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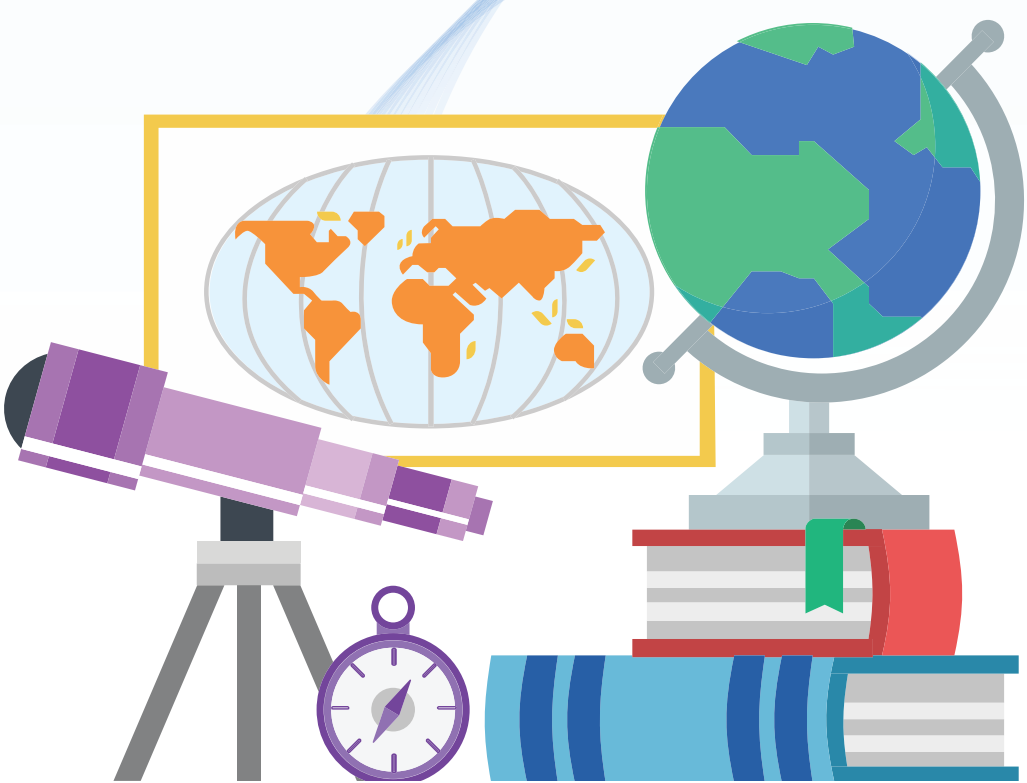
PHYSICAL GEOGRAPHY



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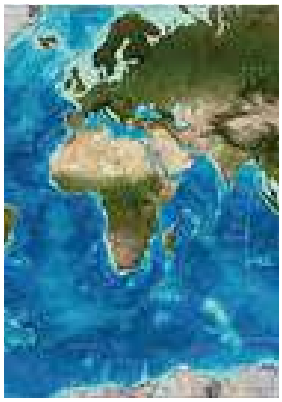

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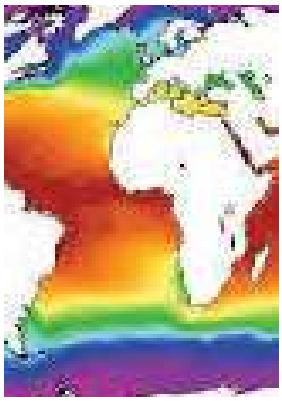

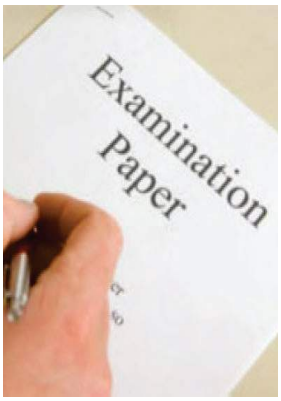

CHAPTER - 1

THE EARTH AND THE UNIVERSE

Introduction

- In our solar system, the Earth is the third planet from the Sun. It is the only planet known, as of yet, to harbour life.
- According to radiometric dating (also called radioactive dating is a method to determine the age of rocks or carbon) and various other sources of evidence, Earth was formed nearly before 4.5 billion years ago.
- Earth's gravity constantly interacts with other objects in space, particularly the Sun and the Moon. The Moon is the only natural satellite of the Earth.
- Earth revolves around the Sun in 365.26 days, this period is known as an Earth year. During this time, Earth rotates about its own axis about 366.26 times.
- When we look up from the Earth, we see the sky studded with innumerous stars. These stars as we see are not scattered uniformly across space. They occur in clusters which are better known as galaxies or nebulae.
- Each galaxy may contain up to 100 Million stars.
- Earth belongs to the Galaxy called the Milky Way, of which the Solar System is just a part.
- There are some major theories about the origin of the Universe and ultimately, the solar system. The most famous among them is the **Big Bang Theory**.
- In this theory, Georges Lemaitre suggested that the universe evolved from a small singularity and then expanded for over 13.8 billion years. It is still believed to be expanding continuously. It led to the formation of billions of galaxies, solar systems, stars etc.
- Our solar system lies in a spiral shaped galaxy called the Milky Way. The nearest galaxy to this is called Andromeda.
- Generally, there is a black hole in the centre of most of the galaxies. The black hole of Milky Way is called Sagittarius A.

The Solar System

- The solar system comprises of the Sun, eight planets (developed from condensation of gases and other lesser bodies) and their satellites, asteroids, comets, meteors and other dwarf planets.
- The Sun is at the centre of the solar system and the planets revolve around the Sun in elliptical orbits. The planets shine only due to the light from Sun reflected from their surface.
- These eight planets have been classified into Solid Planets or Inner Planets and Gaseous Planets or Outer Planets.
- **Solid Planet or Inner Planets:** Mercury, Venus, Earth and Mars are called Solid Planets. They are composed of mainly Silicates and metals. They are also called as the terrestrial (Earth like) planets.
- Important characteristics of these planets are:

» They have dense and rocky compositions.

» They are fair smaller in size, especially when compared with the Outer Planets.

» They possess no or small number of Moons.

» They have no ring systems.

» They take a relatively short length of time to complete an orbit around the Sun.

- **Gaseous Planets or Outer Planets**: Jupiter, Saturn, Uranus and Neptune are gaseous Planets. They are also called as the Jovian (Jupiter like) planets.
- Important characteristics of these planets are:

» They all are huge in comparison to the Inner Planets, so they are sometimes known as the Gas Giants.

» They are mostly made up of gases so they do not have solid surfaces.

» All four of them have rings spinning around them, with Saturn's ring being the most famous and noticeable one.

» These four planets also have large numbers of Moons (Natural satellites) orbiting around them.

» They take a very long time to complete an orbit around the Sun.

- **Why inner planets are rocky while the outer planets mostly in gaseous form?**

» Temperature of early solar system explains why the inner planets are rocky and the outer ones are gaseous.

» In the inner solar system, temperatures were pretty much as high as 2000 Kelvin, while in the outer solar system it was just about as cool as 50 K.

» In the case of inner solar system, substances having high melting points would have stayed solid and all the rest would have got converted into vapours. Thus, the inner planets are made of Iron, Silicon, Magnesium, Sulfur, Aluminum, Calcium and Nickel.

» The inner planets are a lot more smaller than the external planets and due to this have generally low gravity and couldn't pull or attract a lot of gases to their environments. This is opposite of the external planets which are more gigantic and had the capacity to attract a lot of Hydrogen and Helium.

» In outer part of the solar system where it was cooler, different components like water and Methane didn't disintegrate and had the option to shape the gigantic planets.

» The earthly planets were framed in the nearby region of the parent star where it was excessively warm for gases on a surface to consolidate to solid particles.

» The solar winds was most exceptional closer the Sun; thus, it brushed off loads of gas and residue from the outside of the earthly planets.

» The solar winds were not too extreme to cause comparative expulsion of gases from the Jovian planets.

- Recently, Pluto, Ceres, Charon and Eris were newly grouped as Dwarf Planets. The dwarf planets also revolve around the Sun. But do not have all the properties of a planet and thus are called Dwarf planets.
- International Astronomical Union (IAU) in 2006 adopted the definition for dwarf planets. According to IAU, a dwarf planet is, "a celestial body orbiting a star that is massive enough to be rounded by its own gravity but has not cleared its neighboring region of planetesimals and is not a satellite."

Sun

- Sun can be said as the heart of our solar system. It is the largest object within our solar system, comprising 99.8% of the system's mass.
- The Sun has a surface temperature of 6000°C and increases up to 20 Mn.°C in the interior.
- It is made up of fiery gases on its surface which leap up in whirls of glowing flame like volcanoes in eruption.

- The Sun has 300,000 times more mass than Earth.
- The Sun is the only star in our solar system and is the powerhouse of the solar system.
- It is composed of Hydrogen (73%), Helium (25%) and other elements.
- The light from the Sun takes an average of 8 minutes and 20 seconds to reach the Earth while light from Moon takes only a second. Sun's body comprises of various regions.
- **Corona:** It is the outer layers of the Sun, extending to thousands of km. above the disc (photosphere).
- It has a temperature which exceed 1,000,000 Kelvin which is a lot higher than the solar disc temperature of around 6000K. How the outer layer of Sun gets warmed to such high temperatures is as yet an unanswered inquiry in solar physics.
- The Sun's visible surface has dark Sunspots sometimes, which are regions of extraordinary magnetic activity which can prompt solar blasts.
- **Heliosphere:** The electric flows in the Sun create a complex magnetic field that reaches out into space to form the interplanetary magnetic field. The volume of space constrained by the Sun's magnetic field is known as the heliosphere.
- **Solar Wind:** These are the storms of electrically charged gas blowing outward from the Sun in every direction. The Sun's magnetic field is carried out through the solar system by the solar wind.
- The Sun's rotation causes the magnetic field streamlines to assume a spiral shape, also known as the Parker spiral.

Planets

- Mercury is the smallest and the nearest planet to the Sun. It completes its revolution around the Sun in only 88 days. This planet is made up of Nitrogen, Hydrogen, Oxygen and Carbon Dioxide but has no water.
- Venus is the hottest planet in entire solar system with the surface temperature reaching up to 478°C. Venus is often called **Earth's twin** because of their similarity in size, mass and density. It is the brightest planet in the solar system and has earned itself the title of **Evening Star and Morning Star**. Venus rotates around Sun in a clockwise direction.
- Earth is third planet from the Sun after Mercury and Venus. This is the only planet in our solar system to have presence of life in all its majestic forms. It is also called the **Blue Planet** due to the presence of water. Our Earth has one natural satellite called the Moon.
- Mars is called the **Red Planet** due to the presence of Iron rich red soil. It is the second smallest planet after Mercury and has dark patches on its surface. Mars has a thin atmosphere and surface with valleys, craters, deserts and even ice-caps. Mars has two natural Moons named Phobos and Deimos. After Earth, the only planet that has come close to the possibility of having life, is Mars. Mars has the largest known volcano and second tallest mountain in the solar system called Olympus Mons.
- Jupiter is the largest planet in entire solar system. It's surface is made up of Hydrogen, Helium and Methane. It is differentiated from other planets by its circular dark and lighter bands. Jupiter has 53 named moons and another 26 awaiting official names encircle the planet and has an unclear ring around it. Largest Moon Ganymede was discovered by Galileo Galilee in 1610. Others are Lo, Callisto and Europa.
- Saturn is second largest planet and is entirely gaseous in nature. It is a very unique planet with its three concentric

rings which can be easily observed from Earth and nine satellites around it. Saturn takes 29.5 years (i.e. Earth years) to complete its orbit. Saturn can float on water since it has less density than water. It has 82 Moons, Titan being the largest.

- Uranus also orbits around the Sun in clockwise direction like Venus. Through telescope it is seen as greenish-bluish disc. Uranus is composed of Hydrogen and Helium and contains water and ammonia. Uranus has at least 20 Moons. Miranda, Ariel, Titania are few larger ones.
- Neptune is the farthest planet from the Sun. Neptune has bluish colour due to the presence of Methane. Uranus and Neptune (the ice giants) are called the twins of the outer solar system.
- This planet was discovered by mathematical predictions and disturbances in Uranus's orbit. Neptune has about 14 Moons, Triton being the largest.

Planet	Distance from Sun (Million of km)	Orbital Velocity (km. per second)	Period of Revolution
Mercury	58	48	88 days
Venus	108	35	225 days
Earth	150	30	1 years
Mars	228	24	2 years
Jupiter	778	13	12 years
Saturn	1429	10	29 years
Uranus	2875	7	84 years
Neptune	4504	6	165 years

Other Planetary Bodies:

• Moon:

» The Moon is only natural satellite of Earth and the fifth largest Moon in the solar system. The Moon is considered to be formed after a Mars-sized body collided with Earth.

» It goes around the Earth at a distance of about 239,000 miles (385,000 km.).

» The Moon is a rocky, solid surface body with much of its surface cratered and pitted from impacts.

» The Moon has extremely thin and weak atmosphere which is known as an exosphere. It is not breathable.

» The Earth and Moon are tidally-locked. Their rotations are so in sync we only see one side of the Moon all the time.

• Asteroids:

» These are small rocky (mostly debris) which revolve around the Sun. Mostly they are found on the Asteroid belt between the orbits of Mars and Jupiter. They are also called Minor Planets. Larger asteroids are also called Planetoids. Ceres, Vesta and Psyche are some of the most famous and biggest asteroids.

• Meteors and Meteorites:

» The sudden streak of light seen on a starry night is called Meteors. They are also called shooting stars. They are small rocky materials that are formed due to an asteroid collision.

Meteorites are seen when the remains of the rocky parts of comets strike the Earth's atmosphere and streaks of lights are generated due to friction. These meteors cannot reach the Earth's surface since they get burnt out in the atmosphere due to the friction.

- **Comets:**

» They are made up of dust and ice. They are shiny, luminous and tailed stars. These rocky and metallic materials are surrounded by frozen gases. Found in the Kuiper Belt, they travel towards the Sun. The long tail is seen when the comet approaches the Sun and in turn the ice melts and reflects the light of Sun.

» Halley's Comet is the most famous comet. It is a "periodic" comet and returns to Earth's vicinity about every 75 years.

- **Asteroids are distinguished from comets and meteoroids:**

» In case of comets, the difference is one of compositions: asteroids are mostly made up of minerals and rock, comets are mainly composed of dust particles and ice. Moreover, asteroids formed closer to the Sun, preventing the development of cometary ice.

» Another noticeable difference between asteroids and meteoroids is mainly of size: meteoroids have a diameter of one meter or less than that, whereas asteroids have a diameter greater than one meter and can be even bigger.

» Lastly, meteoroids can be composed of either cometary or asteroidal materials.

Black Hole:

- A black hole is a place in space with very high gravity that even light can not get out of it. The gravity is so strong because matter has been squeezed into a tiny space.
- This can happen when a star is dying.
- When a star burns through the last of its fuel, the object may collapse, or fall into itself which leads to the formation of a black hole. In case of smaller stars the new core may become a neutron star or a white dwarf. But when a larger star collapses, it continues to compress and creates a stellar black hole.
- In 1916, Albert Einstein with his general **theory of relativity** first predicted the existence of black holes.
- Black holes are invisible. As no light can get out, so people can't see the black hole. The scientists can locate the black hole by observing the effects of strong gravity on the stars and gases around the black hole
- Black holes can be as small as just one atom. These black holes are very tiny but have the mass of a large mountain. On the other hand they can be 20 times more than the mass of the Sun. "Supermassive" black holes are the largest black holes. These black holes have masses that are more than 1 Million Suns together. Supermassive black holes may be the result of hundreds or thousands of tiny black holes that merge together. Large gas clouds could also be responsible for collapsing together and rapidly accreting mass.

The Shape of the Earth

- The Earth is spherical in shape; it is an established fact, backed by several evidences.
- The equatorial circumference of the Earth is 24,897 miles, while its polar circumference is less than 83 miles than that of the equatorial circumference.

This shows the Earth is not a perfect sphere.

- The Earth is flattened at both ends (poles) like an orange. This shape is called Geoid (Earth like).
- There are many ways to prove that the Earth is spherical. They are as follows:

» **Circumnavigation of the Earth:** The first voyage by Sir Magellan around the world proved that the Earth, if not a sphere, for sure was not of a shape which had abrupt edges. It was also discovered that once you start at one point, you are bound to reach that place completing a circular path. Modern day air routes and ocean navigations are based on the assumption that the Earth is a sphere.

» **The circular horizon:** The distant horizon as seen from a ship or a cliff or a landmass is often seen as circular in shape. In fact, with increase in altitude, the circular horizon broadens. This is a feature only of a spherical body.

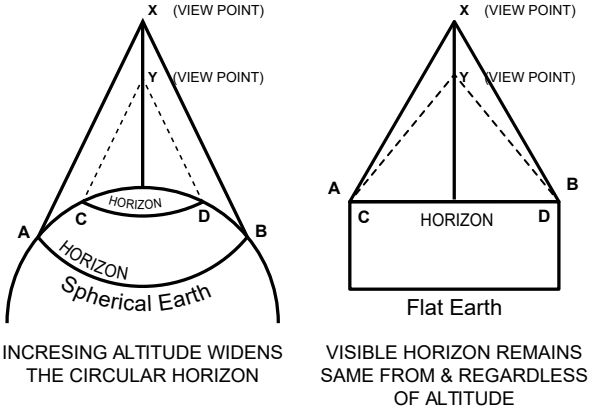

Image 1.1: Evidence of spherical earth

» **Ship's Visibility:** When a ship appears over a distant horizon, the mast of the ship is seen first followed by the hull. Similarly, when the ship leaves the harbour, the disappearance of the ship over the curved surface is gradual. This would not have happened had the Earth been flat, the entire ship would be visible or obscured from view.

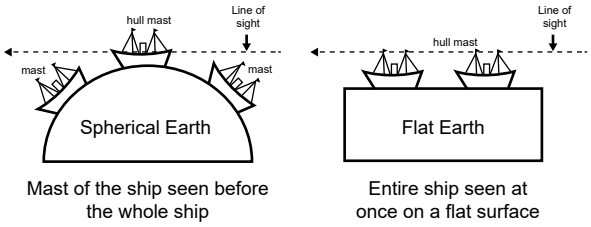

Image 1.2: Evidence of spherical earth

» **Sunrise and Sunset:** The Sun rises and sets at different times at different places in the world. As the Earth rotates from west direction to east direction, places in the east see Sunrise before the places in the west. Had the Earth been flat, the entire Earth would have had Sunrise and Sunset at the same time.

» **The Lunar Eclipse:** The shadow cast by the Earth on the Moon is always circular during the lunar eclipse. It takes the shape of an arc of a circle on the Moon.

» **All planetary bodies are spherical:** When looking through a telescope, all the planetary bodies like the Sun, the Moon and other planets appear circular or spherical in nature, no matter they are viewed from whichever angle. Earth, by analogy, cannot be the only exception.

» **Aerial photographs:** The pictures that are taken by satellites always show the curved edge of the Earth. This is the most convincing and modern proof of Earth's sphericity.

» **Driving Poles on Level Ground on a Curved Earth:** Engineers when drive poles of equal length at regular intervals on the ground find that they do not get a perfect horizontal level. The centre pole normally projects slightly above the poles on either side because of the earth's curvature.

The Earth's Movement

- The Earth moves in Space in two different ways: Rotation and Revolution.

- Earth rotates on her own axis from west to east direction once every 24 hours (approx). This causes the phenomenon of day and night.
- Earth also revolves around the Sun in its orbit once every 365 days. This revolution around the Earth constitutes a year. This revolution also causes the seasonal variation.

Rotation - Day and Night

- When the Earth rotates on her own axis, only one portion of the Earth gets Sunlight from the Sun. That area receiving Sunlight experiences daylight. The other side of the Earth, which is away from the Sun, experiences darkness or night.
- Because of the west to east rotation of the Earth, every part of the Earth will receive Sunlight sometime or the other.
- When the Earth emerges from darkness to gradual light, it is called Sunrise and later when the Sun's rays give way to darkness, that place experiences Sunset.

The Earth's Revolution

- It is to be noted that the Sun is a stationary body. The Earth revolves around the Sun.
- The Earth spins on an elliptical orbit at a speed of 18.5 miles per second. One complete revolution around the Sun takes 365 ¼ days.
- Thus, a normal year is taken to be of 365 days. The ¼th of the day is added to the year once every 4 years to form one whole new day.
- This added day every four years is called as the Leap Year.

Varying Lengths of Day and Night

- The axis of the Earth is inclined at an angle of 66 1/2° to the plane of the ecliptic (the plane in which the Earth orbits around the Sun). It gives rise to different lengths of days and nights at various places and results in different seasons.
- In the northern hemisphere in winters, as we go northwards, the time of night increases.
- At the Arctic Circle (66 1/2° N) the Sun never 'rises' and there is a constant state of darkness for the whole day in mid winter on 22nd December (Winter Solstice).
- After the Arctic Circle, the number of days with complete darkness increase as we move towards the poles at 90°N.
- This condition is reversed in summers. Daylight increases as we go towards poles.
- At the Arctic Circle, the Sun never 'sets' in mid-summer (21st June) and there is a complete 24 hours daylight.
- At the north pole, in summers there are six months of continuous daylight.
- In Southern hemisphere, the seasons are reversed but the same process takes place. When there is summer in Northern hemisphere, it is winter in the Southern hemisphere. Thus, the conditions are reversed but the same process takes place.
- In Mid-summer (21st June) there is complete daylight in the Northern hemisphere (Arctic Circle) corresponds to complete darkness at mid-winter (21st June) in the Antarctic Circle in the Southern hemisphere.

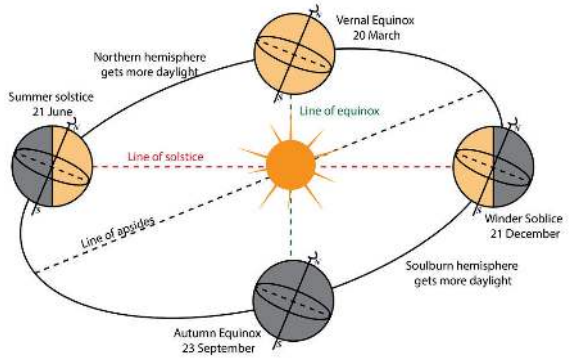

Image 1.3: The Revolution of the earth & its effects on length of the day & season changes

The Altitude of the Midday Sun

- Due to the inclined axis at an angle of 66 1/2°, causes apparent changes in the altitude of the midday Sun.
- Sun is vertically over the head at the equator on two days a year: 21st March and 21st September. These two dates are called equinoxes. On these days, all parts of the world have equal day and night.
- After the Spring equinox on March 21st, the Sun begins its apparent northward shift, such that the Sun is directly over the head at the Tropic of Cancer (23 1/2°N) on June 21. This is known as the Summer Solstice. The northern hemisphere on this day has the longest day and the shortest night.
- The Sun begins it apparent southward shift after this day and reaches the equator directly overhead on 21st September (Autumn Equinox).
- Thereafter, it continues with its southward shift till the Sun is directly overhead on the Tropic of Capricorn (23 1/2°S) on 22 December. This is called the Winter Solstice when the southern hemisphere will have its longest day and shortest night. The northern hemisphere will experience just the opposite and have the longest night and shortest day.
- The tropics thus mark the limit of the overhead Sun. Beyond the tropics, the Sun is never overhead at any time of the year.
- These regions, where the Sun is never directly overhead, are marked by four distinguishable seasons: summer, autumn, winter and spring.
- The areas above the Arctic and Antarctic circles are marked by continuous six months of darkness and remaining six months of daylight. These regions are inherently very cold since the Sun's direct rays never reach these areas. Here the Sun is never high in the sky (even during the summer months).
- The regions within the tropics, the midday Sun varies very little from the overhead vertical position at noon. Thus, there are no distinguishable seasons in this region.

Seasonal Changes and Their Effects On Temperature

- During the summer season, the Sun is directly overhead. The Sun is higher in the sky.
- When the Sun is over the head, the Sun's rays fall almost vertically on the Earth's surface thereby concentrating the heat on a small area and thus intensifying the heat.
- Thus, summers are warm and the temperature rises.
- The days are also longer in summer than the night time. This allows more time to heat up the Earth. Nights are short and thus, there is less time to lose the heat. Thus, there is a net gain in the total heat received and thus temperature increases.
- In the winter, the Sun's rays fall obliquely or slanted on the surface of the Earth. The rays are longer and much of its heat is absorbed by the Earth's atmosphere (water vapour and dust particles).

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- The slanted rays spread over a larger area and thus, the effect of heat is also less.
- The days are shorter. Thus, the heat absorbed is much less than the heat lost during the long winter nights. Here there is net loss in the total heat received and lost.

Dawn and Dusk

- The brief period between Sunrise and full daylight is called Dawn.
- The short span of time period between Sunset and complete darkness is called Twilight or Dusk.
- Dusk and dawn is caused by the fact that during this period, the Earth receives diffused or say refracted light from the Sun while it is still below the horizon.
- In the equator region, the Sun rises and sets in a vertical path and therefore the period during which the refracted light is received is short. But in temperate latitudes, the Sun rises and sets in an oblique way and therefore the period of refracted light is longer.
- In fact, it is so much higher in the poles that the winter darkness is actually the twilight of refracted light, most of the times.

Latitude and Longitude

- The latitudes and longitudes are essentially imaginary lines drawn on the globe to locate any place accurately.
- The latitudes run from east to west, parallel to the equator. The longitude runs from north to south and passes through the poles.
- The location of any place on the Earth can be determined by the intersection of latitude and longitude.
- Latitudes and longitudes both are measured in degrees.

Latitude

- It can be defined as an angular distance of a point on the surface of Earth from the centre of the Earth. Latitudes are parallel to the equator which lies halfway between the two poles.
- The latitudes become smaller towards the poles, following the shape of a sphere.
- The equator represents 0° whereas the North and the South poles are at 90°N and 90°S respectively.
- North of the equator, latitudes are assigned North degree. The south of the equator, the latitudes are assigned South degrees.
- Between the equator and the poles the lines or parallels of latitude are drawn at an interval of 1°.
- For precision of location mapping, each degree of latitude is divided into 60 minutes and each minute into 60 seconds.
- The most important latitudes are Equator at 0°, Tropic of Cancer (23 1/2° N), Arctic Circle (66 1/2° N), Tropic of Capricorn (23 1/2° S) and Antarctic Circle (66 1/2° S).
- Because of the spherical shape of Earth, the physical distance between the latitudes increases very gradually from the equator to the poles. For example, at the equator at 0°, the distance between two latitudes are 68.704 miles, the difference between two latitudes at 45°N are 69.054 miles and the same difference between two latitudes near the pole at 90°N is 69.407 miles. However, for ease of purpose, the average distance between two latitudes are taken as 69 miles.

Longitude

- It is the angular distance, measured in degrees, along the equator, west or east of the Prime Meridian.
- In the globe, longitudes are series of semi circles that run from north to south from one pole to the other.
- Each longitude cuts through the equator.
- Longitudes are also called Meridians.
- Any longitude could have been taken as the prime meridian for the purpose of numbering. But in 1884, by an International Agreement, it was decided that the zero meridian will be the one that passes through the Royal Astronomical Observatory at Greenwich, near London.
- The 0° Longitude is called the Prime Meridian and all the other meridians fall to the left or right of the prime meridian.
- The longitudes are divided into 180° to the east and west of the Prime Meridian.
- The distance between two longitude at the equator is calculated by the length of the circumference divided by 360° (25000 miles ÷ 360 = 69.1 miles)
- However, the longitudes all converge at the poles, so the linear distance between two longitude narrows.
- The degree of longitude thus decreases in length pole wards. At the equator, the distance between two longitudes is the largest at 69.1 miles, at 45°N it is only 49 miles, while at 75°N it is only 18 miles and at the poles its 0 miles.
- The longitudes are extremely important for determination of time.

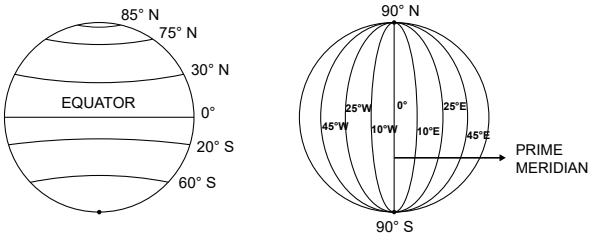

Image 1.4: latitude, parallel to the equator (left) and Longitude, runs east and west of the Prime Meridian.

Longitude and Time

- Rotation of the Earth around the Sun means that at any point in time, different places on Earth will experience a different time of the day.
- Since the Earth makes one complete round of 360° in one day or 24 hours, it means that in one hour, it covers a distance of 15° or 1° in four minutes.
- As the Earth rotates from west to east, so for every 15° eastwards if we go, we will gain an hour. That means the local time is advanced by an hour for every 15° eastward move.
- Conversely, if we go westwards, we will lose an hour in the sense that for every 15° westward move, the time will be reduced by an hour.
- Places to the east of Greenwich thus see Sunrise earlier. A person travelling from Greenwich to east will gain time on reaching the eastern destination as compared to a person travelling to the west of Greenwich, who will lose time. The places west of Greenwich sees Sunrise later than Sunrise in Greenwich.
- Generally time is determined by longitude of the place. It is compared with the local time of Greenwich and then adding or subtracting time, depending on the longitude.

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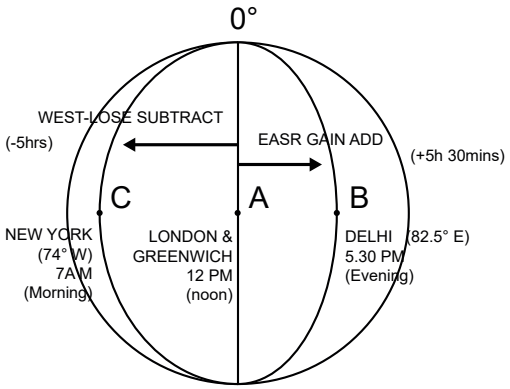

Image 1.5: Longitude & time comparison with Greenwich mean time.

Standard Time and Time Zones

- Now for each city or a place to keep individual time based on its longitudinal position would complicate matters, especially in cases of medium to big countries.
- Since for each degree change in longitude, there is a time difference of four minutes, people travelling from one part to other part of a country would continuously have to keep changing and adjusting time.
- To avoid such confusion and impracticability, a system of standard time is observed by all countries.
- Each country has their own central meridian and the standard time if the country is calculated as per in relation to the Prime meridian at Greenwich with the central meridian of the country.
- In case of India, the meridian of 82.5°E is taken as the Central Meridian. The Indian Standard Time is calculated with respect to the time difference between Greenwich and Indian Central Meridian.
- Indian Standard Time (IST) is 5 hours 30 minutes ahead of Greenwich Mean Time.
- Whole world is divided into 24 standard time zones. Each of them differs in 1 hour and 15° in longitude.
- Large Countries like USA, Russia, Canada etc which have a huge east-west stretch have more than one standard time for those countries, for practical purposes. USA and Canada both have 5 time zones - Atlantic, Eastern, Central, Mountain and Pacific Time Zones. The difference between the Atlantic and Pacific time zones is 5 hours.

International Date Line

- This concept becomes very interesting here.
- A traveller going eastward from Greenwich gains time till he/she reaches 180°E longitude. At 180°E meridian he is 12 hours ahead of GMT.
- Similarly, a traveller going westward from Greenwich, at 180°W meridian, he loses 12 hours.
- Thus, there is a difference of 24 hours or one whole day, on two sides of the 180° meridian.
- This is called the International Date Line where the date changes by exactly one day, once it is crossed. The traveller crossing the International Date Line from west to east, gains a whole day and the traveller crossing from east to west loses a day.
- Suppose, on the Asia side of the International Date line it is midnight on Friday, 13th September, on the American side of the International Date Line, it is actually midnight on Thursday, 12th September. A whole day is thus gained by travelling from east to west of the International Date Line.
- The International Date Line in the mid-Pacific curves from the normal 180° meridian at the Bering Strait, Fiji, Tonga and few other islands to prevent

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confusion of date and time as few of the islands falls on both sides of the International Date Line.

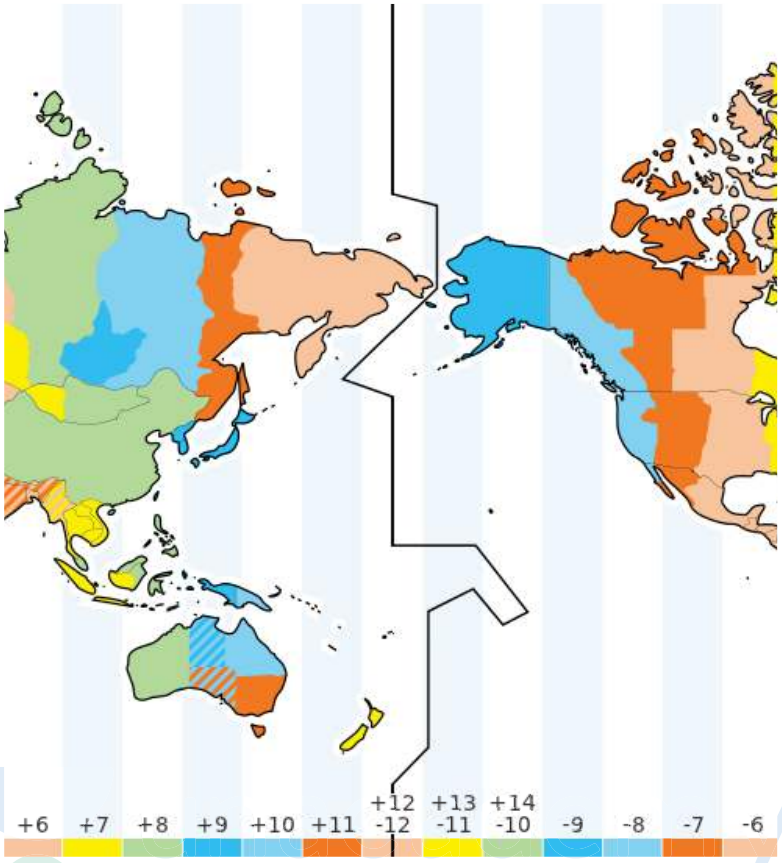

Image 1.6: International Date Line

CHAPTER - 2

THE ORIGIN AND EVOLUTION OF THE EARTH

Introduction

- The universe is almost 13 billion years old. Huge clusters of galaxies comprise the universe.
- There have been many theories proposed by various experts which attempt to explain the origin and evolution of the Universe.
- Different scientists and philosophers have put forward many hypotheses and theories regarding the evolution of the Earth and Universe.
- There have been many early theories propounded by philosophers, but they had lacked proper scientific backing. That led to the formation of new modern theories.

Early Theories: Origin of the Earth

Nebular Hypothesis:

- This theory is proposed by German philosopher Immanuel Kant and revised by mathematician Laplace in 1796.
- Kant argued that gaseous clouds—nebulae, which slowly rotate, gradually collapse and flatten due to gravity and eventually form stars and planets.
- As the nebula shrank, it flattened and shed eight angular momentum rings of material, which later collapsed into the planets.
- Sun was regarded as young and slowly rotating body. Planets were considered to be formed out of a cloud like substance associated with Sun.

Binary Theories:

- In 1900, Chamberlain and Moulton refined the Nebular theory analysis.
- They considered that when a wandering star approached the Sun, a cigar shaped extension came out of the solar surface.
- And when the passing star moved away, the material separated from the solar surface (as the extension) continued to revolve around the Sun and slowly those materials condensed into planets.
- Later, scientists Sir James Jeans and Harold Jaffrey also supported this theory arguments which were called Binary Theories.

Revised Nebular Hypothesis:

- Revised Nebular Hypothesis was given by Otto Schmidt of Russia and Carl Weizascar of Germany in 1950.
- They regarded that the Sun was encircled by solar nebula comprising of mostly Hydrogen and Helium along with dust particles.
- The friction and collision of particles helped in the creation of a disk shaped cloud and the planets formed by the process of accretion.
- (Note: -In astrophysics, accretion is the accumulation of particles into a massive object by gravitationally attracting more matter, typically gaseous matter.)
- These theories only attempted to explain the formation of our solar system and did not quite explain the genesis or origin of the entire Universe.

Modern Theories sought to explain the origin and evolution of the Universe and therefore automatically in the process explained the formation of our Earth.

Modern Theories: Evolution of the Universe

Big Bang Theory

- This is the most popular theory of the Origin of the Universe and it is called as the Big Bang Theory or Expanding Universe Hypothesis.
- On witnessing that the galaxies move far away from each other and the distance between them increasing, Universal expansion is proved by Sir Edwin Hubble in 1920.
- Big bang theory can be explained in three developmental stages:

» At first, all matter forming the universe existed in one place in the form of a tiny ball (this tiny ball called as 'Singularity') with small volume as an atom, having infinite mass (density) and temperature.

» A violent explosion (bang) of tiny ball happened which resulted in huge expansion. As the ball continued to expand, there were changes of some particles into energy form. That means, some energy was converted into matter. There was a particularly rapid expansion within fractions of seconds after the bang. Thereafter the expansion slowed down. This happened about 13.7 billion years ago and continues till today.

» Then the temperature dropped to 4,500K (Kelvin) after 300,000 years of explosion, atomic matter is formed and the universe became transparent.

- The expansion of the universe meant increase in space between the galaxies.

And an alternative was provided to this theory by Hoyle's concept of Steady State.

Steady State Theory

- The standard model of cosmology is the Big Bang Theory of how things came to be; however, there have been a few different theories for the universe.
- Steady State Hypothesis proposes the possibility that the universe looks a similar regardless of the perspective and that the universe has consistently resembled this. Basically, the hypothesis expresses that the universe is uniform all through both existence.
- The favorable position of Steady State hypothesis over some different theories is its basic and stylish clarifications of certain irksome subjects.
- For instance, since the universe is perpetual all through time, the universe needs no tangled clarification of its start. Likewise, to represent the decline in density that would result from expansion, steady state hypothesis asserts new matter continually should be made to keep a constant density (and hence a static appearance).
- The steady State hypothesis offered straightforward answers for the manner in which the universe worked, yet the astronomers found that the universe really develops over the long haul.
- The end of the steady State hypothesis came in the last part of the 1960's with the discovery of the Cosmic Microwave Background.
- Steady State Hypothesis could offer no persuading clarification for the CMB and thus this hypothesis was dismissed on grounds to an excessive amount of straightforwardness.

Cosmic microwave background (CMB):

- It is thought to be leftover electromagnetic radiation from the Big Bang, or the time when the universe began.
- These this radiation are invisible. But using optical telescopes, radio telescopes they can be detected.

Formation of Stars

- The dissemination of matter and energy was lopsided in the universe.
- The density difference offered ascend to differences in gravitational powers. It made the matter get drawn together and lead to formation of galaxies.
- Galaxy contains enormous number of stars. It begins shaping by collection of Hydrogen gas as cloud. The denser gases were consolidated into stars. The distance between the stars is measured with light years.
- One light year can be defined as the distance covered by light in one year (the speed of light is 3 lakh km. per second). It should be remembered that it is a measure of distance and not of time.
- The average diameter of the stars is 80,000 to 1, 50,000 light years.
- A galaxy starts forming by accumulation of Hydrogen gas in the form of a large cloud called Nebula.
- The Nebula develops localised clumps of gas. These clumps continue to grow into denser gaseous bodies.
- The denser gases were condensed into stars. The formation of stars are believed to have formed 5-6 billion years ago.
- The mean distance from the Sun to Earth is 8.311 minutes in terms of light year.

Formation of Planets

- The formation of planets started after the formation of the stars.
- The stars are restricted piece of gases found in nebula.
- The gravitational power prompted the development of the center.
- A gigantic turning gas plate and residue develops around the gas center.
- In the following stage the gas cloud begins getting dense and the matter around the center forms into little rounded items.
- The little rounded items formed into Planetesimals because of the procedure of cohesion.
- Larger bodies began forming because of impact and attraction making the materials remain together. At the last stage, the small planetesimals accumulate to form large bodies in the form of planets.

OUR SOLAR SYSTEM

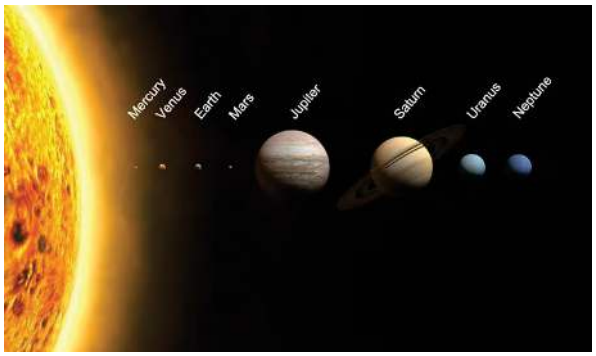

Image 2.1: Solar system

- Our solar system consists of eight planets
- Nebula of our solar system started collapsing about 5-5.6 billion years ago.

- The planets were formed around 4.6 billion years ago.
- Our solar system comprises of eight planets, 146 Moons, millions of asteroids comets, huge quantity of gas and dust.
- There are in general two types of planets - inner planets and outer planets.
- Among the eight planets the first four planets are Inner planets, which are also called rocky or terrestrial planets. The rest of the planets are outer planets and are called gaseous or Jovian planets.

Planetesimal Hypothesis:

A planetesimal is an object formed from dust, rock and other materials. The word has its roots in the concept infinitesimal, which indicates an object too small to see or measure. Planetesimals can be anywhere in size from several meters to hundreds of km. The term refers to small celestial bodies formed during the creation of planets. According to the planetesimal hypothesis, when a planetary system is forming, there is a protoplanetary disk (A protoplanetary disk is a rotating disk of dense gas and dust surrounding a young newly formed star) with materials from the nebulae from which the system came. This material is gradually pulled together by gravity to form small chunks. These chunks get larger and larger until they form planetesimals.

The rocky planets were formed in the close vicinity of the parent star or the Sun where it was too warm for the gases to condense to solid particles. The gaseous or the Jovian planets were formed at quite a distant location from the Sun. The solar wind being quite intense near the Sun, blew off lots of gases and dust from the terrestrial

- The rocky planets cannot hold the gases hence it blew off due to the Sun's gravity. But the gaseous planets cannot strip off their gases hence holds large amount of gases resulted in larger radius and low density.
- Until recently (2006), Pluto was considered a planet. However, in a meeting by the International Astronomical Union, Pluto was declared a dwarf planet.

The Moon Formation

- The Moon is the solitary natural satellite of the Earth.
- In 1838, Sir George Darwin proposed that at first the earth and the Moon becomes a single quickly rotating body.
- The entire mass turned into a body having dumb-bell shape and ultimately it broke.
- The material isolated from the Earth became Moon and the spot turned into the present-day depression of the Pacific ocean.
- This hypothesis anyway isn't acknowledged at this point. The current hypothesis is the Giant Impact hypothesis/Big splat hypothesis.
- An enormous body, which is one to thrice the size of Mars slammed into the Earth not long after its development and shot a huge bit of the Earth into space. (That segment was isolated from the earth).
- The same segment became a Moon which spins around the earth. The Moon is believed to have been formed about 4.4 billion years ago.

Evolution of the Earth

- Initially our earth was an infertile, rough and hot body. A long time later the earth began to cool off. This in the long run made the Atmosphere and lithosphere.