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*by* Dr. Manish Rannjan (IAS)


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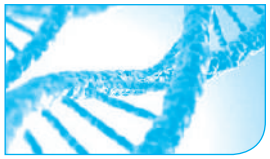




# GEOGRAPHY

# World Geography

## THE UNIVERSE

- The universe comprises billions of galaxies which are made up of millions of stars held together by the force of gravity and these stars account for most of the masses of the galaxy.
- Our own galaxy is called the **Milky Way** (or the Akashganga) and it contains about 300 billion stars and one of these is our Sun. Planets and other objects go round the Sun and make up the solar system with the Sun at the centre.
- In the 14th Century, **Ptolemy** propounded the theory that the Earth was the centre of the universe and the Sun and the other heavenly bodies revolved around it.
- In 1543 AD, **Copernicus** said that the Sun is the centre of universe and not the Earth.
- **Kepler** supported Copernicus but said that the Sun is the centre of solar system and not the universe.

### MEASUREMENT UNITS OF SPACE

- **Light Year:** It is the distance covered by light in one year in vacuum at a speed of 300000 km/s. 1 light year = $9.46 \times 10^{12}$ km.
- **Astronomical Unit (AU):** It is the mean distance between the Earth and The Sun. One Light Year is equal to 63,000 AU
  1 AU = 150 million km.
- **Parsec:** One parsec is the distance to a star that subtends an angle of one second of an arc length of 1 AU
  1 Parsec = 3.26 light years ($3.086 \times 10^{13}$ km).

## ORIGIN: EVOLUTION OF THE UNIVERSE

### (I) BIG BANG THEORY

**(PROPOSED BY GEORGES LE MAITRE).**

- Big Bang was an explosion that occurred 13.8 billion years ago, leading to the formation of galaxies of stars and other heavenly bodies.

### (II) STEADY STATE THEORY

- Bondi, Gold and Fred Hoyle developed this theory and states that although the universe is expanding, it nevertheless does not change its appearance over time, it has neither beginning nor end.

### (III) THE PULSATING THEORY

- According to this theory, the universe is supposed to be expanding and contracting alternately, i.e., pulsating. At present, the universe is expanding.
- **Milky Way Galaxy** formed 5 billion years after the **Big Bang**.
- Latest known galaxy is the **Dwarf Galaxy**.
- Origin of the universe is explained by the **Big Bang Theory,** formulated and proposed by the Belgian astronomer and cosmologist, **Georges Lemaitre**.
- **Andromeda** is our nearest galaxy.

## STAR FORMATION

- Stars are made of hot burning gases.
- They emit light of their own and are very large and very hot.
- Light takes about 4.3 years to reach us from the next nearest star **Proxima Centauri**.

## LIFE CYCLE OF A STAR

1. **Proto Star:** It is the stage, where the helium core becomes increasingly heavy accompanied by expanding out the layers. A Proto Star is a highly condensed cloud of gases mainly hydrogen and helium.
2. **Red Giant:** This stage results into the swelling and reddening of the outer regions of the star. Such stars of gigantic dimension are called Red Giants.
3. **White Dwarf:** If the mass of the star is relatively small like that of our Sun, the gases that reach the outer layer are expelled. As these expelled gases cool and contract, the star becomes a white dwarf.

## THE SOLAR SYSTEM

- The Sun, eight planets (excluding Pluto) and their respective satellites.
- Interstellar debris such as asteroids, meteoroids, comets.
- The electrically charged gases, called **Plasma**.
- Interplanetary dust particles.
- The components of solar system other than planets, dwarf planets and satellites are called the **Small Solar System Bodies (SSSB)**.
- The gravitational pull of the Sun keeps all the planets and other objects revolving around it.
- Planets revolve around the Sun in an elliptical orbit.
- In the solar system, the planet nearest to the Sun is **Mercury** and the planet farthest from the Sun is **Neptune (not Pluto)**.
- The solar system is dominated by the Sun, which accounts for almost 99.9% of the matter in the whole solar system.
- **Pluto** is a dwarf planet.
- **Mercury**, **Venus**, **Earth** and **Mars** are called **terrestrial planets** and **Jupiter**, **Saturn**, **Uranus** and **Neptune** are called **gaseous planets**.

## ORIGIN OF SOLAR SYSTEM

Various theories have been given by different persons to explain the origin of Solar System.

| Hypothesis | Propounder |
|---|---|
| Cepheid Hypothesis | A.C. Banerji |
| Nova Hypothesis | Hoyle and Lyttleton |
| Electromagnetic Hypothesis | H. Alfven |
| Interstellar Dust Hypothesis | Schmidt |
| Nebular Cloud Hypothesis | Dr. Von Weizsacker |
| Protoplanet Hypothesis | G. Kuiper |
| Gaseous Hypothesis | Immanuel Kant |
| Nebular Hypothesis | Laplace |
| Planetesimal Hypothesis | Chamberlin and Moulton |
| Tidal Hypothesis | James Jeans and Harold Jeffreys |
| Binary Star Hypothesis | H.N. Russell |
| Fission Hypothesis | Ross Gun |

## MEMBERS OF THE SOLAR SYSTEM

### THE SUN

- It is the nearest star to the Earth.
- Its diameter is 14 lakh kms.
- It is composed of 71% hydrogen, 26.5% helium and 2.5% other elements.
- Within the Sun, hydrogen is converted to helium due to nuclear fusion releasing a tremendous amount of heat and light.
- The shining surface of the Sun is called Photosphere.
- The outer layer of Sun's atmosphere made up of thin hot gases is called **Corona**.
- The middle surface is chromosphere. The temperature of Photosphere is 6000°C, that of chromosphere about 32400°C and that of Corona about 2700000°C.
- The planet travels with the Sun through millions of stars in our galaxy at a speed of about 70,000 kms per hour.
- The Sun is about 150 million kms away from the Earth.
- Light takes about 8 minutes 20 seconds to reach the Earth from the Sun.
- **Solar Winds**: The Sun is continuously emitting streams of proton in all directions either as spiral streams called Solar Wind or bouts of incandescent material called **Solar Flares**. Solar flares, being hot ionised gases, pose danger to satellite communication.
- **Aurora:** The constituent particles of the solar wind are trapped by the Earth's magnetic field and enter the Earth's upper atmosphere as Aurora. It is described as Aurora Borealis in the Northern hemisphere and Aurora Australia in Southern hemisphere.
- Bright spots are called Plages and dark spots are called Sunspots.

**Specifics of the Sun**

| | |
|---|---|
| Average distance from the Earth | 149,600,000 km |
| Diameter | 1,391,980 km |
| Temperature of the core | 15,000,000°C |
| Rotation speed | 25.38 days (with respect to Equator), 33 days (with respect to Poles) |
| Mass | 333,000 times of Earth |

### THE PLANETS

- These are opaque bodies.
- A ninth planet has been recently discovered by NASA named **Carla**.
- The sequence of planets according to their distance from the Sun is Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune.
- The sequence of planets according to their size (in descending order i.e. from big to small) is Jupiter, Saturn, Uranus, Neptune, Earth, Venus, Mars and Mercury.

### CLASSIFICATION OF PLANETS

- Planets are classified into the following two groups inner and outer planets. These are separated by asteroid belt.

| Inner Planet | Outer Planet |
|---|---|
| They are called as terrestrial or rock planets. They are nearer to the Sun. | They are called as Jovian or gaseous planets. They are far away from the Sun. |
| They have a core of molten metals. | They have ring system around the Sun. |
| They include: Mercury, Venus, Earth and Mars | They include: Jupiter, Saturn, Uranus and Neptune. |

## MERCURY

- The planet has no water on it.
- Mercury planet has no gases like $CO_2$, $N_2$, $H_2$ and $O_2$ which can act as building blocks of life.
- Mercury planet has no protective blanket like Ozone.

## VENUS

- The planet is nearest to the Earth and is also the brightest planet.
- Venus is known as the **"Evening Star"** as well as **"Morning Star"**.
- Known as the **"Veiled Planet".**
- Also called the **"Earth's twin".** It also rotates clockwise like Uranus.
- Venus is the hottest planet (even hotter than Mercury).
- Venus has no water on it. There is insufficient oxygen on the Venus.

## THE EARTH

- The Earth is 23½° tilted on its axis and, thus, makes 66½° angle.
- It takes 23 hours 56 minutes and 4.091 seconds to rotate on its axis.
- Earth is known as the **"watery planet"** or the **"blue planet"**.
- Earth is the only known planet which provides sustenance or life on it.
- The Earth has all the essential elements like carbon (in the form of $CO_2$), hydrogen ($H_2$), nitrogen ($N_2$) and oxygen ($O_2$) which act as building blocks for the origin of life.
- It is in the **'Goldilocks Zone'**.
- The Earth has a lot of water in the form of lakes, rivers and oceans for the growth and survival of life.
- The Earth has enough oxygen gas in its atmosphere for the survival of living beings through breathing.
- The Earth has a protective blanket of ozone layer high up in its atmosphere to save life from the harmful ultra violet radiations coming from the Sun.

## THE MOON

- The Moon is the only satellite of the Earth.
- It has diameter of 3475 km and its circumference is 10864 km while its orbit is elliptical.
- The maximum distance (apogee) of the Moon from the Earth is 4,06,000 km and the minimum distance (perigee) is 3,64,000 km.
- It takes 27 days, 7 hours and 43 minutes to rotate on its axis (this period of about 27½ days is called the sidereal month) and approximately the same period of time it takes to revolve around the Earth. The Moon's period of revolution with reference to the Sun is about 29.53 days (29 days, 12 hours, 44 minutes and 2.8 seconds). This period is called a syndic month.
- Only 59 per cent of the total surface of the Moon is visible from the Earth.
- The highest mountain on moon is Mons Huygens, which in 18,046 ft. The mountain is named after Christiaan Huygens, a Dutch Astronomer.
- The Moon has no atmosphere, no twilight and no sound.
- The temperature during daytime is about 100°C and during night it drops down to about –180°C.
- The light from the Moon takes 1.3 seconds to reach the Earth.
- The size of the **Moon** is one-fourth (1/4th) the size of the Earth.
- Gravitational pull of Moon is one-sixth (1/6th) that of the Earth.
- Moon is also known as the fossil planet.

## MARS

- Iron-rich red soil and pink sky of **Mars** give it the name, **"Red Planet"**.
- Phobes and Demos are two satellites of Mars.

## JUPITER

- Jupiter is also known as **winter planet** as its average temperature is very low (–148°C).
- Ganymede, satellite of Jupiter is the **largest satellite** in the Solar System.

## SATURN

- Saturn has bright concentric rings which are made up of ice and ice-covered dust particles which revolve around it.
- **Titan** is the largest satellite of Saturn.

## URANUS

- Uranus is about **four times the size of the Earth**. This planet appears **Greenish in colour** because of methane gas present in its atmosphere.
- Uranus is the first planet to have been discovered by the use of a telescope.
- Uranus is extremely cold, having surface temperature –190°C and is surrounded by 13 rings.
- Uranus rotates from east to west on its axis, which is opposite to other planets except Venus.
- The axis of Uranus has large inclination so that it appears to be lying down; hence it bears the name "A Planet on its Side".

## NEPTUNE

- Neptune is **very similar to Uranus** and can be considered as its twin.
- Neptune is surrounded by methane rings of sub-zero temperature.

## PLUTO IS NO LONGER A PLANET

- On the basis of the new definition of planet given by the IAU (International Astronomical Union), the world's top institution on space science research, leading astronomers participating in IAU's meet at Prague (Czech Republic) on August 24, 2006 declared that Pluto would no longer remain a planet.
- Now, with the omission of Pluto from the Solar System, its membership has been restricted to **the eight "classical" planets, namely, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune.**

| Specifics of the Planets | |
|---|---|
| Biggest planet | Jupiter |
| Biggest satellite | Ganymede |
| Blue planet | Earth |
| Green planet | Uranus |
| Brightest planet | Venus |
| Brightest star (outside solar system) | Sirius (Dog Star) |
| Closest star of solar system | Proxima Centauri |
| Coldest planet | Neptune |
| Evening star | Venus |
| Farthest planet from Sun | Neptune |
| Planet with maximum number of satellites | Saturn |
| Hottest planet | Venus |
| Densest planet | Earth |
| Morning star | Venus |
| Nearest planet to Earth | Venus |
| Nearest planet to Sun | Mercury |
| Red planet | Mars |
| Smallest planet | Mercury |
| Earth twin | Venus |

## ASTEROIDS (OR PLANETOIDS)

- Asteroids are also known as minor planets.
- They are mostly found between the orbits of Mars and Jupiter. They are a belt of debris which failed to assemble into planets and keep on revolving around the Sun. This has come to be called as 'asteroid belt'.
- **All Asteroids rotate** on their axis, every 5 to 20 hours. Certain asteroids may have satellites.
- **Trojan asteroids** are found in two clouds moving in the orbit of Jupiter, one moving ahead of it and the other moving behind it.

### FACTS TO REMEMBER

- Saturn has maximum number of satellites.
- Pluto has the most eccentric orbit.
- Jupiter is the fastest rotating planet.
- Venus is the slowest rotating planet.
- Venus has the same period of rotation as revolution.
- The length of the day is nearly same on the planet Mars as that of the Earth.
- Jupiter, Saturn, Uranus and Neptune are the Jovian planets.
- The angle of inclination of Mars is nearly same as that of Earth.
- Jupiter, Saturn, Uranus and Neptune are the outer planets.
- Mercury, Venus, Earth and Mars are the inner planets.
- Venus rotates from East to West.
- Uranus rotates from East to West.
- Mercury is the fastest revolving planet.
- Pluto is the slowest revolving dwarf planet.
- Planets revolve around the Sun in Anti-clockwise direction.
- Mercury is the nearest planet to Sun.
- Venus is the nearest planet to Earth.
- Neptune was farthest from Sun during 1979–99.
- Now Pluto (dwarf planet) is the farthest from the Sun after 1999 for the next 228 years.
- Venus is the hottest planet, its atmosphere contains 97% $CO_2$.
- Pluto is the coldest and smallest dwarf planet.
- Jupiter is the biggest planet.
- Earth is the densest planet.
- Venus is the brightest planet.
- Earth is the blue planet.
- Mars is the Red planet.
- Venus is the Morning and Evening Star.
- Pluto is the dwarf planet.
- Venus is also called the Earth's twin.
- Saturn and Uranus are known as the planets with rings.
- Mercury has the shortest year.
- Mercury has the maximum diurnal range of temperature.

| Planets and Their Satellites (Moon) | |
|---|---|
| **Planet** | **Natural Satellites (Moon)** |
| Earth | Earth's Moon |
| Mars | Phobos, Deimos |
| Jupiter | Adrastea, Metis, Amalthea, Thebe, Io, Europa, Ganymede, Callisto, Leda, Himalia, Lysithea, Elara, Ananke, Carme, Pasiphae, Sinope. |
| Saturn | Atlas, Prometheus, Pandora, Janus, Epimetheus, Mimas, Enceladus, Tethys, Calypso, Dione, Helene, Rhea, Titan, Hyperion, Iapetus, Phoebe. |
| Uranus | Cordelia, Ophelia, Bianca, Cressida, Desdemona, Juliet, Portia, Rosalind, Belinda, Puck, Miranda, Ariel, Umbriel, Titania, Oberon. |

| | |
|---|---|
| Neptune | Naiad, Thalassa, Despina, Galatea, Larissa, Porteus, Triton, Nereid |
| Pluto (dwarf planet) | Charon and 2003 UB 313 |

## METEORS AND METEORITES

- Meteors and Meteorites are also called shooting stars.
- When meteors are large and do not burn up completely, they land on the Earth's surface and are known as **Meteorites**.
- All meteorites are believed to originate in the asteroid belt, where a sudden collision may send them towards the Earth and the Earth's gravity attracts them towards its surface.

## COMETS

- Visitors of the Solar System.
- Comets are made up of frozen gases which hold together rocky and metallic materials.
- A comet becomes visible only when it travels close to the Sun.
- Its ice melts and the gas and dust is swept back into a tail.
- The tail always points away from the Sun. So when it is travelling away from the Sun it is led by its tail.

## STARS

- Stars are heavenly bodies made up of **hot burning gases**, thus **shining by their own light.**
- Stars **seem to be fixed** with respect to one another. In fact they are in rapid motion but they are at such great distance that relative changes in position become noticeable only over the centuries.
- A star's colour indicates the temperature of its surface. Blue colour denotes maximum temperature.

## SOME FACTS ABOUT THE STARS

- Brightest Star outside solar system is Sirius, also called Dog Star.
- Closest star to our solar system is Proxima Centauri (4.2 light years away).

## BLACK HOLE AND CHANDRASHEKHAR LIMIT

- The black holes are formed due to collapse and compaction under gravity, at the end of the life cycle.
- A renowned Indian Physicist Chandrashekhar had predicted an upper limit to the mass of stars, which is called as Chandrashekhar limit. It is 1.44 times the mass of Sun.

**Facts about Stars**

- There are $10^{22}$ to $10^{24}$ stars in the Universe.
- About 8000 stars are visible from the Earth with naked eye.
- In either hemisphere, only 2000 stars are visible at any given time.
- The other 2000 are located in the day-time sky and the brightness of the Sun renders them invisible.

## CONSTELLATIONS

- To enable astronomers to identify roughly the position of the stars, the sky has been divided into units. These units are known as **Constellations.**
- At present **88 constellations** are recognized.

## EARTH'S GALAXY: THE MILKY WAY

- **The Milky Way** is a large spiral-shaped galaxy.
- It is called the Milky Way because it appears as a soft **glowing light of billions of stars**. These stars are so far that they can be seen only in constellation, not separately.
- It takes about 250 million years to complete one revolution.

## LIGHT YEAR

- Large distances in outer space are measured in light years.
- A light year is the distance that light travels in one year at the speed of 299,792,458 metres per second or roughly 300,000 km per second.
- No star, apart from the Sun, is close enough to Earth to appear as anything but a point of light.

## COSMIC NEIGHBOURHOOD ANDROMEDA: EARTH'S CLOSEST GALACTIC NEIGHBOUR

- **Andromeda** is a spiral galaxy and also our closest neighbour.
- It is the farthest object that can be seen with the naked eye.
- Along with the Milky Way, it belongs to a group of galaxies known as the **Local Group,** which in turn is a part of **Virgo Cluster** of groups.
- About 30 galaxies, along with the Milky Way and the Andromeda so grouped in one cluster called the Local Group.

## NEBULAE

- Nebulae are hanged interstellar clouds of gas and dust that appear as faint, misty patches of light scattered all over the sky.
- A nebula depends for its luminosity upon the presence of stars that have either arisen from it or are contained in it.
- If there are no suitable stars, the nebula does not shine and remains dark and can be detected only because it blots out the light of the stars beyond.

## THE EARTH IS NOT FLAT

- If the Earth were a flat disc, then the rising Sun would have been seen at all places at the same time.
- When a ship approaches land, its funnel of mast is seen first and then the hull. If the Earth had been flat, the whole ship would have been seen at the same time.

# THE EARTH

- The Earth is rarely oriented in the same position during successive eclipses but it always casts a circular shadow thus proving that the Earth is a sphere.
- At the North Pole, the **Pole Star** can always be observed at 90 degrees in the sky, since the star lies in the line with the axis of the Earth.
- As one travels southwards, the angle of Pole Star decreases.
- At the equator the angle becomes zero degree.
- This observation proves that the path of travel is an arc of a circle.
- The **photographs of the Earth taken from the space** prove beyond any doubt that the Earth is a sphere.

## THE EARTH AS AN OBLATE SPHEROID

- Refined measurements of the Earth have proved that true form of the Earth resembles a sphere that has been **compressed at the poles** and made to **bulge at the Equator.** This form is known as an **oblate spheroid.**

**Geological History of the Earth**

| Period | Beginning (years ago) |
|---|---|
| **Cenozoic Era Quaternary Period** | |
| Holocene Epoch | 10000 |
| Pleistocene Epoch | 2 million |
| **Tertiary Period** | |
| Pliocene Epoch | 5 million |
| Miocene Epoch | 24 million |
| Oligocene Epoch | 38 million |
| Eocene Epoch | 55 million |
| Palaeocene Epoch | 63 million |
| **Mesozoic Era** | |
| Cretaceous period | 145 million |
| Jurassic period | 205 million |
| Triassic period | 240 million |
| **Palaeozoic Era** | |
| Permian period | 290 million |
| Upper carboniferous period | 330 million |
| Lower Carboniferous period | 360 million |
| Devonian period | 410 million |
| Silurian period | 435 million |
| Ordovician period | 500 million |
| Cambrian period | 570 million |
| Pri-Cambrian period | 4.5 billion |

## BIOSPHERE

- The part of the Earth where life exists is called the **Biosphere** ('bios' means 'life').

## LITHOSPHERE

- The uppermost layer of the Earth's crust which is capable of supporting life is called Lithosphere.
- The Lithosphere (or land) covers two-sevenths or 29.22% of the total surface area of the Earth.

## HYDROSPHERE

- Hydrosphere (or sea) covers 70.70% of the total surface area of the Earth.
- Water is freely available in the gaseous, liquid and solid states.

## LATITUDE

- Latitude is the angular distance of a point on the Earth surface from the centre of Earth, measured in degree. These lines are called parallels of latitude and on the globe they are circles.
- The distance between any two parallels of latitude is always equal. One degree latitude = Approx 111 km.
- The most important lines of latitudes are Equator (0°), the Tropic of Cancer (23½°N), The Tropic of Capricorn (23½°S), the Arctic Circle (66½°N) and the Antarctic Circle (66½°S).

## LONGITUDE

- Longitude is the angular distance of a point on the Earth surface along the equator, east or west from the **Prime Meridian.**
- Prime Meridian is the semi-circle from pole to pole, from which all the other meridians radiate Eastwards and Westwards up to 180°.
- 180° meridian **(International Date Line)** is exactly opposite to the Prime Meridian. Such points are called anti-pedal points.

## LOCAL TIME (L) AND TIME ZONES

- The Indian Government has accepted the meridian of 82.5 degree east for standard time, which is 5 hours 30 minutes ahead of the Greenwich Mean Time.
- The Earth is divided into 24 longitudinal zones, each being 15 degree or 1 hour apart in time (360 degree = 24 hours, 360/24 = 15 degree in 1 hour) or 1 degree in 4 minute called Standard Time Zones.
- Russia has as many as 11 time zones.
- Both USA and Canada have five time zones.
  Longitudes are measured from zero to 18° east and 180° west (or 180°) and both 180° longitudes share the same line, in the middle of the Pacific Ocean.
- As the Earth rotates around its axis, at any moment one line of longitude "the noon meridian"–faces the Sun, and at that moment, it will be noon everywhere on it. After 24 hours the Earth has undergone a full rotation with respect to the Sun, and the same meridian again faces noon. Thus, each hour the Earth rotates by 360/24 = 15 degrees.

## INTERNATIONAL DATE LINE (IDL)

- The International Date Line (IDL) is an imaginary line on the surface of the Earth, that runs from the north to the south pole and demarcates one calendar day from the next.
- It passes through the middle of the Pacific Ocean, roughly following the 180° longitude but it deviates at Aleutian Islands, Fiji, Samoa and Gilbert Islands.
- The International Date line is on the opposite side of the Earth Prime Meridian.
- The Prime Meridian helps to define Universal Time and is the meridian from which all other time zones are calculated.
- A traveller crossing the International Date Line eastbound (i.e., from Japan to USA) subtracts one day or 24 hours, so that the calendar date to the west of the line is repeated after the following midnight.
- Crossing the IDL westbound results in 24 hours being added, advancing the calendar date by one day.

| | |
|---|---|
| Longest day in the Northern hemisphere | 21 June |
| Shortest day in the Northern hemisphere | 22 December |
| Equal day and night in the Northern hemisphere | 21 March and 23 September |
| Longest day in the Southern hemisphere | 22 December |
| Shortest day in Southern hemisphere | 21 June |
| Equal day and night in the Southern hemisphere | 21 March and 23 September |

## THE EARTH'S MOVEMENT

1. It rotates on its own axis from west to east once in every 24 hours. It causes day and night.
2. It revolves around the Sun in an orbit once in every 365 days. It causes the season and the year.

## ROTATION OF EARTH

- Spins on its imaginary axis from west to east in 23 hours, 56 minutes and 40.91 seconds.
- The rotational speed at equator is maximum (1967 km/hr) and then decreases towards the poles, where it is zero.

The rotation of the Earth has the following implications such as

1. Causation of day and night.
2. Change in the direction of winds and Ocean currents.
3. Rise and fall of **tides** everyday.
4. A difference of one hour between the two meridians which are 15° apart.

## REVOLUTION OF EARTH

- It is the Earth's motion in elliptical orbit around the Sun.
- It takes 365 days, 5 hours, 48 minutes and 45.51 seconds. The revolution of Earth results in:
  1. Changes of season.
  2. Variation of the length of the days and nights at different times of the year.
  3. Shifting of the wind belts.

## PERIHELION

- The position of the Earth or any other planet in its orbit when it is at its nearest point to the Sun.
- The Earth reaches its perihelion about 3rd January at a distance of about 147 million kilometres.

## APHELION

- The position of the Earth or any other planet in its orbit when it is at its distant point from the Sun.
- The Earth reaches its aphelion on 4th July when the Earth is at a distance of 152 million kilometres.

## SUMMER SOLSTICE

- On June 21, the Earth is so located in its orbit that the Sun is overhead on the Tropic of Cancer (23½°N).
- On this date the northern hemisphere is tipped towards the Sun having the longest day, while the southern hemisphere is tipped away from the Sun having the shortest day.

## WINTER SOLSTICE

- On December 22.
- The Sun is overhead on the Tropic of Capricorn (23½°S), resulting in the shortest day in the northern hemisphere.

## EQUINOXES

- Two days in a year when day and night are equal throughout the world are equinoxes.
- The 'vernal equinox' occurs on **March 21** and it is also called the **spring equinox** in the northern hemisphere.
- The **'autumnal equinox'** occurs on September 23.

## MIDNIGHT SUN

- This phenomenon is observed in the Arctic and Antarctic zones around mid-summer, when the Sun does not sink below the horizon throughout 24 hours of the day and therefore, may be seen at midnight.
- This is the direct consequence of the inclination of the axis of the Earth to the plane of the orbit.

## ECLIPSES

- A 'solar eclipse' occurs between Sun rays and new Moon when the Moon passes directly in front of the Sun so that its shadow lies on the Earth. In other words, the Moon lies between the Sun and the Earth.
- The 'lunar eclipse' takes place when the Earth comes in between the Sun and the Moon so that the shadow of the Earth is cast on the Moon.
- A lunar eclipse takes place on a full Moon.

**Specifics of the Earth**

| | |
|---|---|
| Age | 4.6 billion years |
| Mass | $5.9 \times 10^{-24}$ kg |
| Volume | $1083 \times 10^{12}$ km$^3$ |
| Mean Density | 5.513 g /cm$^3$ |
| Shape | Oblate spheroid or a geoid |
| Radius of Earth | 6400 km |
| Total surface area | 509700000 sq km |
| Land area (29%) | 148400000 sq km |
| Water area (71%) | 361300000 sq km |
| Rotation time | 23 hours, 56 minutes and 4.09 seconds |
| Revolution time | 365 days, 5 hours, 48 minutes and 45.51 seconds |
| Orbit speed about the Sun | 29.8 km/second |
| Mean surface temperature | 14°C |
| Mean distance from the Sun | 149,600,000 km |
| Inclination of polar axis from orbit plane | 23°26 min and 59 sec |
| Deepest Ocean point | 11,034 m, Marina Trench |

# INTERNAL STRUCTURE AND COMPOSITION OF THE EARTH

## THE EARTH'S CRUST

- The outermost solid cover or shell of the Earth is known as the Earth's **crust**.
- The thickness of the crust is about 30 km.
- The crust is the outermost and the thinnest layer of the Earth. This layer has the least density and its thickness varies about 8 to 40 km. **Mohorovicic Discontinuity** or Moho marks the lower limit of the crust.
- This layer is also called **Sial** (silica and aluminium). The average density of this layer is 2.7 gm/cm$^3$.
- It is thicker in the region of the continents and thinner in the region of the Ocean floors.
- The upper part of the crust consists of silica and aluminium in greater proportions. That is why, it is called **'Sial'.**
- Whereas the lower part of the crust is called 'Sima' because the proportion of silica and magnesium is higher in this part.

## THE MANTLE

- This layer is the intermediate layer of the Earth in terms of both its location and density.
- It is about 2900 km in thickness.
- It is divided into further two layers upper mantle and lower mantle. The upper part of the mantle is called the **Asthenosphere,** which is about 250 km thick.
- The mantle layer is also known as **Sima** (silica and magnesium).
- The average density of this layer is about 5.68 gm/cm$^3$.
- The transitional zone separating the mantle from the core is called the **Gutenberg Discontinuity.**

## DISCONTINUITIES

The various layers are separated by discontinuities, which are evident in seismic data.

1. Concord discontinuity lies between upper crust and lower crust.
2. Mohorovicic discontinuity lies between crust and montle.
3. Gutenberg discontinuity lies between core and mantle. Here the Earth's density as well as velocity of 'P' waves increases.
4. Lehman discontinuity divides upper core and lower core.
5. Repetti discontinuity lies between upper mantle and lower mantle.

## CORE

- The core is the innermost layer of the Earth and occupies its centre. It is about 3500 km in radius.
- The outer part of the core is believed to have the properties of a liquid and the innermost part of the core (about 1255 km in radius) may be called solid or crystalline.
- This layer is also known as **Nife** (nickel and iron).
- Temperature of the core is between 2200°C and 2750°C.
- Density of this part of the Earth is 17.2 gm/cm$^3$.

## COMPOSITION OF EARTH

- Made up of over 100 elements.

**Eight most Abundant Elements in the Earth Crust**

| | |
|---|---|
| Oxygen | 46.5% |
| Aluminium | 8.13% |
| Calcium | 3.63% |
| Potassium | 2.62% |
| Magnesium | 2.09% |
| Silicon | 27.72% |
| Iron | 5.01% |
| Sodium | 2.85% |

## CONTINENTAL DRIFT THEORY

- This theory was given by **Alfred Wagener,** in 1915, to explain the origin and evolution of the continents and the oceans.

1. According to this theory, about 250 million years ago, there was only one continent named pangea surrounded by one mass of waterbody named Panthalassa.
2. The present shape of the continents and Oceans is due to the break-up of Pangea.
3. The breaking process started about 200 million years ago.
4. The northern rifts cut pangea from east to west creating laurasia in the north and Gondwana land in south.

5. A shallow sea called tethys was situated between the laurasia and Gondwana land.

## SEA FLOOR SPREADING THEORY

- The concept of sea floor spreading was first formulated by **Harry Hess** in the year of 1960.
- According to this theory, the mid oceanic ridges were situated on the rising thermal convective current coming from mantle.
- The oceanic crust moves in opposite directions from mid oceanic ridges and thus there is continuous upwelling of new molten materials along the mid oceanic ridges. These molten masses cool down and solidify to form new crust.

## PLATE TECTONICS

- Plate tectonic is a scientific theory that describes the large-scale motions of Earth's lithosphere.
- The theory of Plate tectonics states that the lithosphere is divided into several rigid segments, which include both oceanic and continental crusts. These segments are called plates and they are moving on the asthenosphere, which is not a liquid, but a solid which flows under stress.
- About 20 such plates have been identified. There are seven major plates such as Eurasia, Antarctica, North America, Pacific, African and Indian Plates.

## PLATE MARGINS

Depending upon the type of movement, plate margins are of three types:

1. Divergent plate margin (Constructive margins)
2. Convergent plate margin (Destructive margins)
3. Parallel plate margin (Conservative margin or transform boundary)

- Collisions can occur between two oceanic plates, one oceanic and one continental plate or two continental plates.

## EXOGENETIC OR EXTERNAL FORCES

- The forces affecting the surface of the Earth from outside are called the external or exogenetic forces.
- **Weathering** and **Erosion** are the examples of external forces.

## ENDOGENETIC OR INTERNAL FORCES

- The forces originating in the interior of the Earth are called the internal or the endogenetic forces.
- **Volcanoes, Earthquakes** and **Landslides** are the examples of internal forces.

These forces are of two types:

### *Sudden Endogenetic Forces*

- Sudden endogenetic forces are the result of long period preparation deep within the Earth.
- But their cumulative effects on the Earth's furface are quick and sudden.

### *Diastrophic Forces*

- Diastrophic forces include both vertical and horizontal movements which are caused due to forces deep within the Earth. These diastrophic forces operate very slowly and their effects become discernible after thousands and millions of years.
- These forces, termed as constructive forces effect larger areas of the globe and produce meso level reliefs. For example, mountains, plateaus, plains, lakes, big faults etc.
- These diastrophic forces are further subdivided in two groups namely epirogenetic forces and orogenetic forces.

### *Epirogenetic forces*

- It causes upliftment and subsidence of continental masses through upward movements and are infact vertical movements. These forces and resultant movements affect larger parts of the continents.

### *Orogenetic forces*

- Orogenetic movement is caused due to endogenetic forces working in horizontal movement. Horizontal forces and movement are also called as tangential forces.
- Orogenetic or horizontal forces work in two ways, namely
  i. in opposite direction and
  ii. towards each other
- When it operates in opposite direction, called tensional force. Tensional force creates faulting, cracking and fracture. Tensional forces are also called as divergent forces.
- The forces when operate face to face, is called compression forces or convergent forces. Compression creates folding and wrapping.

# THE ROCK SYSTEM

- The **solid parts of the Earth's crust are called rocks.**
- Minerals are obtained from rocks.
- Rocks are classified in three main types depending on the process of their formation:
  (a) Igneous
  (b) Sedimentary
  (c) Metamorphic

## IGNEOUS ROCKS

- Hot lava pours out at the time of volcanic eruptions and cools down later on, forming rocks.
- The molten materials known as **magma** sometimes cool down beneath the Earth's crust, again forming rocks.
- Both these types of rocks are known as **igneous rocks**.
- Igneous rocks are generally **harder and granular**.
- There are no **layers** in igneous rocks.
- **Fossils** are **not found** in igneous rocks.
- Rocks formed by the cooling of molten matter beneath the Earth's surface are called **intrusive igneous**

**rocks**. 'Granite' and 'Gabbro' are the main examples of these rocks.
- Sometimes, the molten matter oozes out through cracks in the Earth's crust and spreads on the surface, forming **extrusive igneous rocks**.
- Gabbro, Obsidian, Basalt, etc. are examples of extrusive igneous rocks.
- A very large area of the Deccan Plateau consists of basalt rocks.
- These rocks contain silica from 40 to 80%.
- Other examples of igneous rocks are–Granite, Diorite, Dolerite, Punic stone, Basalt and Gabbro.

### SEDIMENTARY ROCKS

- They are formed by the deposition, sedimentation and lethification of sediments over a long period of time.
- Sometimes the remains of plants, dead animals etc. are found in the deposited material.
- Limestones, chalk, dolomite change to marble.
- Sandstone changes to quartzite.
- Granite changes to gneiss.
- Shale changes to slate.
- They are fossiliferous. About 75% of the surface area of globe is covered by the sedimentary rocks, but 95% of the crust is composed of igneous and metamorphic rocks.
- Sandstone, limestone, chalk, corals and shale are some examples of sedimentary rocks.

### METAMORPHIC ROCKS

- The nature of igneous and sedimentary rocks changes due to the effect of tremendous heat or pressure, and new, transformed rocks, called **metamorphic rocks,** are formed. Uranium is found in metamorphic rocks.
- The layers of sedimentary rocks hold all reserves of coal, oil and natural gas.

## EARTHQUAKES

- The sudden tremors or shaking of the Earth's crust is called an **Earthquake.**
- The Earth's crust is made up of different parts of various sizes. They are called plates.
- Most of the Earthquakes in the world are caused by the movements of the plates.
- **'Seismology'** deals with the study of Earthquake.
- **'Richter scale'** and **'Mercalli scale'** are the instruments to measure and record the magnitude and the **intensity** of an Earthquake respectively.

### SEISMIC WAVES

- The place where the seismic waves originate beneath the Earth's surface is called the **focus of the Earthquake.**
- The **epicentre** is that point on the ground surface which is closest to the focus.
- The waves generated by Earthquake are called seismic waves and they are classified into 3 types such as:
  i. **Primary Waves (P Waves):** These are the waves of short wavelength and high frequency. They are longitudinal waves and can travel through solid, liquid and gases.
  ii. **Secondary Waves (S Waves):** These are the waves of short wave length and high frequency. They are transverse waves, which travel through all solid particles only.
  iii. **Surface Waves or Long Waves (L Waves):** They are the waves of long wavelength, confined to the skin of the Earth's crust. It causes most of the Earthquake's structural damage.

### SHADOW ZONES

- There are some specific areas where Earthquake waves do not occur or occur rarely, such areas are termed as shadow zones.
- They are located between 105° and 140° from epicentre.

### THE EARTHQUAKE ZONES IN INDIA

- The Indian plate is moving from south to north. That is why there are Earthquakes in the Himalayan regions.

### VOLCANOES REALSCAPE

- There are three types of Volcanoes:
  i. Active Volcanoes
  ii. Dormant Volcanoes
  iii. Extinct Volcanoes

### DISTRIBUTION OF EARTHQUAKES

Most of the world Earthquakes occur in:
- The zones of young fold mountain.
- The zones of lodging and faulting.
- The zone of junction of continental and oceanic margin.
- The zone of active volcanoes.
- Along different plate boundaries.

### THE TRADITIONAL ZONES OF EARTHQUAKES

- Circum-Pacific belt
- Mid-Continental belt
- Mid-Atlantic belt

## VOLCANISM

Volcanic eruptions are closely associated with several integrated processes such as:
- Gradual increase in temperature with increasing depth, due to the heat generated by degeneration of radioactive elements inside the Earth.

- Origin of magma due to the lowering of the melting point caused by reduction in pressure of overlying rocks due to fractures caused by splitting of plates.
- Ascent of magma due to pressure from gases and vapour.
- The pouring out of the magma or molten rock through ground surface is called a **volcanic eruption.**
- At the time of eruption, the magma, steam, fragments of rock, dust and gaseous substances are ejected with great force from under the ground surface through a pipe like passage.
- The opening of this pipe on the Earth's surface is known as the vent which forms a **crater**.

## TYPES OF VOLCANIC ERUPTIONS

- Volcanic eruptions are classified into two types depending on the manner of ejection of the magma:
  i. Central eruption
  ii. Fissure eruption

## CENTRAL ERUPTION

- This type of eruption is sometimes very explosive, because lava, steam, gas, dust, smoke, stone fragments are ejected from a narrow pipe from under the ground with greater intensity. This type of eruption gives rise to conical or dome-shaped hills. Some examples of volcanic mountains formed due to central eruption are **Mt. Kilimanjaro** in Africa, the **Fujiyama** in Japan and the **Vesuvius and Mount Etna** in Italy.

## FISSURE ERUPTION

- A very long fissure (cracks) develops in the ground surface and so, the molten rock, rock fragments, steam and gases within, pour out slowly.
- These eruptions take place at a very slow speed.
- Basalt plateaus are formed due to these eruptions.
- In Maharashtra, the fertile black regur soil has been formed from basalt rocks. It is also called **black cotton soil.**

| Types of Volcanoes | |
|---|---|
| Active volcano | Volcanoes which errupt periodically e.g., Etna (Sicily), Stramboli (Lepari Island), Mayon |
| Dormant volcano | Volcanoes which become quiet after their eruption for some time e.g., Fujiyama (Japan), Krakatoa (Indonesia), Vesuvius (Italy). |
| Extinct volcano | They have no indication of future eruption |

## VARIOUS VOLCANIC BELTS

- **Circum-Pacific Belt** (*Fire girdle of the Pacific or the fire ring of the Pacific*): It extends across the Kamchatka Peninsula, Kurile Islands, the Islands of Japan, Philippines, New Guinea, New Zealand and the Solomon Islands. Highest volcanic peaks—Cotapaxi (South America), Fujiyama (Japan), Valley of ten thousand smokes (Alaska).
- **Mid-continental Belt:** Volcanic zones of convergent continental plate margins. It includes volcanoes of alpine mountain chain, the mediterranean sea and fault zone of eastern Africa of stramboli, Vesuvius, Etna, Kilimanjaro etc.
- **Mid-Atlantic Belt**, in which the volcanoes are fissure eruption type. e.g., Iceland, Canary Island, Cape Verde, Azores etc.

## WEATHERING

- It is the process of disintegration or decomposition of rocks situated on Earth's surface by natural agents. It is a static process.
- **Physical weathering:** It involves rocks disintegration without any change in the chemical constituents of the rocks.
- The factors responsible for physical weathering are temperature change, crystallisation of water into ice, the pressure release mechanism.
- **Chemical weathering:** It involves the decomposition due to chemical changes. There are various chemical processes which cause chemical weathering such as solution, oxidation, carbonation, hydration and hydrolysis.

| Process | Mechanism of Chemical Weathering |
|---|---|
| Solution | It involves the dissolution of soluble particles and minerals from the rocks with the help of water. |
| Oxidation | It represents addition of oxygen to form oxides. |
| Hydration | It is the process of addition of water to the minerals. |
| Carbonation | It is the reaction of carbonate or bicarbonate ions with minerals. |
| Hydrolysis | It is the process wherein both minerals of rocks and water molecules decompose and react in such a way that new mineral compounds are formed. |

- **Biological weathering:** Plants and animals, including man, largely control it.

## EROSION

- It involves removal of rock material and then transportation of it.

# Landforms and Their Evolution

## MOUNTAINS

- Mainly there are three types of landforms–Mountains, Plateaus, and Plains.
- The height of mountains is over 600 metres and these have conical peaks. On the basis of origin there are four types of mountains; Block Mountains, Residual Mountains, Accumulated Mountains and Fold Mountains.

### BLOCK MOUNTAINS

- They are formed when great block of Earth's crust may be raised or lowered due to tectonic activities.
- When the Earth's crust cracks due to tension or compression, faulting takes place.
- Examples of Block Mountain: Narmada, Tapti and Damodar valley in India, the Vosges in France, Salt Range in Pakistan and Block forest (Rhine valley) in Germany.

### VOLCANIC MOUNTAINS

- They are formed due to the accumulation of volcanic material.
- It is also called Mountains of Accumulation.
- Examples: Mt. Fuji (Japan), Cotopaxi in Andes, Vesuvius and Etna in Italy, Mt. Mayon (Philippines), Kilimanjaro in Africa, Mt. Merapi in Sumatra etc.

### RESIDUAL OR DISSECTED MOUNTAINS

- They are formed as a result of erosion of plateaus and high plains by various agents of erosion.
- Examples: Catskill mountains of New York. Nilgiri, Parasnath, Girnar and Rajmahal, Vindhyachal ranges, Aravallis, Satpura, Eastern and Western Ghats of India.

### ACCUMULATED MOUNTAINS

- These are formed due to accumulation of sand, soil, rocks, lava, etc. on the Earth's crust, e.g., sand dunes.

### FOLD MOUNTAINS

- It is formed due to the compressive forces generated by endogenetic forces (Earthquake, landslide, etc.).
- Examples of fold mountains are Himalayas, Alps, Andes, Rockies, Atlas, etc.

(a) **Young/New Fold Mountains:** It came into existence after the continental drift. Himalayas are regarded as the youngest mountains in the world.

(b) **Old Mountains:** They belong to pre-drift era, then subject to denudation and uplift, e.g., Aravallis (India), etc.

**Major Mountain Ranges**

| Range | Location | Length (km) |
|---|---|---|
| Andes | South America | 7200 |
| Himalayan Karakoram and Hindukush | South Central Asia | 5000 |
| Rockies | North America | 4800 |
| Great dividing range | East Australia | 3600 |
| Atlas | North West Africa | 2500 |
| Caucasus | Europe | 1200 |
| Alaska | USA | 1130 |
| Alps | Europe | 1200 |

## PLATEAUS

- Generally the height of plateau ranges from 300 to 500 feet.
- Tibetan plateau (5000 m) is the highest plateau in the world.
- **Tectonic Plateau:** These are formed by Earth movements, which cause uplift and are normally of a considerable size and fairly uniform altitude.
- When plateaus are enclosed by fold mountains, they are known as Intermont Plateau.
- Examples of Tectonic Plateau are: Tibetan Plateau between the Himalayas and the Kunlun and the Bolivian Plateau between two ranges of the world.

### VOLCANIC PLATEAU

These are formed by accumulation of lava, e.g., Deccan Plateau (India).

### DISSECTED PLATEAU

Through the continual process of weathering and erosion by running water, ice and winds, high

extensive plateau are gradually worn down, and their surface made irregular. For example is the Scottish Highlands.

### INTERMOUNTAINOUS PLATEAU

Plateau formed between mountains, Example: Tibetan Plateau.

### MOUNTAINSTEP PLATEAUS

The flat region between a plain and the base of a mountain.

### CONTINENTAL PLATEAUS

These are formed when the Lacolith inside the Earth comes to the surface due to weathering, e.g., the Southern Plateau.

| Plateau | Location |
|---|---|
| Tibetan Plateau | Between Himalayas And Kunlun Mountains |
| Deccan Plateau | Southern India |
| Arabian Plateau | Southwest Asia |
| Plateau of Mexico | Mexico |
| Plateau of Colombia | U.S.A. |
| Plateau of Madagascar | Madagascar |
| Plateau of Alaska | Northwest North America |
| Plateau of Bolivia | Andes Mountains |
| Great Basin Plateau | South of Colombia Plateau U.S.A. |
| Colorado Plateau | South of Great Basin Plateau U.S.A. |

### DOMELIKE PLATEAU

These are formed due to the movement of man and animals on the surface, e.g., Ramgarh Plateau.

## PLAINS

Plains can be defined as flat area with low height (below 500 ft.).

### CLASSIFICATION OF PLAINS

1. **Structural plains:** Formed due to the uplift of a part of the sea floor e.g., the great plains of U.S.A.
2. **Erosional plains:** Formed when the elevated tract of land is worn down to a plain by the process of erosion e.g., plain of north Canada.
3. **Depositional plains:** Formed by filling up of sediments into depressions along the foothills, lakes and seas e.g Indo-Gangetic plain.

### WEATHERED PLAINS

The plain formed due to weathering by rivers, glaciers, winds, etc.

### LOESS PLAINS SETYS

These are formed by the soil and sands brought by winds.

### KARST PLAINS

Plains formed due to the weathering of limestone.

### EROSIONAL PLAINS

Plains near the river banks formed by river erosion.

### GLACIAL PLAINS

Marshy plains formed due to the deposition of ice.

### DESERT PLAINS

These are formed as a result of the flow of rivers.

### DEPOSITION PLAINS

Large plains are formed due to the silt brought by the rivers.

## ATMOSPHERE

- The atmosphere extends to about 1000 km from the surface of the Earth. But 99% of the total mass of the atmosphere is found within 32 km.

### COMPOSITION OF THE ATMOSPHERE

(i) Nitrogen–78%, (ii) Oxygen–21%, (iii) Argon–0.93%, (iv) Carbon dioxide–0.03%, (v) Neon–0.0018%, (vi) Helium–0.0005%, (vii) Ozone–0.006%, (viii) Hydrogen–0.0005%.

- **Water vapour** is the most significant component of the atmosphere as far as its effect on weather is concerned although its quantity varies considerably from practically none (0) to up to about 4% by volume.
- **Dust** intercepts and reflects incoming insolation.
- Dust in the atmosphere contributes to the red and orange colour of Sunrise and Sunset.

## STRUCTURE OF THE ATMOSPHERE

There are five distinct layers of the atmosphere– (a) Troposphere, (b) Stratosphere, (c) Mesosphere, (d) Thermosphere, and (e) Exosphere.

### TROPOSPHERE

- This is the **first layer** of the atmosphere. It extends to a height of **18 km at the equator and 8 km at the poles**.

- In this layer temperature decreases with height. It contains more than 90% of gases in the atmosphere.
- At every **165 m,** there is a drop of 1°C (or 6.4°C per km). This is called **Normal Lapse Rate of Temperature**.
- **Tropopause** separates Troposphere from Stratosphere.
- **All weather phenomena** such as condensation, precipitation and storms, etc. occur in the troposphere only.
- The height at which the temperature stops decreasing is called **Tropopause.** Here the temperature may be as low as **–58°C**.

## STRATOSPHERE

- The Stratosphere extends up to about 50 km, where **Stratopause** separates it from the mesosphere.
- In this layer, the temperature increases with increase in height. This phenomenon is known as **temperature inversion**.
- The temperature rises in this layer from about 60°C at Stratopause.
- The part of the stratosphere, in which there is a concentration of ozone, is often called **Ozonosphere.**
- This is the **second layer** of the atmosphere. It extends from the Tropopause to about **50 km**.
- Temperature increases due to the absorption of the **ultraviolet radiation** of the Sun by **ozone** present in this layer.
- It provides idle flying conditions for large jet planes.
- The end of the Stratosphere is called the **Stratopause.**

## MESOSPHERE

- Above the stratosphere lies the mesosphere.
- The mesosphere extends to a height of **80 km**.
- Here the temperature decreases again, falling as low as **–90°C**.
- The end of this layer is known as the **Mesopause.**
- It is considered the coldest layer of the atmosphere.

## IONOSPHERE

- Ionosphere is located above the mesosphere and extends up to about 600 km.
- This layer is also called as ionosphere because it contains electrically charged ions that reflect the radio waves back to the Earth thus making radio communication possible.

**Thermosphere**

- The zone between the 85 km and 400 km above the surface is often called thermosphere. In this layer, the temperature increases with increasing altitude.
- The upper part of the thermosphere contains only the lighter gases like helium and hydrogen.

## EXOSPHERE AND MAGNETOSPHERE

- The outermost part of the atmosphere of the Earth is called exosphere.
- This zone of the atmosphere extends up to a height of about 900 km.
- The outer part of the exosphere is called magnetosphere.

## CHEMICAL COMPOSITION OF THE ATMOSPHERE

- **Homosphere up to 90 km:** In this region, the proportion of various constituents is same throughout.
- **Heterosphere:** The recent data from the satellite studies suggested that beyond about 100 km the lightest gases separate out, forming several concentric layers around the Earth.

**Greenhouse Gases and Global Warming**

- The primary greenhouse gases in the Earth's atmosphere are water vapour, carbon dioxide, methane, nitrous oxide and ozone.

- **Global Warming** is the increase of Earth's average surface temperature due to effect of greenhouse gases, such as carbon dioxide emissions from burning fossil fuels or from deforestation. This is a type of greenhouse effect.

**Montreal Protocol on Substances that Deplete the Ozone Layer**

- It is an international treaty designed to protect the ozone layer from man-mae chemicals referred to as Ozone-Depleting Substance (ODS) such as chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs).

**Kyoto Protocol**

- The Kyoto protocol is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC), aimed at fighting global warming by decreasing greenhouse gas concentrations in the atmosphere.
- The protocol was initially adopted on December 11, 1997 in Kyoto, Japan and entered to force on February 16, 2005.

## INSOLATIONS

- Solar radiation that is intercepted by the Earth is known as Insolation.
- Insolation is measured with the help of **Pyronometers.**
- The Earth's surface does not absorb all the energy that it receives. The proportion of the solar radiation reflected from the surface is called **Albedo.**

## EARTH'S HEAT BUDGET

- The Earth receives energy continuously from the Sun, its temperature is almost constant except the long term climate changes. This is because the atmosphere loses an amount of heat equal to the gain through insolation. This mechanism of maintaining the same temperature by the atmosphere is called the Head Budget or **Heat Balance.**
- If 100 units of energy reach the top of the atmosphere of the Earth, 14 units are absorbed directly by

the atmosphere and 35 units are lost to space through reflection.
- The remaining 51 units reach the Earth's surface and absorbed by the Earth due to which the surface gets heated.

## TERRESTRIAL RADIATION

- The Sun's energy absorbed by the Earth's surface when radiated out into space is called **terrestrial radiation.**

# WEATHER AND CLIMATE

- **Weather** is the description of the atmospheric conditions of a particular place at **a particular time for a short period of time.**
- **Climate** is the composite or integrated picture of the weather conditions over a long period of time.

## ATMOSPHERIC PRESSURE

- Atmospheric pressure is the pressure at any point on the surface of the Earth due to the weight of the column of air above that point.
- Air is an extremely compressible gas having its own weight. The pressure exerted by air due to its weight is called atmospheric pressure on the Earth's surface.

## INFLUENCE ON THE ATMOSPHERIC PRESSURE

**Altitude:** Air pressure increases, when air descends due to the decrease in volume.

**Temperature:** The pressure of air rises, when its temperature falls.

## THE GLOBAL PRESSURE BELTS

### *Equatorial Low Pressure Belt*

- It is located on either side of the geographical equator in a zone extending between 5°N and 5° S.
- It is thermally induced because of the intense heating of the ground surface by the almost vertical Sun rays.
- It represents the zone of convergence of north east and south east trade winds.
- This convergence zone is characterised by light and feeble winds and because of the frequent calm condition this belt is called as a belt of calm or doldrums.

### *Subtropical High Pressure Belt*

- It extends between 30° to 35° in both the hemispheres.
- This zone of high pressure is also called as horse latitude.
- It is dynamically induced as it owes its origin to the rotation of the Earth and sinking and setting down of winds.

### *Subpolar Low Pressure Belt*

- It extends between 60° to 65° in both the hemispheres.
- The low pressure belt does not appear to be thermally induced because there is low temperature throughout the year and as such there should have been high pressure belt instead of low pressure belt. Thus it is dynamically induced.

### *Polar High Pressure Belt*

- High pressure persists at the poles throughout the year because of the prevalence of very low temperature all the year round.

## MEASUREMENT AND UNITS OF ATMOSPHERIC PRESSURE

- The **mercury barometer** is the standard instrument for measuring atmospheric pressure.
- **Standard sea level pressure is 76 km of 29.92 inches on this scale.**
- Orica atmospheric pressure (76 cm of mercury) = 760 mm of Hg = 1013.25 millibars (mb).

## ISOPLETH

Line drawn on map along which the value of a particular phenomenon is uniform.

**Some Important Isopleths**

| Isopleth | Reaction |
|---|---|
| Isobar | Equal Pressure |
| Isohaline | Salinity |
| Isohypse | Elevation above Sea |
| Isoneph | Cloudiness |
| Isobaths | Equal depth in Sea |
| Isohels | Sunshine |
| Isonif | Snow |
| Isocline | Slope |
| Isobronts | Thunderstorm at the same time |
| Isohyets | Rainfall |
| Isotherms | Temperature |
| Isodapane | Equal transportation cost |

# WINDS

- Wind is the movement of air caused by the uneven heating of the Earth by the Sun.

## WINDS SYSTEM

- The air moves from high pressure to low pressure.
- The imaginary line joining the points having same pressure is called **isobars**.
- The winds blowing parallel to the isobars generally at the height of 600 m is called geotropic winds.

The factors that control the air motion are as follows:
- Pressure gradient
- Rotation of Earth and corriolis force
- Centrifugal force.

## WINDS DIRECTION AND RELATED LAWS

- The Coriolis force generated due to the rotation of Earth acts as a deflective force to the wind direction.
- Because of the Coriolis force, all the winds are deflected to the **right in the Northern Hemisphere** while they are deflected to the **left in the Southern Hemisphere** with respect to the rotating Earth. This is referred to as **Farrell's Law**.
- The Coriolis force is absent along the equator, but increases progressively towards the poles.

## PRIMARY MOVEMENT (PERMANENT WINDS)

- Trade winds
- Polar winds
- Westerllies

## SECONDARY MOVEMENT

- **Cyclone:** Tropical and temperate, thunder-storms and tornado
- Anticyclone
- Seasonal wind i.e. monsoon
- Tertiary movement.

# PRIMARY WIND MOVEMENTS (PERMANENT WINDS)

## TRADE WINDS

- They blow from the Sub-tropical High Pressure Belt to the Equatorial Low Pressure Belt in the tropics between **30° North and 30° South latitudes**.
- They blow as the **N.E. Trades** in the Northern Hemisphere and as the **S.E. Trades** in the Southern Hemisphere.

## WESTERLIES

- They blow from the Sub-tropical High Pressure Belt to the Sub-polar Low Pressure Belt in the temperate latitudes between **30° and 60°, on either side of the Equator**.
- They are more constant and stronger in the Southern Hemispheres because there are **no large landmasses** to interrupt them.
- In places they become so strong that these winds are known as the **Roaring Forties** or the **Brave West Winds** and the **Furious Fifties**.

## POLAR WINDS

- They blow from the Polar High Pressure Belt to the Sub-polar Low Pressure Belt between latitudes 60° and the poles on both sides of the Equator.
- These winds blow from the east to form the Polar Easterlies.

# SECONDARY WIND MOVEMENTS (PERIODIC WINDS)

## CYCLONES

- Cyclones are the centres of low pressure having increasing pressure outward and closed air circulation from outside towards the central low pressure in such a way that air blows inward in anti-clockwise direction in the northern hemisphere.
- Air blows inward in clockwise direction in the Southern hemisphere.

  Cyclones are mainly of two types: 1. Tropical cyclones, 2. Temperate cyclones.

### *Tropical cyclones*

- They are found in the trade wind belt between 8°–20° north and south.
- They travel from east to west in the easterly wind belt.
- Tropical cyclones are much smaller with a diameter of about 200 to 500 km.
- They are formed only in the summer.

### *Temperate cyclones*

- Normally found between 30°–65° north and south in the sub polar frontal zone, where cold polar air mass meets the warm tropical mass.
- They move from west to east embedded in the westerly wind belt.
- They form over much large area with the diameter 300 to 1500 km.
- Temperate cyclones are frontal in nature.
- They are formed either over oceans or over the continents.

### *Anticyclone*

- They are the wind system, which has the highest air pressure at the centre and lowest at the outer margins surrounded by circular isobars where wind blows:
  - from centre to outward in clockwise direction in northern hemisphere.
  - from centre to outward in anti-clockwise direction in southern hemisphere.
- They are generally associated with rainless fair weather and that is why they are called 'weatherless phenomena'.

## THUNDERSTORMS

- Thunderstorms are local storms characterised by swift upward movements of air and heavy rainfall with cloud thunder and lightening.
- Structurally, thunderstorms consist of several convective cells, which are characterised by strong updrift of air.

## TORNADO

- Tornadoes are very strong tropical cyclones of smaller size. In the Mississippi Valley (US), they are called **Twisters.**

# TERTIARY WIND MOVEMENT (LOCAL WINDS)

## LOCAL WINDS

- **Chinook**–Hot, dry wind in Rockies, also called 'Snow eater'
- **Foehn**–Hot, dry wind in Alps
- **Khamsin**–Hot, dry wind in Egypt
- **Sirocco**–Hot, Moist wind from Sahara to Mediterranean Sea
- **Solano**–Hot, moist wind from Sahara towards Iberian Peninsula
- **Harmattan**–Hot, dry wind blowing outwards from the Interior of west-Africa, also called 'Guinea Doctor'
- **Boro**–Cold dry Wind blowing outwards from Hungary to the North of Italy
- **Mistral**–Very cold wind, which blows down from the Alps over France
- **Punas**–Very cold dry wind blowing down towards the western side of Andes.
- **Brickfielder**–hot wind in Australia
- **Purga**–Cold wind in Russian Tundra
- **Levanter**–Cold wind in Spain
- **Norwester**–Hot wind in New zealand
- **Santa Ara**–Hot wind in Southern California in U.S.A.

## CLIMATIC WINDS OR PERIODIC WINDS

- Land and sea breeze and the Monsoon winds are typical examples of periodic winds.

## JET STREAM

- The strong and rapidly moving circumpolar westerly air circulation in a narrow belt of a few hundred kilometres width in the upper limit of troposphere is called Jet Stream.
- The extent of jet streams narrows down during the summer season because of their northward shifting while these extend up to 20° north latitude.

## HUMIDITY

- Humidity of air refers to the contents of the water vapour present in the air at a particular time and place.
- Humidity is measured by an instrument called hygrometer.
- **Absolute humidity:** The total weight of moisture content per volume of air at definite temperature is called absolute humidity.
- **Specific humidity:** The mass of the water vapour in grams contained in a kilogram of air and it represents the actual moisture present in a definite air.
- **Relative humidity:** It is the ratio of the amount of water vapour actually present in the air having definite volume and temperature to the maximum amount the air can hold.
- **Condensation** is the change of physical state of matter from gaseous phase into liquefied phase and is the reverse of **vapourisation**.
- When the relative humidity reaches 100% the air is completely saturated. The air temperature is said to be **dew-point**.
- **Smog** (Smoke + Fog) is a form of fog that occurs in areas, where the air contains a large amount of smoke.
- **Fog** is made from the droplets of water suspended in the lower layer of the atmosphere.

# CLOUDS

- Clouds are a mass of small water droplets or tiny ice crystals.

**There are four groups of clouds:**

i. High clouds 6000 m to 12000 m
ii. Middle clouds 2100 m to 6000 m
iii. Low clouds below 2100 m
iv. Clouds of great vertical extent 1500 to 9000 m

## TYPES OF CLOUDS

### *High Clouds*

- **Cirrus:** Cirrus composed of small ice crystals, white wispy and fibrous in appearance.
- **Cirro Cumulus**: Composed of ice crystals, but globular or rippled in appearance.

### *Middle Clouds*

- **Alto Cumulus:** Composed of water droplets in layers and patches.
- **Alto Stratus:** Composed of water droplets forming sheets of grey or watery looking clouds.

### *Low Clouds*

- **Strato Cumulus:** Large globular masses, bumpy looking, soft and grey in appearance forming a pronounced regular and sometimes wavy pattern
- **Nimbo Stratus:** Dark grey and rainy looking, dense and shapeless, often gives continuous rains.

### *Great Vertical Extent*

- **Cumulus:** Round topped and flat based forming a whitish grey globular mass, consists of individual clouds units.
- **Cumulo Nimbus:** They have great vertical extent, white or black globular masses, whose rounded tops often spread out in the form of anvil. It is characterised by convectional rain, lightening and thunder.

## PRECIPITATION

- **Convectional Rainfall:** It occurs due to thermal convection currents caused due to insolational heating of ground surface.

- **Frontal Rainfall:** It occurs due to upward movement of air caused by convergence of cold air masses against warm air masses.
- **Cyclonic Rainfall:** When the air is caused to rise upward due to cyclonic circulation, the resulting precipitation is called cyclonic rainfall.

## CLIMATE

Weather refers to the sum total of the atmospheric conditions in terms of temperature, pressure, wind moisture, cloudiness, precipitation and visibility.

### World Climate Types

| Climatic Zone | Climate Type | Rainfall | Natural Vegetation |
|---|---|---|---|
| Equatorial zone 0°–10° N and S | 1. Hot, wet equatorial | Rainfall all the year (80 inches) | Equatorial rain forest |
| Hot zone 10°–30° N and S | 2 (a) Tropical Monsoon<br>(b) Tropical marine | Heavy summer rain (60 inches) | Monsoon forest |
| | 3. Sudan type | Rain mainly in summer (70 inches) | Savana (tropical grassland) |
| | 4. Desert type<br>(a) Saharan type<br>(b) Mid latitude type | Little rain (5 inches) | Desert vegetation scrub |
| Warm temperate zone (30°N–45°S) | 5. Western margin (mediterranean type) | Winter rain (35 inches) | Mediterranian forests |
| | 6. Central continental type (steppe type) | Light summer rain (20 inches) | Steppe temperate grassland |
| | 7. Eastern margin<br>(a) China type<br>(b) Gulf type<br>(c) Natal type | Heavier summer rain (45 inches) | Warm wetforest and bamboo |
| Cool temperate zones (45°N–65°S) | 8. Western margin | Rain in autumn and winter (30 inches) | Deciduous forests |
| | 9. Central continental (siberian type) | Light summer rain (25 inches) | Coniferous forests |
| | 10. Eastern margin (laurition type) | Moderate summer rain (40 inches) | Mixed forests coniferous and deciduous. |
| Cold zone | 11. Arctic or polar | Very light summer rain (10 inches) | Tundra mosses |
| | 12. Mountain climate | Heavy rainfall variable | Alpine fern coniferous |

## FORESTS

They are of the following types:

(a) **Tropical Evergreen Rain Forests:** Such forests are found in the equatorial and the tropical regions with more than 200 cms annual rainfall. The leaves of trees in such forests are very wide. Examples: Red wood, palm, etc.

(b) **Tropical Semi-Deciduous Forests:** Such forests receive rainfall less than 150 cms. Saagwan, saal, bamboo, etc. are found in such forests.

(c) **Temperate Mixed Forests:** Such forests are a mixture of trees and shrubs. Corks, oak, etc are the major trees of these forests.

(d) **Coniferous Forests or Triga:** These are evergreen forests. The trees in these forests have straight trunk, conical shape with relatively short branches and small needle like leaves. Example: Pine, Fir, etc.

(e) **Tundra Forests:** Such forests are covered with snow. Only Mosses, a few sledges and Lichens grow here in the summer.

(f) **Mountainous Forests:** Vegetation varies according to altitude.

## FAMOUS GRASSLANDS OF THE WORLD

| Grassland | | Countries |
|---|---|---|
| Steppe | – | Eurasia |
| Prairie | – | U.S.A. |
| Pampas | – | Argentina |
| Veld | – | South Africa |
| Downs | – | Australia |

# HYDROSPHERE

## OCEANS

- There are four oceans. In order of their size, they are: Pacific Ocean, Atlantic Ocean, Indian Ocean and Arctic Ocean.

## PACIFIC OCEAN

- It is the **deepest Ocean** with an average depth of 4,200 m.
- The **Mariana Trench** is the world's deepest trench with a depth of 11,033 metres (36,201 feet).
- Most of the islands of this Ocean are of **volcanic or coral origin.**

## ATLANTIC OCEAN

- The Atlantic Ocean has the **longest coastline.**
- The Atlantic Ocean is the **busiest Ocean for trade and commerce**.
- The Atlantic Ocean was formed millions of years ago when a rift opened up in the Gondwanaland and the continents of South America and Africa separated. The separation continues even today and the Atlantic Ocean is **still widening**.

## INDIAN OCEAN

- The Indian Ocean is **deeper than the Atlantic Ocean**.
- It contains numerous continental islands; **Madagascar** and **Sri Lanka** are being the largest ones.
- Some of the islands of volcanic origin are those of **Mauritius, Andaman** and **Nicobar, Seychelles, Maldives and Lakshadweep** are of coral origin.

## ARCTIC OCEAN

- It lies within the Arctic Circle, hence the name **Arctic Ocean**.
- The **North Pole lies in the middle** of the Arctic Ocean.
- Most of the parts of Arctic Ocean **remain frozen** with thick ice for most of the days every year.
- It is the **shallowest** of all oceans, with an average depth of 1,500 m.
- It has lower salinity than all other oceans.

### Trenches and their Location

| Trench | Location | Depth |
|---|---|---|
| Mariana Trench | Western Pacific Ocean (Near Philippines and Japan) | 10,911 m |
| Tonga Trench | Southern Pacific Ocean (Near New Zealand) | 10,882 m |
| Kuril-Kamchatka Trench | Northern Pacific Ocean | 10,542 m |
| Philippine Trench | Philippine Sea | 10,540 m |
| Kermadec Trench | Southern Pacific Ocean (Near New Zealand) | 10,047 m |

# RELIEF OF THE OCEAN BASIN

## CONTINENTAL SHELF

- The shallow submerged extension of the continent is called the continental shelf.
- Extends to a depth of 100 fathoms (1 fathom =1.8 m).
- Average width 70 km; average slope 17 feet mile or about 1°.
- Continental shelf covers 7.5% area of the oceans. It extends over 13.3% of the Atlantic Ocean, 5.7% of Pacific Ocean and 4.2% of Indian Ocean.

## CONTINENTAL SLOPE

- Extends seawards from the continental shelf.
- Depth is 200–2000 fathoms (3660 m)
- Average slope is 210.5 degrees.

## CONTINENTAL RISE

- Continental rise is an area at the foot of the slope, slightly rising due to the accumulation of debris transported over the slope.
- Oil deposits occur here.
- Average slope –0.5° to 1°.

## ABYSSAL OR THE DEEP SEA PLAINS

- It is the deepest and most extensive part of the oceanic floor.
- It covers about 75.9% of total oceanic area.
- Average depth 3000 m to 6000 m.

## DEEPS/TRENCHES

- Trenches are narrow and steep sides of depressions.
- Marina Trench (challenger deep) is the deepest trench in the world situated in the NW Pacific Oceans, near Philippines. It is more than 11 km deep.

## OCEANIC RIDGES

- Oceanic Ridges are formed by the volcanic activity along the spreading boundary of plates.