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PHYSICAL & WORLD GEOGRAPHY

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Unit I

GEOGRAPHY AS A DISCIPLINE

1 CHAPTER BASICS OF GEOGRAPHY

Fundamentals of Geography

Introduction

The word 'Geography' has been derived from the *Greek Geo (Earth) and Graphos (description)*. It was coined by the Greek scholar '*Eratosthenes*', also known as '*Father of Geography*'.

Geography is a science that deals with the description, distribution, and interaction of the diverse physical, biological, and cultural features of the Earth's surface.

Geography in Relation to Other Disciplines

Geographers do not study only the variations in the phenomena over the Earth's surface (space) but also study the associations with the other factors which cause these variations.

For example, cropping patterns differ from region to region but this variation in cropping pattern, as a phenomenon, is related to variations in soils, climates, demands in the market, capacity of the farmer to invest and technological inputs available to her/him.

Branches of Geography

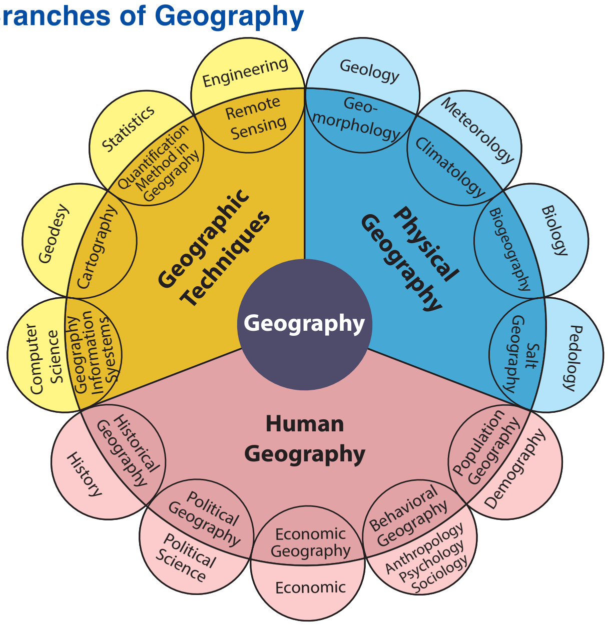


Fig. 1.1: Branches of Geography

- **Physical Geography**
  1. **Geomorphology** is the study of landforms, their evolution and related processes.
  2. **Climatology** is the study of structure of atmosphere and elements of weather and climates and climatic types and regions.
  3. **Hydrology** studies the realm of water over the surface of the Earth including oceans, lakes, rivers and other water bodies and its effect on different life forms including human life and their activities.
  4. **Soil Geography** aims to study the processes of soil formation, soil types, their fertility status, distribution and use.
- **Human Geography**
  1. **Social/Cultural Geography** is the study of society and its spatial dynamics as well as the cultural elements contributed by the society.
  2. **Population and Settlement Geography** studies population growth, distribution, density, sex ratio, migration and occupational structure etc. Settlement geography studies the characteristics of rural and urban settlements.
  3. **Economic Geography** studies economic activities of the people including agriculture, industry, tourism, trade, and transport, infrastructure and services, etc.
  4. **Historical Geography** studies the historical processes through which the space gets organised. Every region has undergone some historical experiences before attaining the present-day status. The geographical features also experience temporal changes and these forms the concerns of historical geography.
  5. **Political Geography** looks at the space from the angle of political events and studies boundaries, space relations between neighbouring political units, delimitation of constituencies, election scenario and develops theoretical framework to understand the political behaviour of the population.
- **Biogeography**

  The interaction between physical geography and human geography has led to the development of Biogeography which includes:
  1. **Plant Geography** studies the spatial pattern of natural vegetation in their habitats.
  2. **Zoo Geography** studies the spatial patterns and geographic characteristics of animals and their habitats.
  3. **Ecology/Ecosystem** deals with the scientific study of the habitats characteristic of species.
  4. **Environmental Geography** is concerned with environmental problems such as land gradation, pollution and concerns for conservation has resulted in the introduction of this new branch in geography.

The Latitudes and Longitudes

Earth is not spherical but "*oblate spheroid*" and objects of such shape (Earth like) are also termed as '*Geoid*'.

When we observe the cross section of the globe we can see that the cut around the equator is circular and the pole to pole cross section shows that it is elliptical in shape rather like a circle. Hence, we can say that the shape of the Earth is geoid.

The rotation of Earth on its rotational axis creates a bulge at the centre that is near equator, this rotation of Earth gives a geoid shape to Earth. Because of this rotation the polar regions are slightly flattened with a difference of around 0.3% compared to the equator. Thus we can say that our globe is oblate spheroid rather than a sphere.

Earth's rotation axis is an imaginary line that connects the points on Earth's surface from north pole to South pole. Perpendicular to the rotational axis of Earth we can find the plane of Equator.

Latitudes

All parallel circles from the equator up to the poles are called parallels of latitudes. Latitudes are measured in degrees.

The equator represents the zero degree latitude. Since the distance from the equator to either of the poles is one-fourth of a circle round the Earth, it will measure 1/4th of 360 degrees, i.e., 90°. Thus, 90 degrees north latitude marks the North Pole and 90 degrees south latitude marks the South Pole. As such, all parallels north of the equator are called 'north latitudes.' Similarly all parallels south of the equator are called 'south latitudes.'

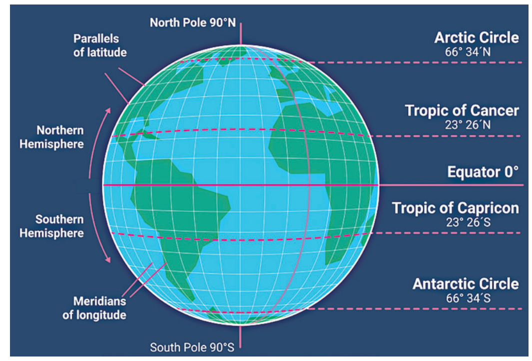


Fig. 1.2: Important Latitudes

Significant Latitudes	
0°	Equator
23.5° N	Tropic of cancer
23.5° S	Tropic of Capricorn
66.5° N	Arctic circle
66.5° S	Antarctic circle
Latitudinal Distribution	
Low latitudes	Between equator and 30° N/S
Mid latitudes	Between 30° and 60° N/S
High latitudes	Latitudes greater than 60° N/S
Equatorial	Within a few degrees of the equator
Tropical	Within the tropics 23.5° N to 23.5° S
Sub-tropical	Pole-ward of tropics 25-30° N/S
Polar	Within a few degrees of N/S pole

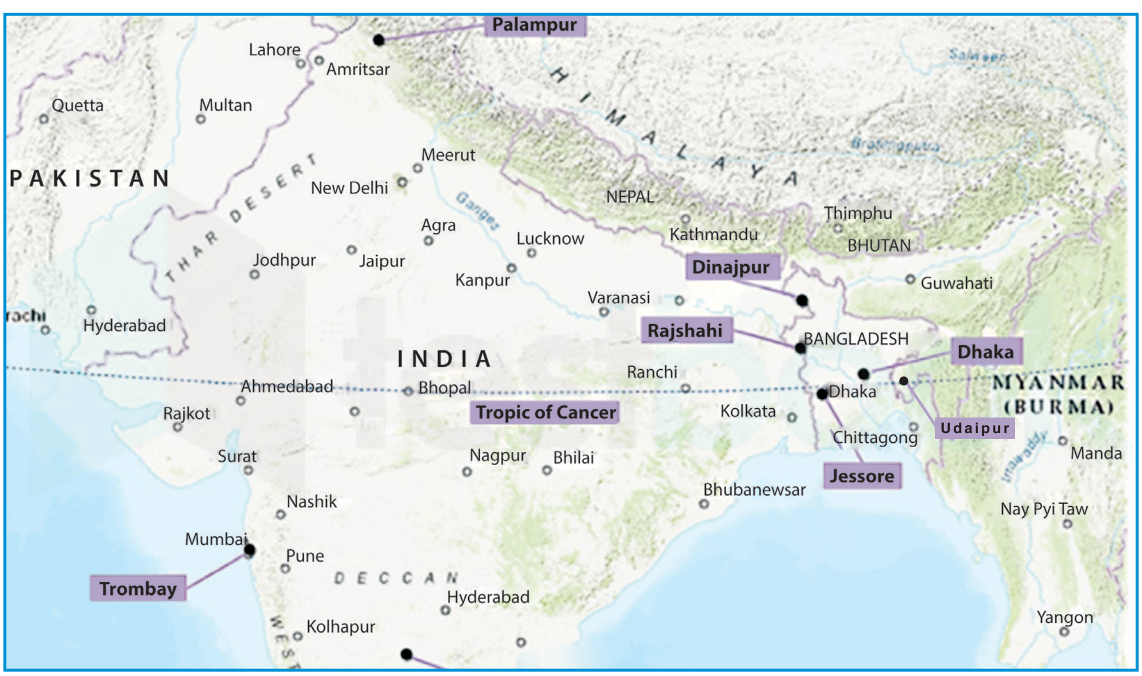


Fig. 1.3: Tropic of Cancer passes by few important Indian cities

Important cities on/near Tropic of Cancer in India: Ahmedabad, Jasdan in **Gujarat**; Kalinjarh, Banswara in **Rajasthan**; Ujjain, Bhopal, Jabalpur, Shahdol, Shajapur in **Madhya Pradesh**; Ambikapur, Sonhat in **Chhattisgarh**; Ranchi, Lohardaga in **Jharkhand**; Hooghly, Krishnanagar in **West Bengal**; Udaipur in **Tripura**; Champhai in **Mizoram**.

Countries Through Which Tropic of Cancer Passes	
Algeria	Niger
Libya	Egypt
Saudi Arabia	UAE (Abu Dhabi)
Oman	India
Bangladesh	Myanmar
China	Taiwan
Mexico	Bahamas
Western Sahara	Mauritania
Mali	

Countries Through Which Equator Passes	
Ecuador,	Colombia,
Brazil,	Sao Tome & Principe,
Gabon,	Republic of the Congo,
Uganda,	Kenya,
Somalia,	Maldives,
Indonesia	Kiribati.
Democratic Republic of the Congo,	
At least half of these countries rank among the poorest in the world.	

Important Water Bodies Through Which Tropic of Cancer Passes	
Red Sea,	Indian Ocean,
Taiwan Strait,	Pacific Ocean,
Philippine Sea,	Gulf of California,
Gulf of Mexico	Atlantic Ocean.

Countries Through Which Tropic of Capricorn Passes	
Argentina,	Australia,
Botswana,	Brazil,
Chile,	Madagascar,
Mozambique,	Namibia,
Paraguay.	

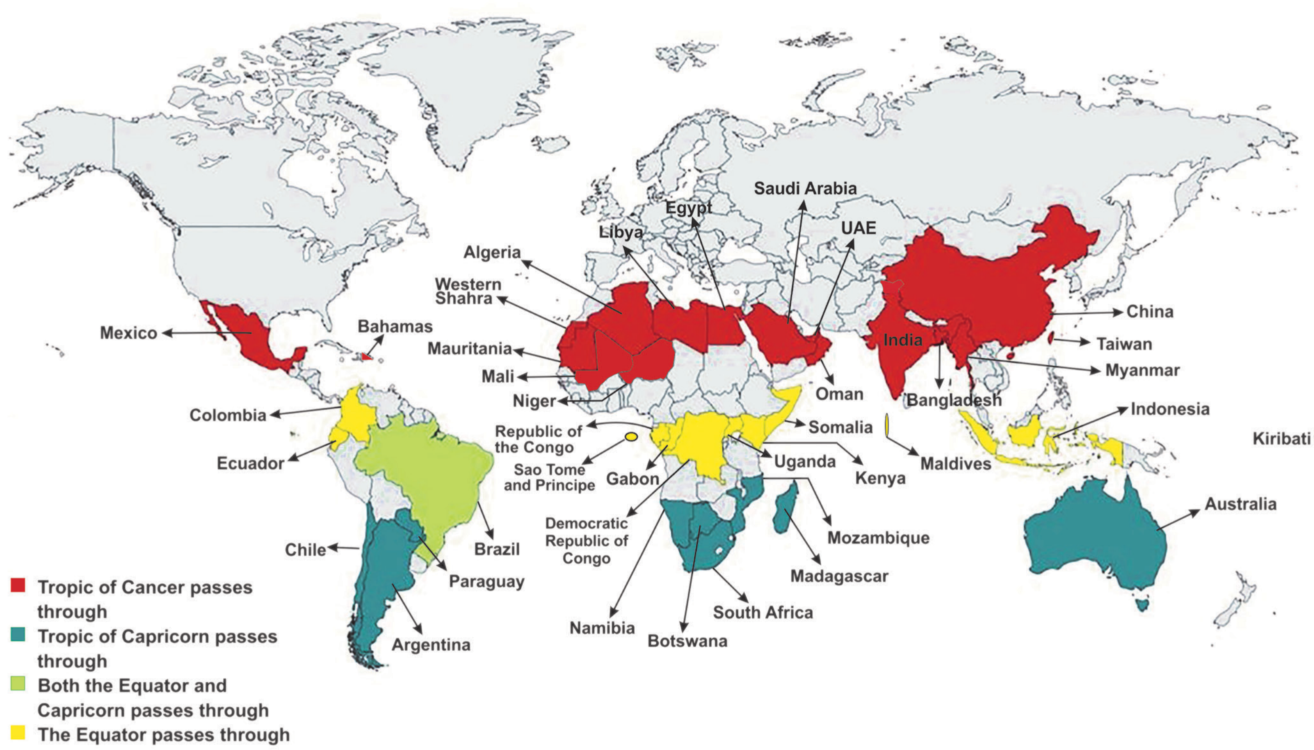


Fig. 1.4: Countries which pass through Equator, Tropics of Cancer and Capricorn

Longitudes

In order to locate a position precisely, we must find out how far east or west these places are from a given line of reference running from the North Pole to the South Pole. These lines of references are called the meridians of longitude, and the distances between them are measured in 'degrees of longitude.'

Each degree is further divided into minutes, and minutes into seconds. They are semi-circles and the distance between them decreases steadily pole wards until it becomes zero at the poles, where all the meridians meet.

Unlike parallels of latitude, all *meridians are of equal length*. The longitudes which passes trough Greenwich near London, where the British Royal Observatory is located is called the *Prime Meridian*.

Its value is 0° longitude and from it we count 180° eastward as well as 180° westward.

The Prime Meridian divides the Earth into two equal halves, the Eastern Hemisphere and the Western Hemisphere. Therefore, the longitude of a place is followed by the letter E for the east and W for the west.

It must be noted that *180° East and 180° West meridians are on the same line***.**

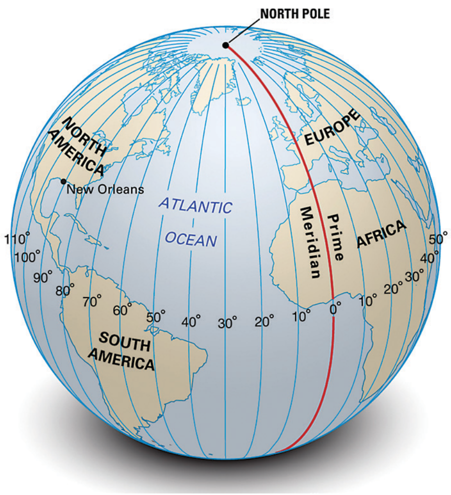


Fig. 1.5: Prime Meridian

Important cities of the world on/near prime meridian

The city which is closest to the prime meridian is London. The prime meridian runs through the Royal Observatory in the town of Greenwich, which is in southeast London. Other important cities which are located near the prime meridian are *Aberdeen, Paris, Algiers, Accra (Ghana)* etc.

Important Countries of the World on/near Prime Meridian

In the Northern Hemisphere, the Prime Meridian passes through the *UK, France and Spain in Europe and Algeria, Mali, Burkina Faso, Tongo and Ghana in Africa***.**

The only landmass crossed by the Meridian in the Southern Hemisphere is Antarctica.

Fig. 1.6: Important Countries of the World on/near Prime Meridian

Time Zones

- Time Zones are a geographical division of 15° each, starting at Greenwich, in England. It has been created to know local time of a place with respect to *Greenwich Mean Time (GMT)***.**
- In order to make local time suitable and convenient different types of time such as the *Daylight Savings Time* and place specific time such as *Chai Bagan Time* has been developed.
- There are spatial variations in time zones across the world. Time Zones are usually defined by the country's government or some astronomical institute.
- **Council of Scientific & Industrial Research (CSIR) -National Physical Laboratory (CSIR-NPL)** is the custodian of Indian Standard Time (IST) and has the responsibility for realization, establishment, maintenance and dissemination of IST through an Act of Parliament.

Greenwich Mean Time

- Greenwich Mean Time is the yearly average (or 'mean') of the time each day when the Sun crosses the Prime Meridian at the Royal Observatory, Greenwich.

Indian Standard Time

- Indian Standard Time calculates on the basis of 82.5° E longitude, just west of the town of Mirzapur, near Prayagraj (Allahabad) in the state of Uttar Pradesh.
- The longitude difference between Mirzapur and the United Kingdom's Royal Observatory at Greenwich translates to an exact time difference of 5 hours 30 minutes.

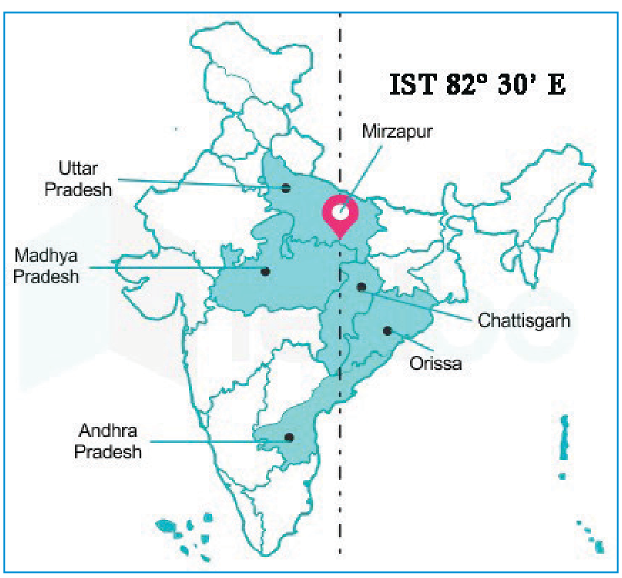


Fig. 1.7: Indian Standard Meridian

Cities and States Through Which 82.5° Longitude Passes

- Mirzapur and the Rampur, Korba and the Handi are major cities through which Indian Standard Meridian passes.
- It also passes through five states of Indian such as Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Odisha and Andhra Pradesh.

International Date Line

- The International Date Line, established in 1884, passes through the mid-Pacific Ocean and roughly follows a 180 degrees longitude north-south line on the Earth.
- It is located halfway round the world from the prime meridian—the zero degrees longitude established in Greenwich, England, in 1852.
- The International Date Line functions as a "line of demarcation" separating two consecutive calendar dates.

  For Example: When you cross the dateline, you become a time traveler of sorts! Cross to the west and it's one day later; cross back and you've "gone back in time."
- When you cross the International Date Line from west to east, you subtract a day, and if you cross the line from east to west, you add a day.
- The dateline is not defined by international law. Countries are free to choose the date and time zone that they want to observe.

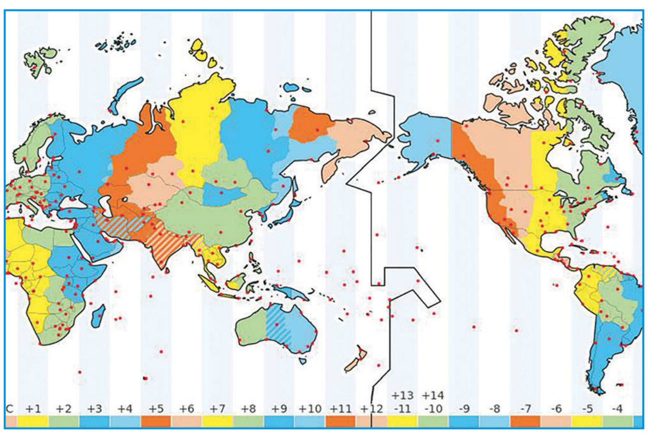


Fig. 1.8: The International Date Line (Different colours are indicating different time zones respectively)

While the date line generally runs north to south from pole to pole, it zigzags around political borders such as eastern Russia and Alaska's Aleutian Islands. It is done to ensure that it is the same date within a country.

Daylight Saving Time

- Daylight Saving Time is used to make the best use of daylight hours by shifting the clock forward in the Spring and backward in the Fall (autumn).
- It has been used throughout much of the United States, Canada and Europe since World War I.
- Regions that use Daylight Saving Time (DST) change the time zone name and time during the DST period.
- The words "daylight" or "summer" are then usually included in the time zone name. The areas that don't use DST remain on standard time zone all year.
- Proponents of DST generally argue that it saves energy, promotes outdoor leisure activity in the evening (in summer), and is therefore good for physical and psychological health, reduces traffic accidents, reduces crime and it promotes economic growth.

Chai Bagan Time

- A separate Chai Bagan Time zone is ahead of the Indian Standard Time by an hour and it was present in the British colonial era as well.
- Chai Bagan Time is essentially called ***daylight saving*** and north-eastern states have been demanding to allow them to advance their clocks by some time (0.5-1 hour approx) to save more daylight hours.
- This time zone was ***abolished in 1906*** however, it was adopted during the Indo-China war of 1962 and the Indo-Pak war of 1965 and 1971
- For those living in north-eastern states, a change in time would mean a delayed sunset. This will allow the citizens to make use of added daylight hours.

Leap Second

Every now and then a leap second is added to Coordinated Universal Time (UTC) in order to synchronize clocks worldwide with the Earth's ever slowing rotation.

Two components are used to determine UTC (Coordinated Universal Time):

- **International Atomic Time:** A time scale that combines the output of some 200 highly precise atomic clocks worldwide, and provides the exact speed for our clocks to tick.
- **Universal Time:** It is also known as Astronomical Time, refers to the Earth's rotation around its own axis, which determines the length of a day.

When the difference between International atomic time and Universal time approaches 0.9 seconds, a leap second is added to UTC and to clocks worldwide.

By adding an additional second to the time count, our clocks are effectively stopped for that second to give Earth the opportunity to catch up.

■■■■

Unit II

Geomorphology

CHAPTER 2

ORIGIN AND EVOLUTION OF UNIVERSE

Introduction

The Earth along with seven other planet form a system known as the Solar System. All the planets of the Solar System revolve around the Sun which is the central star.

Sun along with other planets including Earth is part of a Galaxy called as the Milky Way. There are various theories which have been propounded in order to explain the formation of universe and other celestial bodies within it some of these theory are as follows:

Earlier Theories

Nebular Hypothesis

It is one of the earliest hypotheses originally propounded by German philosopher **Immanuel Kant** and further revised by Laplace in 1796.

This hypothesis considered that the planets were formed out of a cloud of material associated with a youthful Sun, which was slowly rotating.

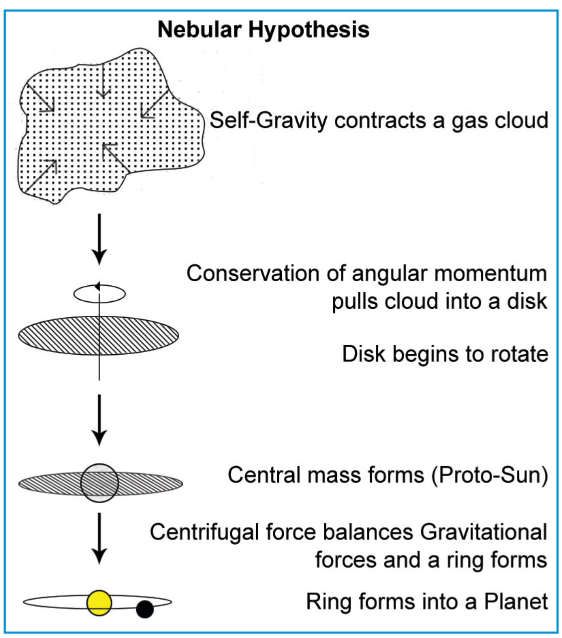


Fig. 2.1: Nebular Hypothesis

Binary Star Hypothesis

- Binary Star Hypothesis was propounded by **H.N. Russell** in the year 1937. Russell opined that there were two stars near the primitive Sun in the universe. In the beginning the 'companion star' was revolving around the primitive Sun.
- When the giant approaching star came nearest to the companion star, large amount of matter was ejected from the companion star due to maximum gravitational force exerted by the giant approaching star.
- The ejected matter started revolving in the direction of the giant approaching star and thus opposite to the direction of revolution of companion star. Later on planets were formed from the ejected matter.

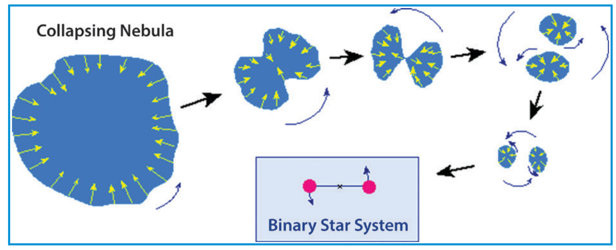


Fig. 2.2: Binary Star Hypothesis

Supernova Hypothesis

- This hypothesis was propounded by **F. Hoyle**, a mathematician at Cambridge University. According to Hoyle, initially there were two stars in the universe viz.
  - The primitive Sun and
  - The companion star
- The companion star was of giant size and later on became supernova due to nuclear reaction.
- The violent explosion of the companion star (now supernova) resulted into the spread of enormous mass of dust which started revolving around the primitive Sun. Hoyle maintained that when the companion star was violently exploded, the recoil of the gigantic stellar explosion threw the nucleus of the companion star out of the gravitational field of the primitive Sun.
- The gaseous matter coming out due to violent explosion of the companion supernova star changed into a circular moving disc which started revolving around the primitive Sun. Thus, the matter of this disc became building material for the formation of future planets.

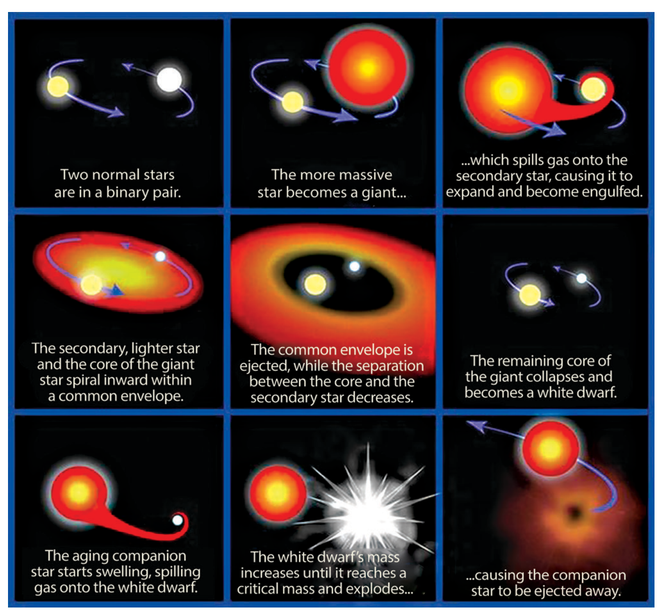


Fig. 2.3: Supernova Hypothesis

Modern Theories

Steady State Hypothesis

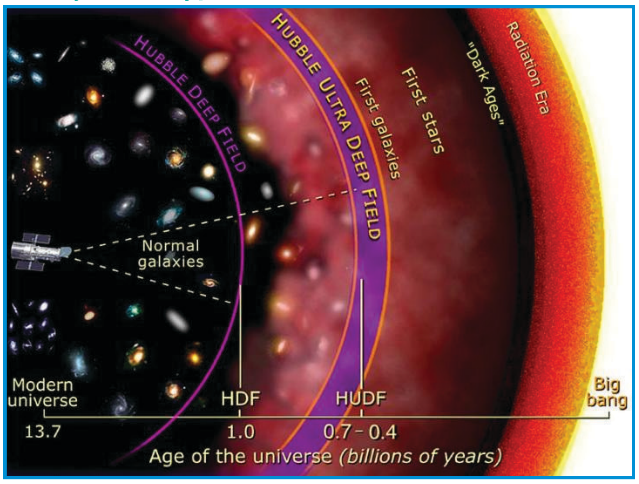


Fig. 2.4: Illustrations of Steady State Model

- The Steady-State model states that the *density of matter in the expanding universe remains unchanged* over time because of the continuous creation of matter. In other words, the observable Universe essentially remains the same regardless of time or place.
- This theory is in contrast to the theory that the majority of matter was created in a single event (the Big Bang) and has been expanding ever since.
- Although the concept of steady state emerged a long period ago but from the early modern period, the scientists began to embrace it by defining it in a astrophysical way.
- The theory was first put forward in 1948 by British scientists Sir Hermann Bondi, Thomas Gold, and Sir Fred Hoyle.

Criticism of the Steady State Model

Observations since the 1950s such as those of the cosmic microwave background, which was predicted by the big-bang model have produced much evidence contradictory to the steady-state picture which have led scientists to overwhelmingly support the big-bang model.

Big Bang Theory

The most popular argument regarding the origin of the universe is the Big Bang Theory. It is also called expanding universe hypothesis.

Edwin Hubble, in 1920, provided evidence that the universe is expanding. As time passes, galaxies move further and further apart.

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

1. In the beginning, all matter forming the universe existed in one place in the form of a **tiny ball** with an unimaginably small volume, infinite temperature and infinite density.
2. 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. As it grew, some energy was converted into matter.
3. Within 300,000 years from the Big Bang, temperature dropped to 4,500 K (Kelvin) and gave rise to atomic matter. The Universe became transparent.

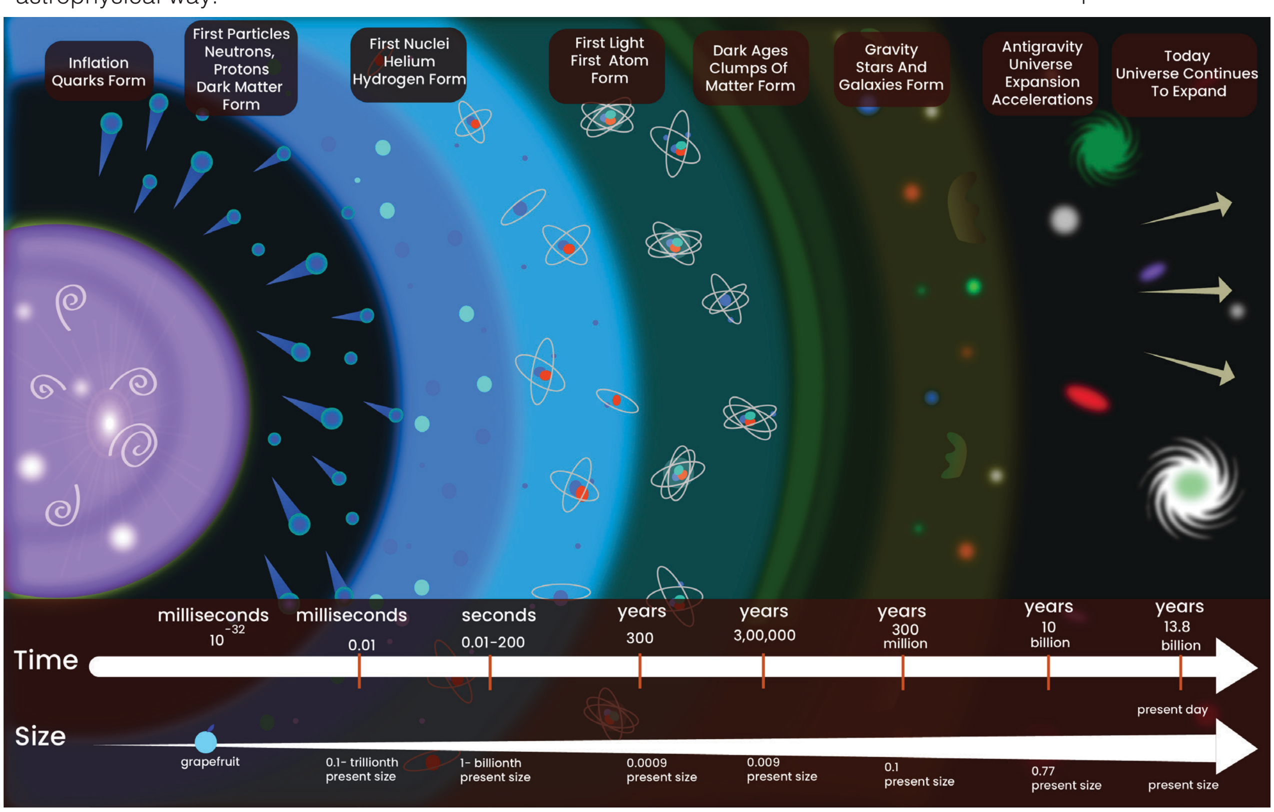


Fig. 2.5: The Big Bang Hypothesis

The expansion of universe means increase in space between the galaxies.

Formation of Planets

The following are considered to be the stages in the development of planets:

1. The stars are localized lumps of gas within a nebula. The gravitational force within the lumps leads to the formation of a core to the gas cloud and a huge rotating disc of gas and dust develops around the gas core.
2. In the next stage, the gas cloud starts getting condensed and the matter around the core develops into small rounded objects.

   These small-rounded objects by the process of cohesion develop into what is called **planetesimals**.

   Larger bodies start forming by collision, and gravitational attraction causes the material to stick together. Planetesimals are a large number of smaller bodies.
3. In the final stage, these large number of small planetesimals accrete to form a fewer large bodies in the form of planets.

- Terrestrial, Jovian and Ice Giants were formed through the following processes:
  1. **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
  2. **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 planet.
  3. The terrestrial planets are smaller and their lower gravity could not hold the escaping gases.
  4. **The Jovian planets** have a ring system around them and have large number of moons.

Our Solar System

A Solar System consists of a star (Sun) and all of the objects that travel around it—planets, moons, asteroids, comets and meteoroids. The gravitational attraction between the Sun and these objects keeps them revolving around it. Most stars host their own planets, so there are likely tens of billions of other solar systems in the Milky Way Galaxy alone.

The Solar System extends much farther than the eight planets that orbit the Sun. The Solar System also includes the Kuiper Belt that lies past Neptune's orbit.

This is a sparsely occupied ring of icy bodies, almost all smaller than the most popular Kuiper Belt Object, dwarf planet Pluto.

Goldilocks Zone

- The Goldilocks zones are those habitable zones or the area around a star where it is not too hot and not too cold for liquid water to exist on the surface of surrounding planets.
- Rocky exo-planets found in the habitable zones of their stars, are more likely targets for detecting liquid water on their surfaces.

The heliosphere is the bubble created by the solar wind—a stream of electrically charged gas blowing outward from the Sun in all directions. The boundary where the solar wind is abruptly slowed by pressure from interstellar gases is called the termination shock. This edge occurs between 80-100 astronomical units.

Structure of the Solar System

The order and arrangement of the planets and other bodies in our Solar System is due to the way the Solar System formed. Nearest the Sun, only rocky material could withstand the heat when the Solar System was young. For this reason, the first four planets—Mercury, Venus, Earth and Mars—are terrestrial planets. They're small with solid, rocky surfaces.

Meanwhile, materials we are used to seeing as ice, liquid or gas settled in the outer regions of the young Solar System. Gravity pulled these materials together, and that is where we find gas giants Jupiter and Saturn and ice giants Uranus and Neptune.

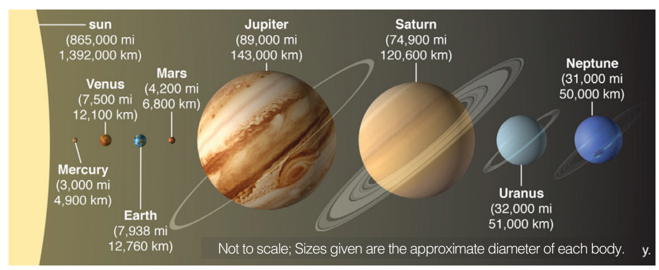


Fig. 2.6: The Solar System

Sun

The Sun is the largest object in the solar system, with a diameter of 1.39 million kilometres and an approximate age of 4.5 billion years. It is a huge burning ball of gases that contain approximately 73.4% Hydrogen and 25% Helium. The Hydrogen fuel of the Sun can sustain for more than 5 billion years. After that, it will expend to form a red giant and will engulf the Earth.

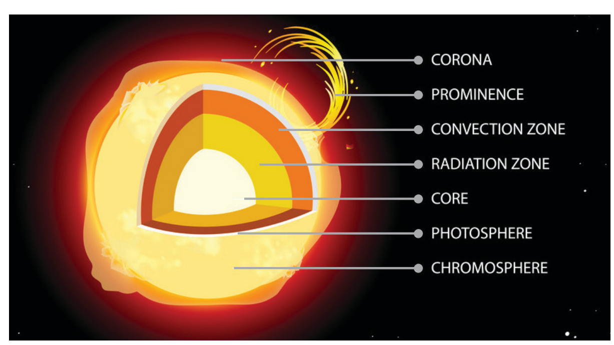


Fig. 2.7: Structure of the Sun

Core

This is the region where Hydrogen turns into Helium through the nuclear fusion reaction. With temperatures believed to be reaching more than 15 million degrees Celsius, the core is considered to be the hottest region of the Sun. The density is about 150 g/cm^3 at the centre of the core.

Radiative Zone

Between the core and the convection zone, there lies the radiative zone; by means of radiative diffusion and thermal conduction, the energy in this layer transports outside, which travels in the form of electromagnetic radiation by photons. At the edge of the radiative zone, the density of this layer is about 0.2 g/cm^3.

Convection Zone

The outermost layer of the Sun's interior is known as the convection zone. This zone uses convection mode to transfer energy. The temperature at its base is about 2 million degrees Celsius.

Photosphere

All the visible light from the Sun comes from this layer. With temperature coming down to approximately 5500 degrees Celsius, it is said to be the coolest part of the Sun because with an increase in height, the temperature drops. The phenomenon of Sunspots happens in the Photosphere.

Chromosphere

The Chromosphere is visible as a dim red ring, and it lies just above the Photosphere. Only during the Solar Eclipses, when the Photosphere is hidden, visible light from the Chromosphere can be seen.

Corona

The Corona layer is the outermost layer of the Sun's atmosphere, and it lies above the Chromosphere. During a total Solar Eclipse, it can be seen as a white glowing Corona. Coronal mass ejection, Solar winds, and Solar flares are the phenomenon related to Corona.

Sunspots

The dark spots on the surface of the Sun are known as Sunspots; this happens because the region becomes darker and cooler than the surroundings due to intense magnetic fields on the surface.

The lifetime of Sunspots is generally less; it fluctuates from a few days to a few months.

The absence of Sunspots might affect the Earth's climate because it is supposed that the Sun becomes 1% cooler in the absence of Sunspots.

Umbra is named as the centre of a sunspot, and penumbra is known as the lighter region of the surrounding.

Mercury

- Mercury is the closest planet to the Sun in the Solar System. It takes only 88 days to complete its revolution around the Sun.
- Although it is closest planet to the Sun but has low albedo because it is mainly composed of dark porous rock surface. The planetary albedo of Mercury is 6 percent.
- It is the densest planet of the Solar System after Earth with a huge metallic core having a radius of about 2000 km (1240 miles). It does not have any natural satellite.
- Mercury's surface resembles that of Earth's Moon, scarred by many impact craters resulting from collisions with meteoroids and comets.

Venus

- Venus is second planet from the Sun and our closest planetary neighbor.
- Venus has the highest albedo among all planets of our Solar System having an albedo of 75 percent. It does not have any natural satellite.
- Venus makes a complete orbit around the Sun (a year in Venusian time) in 225 Earth days or slightly less than two Venusian day-night cycles.
- Its orbit around the Sun is the most circular of any planet — nearly a perfect circle. Other planet's orbits are more elliptical, or oval-shaped. Venus has no moons and rings.
- The atmosphere of Venus has primarily carbon dioxide, followed by nitrogen. Making it hotter and unsuitable for existence of human life.

Why does Venus have Highest Albedo?

- The surface of Venus is completely obscured by the dense atmospheric cloud that blankets the planet.
- The atmospheric clouds primarily consist of sulfuric acid, which reflect the vast majority of sunlight that is incident upon them.
- This makes Venus the planet with the highest albedo in the Solar System.

Prograde and Retrograde Motion

- **Prograde motion** is when a planet moves west-to-east relative to the stars, so from night to night it falls behind the stars around it. This motion is also called anti-clockwise motion. For Example: The Sun and Moon always move prograde. All the planets except Venus and Uranus do Prograde motion.
- **Retrograde motion** is when a planet moves east-to-west relative to the stars. This motion is also called clockwise motion. For Example: Venus and Uranus are two planets which do this type of motion.

Earth

- Earth is densest planet of our Solar System which has the density of 5.5 g/cc.
- It also has highest inclination among all planets with 23.5° inclination on its axis.
- The shape of the Earth is also called "oblate spheroid " and objects of such shape (Earth like) are also termed as 'Geoid'.
- Earth is the third planet from the Sun and the fifth largest in the Solar System.
- Just slightly larger than nearby Venus, Earth is the biggest of the terrestrial planets.
- Our home planet is the only planet in our Solar System known to harbor living things. It is also the densest of all planets in our Solar System.
- It takes about eight minutes for light from the Sun to reach our planet.

- As Earth orbits the Sun, it completes one rotation every 23.9 hours. It takes 365.25 days to complete one trip around the Sun.
- To keep our yearly calendars consistent with our orbit around the Sun, every four years we add one day. That day is called a **leap day**, and the year it's added to is called a **leap year**.
- Earth is the only planet that has a single Moon.

Density of the Planets (Decreasing Order)	
Earth	5.5 g/cc
Mercury	5.4 g/cc
Venus	5.2 g/cc
Mars	3.9 g/cc
Neptune	1.6 g/cc
Uranus	1.3 g/cc
Jupiter	1.3 g/cc
Saturn	0.7 g/cc

Astronomical Unit

On the planetary scale, one astronomical unit (abbreviated as AU), is taken as the average distance from the Sun to the Earth, which is approx 150.26 million km.

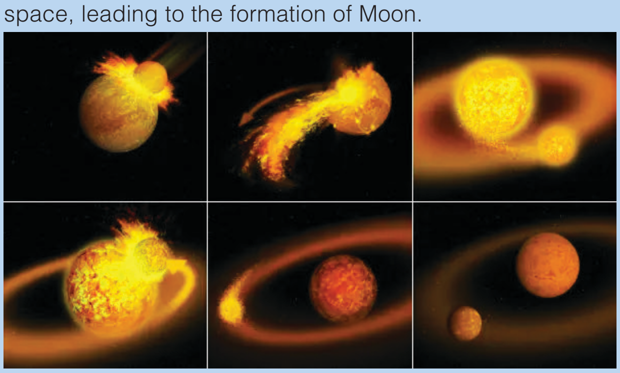
Formation of the Moon: The Big Splat Event

This hypothesis is also termed as '*The giant-impact hypothesis*'. According to this theory an object larger than Mars slammed into proto-Earth during the final stages of its accumulation, giving birth to the Moon.

This event occurred more than 3 billion years ago. The hypothetical planet which collided with Earth has been named as '**Thea**'.

During the event both planets i.e. 'Thea' and primordial Earth merged to form the present day Earth.

In the mean time during the collision event the raw fragments of material for the formation of the Moon were flung into space, leading to the formation of Moon.



Mars

- It is seventh largest planet of our Solar System. Mars is a rocky body about half the size of Earth.
- Mars has two small moons, *Phobos* and *Deimos*, that may be captured asteroids. Like Earth, Mars experiences seasons due to the tilt of its rotational axis.
- Mars' orbit is about 1.5 times farther from the Sun than Earth's and is slightly elliptical, so its distance from the Sun changes.
- That affects the length of Martian seasons, which vary in length. The polar ice caps on Mars grow and recede with the seasons. Also diameter of Mars is smaller than the Earth.

Jupiter

- Jupiter is the fifth planet from our Sun and the *largest planet in the Solar System*. It's stripes and swirls are cold, windy clouds of ammonia and water.
- The atmosphere is mostly hydrogen and helium, and its iconic Great Red Spot is a giant storm bigger than Earth that has raged for hundreds of years.
- Previously Jupiter had the largest number of moons in the Solar System. But according to new discoveries now Saturn has the largest number of moons.

Number of Moons (Decreasing Order)	
Planet	**Number of Moons**
Saturn	145
Jupiter	92
Uranus	27
Neptune	14
Mars	02
Earth	01
Venus	00
Mercury	00

Saturn

- The *second largest planet* in our Solar System. It has thousands of ringlets.
- Like fellow gas giant Jupiter, Saturn is a massive ball of mostly hydrogen and helium.
- It is the least dense among all the planets. Its density is less than that of water.
- From the jets of Enceladus to the methane lakes on smoggy Titan, the Saturn system is a rich source of scientific discovery and still holds many mysteries.

Uranus

- The seventh planet from the Sun with the third largest diameter in our Solar System, Uranus is very cold and windy.
- The ice giant is surrounded by 13 faint rings and 27 small moons as it rotates at a nearly 90°degree angle from the plane of its orbit.
- This unique tilt makes Uranus appear to spin on its side, orbiting the Sun like a rolling ball. Uranus is 4 times wider than Earth.

Neptune

- The ice giant Neptune was the first planet located through mathematical predictions rather than through regular observations of the sky.
- Neptune orbits the Sun once every 165 years. It is invisible to the naked eye because of its extreme distance from Earth.

Why Did Pluto Lose its Status as a Planet?

The International Astronomical Union (IAU) downgraded the status of Pluto to that of a dwarf planet.

Following are different criterias which have been set by the International Astronomical Union (IAU) to define a full-sized planet.

- It is in orbit around the Sun
- It has sufficient mass to assume hydrostatic equilibrium (a nearly round shape).
- It has "cleared the neighborhood" around its orbit.

'Clearing its neighboring region of other objects' means that the planet has become gravitationally dominant.

It means that there are no other bodies of comparable size other than its own satellites or under its gravitational field to its vicinity in the space.

Pluto has not satisfied the third criteria set by IAU because it shares its orbital neighborhood with Kuiper belt objects such as the plutinos.

Classification of Planets on the Basis of Their Composition

Our solar system consists of eight planets. These planets can be classified into three categories on the basis of their composition.

- **Terrestrial Planets (Earth like planets):** Those planets like Mercury, Venus, Earth and Mars that have a core of metal surrounded by rock. These are also called inner planets and they lie between the Sun and the belt of Asteroids.
- **Jovian Planets (Jupiter like planets):** These are those planets that consist predominantly of hydrogen and helium. These planets are also called Gas Giants. Plants like Jupiter and Saturn are categorized under this category.
- **Ice Giants:** Those planets that consist largely of water ice, methane (CH_4) ice, and ammonia (NH_3) ice, and have rocky cores are called Ice Giants. Planets such as Uranus and Neptune are grouped in this category.

Note: Often, the ice giant planets Uranus and Neptune are grouped with Jupiter and Saturn as gas giants; however, Uranus and Neptune are very different from Jupiter and Saturn.

Asteroids: These are small, rocky objects that orbit the Sun. There are lots of asteroids in our solar system. Most of them are located in the main asteroid belt – a region between the orbits of Mars and Jupiter. Some times Asteroids are called minor planets.

Comet: It is a small body orbiting the Sun with a substantial fraction of its composition made up of volatile ices. A comet appears generally as a bright head with a long tail. For Example: Halley's Comet or Comet Halley is a short-period comet visible from Earth every 75–76 years.

Meteors and Meteorites: A meteor is usually a small object that occasionally enters the Earth's atmosphere. However, due to friction of atmosphere it heats up and evaporates quickly. That is why it lasts for short time as a bright steaks of light. It is commonly known as shooting stars, although they are not stars.

Some meteors are large and so they can reach the Earth before they evaporate completely. The body that reaches the Earth is called a meteorite.

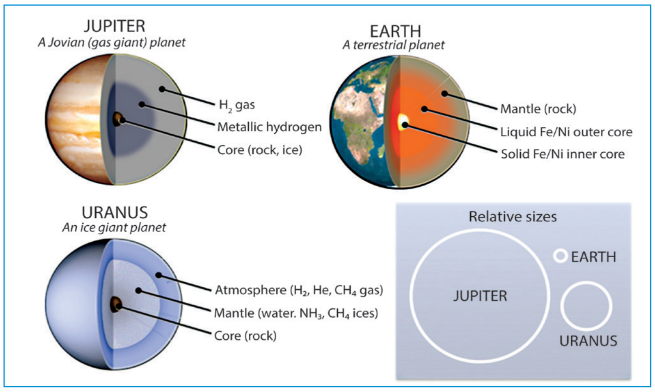


Fig. 2.8: Classification of Planets on the basis of their Composition

Rotation and Revolution

As a planet of the Sun, the Earth revolves around the Sun. Besides this, it also rotates on its own axis. Thus the Earth has two motions: the rotation and the revolution.

Rotation

- The Earth rotates on its axis from west to east. The axis is an imaginary line passing through the northern and the southern poles.
- Earth's rotation is completed in about 24 hours—this is called the daily motion of the Earth.
- This motion is responsible for the occurrence of day and night. One rotation is completed when a given heavenly body crosses the observer's meridian two times in succession.
- Solar Days and Sidereal Days: The solar day is a time period of 24 hours, and the duration of a sidereal day is 23 hours 56 minutes. A sidereal day is the actual time taken by the planet for a rotation of exactly 360 degrees on its axis.
- This difference of four minutes between a solar day and a sidereal day is due to the fact that the position of the Earth keeps changing with reference to the Sun due to the revolution around it; while with reference to a star at infinity, it will remain unchanged.
- As a result of the apparent motion of the Sun, the appearance of the night sky as seen from the Earth changes from day to day. The stars rise every day, four minutes earlier than the preceding day.

Revolution

- The movement of the Earth around the Sun in its orbit is called revolution. This movement of the Earth is also from west to east. The period of revolution is one year (365.256 days).
- The orbit of the Earth around the Sun is elliptical and not circular. Due to this, the distance between the Earth and the Sun keeps changing.
- When this distance is minimum, the Earth is said to be in *perihelion* (around January 3).
- When the distance is the maximum, it is said to be in *aphelion* (around July 4). The average of the maximum and minimum distances is called the mean distance and this distance of the Sun from the Earth is 150 million kilometers.

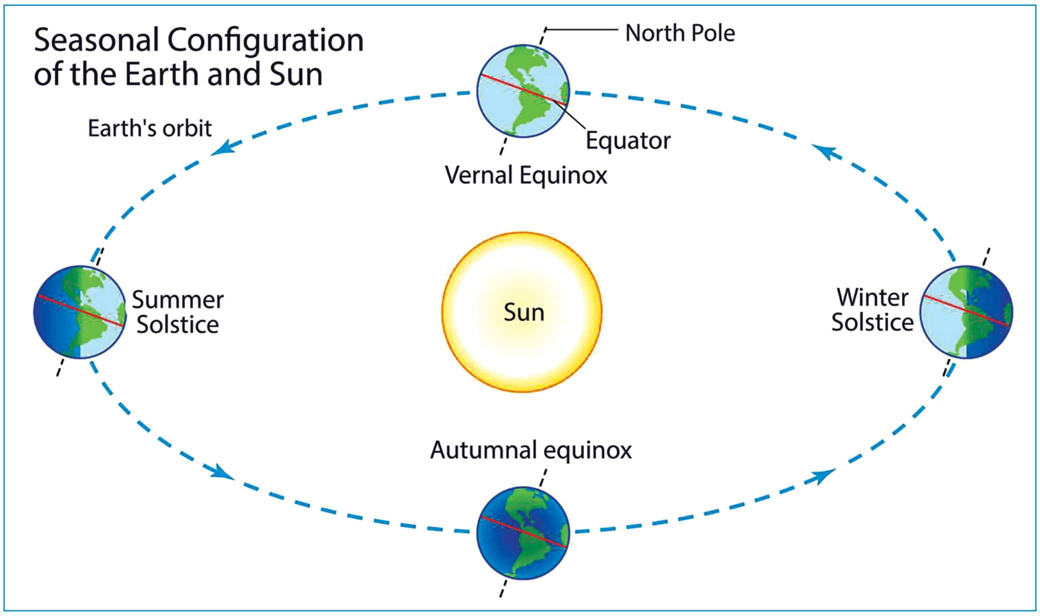


Fig. 2.9: Equinoxes and Solstice

- The apparent annual track of the Sun through the fixed stars in the celestial sphere is called the *ecliptic*, and an imaginary plane passing through this plane and extending outward through all points is called the *plane of ecliptic.* This plane is imagined to be horizontal.
- The axis of the Earth (rotational or polar axis) makes an angle of *66.5° to the plane of ecliptic.*
- **The Earth has four critical positions with reference to the Sun. These are:**
- **Equinoxes:** When the Sun's rays are vertical at the equator and the entire world experiences equal day and night.
  - **Spring Equinox:** On 21st March,
  - **Autumnal Equinox:** On 23rd September.
- **Summer Solstice:** On 21st of June the Sun's rays are vertical over the Tropic of Cancer as the north pole of the Earth is inclined at its maximum towards the Sun.

  At this time, the north pole experiences a long continuous day and the south pole a long continuous night (ergo, what we know as summer solstice).

  The northern hemisphere has the summer season at this time and the southern hemisphere experiences winter now. Also the days are longer than the nights in the northern hemisphere at this time.
- **Winter Solstice:** On December 22, the position of the Earth with respect to the Sun is such that the south pole is inclined at its maximum towards the Sun and the Tropic of Cancer receives the vertical rays of the Sun.

  This position is called the winter solstice when the Sun shines continuously in the south polar region and it is a long continuous night at the north pole.

  This is the winter season in the northern hemisphere and the summer in the southern hemisphere. During the winter solstice, the days are longer than the nights in the southern hemisphere.

  Thus, the variation in the duration of day and night and the change of seasons are due to the Earth's revolution and the inclination of the axis of the Earth.

  Also the seasons are reversed from the northern to the southern hemisphere.
- **Seasonality:**

  The axis of rotation of the Earth is not perpendicular to the plane of its orbit. The tilt is responsible for the changes of seasons on the Earth.

  The plane of the equator is called the *equatorial plane*. The plane in which the Earth revolves round the Sun is called the **orbital plane of the Earth**. *These two planes are inclined to each other at an angle of 23.5°.* This means that the axis of the Earth is inclined to its orbital plane at an angle of 66.5°.

  It is summer in June in the Northern Hemisphere because the Sun's rays hit that part of Earth more directly than at any other time of the year. It is winter in December in the Northern Hemisphere, because that is when it is the South Pole's turn to be tilted toward the Sun.

■■■■

TRY SOME MAINS PREVIOUS YEAR QUESTION

1. How does the Juno Mission of NASA help to understand the origin and evolution of the Earth? (Write in 150 words) **(2017)**