **food, energy, and minerals** like manganese nodules.
- **Biosphere**
  - Focuses on life forms including humans, plants, and animals.
  - Studies food chains, ecosystems, and ecological balance.
- **Soil Geography**
  - Examines **soil formation (Pedogenesis),** types, fertility, and use.
  - Soils are renewable and vital for agriculture and vegetation, soils form very slowly and may be considered renewable over geological time, but are **vulnerable to degradation.**

Importance of Physical Geography in Human Life

- **Landforms influence land use:** plains for farming, plateaus for minerals, mountains for tourism and water sources.
- Climate affects **vegetation, cropping patterns, industries, and water availability.**
- Precipitation replenishes **groundwater, vital for agriculture and domestic use.**
- Oceans provide **food, energy, and mineral resources.**
- Soils sustain **agriculture, forests, and biodiversity.**

- Natural barriers like **mountains and oceans** historically guided **human migration routes, established political boundaries**, and isolated or connected cultures.

Relevance of Physical Geography Today

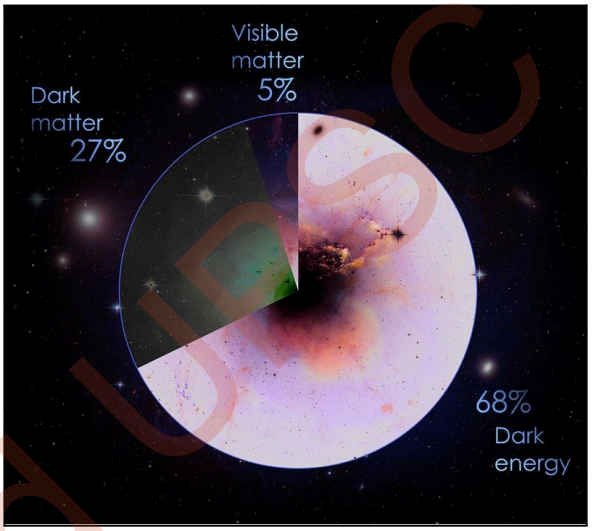
- Helps in **evaluating and managing natural resources** effectively.
- Aids understanding of the interdependence between **nature and human life.**
- Essential for sustainable development by promoting responsible resource use.
- Addresses challenges like **ecological imbalance** caused by excessive resource exploitation.

Geography is the study of Earth's **landscapes, environments, and the relationships** between people and their surroundings. Its subject matter spans both physical processes and human activities, making it a bridge between **natural and social sciences.**

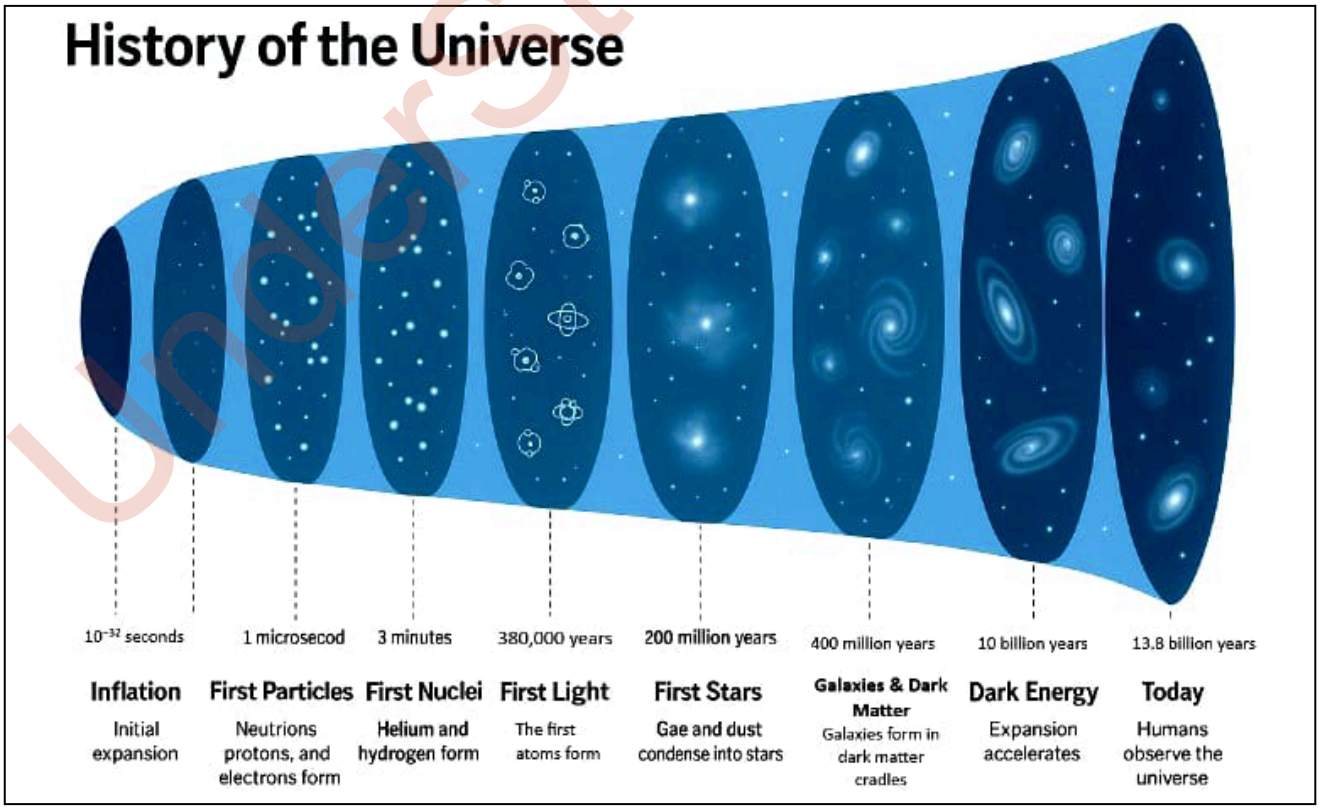
The Origin and Evolution of Earth

The **Universe** encompasses everything that exists: **planets, stars, galaxies, intergalactic space, subatomic particles, matter, and energy.** Within this **vast Universe** lies the solar system, which includes the Sun, eight planets, numerous **dwarf planets**, millions of smaller bodies like asteroids and comets, as well as vast amounts of gas and dust. **All these celestial objects** orbit the **Sun** in a consistent pattern.

Universe and Galaxies



- **The universe is everything. It includes all of space, and all the matter and energy that space contains. It even includes time itself. (NASA)**
- According to the widely accepted **"Concordance model"** of the **Universe,** about **70%** of the cosmos consists of dark energy, **25%** is dark matter, and **only 5%** is ordinary matter.
- **Galaxies** are vast space systems composed of dust and **countless stars.**
- The number of galaxies cannot be precisely counted.
- Some galaxies resemble our **Milky Way**, while others are quite different.
- The Milky Way has a diameter of about **100,000 light-years** and contains more than a 100 billion stars.
- Our Sun, along with its solar system, is located about **30,000 light-years** from the center of the **Milky Way.**
- Like other stars, the Sun and its solar system revolve around the galactic center, completing one revolution approximately every **224 million years**.



Theories related to origin of Universe

Early Theories:

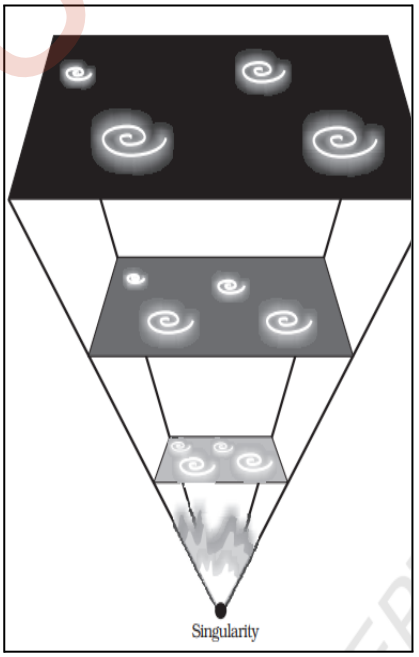
- Throughout history, many philosophers and scientists proposed hypotheses about how the **Earth** formed.
- One of the earliest and most popular was proposed by **Immanuel Kant (German Philosopher).**
- **Pierre-Simon Laplace (French Mathematician)** revised this theory in **1796**. This came to be known as the **Nebular Hypothesis**.

The Nebular Hypothesis (Kant–Laplace Model)

- Suggested that planets formed from a **cloud of material** linked to a young, slowly rotating **Sun.**
- This cloud of gas and dust gradually condensed, leading to the **formation of planets.**

Modified Nebular Hypothesis (1950s)

- **Otto Schmidt (Russia)** and **Carl Weizsäcker (Germany)** revised the original **Nebular Hypothesis.**
- **Their version proposed:**
  - The Sun was surrounded by a **solar nebula** consisting mainly of **hydrogen, helium, and dust**.
  - **Friction and collisions** between particles caused the material to flatten into a **disk-shaped cloud**.
  - Planets formed through the **process of accretion (Gradual Accumulation Of Particles).**



Later scientists moved beyond just explaining the Earth's origin. Research expanded to address the origin of the universe as a whole, **not only** the Earth or the **Solar System.**

MODERN THEORIES

1. Big Bang Theory (Expanding Universe Hypothesis)

- **Most widely accepted theory** for the **origin of the universe.**
- Proposed as an **expanding universe hypothesis**.
- **Edwin Hubble (1920s)** provided observational evidence that galaxies are moving away from each other, indicating the **universe** is expanding.
- **Balloon Analogy-** Mark points **(Galaxies)** on a balloon; as the balloon inflates, the points move farther apart.
- **Limitation**:
  - In reality, galaxies themselves are **not expanding, only** the **space between them** is increasing.
  - The analogy is **only partially correct**.
  - The **Big Bang Theory** does not actually explain what banged, why it **banged, or what existed** before the bang.

The Big Bang Theory considers the following stages in the development of the universe:

Stage 1: Initial State	• All matter in the universe was concentrated in a **tiny, dense, extremely hot point (“Singular Atom”)** with infinite temperature and density.
Stage 2: Big Bang Event	• Occurred **13.7 billion years ago**. • The tiny point exploded violently, leading to a **rapid expansion**. • Some **energy** is converted into matter. • Expansion was fastest in the **first fractions** of a second, then slowed down. • **Within the first 3 minutes**: Formation of the first atoms began. • The expansion continues even to the present day.

Stage 3: Formation of Atomic Matter	• **Within 300,000 years** of the Big Bang:
	  ○ The temperature dropped to **4,500 Kelvin**.
	  ○ Atomic matter formed.
	  ○ The universe became **transparent** (radiation could pass through space freely).

The **expansion of the universe** refers to the increase in the space separating galaxies. An alternative explanation, proposed by **Fred Hoyle**, was the **Steady State Theory**, which suggested that the universe remains essentially the same **at all times**. However, with stronger evidence supporting the expansion of the universe, the **scientific community now widely accepts the expanding universe model** over the steady state concept.

Classification of Galaxies (Edwin Hubble)

1. Spiral Galaxies	• Have a **central bulge** and a **flattened disk** containing spiral arms.
	• Classified based on **bulge size**, **tightness**, and **appearance of arms**.
	• **Spiral arms** contain:
	  ○ Many young, blue stars.
	  ○ Large amounts of gas and dust.
	• Stars in the bulge are generally **older and redder**.
	• Disk rotation resembles a **hurricane or whirlpool**.

2. Barred Spiral Galaxies	• A type of spiral galaxy with a **bar-shaped collection of stars** running through the central bulge. • Our own **Milky Way** is now classified as a **barred spiral galaxy.**
3. Elliptical Galaxies	• Lack of disks and spiral arms. • Have a **smooth, oval-shaped appearance**. • Contain mostly **old stars** with very little gas or dust. • Shape ranges from **nearly round** to **highly elongated** (baseball-shaped to football-shaped). • Stars move in **random orbits**, unlike the organized rotation in spirals. • Motion resembles a **swarm of bees**.
4. Irregular Galaxies	• Do not fit into spiral or **elliptical categories.** • Have **no definite shape**. • Usually **smaller** in size. • Contain **very hot, young stars** along with large amounts of gas and dust.

The Formation of Stars

- A galaxy contains a large number of stars. **Galaxies** spread over vast distances that are measured in thousands of **light-years.**
- The diameters of individual galaxies range from **80,000-150,000** light years.
- A galaxy starts to form by accumulation of **hydrogen gas** in the form of a very large cloud called a **Nebula**.
- Eventually, growing **nebulae** develop localised **clumps of gas.** These clumps continue to grow into even denser gaseous bodies, giving rise to formation of stars. (**CSE 2023)**
- The formation of stars is believed to have taken place **5-6billion years ago.**

Light Year
• A **light year** is a measure of distance and **not of time.**

- **Light travels** at a speed of 300,000 km/second.
- Considering this, the distance the light will travel in one year is taken to be one light year. This equals 9.461×10^{12} km.
- The mean distance between the **sun** and the **earth** is 149,598,000 km.
- In terms of light years, it is **8.311** minutes.
- The speed of light is **always the same** , that's why astronomical distances are measured in light years. (**CSE 2021**)

The Solar System

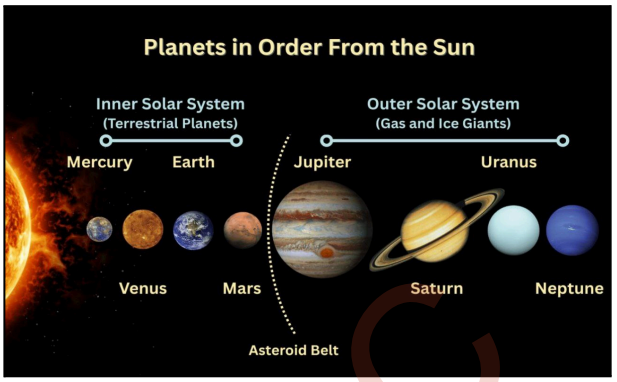
- The Solar System is believed to have formed about **4.6 billion years ago** through the gravitational collapse of a **giant molecular cloud.**
- It is made up of the **Sun and all the objects** that orbit it, either **directly or indirectly.**
- Objects that orbit the Sun directly include the **8 largest bodies** known as planets, along with many smaller objects such as dwarf planets, asteroids, and comets, collectively called **Small Solar System Bodies (SSSBs).**

The Solar System

	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Distance*	0.387	0.723	1.000	1.524	5.203	9.539	19.182	30.058
Density@	5.44	5.245	5.517	3.945	1.33	0.70	1.17	1.66
Radius#	0.383	0.949	1.000	0.533	11.19	9.460	4.11	3.88
Satellites	0	0	1	2	about 53	about 53	about 27	13

- Those that orbit the Sun indirectly are the **natural satellites, or moons, of planets and other bodies.**
- **All the planets** revolve around the Sun in **Elliptical orbits.** Like the earth, they shine only by reflecting the **Sun's light.**
- The Sun has a surface temperature of 6,000°C.
- **Mercury** is the smallest and closest to the sun. A year on Mercury is only 88 days. It is also the planet with lowest Albedo. **[CSE 2008]**
- Second in line is **Venus, considered** as **'Earth's Twin'** because of their close proximity in size, mass (weight) and density.
- It is also the hottest planet in the **Solar System** because of its thick atmosphere of carbon dioxide and runaway greenhouse effect **[CSE 2005].** It is the planet with the highest albedo.
- Next is **Earth,** the only planet with life. Often referred to as the **"Blue Planet"** due to water covering roughly 71% of its surface.
- It has the highest density among all the planets in the solar system. The fourth planet from the sun is **Mars**. It has two moons, **Phobos and Deimos.**
- Mars hosts **Olympus Mons**, the largest volcano and highest known mountain in the entire solar system.
- Next comes **Jupiter**, the largest planet in the solar system. Its surface is made up of many gases like **hydrogen, helium, and methane.[CSE 2009]**
- Another planet is **Saturn, second** largest in size. It is so far from the sun that it takes 29 and half years to complete its orbit.
- The seventh planet, **Uranus**, unlike other planets orbits around the sun on its side, with its axis tilted nearly **98 degrees.**This causes extreme **21-year-long seasons**. It rotates in a retrograde motion **(East to West).**
- The last one **Neptune** closely resembles **Uranus** in terms of composition and appearance.
- The planets vary in size, with those located toward the middle of the Solar System being larger than those at the edges. Geophysicists refer to this size arrangement as **"cigar-shaped."**
- The planets are generally classified into **two groups:** the **inner or terrestrial planets,** which are smaller and rocky, and the outer planets, which are larger and composed mainly of gases.

1. Inner or Terrestrial Planets: The inner circle consists of four planets including **Mercury, Venus, Earth** along with **Mars** and **Asteroids.** These planets are called **inner planets** as they lie between the Sun and the belt of asteroids and are closer to the Sun.



- They are called terrestrial which means **Earth like**, as they are made up of rocks and metals.
- These planets are comparatively small in size and have relatively higher density.
- Their speed of **rotation is less.**
- They either have no satellite or very few satellites for example the Earth has **only one** and Mars have **two satellites.**

2.The outer planets: They are also known as the **giant planets** or **Jovian planets** (Jupiter like). The outer circle consists of four planets namely **Jupiter, Saturn, Uranus, and Neptune**.

- These planets are bigger in size and are less dense.
- They have a thick atmosphere mostly composed of helium and hydrogen eg- Jupiter and Saturn.
- The two outermost planets, **Uranus** and **Neptune**, are composed largely of substances with relatively high melting points (compared with hydrogen and helium), called **ices**, such as water, ammonia and methane, and are often referred to separately as **"ice giants".**
- Their speed of rotation and number of satellites are more compared to the inner planets.

The difference between terrestrial and jovian planets can be attributed to the following conditions:

- The terrestrial planets were formed in the close vicinity of the parent star where it was too warm for gases to condense to solid particles. **Jovian planets** were formed at quite a distant location.
- The solar wind was most intense nearer the sun; so, it blew off lots of gas and dust from the terrestrial planets. The solar winds were not all that intense to cause similar removal of gases from the **Jovian planets.**
- The terrestrial planets are smaller and their lower gravity could not hold the escaping gases.

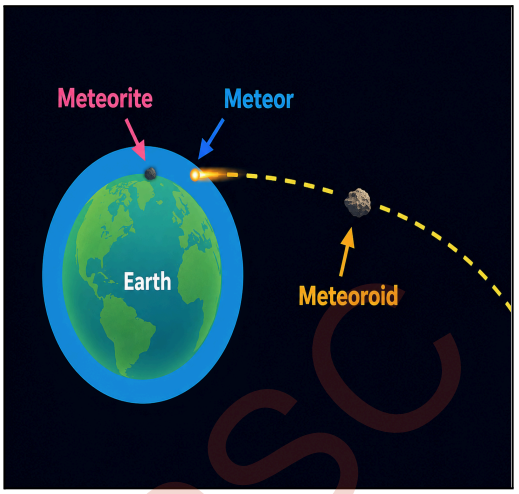
Characteristics of the Solar System

- All planets have some tilt of their rotational axes relative to their **orbital planes (ecliptic)**. The degree of tilt varies from planet to planet
- All the planets rotate around their axis and the speed of rotation of these planets vary from each other.
- Seen from above the Sun's north pole, all planets revolve around the Sun in an anti-clockwise direction.
- The path of these planets is either **circular or elliptical.**
- All these planets are very small in size and mass when compared to the Sun. The Sun comprises about **99.86% of the mass of the Solar System**.
- In the Solar System, angular momentum is unevenly distributed. While the Sun holds **99.9% of the total mass**, it has only **1.7% of the total angular momentum**.
- The planets, which contain just **0.1% of the mass**, possess the remaining **98.3% of the angular momentum**.

Solar Objects

- **Asteroid:** An asteroid is a small, rocky object and when seen in a telescope, it appears as a point of light. Most asteroids are found in a ring between the orbit of Mars and Jupiter called the **Asteroid belt.** **[CSE 2011]**
- **Comet**: A comet also orbits the Sun, but unlike an asteroid, it's composed of ice and dust. So, when a comet gets close to the Sun, its ice and dust content start to vaporize.
- So, when seen in a telescope, a comet appears fuzzy and/or has a tail**.** They are often famously described by astronomers as **"Dirty snowballs." [CSE 2011,1995]**

- **Meteoroid:** A meteoroid is a small piece of asteroid or a comet, typically pebble-sized, but could be a little smaller or a little larger, and often created from a collision.
- **Meteor**: When a meteoroid gets close to the Earth and enters the Earth's atmosphere, it's called a **meteor.** And a **meteor enters** the Earth's atmosphere at a very high speed. So it burns up and produces a streak of light called a **shooting star.**
- **Meteorite**: If a meteor survives the burn and lands on the ground, it's called a meteorite. A classic Indian example is the **Lonar Crater Lake in Maharashtra**, which was formed by a basaltic meteorite impact during the **Pleistocene Epoch.**



Important facts with respect to solar system

- **Kuiper Belt & Scattered Disc**: Located beyond **Neptune's orbit**; populated mainly by icy bodies **(Trans-Neptunian Objects).**
- **Dwarf Planets:** Objects large enough to be rounded by their own gravity but **not** classified as full planets. **Examples:**
  - **Ceres** (in the **Asteroid Belt**).
  - **Pluto** and **Eris** (in the **Kuiper Belt/Scattered Disc**).
- **Dwarf Planets Criteria:** According to the **International Astronomical Union (IAU)**, dwarf planets meet the first two criteria of a planet (orbiting the Sun and being spherical) but fail the third: **they have not "Cleared the neighborhood" around their orbit.**
- **Other Small-Body Populations**
  - **Centaurs**: icy-rocky bodies with unstable orbits between **Jupiter and Neptune.**
  - **Interplanetary Dust**: fine particles traveling freely between regions.
- **Natural Satellites:** Found orbiting six planets, at least **three dwarf planets,** and many smaller bodies.
- **Planetary Rings:** Each outer planet is surrounded by rings composed of dust and small objects.
- **Solar Wind and Heliosphere: Solar Wind** is the flow of plasma from the Sun. It creates a bubble in interstellar space called the **heliosphere**, extending to the edge of the scattered disc. Beyond the heliopause lies pristine interstellar space.
- **Oort Cloud & Heliopause**
  - **Oort Cloud**: hypothetical region far beyond the heliosphere; source of **long-period comets**; possibly 1,000× farther than the **heliosphere.**
  - **Heliopause**: boundary where solar wind pressure equals opposing interstellar wind pressure.
- **Location in the Galaxy:** The **Solar System** lies in one of the outer arms of the **Milky Way Galaxy**, which contains about 200 billion stars.
  - Our Solar System is specifically located in the **Orion Cygnus Arm** (also known as the **Orion Spur)** of the **Milky Way.**
- Saturn has thousands of Ringlets (Grouped into **7 main rings**) and 145 known **Satellites (Moons)** as of 2025 **(NASA)**. In size, it is the second largest planet (after **Jupiter**).
- Uranus orbits around the sun in a clockwise direction from east to west, with 27 known moons **(E.g., Miranda, Ariel, Umbriel, Titania, Oberon).**

Formation of Planets

- **Initial Stage:** Stars begin as concentrated clumps of gas within a **Nebula**. **Gravitational forces** cause these clumps to form a dense central core, surrounded by a large rotating disc of gas and dust.
- **Planetesimal Formation:** The gas cloud condenses, and matter around the core forms small, rounded objects. Through cohesion, these objects become **planetesimals** and numerous small celestial bodies. **Collisions and gravitational attraction** cause some to merge into larger bodies.
- **Planet Formation:** Over time, planetesimals combine through accretion, forming fewer but larger bodies, which **evolve into planets.**

Importance of Stars and Planets

Stars:	• **Source of Energy:** The Sun, our nearest star, through **Nuclear Fusion** in its core provides light and heat essential for **life on Earth.** • **Element Formation:** Supernova explosions of dying stars create heavy elements like iron and gold. • **Navigation:** Ancient sailors used the **North Star (Polaris)** to find direction at sea. • **Understanding the Universe:** Observing stars like **Betelgeuse** helps scientists study how stars age and die.
Planets:	• **Support Life:** Earth is the only known planet to support life due to its atmosphere and water. ○ **Goldilocks Zone:** Region around a star where **conditions** are **"Just right"** neither too hot nor too cold for liquid water to exist on the surface of a planet.**[CSE 2015]** • **Learning about Other Worlds:** Mars is studied for signs of past water and possible microbial life. • **Stability in the Solar System:** Jupiter's gravity helps protect Earth by attracting comets and asteroids. • **Space Exploration:** Missions like **Voyager and Juno study** planets to advance science and technology.

IAU Parameters for a planet:
A planet is a celestial body that (a) is in **orbit around the Sun,** (b) has **sufficient mass** for its **self-gravity** to overcome rigid body forces so that it assumes a **hydrostatic equilibrium** (nearly round) shape, and (c) has cleared the neighborhood **around its orbit.**

Geological Time Scale

- **Geologists** have classified the **Earth's history** into a number of time intervals of different length of time depending on the major events in the life history of the **Earth** depending on the **evidence of the fossils.**
- The **geological time scale** presents the history of the Earth divided in a **hierarchical set of divisions** of geologic time based on geochronology and dating of the sequential events throughout the Earth's history.
- While most geologists agree on the use of **Eon**, **Era**, **and Period**, local terms are often used at lower levels to describe specific depositional environments.

A) EON	The geological time scale has been divided into **four major time divisions** called **eons. These are** 1. Hadean (4570 to 3850 Ma), 2. Archean (3850 to 2500 Ma), 3. Proterozoic (2500 to 541 Ma), and 4. Phanerozoic (540 Ma to present) **(1) Hadean Eon (4500–4000 Ma)** ● Oldest phase in Earth's history (4500 Ma). ● Marked by heavy **meteorite bombardment.** ● No evidence of life on rocks. ● This is the era when the **Earth** completely melted, causing heavy **iron and nickel** to sink to the center to form the **Core.** **(2) Archean Eon (4000–2500 Ma)** ● First evidence of life: **prokaryotes like blue-green algae and bacteria.** ● Stromatolites (3500 Ma) found globally. **(3) Proterozoic Eon (2500–541 Ma)** ● Emergence of multi-cellular life (trace fossils like worm trails). ● Life forms lacked shells; rocks lacked coal, oil, and gas. ● **Hematite (Fe_2O_3)** deposits formed. ● Stromatolites from **blue-green algae** were present. ● **Great Oxidation Event (GOE):** The oxygen produced by **cyanobacteria** reacted with dissolved iron in the oceans, causing it to rust and settle to the ocean floor. This created the world's most valuable **Banded Iron Formations (BIFs)**, which we mine for iron ore today. **(4) Phanerozoic Eon (541 Ma – Present)** ● Era of **"Visible life"**; most fossil records from this time. ● **Diverse life forms: plants, animals, fungi, algae.** ● Evolution of **skeletons, shells, and vertebrates.**
B) ERA	The **Phanerozoic Eon** has been divided into **Paleozoic: "Age of Fishes", Mesozoic: "Age of Dinausaurs "and Cenozoic era : "Age of Mammals".** **1) Paleozoic Era (541 – 252 Ma):** Divided into six periods: ● **Cambrian (541–485 Ma):** ○ First organisms with shells (e.g. trilobites). ○ Mud-burrowing scavengers are considered as the index species of this Period ○ **"Cambrian Explosion"** of multi-cellular invertebrates. ● **Ordovician (485–444 Ma):** ○ This period is known as the **"Years of Invertebrates"** ○ Abundant **invertebrates** like trilobites and brachiopods. ○ First appearance of fishes. ● **Silurian (444–419 Ma):** ○ First land plants. ● **Devonian (419–359 Ma):** ○ Dominance of fishes, early sharks, insects, seed plants. ○ Evolution of lungfish and amphibians. ○ By the end of the Devonian,growth of forest formation. ○ It is also called **"Age of Fishes"** due to high fish diversity. ● **Carboniferous (359–299 Ma):**

- **First reptiles appeared.**
- Large **coal deposits** formed from tropical swamps.
- Sometimes split into **Mississippian** and **Pennsylvanian periods.**

- **Permian (299–252 Ma):**
  - Known as **"Age of Amphibians".**
  - Ends with the **Great Paleozoic Extinction**: Towards the end of the Permian Period the dominance of trilobites and many more marine species started becoming extinct.
  - Theory of plate tectonics suggested that by the end of this **Permian Period**, all the continents were together as one super continent called **Pangaea** which subsequently started breaking and spreading into the present configuration.

2) Cenozoic Era (66 Ma – Present): Known as the "Age of Mammals"
This era consists of two distinct periods i.e. **Tertiary and Quaternary.** The Tertiary period again is divided into two periods of **Paleogene and Neogene."**

- **Paleogene Period (66–23 Ma):**
  - Post-dinosaur extinction recovery.
  - Rise of mammals and flowering plants.
  - Subdivided into **Paleocene, Eocene, Oligocene.**
  - Britain shifted from warm to cooler climate.
  - The Indian Plate collided with the **Eurasian Plate**, initiating the rise of the Himalayas.
- **Neogene Period (23–2.6 Ma):**
  - Includes Miocene and Pliocene epochs.
  - Further diversification of mammals and birds.
- **Quaternary Period (2.6 Ma – Present):**
  - Includes **Pleistocene** (Ice Age) and **Holocene** (Modern time).
  - Human evolution and spread.
  - Glaciation shaped much of Britain's landscape

The **Geological Time Scale** divides Earth's 4.6-billion-year history into eons, eras, periods, and epochs, marking key geological and biological events.It provides a framework to study Earth's evolution, extinctions, and future changes.