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World Physical Geography

CONTENTS

ORIGIN OF THE UNIVERSE

The Big Bang

- The Big Bang Theory is the most well-liked explanation for how the cosmos came into being.
- It is also known as the expanding universe hypothesis.
- In 1920, Edwin Hubble presented proof that the cosmos is expanding.
- The distances between galaxies increase over time. Similar to how the distance between galaxies is increasing, the universe is thought to be expanding. Despite the fact that the distance between galaxies is growing, scientists contend that the evidence for galaxy expansion is lacking.

The following stages in the evolution of the universe are taken into account by the Big Bang Theory.

- In the beginning, the universe's constituent parts were all present in a single location as a **"little ball" (Single atom)** with an unfathomably small volume, an infinite temperature, and an infinite density.
- The **"tiny ball"** erupted furiously at the **Big Bang.** Huge expansion resulted from this. The big bang event, which occurred **13.7 billion years ago**, is now largely acknowledged. Even today, there is still expansion going on. Some energy was changed into matter as it expanded. Immediately following the boom, there was an especially quick expansion. After that, the expansion slowed down. After the Big Bang event, within the first three minutes, the first atom began to form.
- Increased distance between galaxies results from the universe's expansion.
- Hoyle's idea of steady state offered an alternative to this. It believed that at all times, the universe was essentially the same. However, as more proof of the universe's expansion becomes available, the scientific community is currently in favour of this theory.

Early Theories

Nebular Hypothesis

- One of the earlier and popular arguments was by German philosopher Immanuel Kant. Mathematician Laplace revised it in 1796. It is known as Nebular Hypothesis.
- The hypothesis considered that the planets were formed out of a cloud of material associated with a youthful sun, which was slowly rotating.

In 1950, Otto Schmidt in Russia and Carl Weizascar in Germany somewhat revised the 'nebular hypothesis', though differing in details.

They considered that the sun was surrounded by solar nebula containing mostly the hydrogen and helium along with what may be termed as dust. The friction and collision of particles led to formation of a disk-shaped cloud and the planets were formed through the process of accretion.

Chamberlain and Moulton theory

Later in 1900, Chamberlain and Moulton considered that a wandering star approached the sun. As a result, a cigar-shaped extension of material was separated from the solar surface. As the passing star moved away, the material separated from the solar surface continued to revolve around the sun and it slowly condensed into planets.

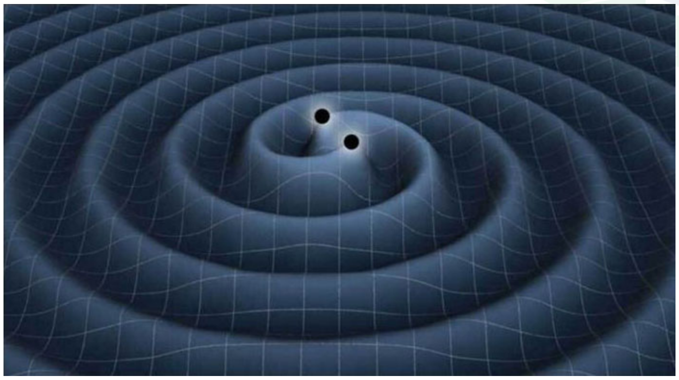
Binary theories

Sir James Jeans and later Sir Harold Jeffrey supported

Chamberlain and Moulton argument. At a later date, the arguments considered of a companion to the sun to have been coexisting. These arguments are called binary theories.

Gravitational Waves

- Gravitational waves are '**ripples**' in space-time that are produced by some of the Universe's most ferocious and intense phenomena.
- With knowledge about their beginnings, these ripples move through the universe at the speed of light.
- **In 1916, Albert Einstein** foresaw gravitational waves in his general theory of relativity.
- He saw that huge speeding objects, such neutron stars or black holes orbiting one another, would warp space-time in a way that would cause "**waves**" of distorted space to radiate from the source (like the movement of waves away from a stone thrown into a pond).
- The **USA's Laser Interferometer Gravity-Wave Observatory, or LIGO,** first observed the anomalies in spacetime brought on by two gravitational waves travelling through it in 2015.



Galaxy

- A galaxy is made up of millions or billions of stars and planets that are drawn together by gravity.
- A galaxy like Milky Way. Within this galaxy, the earth is present because it resembles a river of milky light flowing from one horizon to another, the Milky Way is so named.
- It has a **spiral shape.**
- We refer to it as **Akash Ganga.**
- Andromeda is the Milky Way galaxy's closest neighbour.
- The distance to the spiral galaxy Andromeda is roughly 2.5 million light-years.

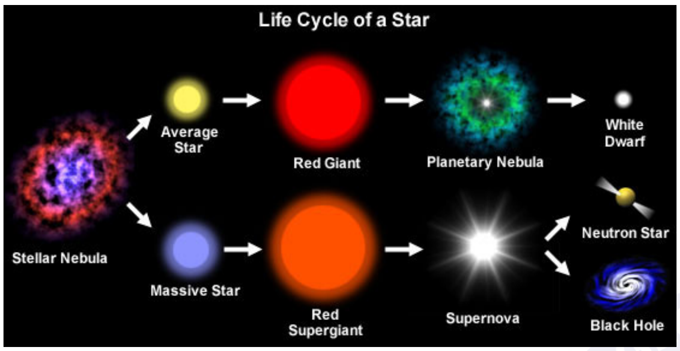
Stars

- Stars are luminous celestial bodies that emit their own light and various forms of radiant energy.
- They are constructed from incredibly hot, burning gases.
- The colours of the stars are red for low temperatures, yellow for higher temperatures, and blue for extremely high temperatures.

Star (Birth to Death)

- The formation of stars is believed to have taken place some 5-6 billion years ago.
- Stars begin their lives as **nebulous clouds** of gas and dust.
- Nebula's gaseous material further constricts to form the dense region known as **Proto Star.**
- The ProtoStar continues to condense until it reaches a critical mass at which nuclear fusion starts and a star finally forms.
- When a star runs out of hydrogen, its helium starts fusing with carbon. At some point, the star's ability to produce energy through the fusion of helium stops. A white dwarf star is created when a star's core collapses under its own weight to a very high density.
- A white dwarf star cools down to form a black dwarf star, which is composed of dark balls of stuff.
- White dwarf star mass, also known as Chandrasekhar Limiting Mass, is less than 1.44 times that of the Sun.
- Due to the cessation of the fusion reaction and energy production, the White Dwarf Star is a dead star.

- It radiates its heat reserves in order to shine.
- Following the consumption of its fuel, the massive star grows into a Red Supergiant (H & He). It eventually explodes as a supernova, transforms into a neutron, or becomes a black hole.
- The Sun, Proxima, Alpha Centauri, and radiant energy are the stars closest to Earth. 4.35 light-years.

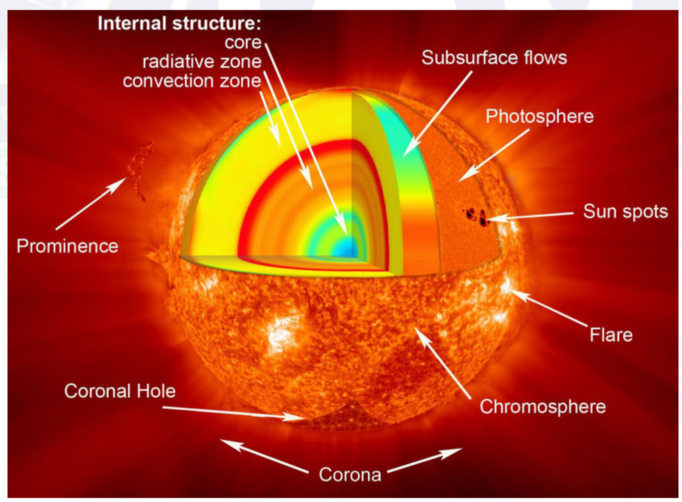


Constellations

- A constellation is a collection of stars that appears as a fictitious shape in the night sky.
- As they are visible in a specific direction at specific times of the year, it aids with marine vessel navigation at night.
- Some examples of constellations are Cassiopeia, Orion, the Big Dipper, leo Major, Ursa Maor (Saptarshi) and the Great Bear.
- In the winter, late-evening views of Orion or Mriga and Cassiopeia in the Northern Sky are possible.
- Summertime early-night viewings of the Great Bear, which is made up of Ursa Minor (Laghu Saptarishi) and Ursa Major (Vrihat Saptarishi), are common.

Formation of the Sun

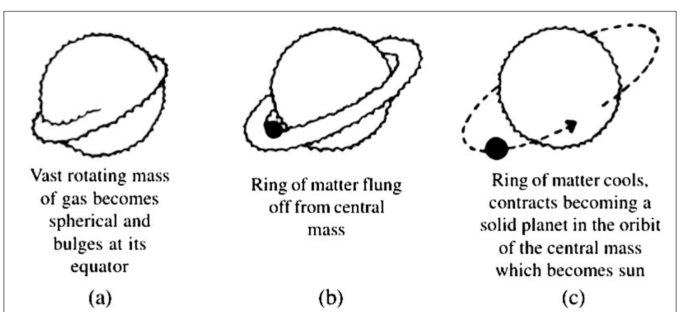
- After gravitationally becoming unstable, the nebula started to gravitationally collapse in on itself.
- This may have occurred as a result of a nearby supernova spreading shock waves through space.
- Then, due to gravity, gas and dust gathered in the nebular cloud's centre.
- The centre became denser and hotter as more stuff was drawn in, increasing gravity and drawing even more dust inwards, creating a snowball effect.
- The protosun was created when nearly all of the material fell into the centre (no sunlight yet).
- The Sun was created when the cloud's core heated up enough to cause nuclear fusion.
- Helium is produced when hydrogen atoms in the sun's core fuse together as a result of compression. Nuclear fusion is the term for this.
- The energy produced by nuclear fusion is enormous. To the surface, atmosphere, and further, it radiates.
- The sun's convection zone is located right adjacent to the sun's core. Here, the temperature falls to 2,000,000C.
- 6,000 C is the temperature of the photosphere.
- The chromosphere and corona make up the sun's atmosphere.
- Iron, calcium, and nickel ions emit spectral lines that are visible as the corona.



The Formation of Planets

- The haphazardly formed gas cloud assumed a flat disc shape as the 0.1% of matter that was left orbited the Sun.
- The planets formed on this flat disc, also known as the **protoplanetary disc.**

- The dust in the gas occasionally clashed and clumped together within the solar nebula.
- The miniscule particles created planetesimals, the infant stage of planets, with sizes up to a few kilometres across, through a process known as accretion.
- Planetesimals expanded in size through accretion to produce protoplanets as the disc continued to cool.
- They grew bigger and bigger over time, collecting all the residual dust, other protoplanets, and planetesimals until they finally developed into planets.
- Planetesimals were located in the hotter, inner region of the solar nebula.
- They grew bigger and bigger over time, collecting all the residual dust, other protoplanets, and planetesimals until they finally developed into planets.
- Planetesimals in the hotter, inner region of the solar nebula were primarily made of silicates and metals.
- Water ice predominated in the outer, colder region of the nebula.
- Mercury, Venus, Earth, and Mars are terrestrial planets with metal cores that are primarily made of iron and nickel. They were formed from the hot, rocky material that was close to the solar system's centre.
- The gas and ice giants Saturn, Jupiter, Neptune, and Uranus were created on the chilly borders.
- Asteroids are rocks that managed to elude the gravitational attraction of planets and are dispersed throughout the solar system.



Formation of planets

- In a region, many of these rocks orbit the Sun.

Planets are divided into two categories

Terrestrial planets

- The terrestrial planets were formed in the close vicinity of the parent star where it was too warm for gases to condense to solid particles. Also, known as earth-like planets, these are heavy, rocky entities. It includes Mars, Venus, Earth, and Mercury. They go by the name "inner planets" as well.

Jovian Planets

- These enormous outer planets, which are composed primarily of gas (Mostly Helium and Hydrogen) and have sizable satellites, are referred to as Jovian planets. These are referred to as "Jupiter-like planets" because they share characteristics with Jupiter.
- Mercury, Venus, Earth, and Mars make up the inner circle of planets, which are smaller and denser, while Jupiter, Saturn, Uranus, and Neptune are in the outer circle and are larger and less dense, with thick atmospheres made primarily of helium and hydrogen.
- Jupiterian planets resemble the sun more than they do Earth-like planets.
- The size of the planets decreases as we move away from either side of Jupiter, the largest planet in our solar system, if we consider it to be their centre.
- The planets' orbits are almost circular, but many comets, asteroids, and objects in the Kuiper belt have highly elliptical paths.
- An Astronomical Unit (AU) is the average distance between Earth and the Sun, which is about **150 million km.**

Inner Planets

- The region that includes the terrestrial planets and asteroids is known as the inner Solar System.

- Metals and silicates make up the majority of their makeup.
- The four inner or terrestrial planets lack ring systems, have few to no moons, and are composed primarily of solid material.
- Their crusts and mantles are primarily made of refractory minerals like silicates, while their cores are made of metals like iron and nickel.
- All four of the inner planets have impact craters and tectonic surface features like rift valleys and volcanoes, and three of them-Venus, Earth, and Mars-have atmospheres thick enough to produce weather.

Planet's of Solar System

Mercury

- Since Mercury's surface is extensively cratered and resembles the Moon in appearance, it has likely been geologically dormant for billions of years (because there is no atmosphere on Mercury).
- The planet can only be seen from Earth when it is near the western or eastern horizon in the early morning or early evening.
- Although less brilliant than Venus, it may appear to be a dazzling star-like object.
- Its surface temperatures vary more throughout the day than any other planet in the Solar System because it has essentially no atmosphere to trap heat (173 C at night to 427 C during the day).
- It takes only about 88 days to complete one round along its orbit.
- Mercury is smaller than Titan and Ganymede, the two biggest natural satellites in the Solar System (largest moon of Saturn).

Venus

- Because of the highly reflective sulfuric acid that coats its atmosphere, it has the highest albedo of all the planets, making it the brightest one. In bright sunlight, it can occasionally be seen without a lens.
- Because of their similar size, mass, proximity to the Sun, bulk composition, and presence of similar physical features like high plateaus, folded mountain belts, numerous volcanoes, etc., Venus is sometimes referred to as Earth's sister planet or twin. Venus's atmosphere, which is around 96% carbon dioxide and coated in clouds of highly reflecting sulfuric acid, completely obscures the planet's surface.
- Of the four terrestrial planets, it has the densest atmosphere. The planet's surface has an atmosphere with 92 times the pressure of Earth.
- This is because of the greenhouse effect arising from high concentrations of CO_2 and thick atmosphere.
- A day on Venus is equivalent to 243 earth days and lasts longer than its year (224 days).
- It rotates in the opposite direction (clockwise) to most other planets.
- In the ancient literature, Venus was often referred to as the morning star and evening star.

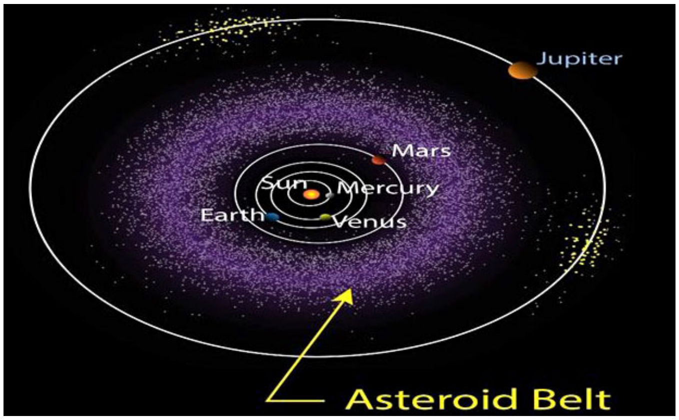
Earth

- At a distance of roughly 150 million kilometres from the sun, Earth is the third nearest planet to the sun. In size, it is the fifth largest planet (93 million miles). It is slightly flattened at the poles. That is why, its shape is described as a Geoid. Geoid means an earth-like shape.One astronomical unit, then (AU).
- On Earth, a day is 24 hours (the time it takes the Earth to rotate or spin once).
- Earth's atmosphere is made up of 78% nitrogen (N_2), 21% oxygen (O_2), and 1% other substances, which is the ideal ratio for life to exist. The only breathable atmosphere among the several planets in our solar system is on Earth.
- Earth has one moon. A moon may also be referred to as a natural satellite.

- The planet Earth is ideal for life as we know it.
- The majority of incoming meteoroids fragment in our atmosphere before they can impact the surface as meteorites, shielding us from harm.

Mars

- IT is located at a distance of 1.52 AU, or 228 million kilometres (142 million miles), the fourth planet from the sun.
- On Mars, a day lasts just a little bit longer than 24 hours (the time it takes for Mars to rotate or spin once).
- Mars, also referred to as a terrestrial planet, is a rocky planet. Volcanoes, collisions, crustal movement, and atmospheric phenomena like dust storms have all changed the solid surface of Mars.
- The majority of the gases in Mars' thin atmosphere are carbon dioxide (CO_2), nitrogen (N_2), and argon (Ar).
- Phobos and Deimos are the names of Mars' two moons.
- From flybys and orbiters to rovers on the surface of the Red Planet, many missions have visited this planet.
- Mars is known as the Red Planet because iron minerals in the Martian soil oxidize, or rust, causing the soil and the dusty atmosphere to look red.



Jupiter

- Jupiter has enough room to fit almost 1,300 Earths.
- At a distance of around 778 million kilometres (484 million miles), or 5.2 astronomical units, Jupiter is the fifth planet from the sun (AU). One AU separates Earth from the sun.
- On Jupiter, a day lasts roughly 10 hours (the time it takes for Jupiter to rotate or spin once).
- Jupiter lacks a solid surface since it is a gas-giant planet. The inner core of Jupiter may be a solid mass the size of the Earth.
- Helium (He) and hydrogen (H_2) make up the majority of Jupiter's atmosphere (He).
- Jupiter has 67 moons in total, of which 50 are acknowledged to exist. An additional 17 moons are still awaiting confirmation of their finding.
- Many missions have visited Jupiter and its system of moons. The Juno mission will arrive at Jupiter in 2016.
- Jupiter cannot support life as we know it. However, some of Jupiter's moons have oceans underneath their crusts that might support life.
- It also has faint rings around it.

Saturn

- At a distance of around 1.4 billion kilometres (886 million miles), or 9.5 AU, Saturn is the sixth planet from the sun.
- Saturn's day lasts 10.7 hours (the time it takes for Saturn to rotate or spin once).
- Saturn lacks a solid surface since it is a gas-giant planet. Helium and hydrogen (H_2) make up the majority of the atmosphere of Saturn (He).
- There are 62 moons overall on Saturn, including 53 that are known to exist and nine more that are pending confirmation of their existence.
- The most impressive ring system is that of Saturn, which consists of seven rings with various gaps and divisions between them.
- The missions Pioneer 11, Voyager 1 and 2, and Cassini-Huygens are the only ones to have visited Saturn.

Uranus

- The seventh planet from the sun, Uranus, is located 19.19 AU, or 2.9 billion kilometres (1.8 billion miles), away.
- On Uranus, a day lasts roughly 17 hours (the time it takes for Uranus to rotate or spin once).
- An ice giant, Uranus. Over a tiny rocky core, a heated, dense fluid of "icy" materials like water (H_2O), methane (CH_4), and ammonia (NH_3) makes up the majority (80% or more) of the planet's mass.
- The atmosphere of Uranus is primarily composed of hydrogen (H_2) and helium (He), with a trace quantity of methane (CH_4).
- 27 moons make up Uranus. The names of the moons of Uranus are taken from literary figures from Alexander Pope and William Shakespeare.
- Like Venus, Uranus also rotates from east to west, , which means it spins horizontally..

Neptune

- With a distance from the sun of around 4.5 billion kilometres (2.8 billion miles), or 30.07 AU, Neptune is the eighth and furthest planet.
- On Neptune, a day lasts roughly 16 hours (the time it takes for Neptune to rotate or spin once).
- Uranus' sister ice giant is Neptune.
- H_2, He, and methane make up the majority of the atmosphere of Neptune (CH_4).
- 13 moons make up Neptune. The names of Neptune's moons are taken from various Greek sea nymphs and gods.
- Six rings encircle Neptune.
- The only spacecraft to have travelled to Neptune is Voyager 2.
- Neptune cannot support life as we know it on Neptune.

The dwarf planet Pluto

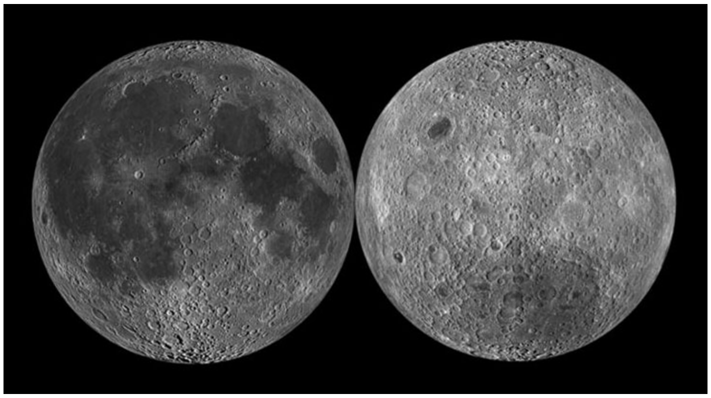
- Pluto was regarded as the ninth planet from the sun and the smallest planet in the solar system.
- Pluto is now referred to as a "dwarf planet."
- Pluto is located more than 3.6 billion kilometres from the sun on average.
- The Kuiper Belt is the region where Pluto is located. On Pluto, a day equates to roughly 61/2 days on Earth.
- Five moons are on it. Charon is the name of its biggest moon.
- Kerberos, Styx, Nix, and Hydra are the names of Pluto's other four satellites

Kuiper belt

The Solar System's Kuiper Belt, sometimes called the Edgeworth-Kuiper belt, is the region beyond the eight major planets. It stretches from Neptune's orbit at 30 AU to roughly 50 AU from the Sun. In that it is made up of numerous tiny bodies that are all leftovers from the Solar System's origin, it is comparable to the asteroid belt. But in contrast to the Asteroid Belt, it is far bigger-20 times wider and 20–200 times more massive.

Moon

- The moon circles the Earth as a natural satellite at a distance of around 384 thousand kilometres (239 thousand miles), or 0.00257 AU.
- The moon rotates or spins at the same rate and takes the same length of time to complete one orbit of Earth, which takes around 27.32 Earth days (roughly 28 days). As a result, during the moon's orbit, it maintains the same side or face toward Earth.



- The moon is a stony, solid-surface body with many craters and pits on its surface caused by impacts.
- The moon has an exosphere, which is an extremely tenuous and faint atmosphere.
- To investigate the moon, more than 100 spacecraft have been launched. Beyond Earth, it is the only celestial body that has been visited by humans.

Asteroids

- Minor planets include asteroids, notably those in the inner solar system.
- The Asteroid Belt is an area of space between Mars and Jupiter's orbits where asteroids orbit our sun.
- Solid, rocky, and irregular bodies are what asteroids are.
- There is no atmosphere on asteroids.
- It is known that more than 150 asteroids have a tiny companion moon (some have two moons). Asteroid Ida and her moon Dactyl were the first asteroid-moon system to be found, in 1993.
- There are no rings on asteroids.
- Asteroids have been seen and flown by NASA space missions. The Dawn mission (2011) is the first mission to orbit an asteroid in the main belt (Vesta).
- Life cannot exist on asteroids.
- Ceres, the first and largest asteroid to be discovered (1801 by Giuseppe Piazzi), encompasses over one-third of the estimated total mass of all the asteroids in the asteroid belt.

Meteorites

- The size of meteorites can range from small grains to huge boulders. The Hoba meteorite, which originates from southwest Africa and weighs around 54,000 kg, is one of the biggest meteorites ever discovered on Earth (119,000 pounds).
- The names of meteor showers are typically derived from nearby stars or constellations. As meteoroids, which are tiny pieces of rock and debris in orbit, meteors and meteorites first form.
- Iron, stony, or stony-iron make up the majority of meteorites.
- The Leonid MAC airborne mission, which operated from 1998 to 2002, investigated how meteoroids and the Earth's atmosphere interact.
- Life cannot exist on meteors, meteoroids, or meteorites. However, they might have given the planet Earth a source of amino acids, which are the basis for life.

Indian Meteorite Craters

- Lonar Lake in Maharashtra's Buldhana District has a diameter of 1.8 kilometres.
- Ramgarh crater (3.5 km in diameter) is a possible meteorite crater on the Kota plateau in Rajasthan, and Dhala crater (14 km in diameter) is located in Shivpuri district of Madhya Pradesh.

Comets

- Comets are icy balls of rock, dust, and gas throughout the universe.
- As a comet approaches the sun, it warms up and creates an atmosphere, or coma. The coma may have a diameter of hundreds of thousands of kilometres.
- Moons are absent from comets.
- Rings are not found on comets.
- Comets create a dusty trail as they orbit the sun. Each year, the Earth passes through the comet tails, allowing the dust to reach our atmosphere where it burns up and leaves behind fiery and vibrant streaks in the sky known as meteors.
- Comets might not be able to support life on their own, but through collisions with the Earth and other bodies in our solar system, they may have brought water and organic molecules, or the building blocks of life.

Goldilock Region

- The habitable region surrounding a star known as the "Goldilocks Zone" is where temperatures are just ideal for liquid water to exist on planets without being either too hot or too cold.
- The Goldilocks zone of the Sun surrounds our planet. All of Earth's water would freeze if it were located where the dwarf planet Pluto is; however, all of Earth's water would boil out if it were located where Mercury is.
- Water is a fundamental component for life as we know it and is where life first began on Earth.
- Therefore, any rocky exoplanet in the star's habitable zone is exciting to discover when astronomers are looking for evidence of extraterrestrial life.

Motions of the Earth

The earth has two types of motions, namely rotation and revolution. Rotation is the movement of the earth on its axis. The movement of the earth around the sun in a fixed path or orbit is called Revolution.

The Solar System

Categories	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Rocky or Gag	**Rocky**	**Rocky**	**Rocky**	**Rocky**	**Gas**	**Gas**	**Gas**	**Gas**
Distance from Sun (Million of kilometers)	57.9	108.2	149.6	227.9	778.3	1,427	2,871	5,914
Revolution Years	88 days	225 Days	365 Days	687 Days	12 Year	29 Year	84 Years	165 Years
Ratation Days	59 Days	223 Days (Backwards)	23 hours 59 min.	24 hours 31 min.	9 hours 55 min.	10 hours 42 min.	17 hours 12 min.	16 Hour 6 min.
Diameter (kilometers)	4,880	12,100	12,756	6,794	143,200	120,000	51,800	49,528
Moons	0	0	1	2	63	63	27	13
Rings	No	No	No	No	Yes	Yes	Yes	Yes
Temperature	300^0F to 800^0F	900^0F	-125^0F to 125^0F	-200^0F to 72^0F	-230^0F (Average)	-284^0F (Average)	-383^0F (Average)	-392^0F (Average)
Weight on Planet	.38	.86	1	.38	2.87	1.32	.93	1.23

Rotation of Earth

- Rotation is the movement of the earth on its axis. The movement of the earth around the sun in a fixed path or orbit is called revolution.Like a top spinning on its spindle, the Earth too revolves around its axis. The term "Earth's rotation" refers to this spinning motion. The imaginary line that makes up the earth's axis intersects its orbital plane at an angle of 6612 degrees.
- The orbital plane is the plane that is created by the orbit.
- Sunlight reaches the planet earth.
- Only half of the spherical earth receives light from the sun at any given time due to its form.
- Daytime is experienced by the half that is exposed to the sun, while nighttime is felt by the other half.

- **Effects of Rotation**

- ✓ The diurnal cycle of light and darkness, changes in temperature, and humidity is brought about by rotation.
- ✓ The day-night cycle is caused by rotation, and this cycle also influences the temperature and humidity levels.
- ✓ The establishment of uniform time zones is necessary for rotation. Each hour that the earth rotates has one of them.
- ✓ The twice-daily rise and fall in sea level is caused by rotation.
- ✓ Because they are the result of both the gravity of the moon and the gravity of the sun, tides are exceedingly difficult. The sun and moon occasionally align with the earth, but this is not the case most of the time. When the earth, sun, and moon are in a straight line, tides are at their highest.

Revolution

- At the same time that the Earth spins on its axis, it also orbits, or revolves around the Sun. This movement is called revolution.
- It takes the sun 36514 days (or one year) to complete one orbit. For convenience's sake, we disregard six hours and only count 365 days in a year.
- Over a period of four years, saving six hours annually results in a day (24 hours). This extra day is added to February's calendar.
- As a result, every fourth year, February has 29 days rather than 28. A year with 366 days is referred to as a leap year.
- Earth and the other planets are maintained in their orbits by the Sun's gravitational pull. Earth, like the other planets, orbits the Sun on an elliptical path, which causes the planet to occasionally be farther from the Sun than at other times.
- The average distance that Earth travels in one revolution around the Sun is roughly 150 million kilometres.
- The average speed at which the Earth orbits the Sun is approximately 27 km (17 km) per second, though this speed varies.
- At aphelion, the planet moves more slowly, while at perihelion, it moves more quickly.
- Seasons exist on Earth (or any other planet) because of the tilt of the planet's axis, which is 23 1/2 degrees.
- The North Pole tilts away from the Sun during the Northern Hemisphere winter and toward it during the Northern Hemisphere summer.

Effects of Revolution

- Seasons Change across the hemispheres due to revolution and the tilted axis fo teh planet.
- The rate at which the Earth the revolves has an impact on its condition. Due to the speed of the pivot, a diffusive force is created, causing the Earth to straigh at its shafts and protude in the middle.
- Thes growths water in the seas is influenced by the speed of revolution. The turn causes the tides chages course.
- The growth of the breeze is also influenced by the speed of revolution. Due to revolution, the Northern Hemisphere's winds and the Southern Hemisphere's sea currents redirect to opposite side.

Summer Solstice

- The Northern Hemisphere is inclined toward the sun on June 21.
- The Tropic of Cancer is directly exposed to the sun's beams.
- These places thus experience higher heat.
- Because the sun's beams are slanted, the places close to the poles get less heat.
- Due to the North Pole's inclination toward the sun, areas outside the Arctic Circle enjoy nearly six months of nonstop daylight.
- It is summer in the areas north of the equator because a huge percentage of the Northern

Hemisphere receives light from the sun.

- The longest day and the shortest night are on June 21st in these locations.

Winter Solstice

- All of these circumstances are currently inverted in the Southern Hemisphere.
- There, winter has arrived.
- The South Pole tilts toward the Tropic of Capricorn on December 22, allowing it to receive direct sunlight.
- The Southern Hemisphere receives more light because the sun's rays fall vertically at the Tropic of Capricorn (231.2 S).
- As a result, the Southern Hemisphere is experiencing summer, with longer days and shorter nights.
- In the Northern Hemisphere, the opposite occurs.
- The Winter Solstice occurs when the earth is in this position.

Equinox

- On March 21 and September 23, the equator receives direct sunlight.
- Since neither pole is oriented toward the sun in this configuration, there are equal numbers of days and nights on the entire planet. It is referred to as an equinox.
- In the Northern Hemisphere, it is fall on September 23, but in the Southern Hemisphere, it is spring.
- On March 21, however, spring is in the Northern Hemisphere and fall is in the Southern Hemisphere.

Standard Time

- The time that an area or nation uses as its official civil time is known as Standard Time.
- With the prime meridian passing through Greenwich, England, the current system uses 24 standard meridians of longitude, which are spaced 15 degrees apart and run from the North Pole to the South Pole at right angles to the Equator.
- The International Date Line was extended eastward around the Pacific island nation of Kiribati, which is a notable example of this alteration. These meridians are theoretically the centres of 24 Standard Time zones, but in practise the zones are frequently divided or changed in shape for the convenience of the inhabitants.
- Each zone's time is the same, but it is different from Coordinated Universal Time, which serves as the basis for international law and science.

Indian Standard Time

- With a time offset of UTC+5:30, Indian Standard Time (IST) denotes the time observed in India. Despite briefly adopting DST during the Indo-Pakistani Wars of 1965 and 1971 as well as the Sino-Indian War of 1962, India chose not to observe DST or other seasonal adjustments.
- E*("Echo-Star") stands for IST in both aviation and military time.
- The longitude of 82.5 E, immediately west of the town of Mirzapur, close to Allahabad in the state of Uttar Pradesh, is used to compute Indian Standard Time.
- A precise time difference of 5 hours 30 minutes exists between Mirzapur and the Royal Observatory at Greenwich in the United Kingdom due to differences in longitude.

Issues swith IST

- Due to the nation's greater than 2,000 km (1,200 mi) east-west distance, which spans over 28 degrees of longitude, the sun rises and sets over two hours earlier in the north-eastern Seven Sister States than in the far-western Rann of Kutch.

- To save energy, a group of experts suggested splitting the nation into two or three time zones in the late 1980s.
- The administration disregarded the adopted suggestions since the binary system they proposed required a return to time zones from the British era.
- In order to investigate the necessity of multiple time zones and daylight saving, the government established a four-person committee in 2001 under the Ministry of Science and Technology.

Day Light Savings

- Summer time, or Daylight Saving Time, is a mechanism for consistently moving clocks forward to prolong daylight hours during regular waking hours in the summer. The clocks are typically moved forward one hour in late March or early April and backward one hour in late September or early October in nations in the Northern Hemisphere.

- **Objective of Employing DST**

  ✓ **Achieve energy efficiency:** The growing emphasis on energy efficiency is a result of climate change and excessive energy usage, which makes DST crucial. DST is therefore an environmentally friendly concept.

  ✓ in order to provide a longer evening daytime by making sure the clocks reflect a later dawn and later sunset.

  ✓ An hour earlier completion of everyday tasks.

  ✓ DST is intended to reduce energy use.

The International Date Line (IDL)

- IT Is a imaginary line that divides two calendar days and extends from the North to the South Pole.
- The IDL is significant for timing purposes and is essential for immediate communication, politics, and business.
- The IDL is a fictitious line that traverses the Pacific Ocean while nearly tracing the 180 line of longitude.
- This line, however, is not perfectly straight and occasionally deviates from the 180 meridian.
- It sometimes has a zigzag appearance, veering to the east or west of the meridian.
- The variations make it possible for locations with similar racial, ethnic, and partisan affinities to share the same date or time.
- Otherwise, the IDL would divide some landmasses into two halves with two distinct dates on the same day if it were a straight line.

Why The 180 Degree Meridian?

- The International Meridian Conference created the IDL in 1884 as a hypothetical line roughly following the 180 meridian and not any other meridian (including the Prime Meridian).
- 26 countries participated in the conference, which chose 180 longitude because it crosses an ocean (the Pacific Ocean) and zigzagged it to keep the nearby countries, particularly island ones, inside the same day and date.

Time and Date Across IDL

- **Depending on which way you are moving** when you cross the IDL, you either gain or lose a day.
- You gain a day if you are moving westward and lose a day if you are moving eastward.
- For instance, if a traveller journeys from Wake Island to the Hawaiian Islands on June 25 in an easterly direction across the Pacific Ocean, they will immediately go back to June 24 as they cross the IDL. On the other hand, if they are going the other way, they will reach Wake Island on June 26.

- Every 15 of longitude westward of the IDL is worth one hour, but every 15 eastward is worth one hour less. Consequently, anyone heading west without changing their clocks back an hour for for every 15 meridian will discover that they have gained an extra day when they return home.

Eclipse

- An eclipse is when one heavenly body completely or partially blocks out another. When three celestial bodies are in line with one another, an eclipse happens.
- Astronomers are aware of two main categories of eclipse occurrences.
- In the first, an observer and the eclipsed object are separated by the eclipsing body, which causes the latter to appear completely or partially obscured to the observer.
- The Sun's eclipses, the Moon's occultations of stars, Venus or Mercury's transits across the Sun's disc, and eclipses of binary stars are examples of this type.
- The second sort of eclipses only have an impact on planets or naturally occurring satellites that are not self-luminous.
- The eclipsing body in this instance stands between the Sun and the eclipsed item.

Solar Eclipse

- A solar eclipse happens when, at just the right moment, the Moon passes between the Sun and Earth.This causes an eclipse of the Sun, or a solar eclipse. During a solar eclipse, the Moon casts a shadow onto Earth.

Lunar Eclipse

- A total lunar eclipse takes place when the Earth comes between the Sun and the Moon and its shadow covers the Moon. Eclipse watchers can see the Moon turn red when the eclipse reaches totality.
- Instead of light hitting the Moon's surface, Earth's shadow falls on the Moon. This is an eclipse of the Moon, or a lunar eclipse. A lunar eclipse can occur only when the Moon is full.

Importance of Studying Eclipse

- Scientists can measure the Sun's diameter precisely during solar eclipses and look for fluctuations over a wide time range.
- Geophysicists measure eclipse-induced phenomena in the upper atmosphere.
- Total solar eclipses make it possible to observe solar coronal features that are typically inaccessible for study because of the daytime skylight's higher than usual luminance.
- The corona's structures resemble the patterns that surround magnets. In reality, it has been established that sunspots are solar surface magnetic structures with a coronal counterpart.
- We learn a lot about the Sun's surface and its global variations from research on the solar corona.
- Because of the surface's reorganization, the corona's morphology is changing.

Personal Notes

GEOMORPHOLOGY

Interior of Earth

- One of two divisions-mechanical or chemical-can be made in the Earth.
- The lithosphere, asthenosphere, mesospheric mantle, outer core, and inner core can all be thought of mechanically (or rheologically), which is the study of liquid states.
- The crust, the mantle (which can be further separated into the upper and lower mantle), and the core-which can further be divided into the outer core and inner core - can all be classified according to their chemical or compositional makeup, which is the more popular of the two.

Sources to study the earth's interior

The sources which provide knowledge about the interior of the earth may be classified into 2 sources-

- **Direct Sources**
  - ✓ Surface rock
  - ✓ Volcanos
  - ✓ Mining Projects
  - ✓ Drilling Projects
  - ✓ Deep Ocean Drilling Project
  - ✓ Integrated Ocean Drilling Project

- **Indirect Sources**
  - ✓ Temperature and pressure variation
  - ✓ Seismic activities
  - ✓ Meteorites
  - ✓ Gravitation
  - ✓ Magnetic field

- **Earth's interior Direct Sources**
  - ✓ Drilling and mining deep underground reveal the types of rocks that are present there.
  - ✓ However, since mining and drilling are impractical above a certain depth, they don't provide much insight into the interior of the earth.
  - ✓ The Mponeng gold mine, which is the deepest mine in the world, and Tau Tona gold mine, which is the second deepest mine in the world, are both located in South Africa and only go down 3.9 km.
  - ✓ The Soviet Union drilled the Kola Peninsula's deepest hole in the 1970s, but it was only about 12 km deep.
  - ✓ Another direct information source is a volcanic eruption.

- **Earth's Interior's Indirect Sources**
  - ✓ By examining the rate of temperature and pressure change from the exterior to the interior.
  - ✓ As they are made of the same components as the earth, meteors.
  - ✓ gravity, which is stronger close to the poles and weaker in the equator.
  - ✓ We can learn about the materials that make up the earth's interior via a phenomenon known as gravity anomaly, which is the change in gravity value as a function of the mass of a substance.
  - ✓ **Source of Magnetism:** The distribution of materials in the crustal portion is also revealed through magnetic surveys, which also reveal information about the distribution of magnetic materials there.
  - ✓ **Seismic Waves:** We can learn about the condition of materials inside a structure by looking at the shadow zones of body waves (both primary and secondary waves).

Structure of the Earth's interior

The interior of the earth is divided into a number of concentric layers. Three layers make up the Earth's internal structure.

- Crust
- Mantle
- Core

Crust

- It is the solid outermost portion of the earth and is typically 8 to 40 kilometres thick.
- Its nature is fragile.
- The crust makes up over 1% of the earth's volume and 5% of its mass.
- Oceanic and continental regions have various crustal thicknesses. The oceanic crust is 5 km thinner than the continental crust (about 30kms).
- Silica (Si) and aluminium (Al) are the two main components of crust, which is why it is frequently referred to as SIAL (Sometimes SIAL is used to refer Lithosphere, which is the region comprising the crust and uppermost solid mantle, also).
- The crust's components have an average density of 3g/cm3.
- The Conrad Discontinuity is the name given to the separation between the hydrosphere and crust.
- The most abundant elements of the Earth's Crust

Element	Approximate % by Weight
Oxygen (O)	46.6
Silicon (Si)	27.7
Aluminum (Al)	8.1
Iron (Fe)	5.0
Calcium (Ca)	3.6
Sodium (Na)	2.8
Potassium (K)	2.6
Magnesium (Mg)	1.5

Mantle

- The mantle is the area of the interior that is above the crust.
- The **Mohorovich Discontinuity,** or Moho discontinuity, is the separation between the crust and the mantle.
- The mantle has a thickness of around 2900 km.
- The mantle makes up around 84% of the earth's volume and 67% of its mass.
- The mantle is also known as SIMA since it primarily consists of silicon and magnesium.
- The layer's density, which ranges from 3.3 to 5.4g/cm3, is higher than that of the crust.
- The Lithosphere is made up of the entire crust and the topmost solid portion of the mantle.
- A extremely viscous, weakly elastic, ductile, deforming zone of the upper mantle, the asthenosphere (between 80 and 200 km), is located just beneath the lithosphere
- The discontinuity between the upper mantle and the lower mantleis known as Repetti Discontinuity.
- The portion of the mantle which is just below the lithosphere and asthenosphere, but above the core is called as Mesosphere.

Core

- It is the layer that surrounds the earth's core that is the deepest.
- **Guttenberg's Discontinuity** divides the mantle from the core.
- It is also known as NIFE since its primary ingredients are nickel (Ni) and iron (Fe).
- Nearly 15% of the earth's volume and 32.5 percent of its mass are made up by the core.
- The density of the earth's core, which fluctuates between 9.5 and 14.5 g/cm3, is the highest.
- The inner core and the outer core are the two sub-layers that make up the Core.
- The outer core is liquid, while the inner core is in a solid condition (or semi-liquid).
- The **Lehmann Discontinuity** is the separation of the upper core from the lower core.
- The term "barysphere" is occasionally used to refer to the core of the Earth or Sometimes whole Interior.

Mechanical Layers of the Earth

The structure of the Earth can also be defined and divided based on how the insides of the planet behavior.

Thereby, the mechanical layers correspond to the physical or mechanical properties of these layers.

Lithosphere

- The entire crust plus the uppermost part of the mantle make up the lithosphere, which is the Earth's outermost layer.
- The thickness varies widely, with an average of about 70 km: It can be extremely thin, only a few kilometres thick under the oceanic crust or mid-ocean ridges, or extremely thick, 150 kilometres or more thick under the continental crust, notably mountain belts.
- 0-100 kilometres of depth
- They are additionally separated into parts known as tectonic plates.
- These plates' movements are also responsible for earthquakes, volcanic eruptions, and the formation of oceanic trenches.

Asthenosphere

- The asthenosphere includes the soft layer of the mantle on which the lithosphere moves.
- Depth- 100km to 350 km .
- It is made of solid silicate materials, but the high temperature allows it to flow on very long timescales.
- The lithosphere-asthenosphere boundary is where geophysicists mark the difference in ductility between the two layers.

Mesosphere

- The mesosphere is the layer below the asthenosphere but above the outer core. It is essentially the lower mantle.
- Average depth-350-2900km
- Despite its high temperature, the intense pressure in this region restricts the movements of the molecules of the silicate material despite being under high temperature, thus making it extremely rigid.

Outside Core

- The inner core is encircled by the outer core, which extends from the lower mantle or mesosphere.
- The high temperature enables these metals, which are composed of iron and nickel, to stay in their liquid states.
- It is the only part of the Earth's crust that truly contains liquid.
- Additionally, it creates the magnetic field through movement.

Inner Core

- The inner core also contains some nickel and iron.
- It is a solid ball, as opposed to the outer core, though.
- The high pressure from the top layers is what gives the structure its rigidity.
- Thus, despite being as hot as the Sun's surface, it is believed that the inner core is gradually expanding as the liquid outer core at the boundary with the inner core cools and solidifies as a result of the interior's gradual cooling.

Earth's Chemical Composition

- Earth's mass is approximately 5.97×1024 kg (5,970 Yg).
- It is composed mostly of

  ✓ Iron (32.1%),
  ✓ Oxygen (30.1%),
  ✓ Silicon (15.1%),
  ✓ Magnesium (13.9%),
  ✓ Sulfur (2.9%),
  ✓ Nickel (1.8%),
  ✓ Calcium (1.5%), and aluminum (1.4%),
  ✓ With the remaining 1.2% consisting of trace amounts of other elements.

Temperature

- A rise in temperature with increase in depth is observed in mines and deep wells.

- The rate of increase of temperature is at an average rate of 1C for every 32m increase in depth.
- While in the upper 100kms, the increase in temperature is at the rate of 12C per km and in the next 300kms, it is 20C per km. But going further deep, this rate reduces to mere 10C per km.

Pressure

- Similar to how the temperature rises from the surface of the planet toward its centre, so does the pressure.
- It is because of the heavy materials above, such rocks.
- According to estimates, the pressure in the deeper regions is extremely high and will be between 3 and 4 million times more than the atmospheric pressure at sea level.
- The materials below will melt toward the centre of the earth at high temperatures, but under heavy pressure, they take on the characteristics of solids and are likely in a plastic form.

Density

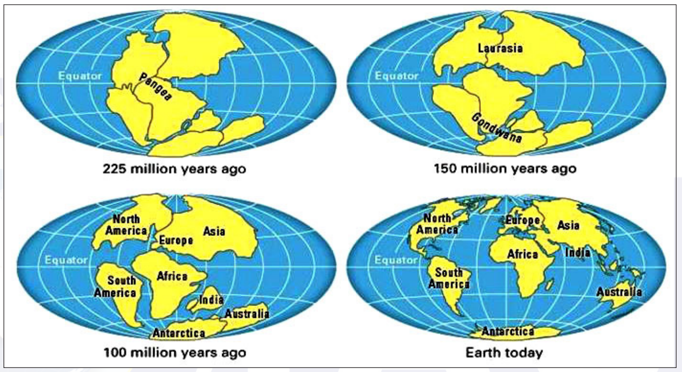
- Due to increase in pressure and presence of heavier materials like Nickel and Iron towards the centre, the density of earth's layers also gets on increasing towards the centre.
- The average density of the layers gets on increasing from crust to core and it is nearly 14.5g/cm^3 at the very centre.

Oceans and Continents Distribution

- Several theories have been put up to explain how the continents and oceans are currently distributed.

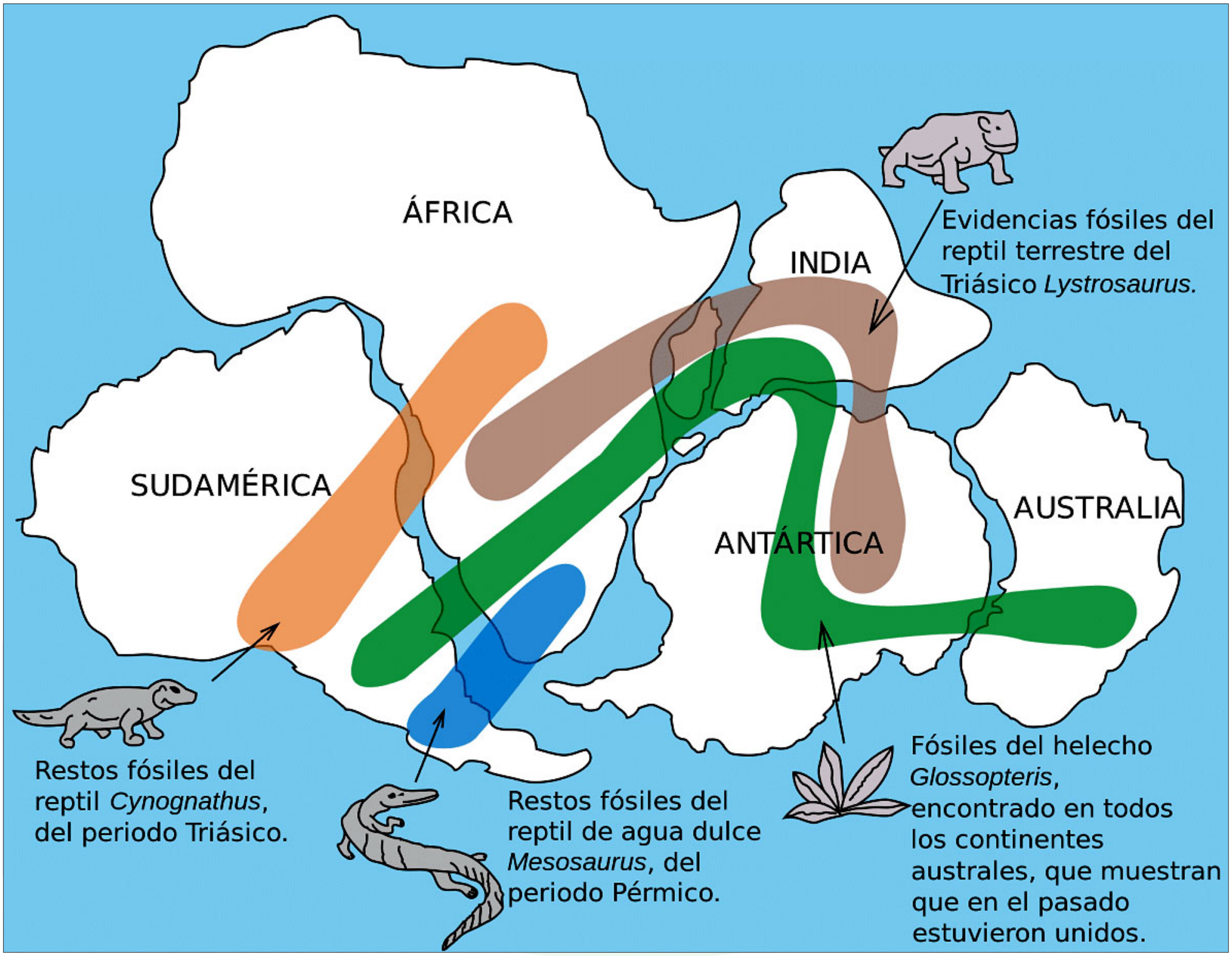
Theory of Continental Drift through Alfred Wegener.

- The Earth was made up of a single continent called Pangaea and an ocean called Panthalassa during the majority of geologic time, according to the continental drift theory.
- Pangaea was separated into two enormous landmasses by a sea called Tethys: Laurentia (Laurasia) to the north and Gondwanaland to the south.
- Around 200 million years ago, drift first appeared (Mesozoic Era). The continents started to split apart and drift apart.
- The continent gradually drifted away, and the seven current continents were formed.



Force for Continental Drift

- Polar-fleeing force Centrifugal effect is brought on by the earth's rotation.
- Force that buoys (Object floats in the fluid due to this property)
- **Tidal force:** (Due to the attraction of the moon and the sun that develops tides in oceanic waters)
- The power of gravity
- Since the drift has continued for millions of years, Wegener thought these forces would become effective when applied.
- There was a two-way drift.Due to the interaction of the forces of gravity, the equator is tilted.
- Force reversing a pole
- **Floating force:** Due to tidal currents brought on by the earth's rotation from west to east, westward (Tidal currents act from east to west)



- **Supporting Data for Continental Drift**

1. Along the shores of South America, Africa, and Europe and North America, there are geomorphological and geological parallels.
   - ✓ The continents' Jig-Saw-Fit.
   - ✓ Gold placer deposits in Ghana's coast without any adjacent source rocks.

2. Tillite
   - ✓ The sedimentary rock in question was created by glacial deposits.
   - ✓ There are counterparts to the Indian Gondawana systems of sediments in six distinct Southern Hemisphere landmasses.

3. Rocks in all oceans are the same age. Ranges in Canada, for instance, are comparable to those in Sweden and Norway.
   - ✓ Similar to UK Mountains are the Appalachian Mountains.

4. Paleoclimate evidence from fossils
   - ✓ Fossilised vegetation and animals from vastly different continents
   - ✓ Freshwater reptile Mesosaurus was mentioned.
   - ✓ Glossopteris, a fern from the tropics.
   - ✓ Similar plants and animals found on such diverse geographical masses point to the unity of the continents.

Drawback of the Continental Drift Hypothesis

- Too broad with clumsy and perhaps nonsensical proof.
- Gravity and buoyancy have opposing effects.
- If the tidal force generated by the sun and moon was strong enough to rift the continents, the Earth would have ceased rotating.
- It does not clarify why drift began only during the Mesozoic era and not earlier.
- The strong explanation for continent movement could not be offered by the continental drift theory. The subsequent investigations did away with this problem.

Convectional Current Theory

- Given by Arthur Holme.
- Thermal differences are produced in the mantle region as a result of heat produced by radioactive materials decaying.
- The thermal differences create a convection current cycle in the mantle that allows heat to escape.
- Rising (ascending) limbs of these currents = formation of oceanic ridges (Due to the divergence of the lithospheric plate)
- Trenches occur as a result of these currents' falling (descending) limbs (Due to the convergence of the lithospheric plate)
- The movement of the magma in the mantle is what propels the lithospheric plate (Driven by convective process).
- The entire mantle portion is covered by this current arrangement.

- **Mapping of the Ocean Floor**
  - ✓ During the World War II, mankind reached to the bottom of ocean floor through the usage of submarines.
  - ✓ Detailed studies of bottom of ocean revealed that the floor is full of relief with mountain ranges, deep trenches etc.

Ocean Floor

- **The continental shelf** has a 1o angle, a depth of 120 to 150 metres, and a typical length of 70 kilometres. But this differs greatly.
  - ✓ The west coast of South America has almost no continental shelf.
  - ✓ On North America's east coast, it is 120 kilometres broad. It is also quite broad in the Bay of Bengal.
- **Continental slope:** The slope rapidly steepens at the end of the continental shelf. Blocks of continents come to an end at its conclusion.
- **Continental Rise:** The slope eases back to between 0.5 and 1 degrees at the conclusion of the continental slope. The continental margin comes to an end at its end.
- **Deep Sea Plain (Abyssal Plains):** Two to three miles below sea level, undulating plains make up two-thirds of the ocean bottom.Sea hills on abyssal plains that rise less than 1000 metres above the surface are referred to as abyssal hills.
- **Sea mounts** are sea hills on abyssal plains that rise more than 1000 metres above the surface.
- **Guyots:** Guyots are flat-topped seamounts. Generally speaking, they are all of volcanic origin.
- **Deeps or trenches in the ocean:** A trench is a long, narrow, and steep depression that is located on an abyssal plain. Deeps refers to the deeper ditches (> 5500 metres).
- **Deep concave gorges** can be found on a continental shelf, slope, or rise as canyons.
- **A strait, sound, or channel** is a thin body of water that connects two wider bodies of water. More narrow than a waterway or sound are straits.

Sea Floor Spreading

- **Harry Hess** developed the gave sea floor spreading using research on convection current and paleomagnetism.
  - ✓ The oceanic crust is being consumed, as evidenced by its shorter age and the fact that the expansion of one ocean does not result in the contraction of the other.

- ✓ Through the mid-oceanic ridges, hot lava from the Earth's mantle constantly creates new oceanic crust.
- ✓ As it cools, the crust slides sideways to create a new seafloor. It is recycled millions of years later as it sinks into the deep ocean trenches and returns to the mantle.
- ✓ This suggests that because basaltic lava recently erupted from the earth's interior, the crust along the oceanic ridge would be among the youngest.
- ✓ Age and the distance between two equally spaced magnetic strips determine the rate of sea floor spreading.
- ✓ This suggests that convection currents in the mantle are responsible for the periodic development and decomposition of the oceanic crust.
- ✓ The hypothesis of seafloor spreading aids in explaining continental drift in the context of plate tectonics.

Plate Tectonic Theory

Theory

- The sea floor spreading theory successfully explained the movement of the oceanic crust, but it did not explain why continental plates moved. **McKenzie and Parker's** plate tectonic hypothesis addresses this problem.
- The top mantle and crust of the Earth are divided into different plates, which are together referred to as tectonic plates. As a rigid entity, these plates float atop the ductile upper mantle asthenosphere.
- Lithospheric plates can be classified as Minor plates or Major plates (or crustal plates or tectonic plates).
- Oceanic or continental plates (Arabian plate) (Pacific plate)
- Sometimes a blend of the two (Indo-Australian plate)
- Depending on which of the two occupies a bigger percentage of the plate, it may be referred to as the continental plate or oceanic plate.
- Simatic and comparatively thinner oceanic plates
- Sialic and somewhat thicker continental plates
- Plate thickness (Denser plate goes for the subduction)
- Continental Plate follows Oceanic Plate.
- Larger plates are preferable to smaller plates.

Types of Tectonics Plates

The earth's lithosphere is divided into seven major and some minor plates.

- **Major tectonic plates**
  - ✓ Antarctica and the surrounding oceanic plate
  - ✓ North American plate
  - ✓ South American plate
  - ✓ Pacific plate
  - ✓ India-Australia-New Zealand plate
  - ✓ Africa with the eastern Atlantic floor plate
  - ✓ Eurasia and the adjacent oceanic plate

- **Minor Tectonic Plates**
  - ✓ **Cocos Plate:** Between Central America and Pacific plate
  - ✓ **Nazca Plate:** Between South America and Pacific plate
  - ✓ **Arabian Plate:** Mostly the Saudi Arabian landmass
  - ✓ **Philippine Plate:** Between the Asiatic and Pacific plate
  - ✓ **Caroline Plate:** Between the Philippine and Indian plate (North of New Guinea)
  - ✓ **Fuji Plate:** North-east of Australia.
  - ✓ Turkish plate
  - ✓ Aegean Plate (Mediterranean region)
  - ✓ Caribbean plate
  - ✓ Juan de Fuca Plate (between Pacific and North American plates)
  - ✓ Iranian Plate

Types of Plate boundaries interaction

- Divergence or Divergent Edge or the Constructive Edge
- Convergence or Convergent Edge or Destructive Edge
- Transcurrent Edge or Conservative Edge or Transform Fault.

Divergence or Divergent Edge or the Constructive Edge

- Such edges are places where the earth's crust forms, making them constructive, and volcanic earth forms are frequent there.
- Along diverging edges, shallow focus earthquakes are frequent.
- Spreading sites are the locations where the plates separate from one another.
- The Mid-Atlantic Ridge is the most prominent illustration of diverging borders.
- **At Ocean** Mid-oceanic ridges are formed, allowing basaltic magma to erupt and spread apart (sea floor spreading).

- **At Continents**
  - ✓ emergence of the Rift Valley (East African Rift Valley on African and Somali plates).
  - ✓ The first stage of a continental breakup is a rift.
  - ✓ A new ocean basin may arise due to the constant diverging force beneath the rifts.

- **New Ocean Formation from Rift Valley**
  - ✓ A huge rift forming in the **Ethiopian Afar desert** is expected to become the world's newest ocean. When this happens, the Afar Rift will turn into a **new ocean** that will split the African continent and release the Horn of Africa from its land mass.

Convergence or Convergent Edge or Destructive Edge

- There are mainly 3 ways in which convergence can occur

- **Oceanic-Oceanic Boundaries**
  - ✓ When two oceanic plates clash, the denser plate descends below the lighter plate.
  - ✓ Due to its increased density, the older plate usually subducts.
  - ✓ Along the border, it creates a trench.
  - ✓ The rocks in the subduction zone change into
  - ✓ Due to the buoyant force, low density, high pressure magma develops and rises.
  - ✓ On the ocean below, volcanic islands are produced by magma rising continuously.
  - ✓ Volcanic eruptions and earthquakes are frequent.
  - ✓ The Pacific Plate slipping beneath the Mariana Plate caused the deepest oceanic trench, known as the Mariana Trench Examples include the **Philippine Island Arc and the Indonesian Archipelago**

- **Oceanic-Continental Borders**
  - ✓ Oceanic plates undergo subduction when they meet with continental plates.
  - ✓ The potential for subduction is higher for oceanic than for continental plates because oceanic plates are denser.
  - ✓ They are continuously dragged into the mantle, where they melt and are recycled into fresh magma.
  - ✓ Along the border, it digs a trench. In comparison to ocean-ocean convergence, the trenches that form here are shallower.
  - ✓ The metamorphosis of the rocks in the subduction zone.
  - ✓ Due to the force of buoyancy, low density, high pressure magma develops and rises.
  - ✓ Volcanic activity and earthquakes are frequent.
  - ✓ At the surface of the continental plate along the border, magma is continuously rising, causing constant volcanic eruptions.
  - ✓ Western North American mountains like the Cascades and Western South American mountains like the Andes

- **Continental Boundaries**
  - ✓ Large chunks of crust collide at continental-continental convergent borders.
  - ✓ Since most rock is too light to be transported very deeply into the thick mantle, there is very little subduction.
  - ✓ Mountains that are folded may arise from the impact zone.
  - ✓ This strong crust prevents magma from penetrating; as a result, intrusively cooling magma becomes granite. Rock that has undergone extensive metamorphism, such as gneiss, is also typical.
  - ✓ There are frequently earthquakes but no volcanic activity.
  - ✓ Between the two convergent plates lies the ocean basin or a sedimentary basin (geosynclinal sediments located along the continental edges).
  - ✓ The Tethys Sea, a massive geosyncline, is where the Himalayan Mountains emerged.
  - ✓ An orogenic collision has just occurred. One such example is the Himalayan Boundary Fault.

Transcurrent Edge or Conservative Edge or Transform Fault.

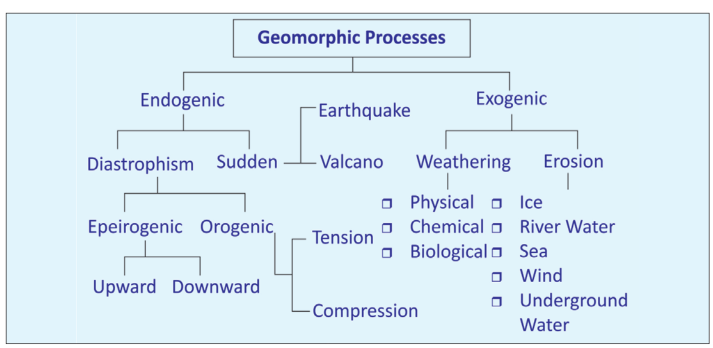
- A fault along a plate boundary when the motion is primarily horizontal is known as a transform fault or transform boundary, also known as a strike-slip boundary. Transform plate boundaries are places where two plates are slamming against one another. At these areas, no new landforms are being created or destroyed; only the present landform is being deformed. Transform faults are the fracture zones that define the boundaries of transform plates.
- Transform faults in seas are axes of separation that are typically perpendicular to mid-oceanic ridges.
- The best example of a transcurrent edge on a continent is the North Anatolian Fault and San Andreas Fault, which run down the western coast of the United States and pass perilously near to Silicon Valley.
- A Californian fault called San Andreas

Plate Tectonics' importance

- Plate tectonics is the primary cause of almost all significant landform formation.
- As a result of magmatic eruptions, new minerals are ejected from the core.
- Near the plate boundaries, one can find economically valuable minerals like copper and uranium.
- The shape of landmasses in the future can be predicted using current knowledge of crustal plate movement.
- North and South America will split, for instance, if the current patterns continue. From Africa's east coast, a portion of land will separate. It will bring Australia nearer to Asia.

Geomorphic Processes

- The forces that shape the earth's surface originate both below (endogenetic forces) and above (exogenetic forces) the surface.
- Geomorphic processes are caused by endogenic and exogenic forces, which put physical strain and chemical reactions on earth materials and modify how the planet's surface is shaped.
- In general, land is primarily built by endogenic forces, while land is primarily worn away by exogenic processes.
- Exogenic pressures cause the earth's surface relief and heights to deteriorate (degrade) and basins and depressions to aggrade (fill).
- The exogenic processes fail to even out the relief variations of the surface of the earth due to the endogenic forces that continuously elevate or build up parts of the earth's surface.



Endogenic Processes

- The energy emanating from within the earth is the main force behind endogenic geomorphic processes.
- This energy is mostly generated by radioactivity, rotational and tidal frictionand primordial heat from the origin of the earth.
- Due to variations in geothermal gradients and heat flow from within, the action of endogenic forces are not uniform. Hence the tectonically controlled original crustal surface is uneven.
- Endogenetic forces are of 2 types based on direction
  - ✓ Horizontal
  - ✓ Vertical

- **Endogenetic Forces are of 2 types based on intensity**
  - ✓ Sudden forces
  - ✓ Diastrophic forces

- **Sudden Movements**
  - ✓ It is due to sudden forces from deep inside the earth.
  - ✓ It can cause huge damage both at the surface and below the surface.
  - ✓ These are extreme events and become disaster when they occur in densely populated areas.
  - ✓ It is a result of long period preparation deep within the earth; but the effects on the earth surface were quick and sudden.
  - ✓ Geologically, they are known as 'Constructive forces' as they create relief features on the Earth's surface.
  - ✓ The two main phenomenon for sudden movement are
  - ✓ **Volcanism** = It includes the movement of molten rock (magma) onto or towards the earth's surface through narrow volcanic vents or fissures.
  - ✓ **Earthquake** = It is a sudden motion or trembling in the earth caused by the abrupt release of slowly accumulated energy.
  - ✓ **Diastrophic:** Diastrophism refers to any process that alters, raises, or builds up a section of the Earth's crust.
  - ✓ extremely slow, with impacts only becoming apparent after thousands or millions of years.
  - ✓ Larger global areas are impacted by constructive forces, which result in meso-level reliefs.
  - ✓ For instance, plains, plateaus, and mountains.
  - ✓ Diabolical motions are further subdivided

- **Epeirogenic Movements**
  - ✓ Movements that build continents or are epeirogenic are radial movements (act along the radius of the earth).
  - ✓ Through upward and downward movements, it elevates and lowers continental masses.
  - ✓ Vertical movements have a greater overall impact.
  - ✓ Most often, vertical movements lead to the development of continents and plateaus (continental building process).
  - ✓ There are two different kinds of upward movement: upliftment and upward movement.
  - ✓ Emergence is the name given to the coastal land of a continent, whether it is its entirety or a portion.
  - ✓ Coast of Coramandal (Tamil Nadu Coast)
  - ✓ Coast of Malabar (Kerala Coast)
  - ✓ Maharashtra's and Goa's Konkan coasts
  - ✓ Downward movement or subsidence
  - ✓ Of whole continent or part there of coastal land near the coast called submergence
  - ✓ **Features** = Ria, fjord, Dalmatian and drowned lowlands
  - ✓ The Andamans and Nicobars is the visible part of the submerged Arakan range.
  - ✓ A part of the Rann of Kachchh was submerged as a result of an earthquake in 1819.

- **Orogenic Movements**
  - ✓ movement that is horizontal or tangential.
  - ✓ Either move closer or farther apart from one another.
  - ✓ The "tensional forces" or "divergent forces" are what cause them to move in opposing directions (create rupture, cracks, fracture and faults).
  - ✓ Due to "compressional forces or convergent force," they move in the same direction (create crustal deformation leading to formation of folds or subsidence of crustal parts).

- **Folds**
  - ✓ When compressional force is applied to rocks or a portion of the earth's crust, an undulating structure (wave-like) known as a fold results. Multiple strata make up the folds (rock layers)
  - ✓ Anticlines and synclines are the most common up-and-down folds that result from compression.
  - ✓ **Anticline is ()** shape with the oldest rocks in the centre of the fold.
  - ✓ **Syncline is (U)** shape, with the youngest rocks in the centre of the fold.
  - ✓ **Overturned Fold** is a highly inclined axial plane such that the strata on one limb are overturned.
  - ✓ **Recumbent Fold** has an essentially horizontal axial plane.
  - ✓ **Nappe** is a sheet of rock that has moved sideways over neighbouring strata as a result of an overthrust or folding.

- **Types of Mountains**

- **Fold Mountains**
  - ✓ At the point where two or more tectonic plates on Earth collide, fold mountains are formed.
  - ✓ It is the result of compressional forces caused by endogenic or internal forces folding the rocks that make up the Earth's crust.
  - ✓ They are regarded as the "real mountains."
  - ✓ Fold Mountains are frequently referred to as the result of orogenesis, or mountain construction.
  - ✓ These are a large chain of mountains with tremendous heights, although their width is quite narrow.
  - ✓ These mountains feature ongoing seismic activity because they were formed along an unstable portion of the earth.
  - ✓ They also have abundant mineral resources, like gold, copper, and tin.

- **Examples**
  - ✓ Rockies (North America) – 4,830 km
  - ✓ Andes (South America)– 7,000 km
  - ✓ Alps (Europe)– 1,200 km
  - ✓ Atlas (Africa) – 2,500 km
  - ✓ Himalayas (Asia) – 2,400 km

- **Types of Fold Mountains**
  - ✓ **On the basis of Nature of Fold**

1. **Simple folded mountains –** Folds are arranged in waves like pattern with a well-developed system of anticline and synclines.
2. **Complex folded mountains –** Folds are complex in nature due to extreme compressional forces like overfold, recumbent fold and nappe. Himalayas are one such example.

On the basis of the Period of Origin

- **Old fold mountains**
  - ✓ Mountains which originated before the Tertiary period.
  - ✓ These mountains have been so greatly eroded that they have become residual fold mountains.
  - ✓ Example

- ✓ Aravalis – 800 km
- ✓ Appalachians – 2,414 km

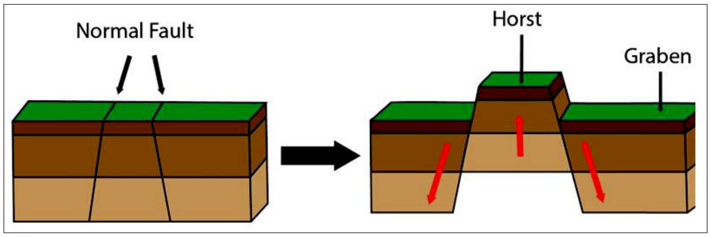
- **Young or New fold mountains**
  - ✓ Fold mountains of the Tertiary period.
  - ✓ They are further subdivided based on their location
  - ✓ Andean type
  - ✓ At the ocean-continental convergent boundaries (C-O).
  - ✓ Prone to both earthquakes and volcanic activities.
  - ✓ Example
  - ✓ Rockies
  - ✓ Andes

- **Himalayan type**
  - ✓ At the continental - continental convergent boundaries (C-C).
  - ✓ No active volcanism here.
  - ✓ Presence of sedimentary deposits of marine origin because of

- **Example**
  - ✓ Great Himalayas

- **Block Mountains**
  - ✓ Block Mountains are created where two or more of Earth's tectonic plates are drifted away.
  - ✓ Result of rifting of the Earth's crustal rocks by tensile forces arising from the endogenic or internal forces.
  - ✓ Also called fault-block Mountains since they are formed due to faulting as a result of tensile and compressive forces.
  - ✓ The uplifted blocks are termed as horsts, and the lowered blocks are called graben.

- **Examples**
  - ✓ Great African Rift Valley (valley floor is graben)
  - ✓ Rhine Valley (graben) and Vosges mountain (horst) in Europe



- **Volcanic Mountain**
  - ✓ A mountain formed due to volcanic activity is called Volcanic Mountain.
  - ✓ As these are formed by the accumulation of volcanic material, they are also known as mountains of accumulation.

- **Examples**
  - ✓ Kilimanjaro (Tanzania)
  - ✓ Fujiyama (Japan)
  - ✓ Andaman and Nicobar islands in India is the tip of the volcanic mountains which rise from the ocean floor.

- **Residual or Dissected Mountain**
  - ✓ These mountains are evolved by denudation.
  - ✓ That is why they are also known as relict mountains or mountains of circumdenudation.
  - ✓ They have been worn down from previously existing elevated regions.

- **Examples**
  - ✓ Nilgiri Hills
  - ✓ Parasnath
  - ✓ Girnar
  - ✓ Rajmahal
  - ✓ But Nilgiris got their present height as a result of subsequent uplift.

Exogenic Processes

- Exogenetic activities are a direct result of stress brought about in earth materials by various pressures that are created as a result of solar heat.
- Any exogenic natural force that can gather and move earth materials, such as water, ice, wind, etc., is

referred to as a geomorphic agent (mobile medium)

- The majority of exogenic geomorphic processes have tiny, gradual effects, but over time, because of constant wear and tear, they have a detrimental influence on the rocks.

- **Denudation**
  - ✓ Denudation is the collective term for all exogenic geomorphic processes, including weathering, mass wasting/movements, erosion, and transportation.
  - ✓ Denude is a verb that implies to expose or strip off.
  - ✓ Stress is the internal opposing force that is applied per unit area. The main cause of weathering, erosion, and deposition is the formation of stresses in the earth's underlying components.
  - ✓ Shear stresses are forces pushing on the surfaces of earth materials (separating forces). Rocks and other materials made of the ground are broken by this stress.
  - ✓ The two major climatic factors that regulate different processes by putting stress on the materials of the planet are temperature and precipitation.
  - ✓ Temperature changes subject materials found on Earth to molecular stresses.
  - ✓ Chemical reactions that cause the links between grains to weaken.

- **Weathering**
  - ✓ Mechanical disintegration and chemical decomposition of rocks through the actions of various elements of weather and climate.
  - ✓ An in-situ or on-site process (very little or no motion of materials takes place).

- **Type of Weathering**
  - ✓ A group of weathering process acts on the rocks to chemically decompose, dissolve or reduce them to a fine state.

1. Solution

- Something is dissolved in water or acids.
- This phenomenon is depends upon the solubility of a mineral in water or weak acids.
- Soluble rock forming minerals like nitrates, sulfates, and potassium etc. are affected by this process.
- Easily leached out without leaving any residue in rainy climates and accumulate in dry regions.

2. Carbonation

- Reaction of carbonate and bicarbonate with minerals
- Carbonic acid form by absorbing Carbon Dioxide from the atmosphere that acts as a weak acid on various minerals (like limestone).

3. Hydration

- Chemical addition of water.
- Minerals take up water and expand causing an increase in the volume of the material itself or rock.
- This process is reversible and long. Continued repetition causes fatigue leading to disintegration of rocks.
- The volume changes in minerals due to hydration will also help in physical weathering through exfoliation and granular disintegration.

4. Oxidation and reduction

- Oxidation is gain of oxygen. Reduction is loss of oxygen.
- Oxidation occurs where there is ready access to the atmosphere and water.
- A combination of a mineral with oxygen forms oxides (rusting in case of iron) or hydroxides.
- Reduction takes place on placement of oxidized minerals in an oxygen deficient environmen

- **Biological Weathering**
  - ✓ Biological weathering is physical changes (removal of minerals and ions) due to growth or movement of organisms.
  - ✓ New surfaces for chemical attack is exposed by Burrowing and wedging by organisms like earthworms, rodents etc.
  - ✓ Human being by disturbing vegetation, ploughing and cultivating soils.

- **Physical or Mechanical**
  - ✓ Depend on some applied forces like

1. Gravitational forces.
2. Expansion forces due to temperature changes, crystal growth or animal activity.
3. Water pressures controlled by wetting and drying cycles.

Expansion and Unloading

- Vertical pressure is released when the overlying rock weight is removed as a result of ongoing erosion. It results in the breakup of rock masses by causing the upper layers of the rock to expand.
- Arched fractures frequently result in huge rock sheets or exfoliation slabs in places with curved ground surfaces.
- Exfoliation domes are large, spherical, smooth domes that result from this procedure.

Granular Disintegration

- A form of weathering where the grains of a rock become loosened and fall out.

- **Exfoliation due to the Temperature Changes and Expansion**
  - ✓ Due to the diurnal changes in the temperatures, the surface layers of the rocks tend to expand more than the rock at depth that leads formation of stress within the rock.
  - ✓ Due to this, surface layers undergo from exfoliation that result in smooth rounded surfaces in rocks known as exfoliated tors.
  - ✓ This process is most effective in dry climates and high elevations where diurnal temperature changes are drastic.

- **Block Separation**
  - ✓ This type of disintegration takes place in rocks with numerous joints acquired by shrinkage due to cooling or mountain-making pressures.
  - ✓ This type of disintegration in rocks can be achieved by comparatively weaker forces.
  - ✓ Shattering

- **Freezing, Thawing and Frost Wedging**
  - ✓ Water penetrates the pore spaces or fractures in rocks during the warm season. This water freezes into ice during the cold season and its volume expands as a result.
  - ✓ This exerts tremendous pressure on rock walls to tear apart even where the rocks are massive.
  - ✓ Frost weathering occurs due to growth of ice within pores and cracks of rocks during repeated cycles of freezing and melting.

- **Salt Weathering**
  - ✓ Salts in rocks expand due to thermal action, hydration and crystallisation.
  - ✓ Many salts like calcium, sodium, magnesium, potassium and barium have a tendency to expand.
  - ✓ High temperature ranges in deserts favor such salt expansion.
  - ✓ Salt crystals in near-surface pores split the individual grains within rocks which eventually fall off.
  - ✓ This process of falling off of individual grains may result in granular disintegration or granular foliation.

- **Significance of Weathering**
  - ✓ The initial step of soils formation.
  - ✓ Weathering helps in soil enrichment (enhancing certain valuable ores of iron, manganese, aluminium, copper etc.) making extraction of the same valuable material sufficient and economically viable.

Mass Movement

- Mass movement, also called Mass Wasting, is a bulk movement of soil and rock debris down slopes under the influence of gravity.
- Mass of rock debris moves down the slope under the direct influence of gravity rather than air, water, or ice (but mass may carry with it air, water, ice).
- Weathering is not pre-requisite for mass movement though it aid mass movement (mass movement is more active on weathered slope).

Types of Mass Movement Processes

- **Slow mass movements**
  - ✓ Creep
  - ✓ Solifluction

- **Rapid mass movements**
  - ✓ Earth flow
  - ✓ Mud flow
  - ✓ Debris avalanche

- **Landslide**
  - ✓ Slump
  - ✓ Rock slide
  - ✓ Debris Slide

Earthquake

- An earthquake is a sudden release of energy in the Earth's lithosphere that results in seismic waves, which cause the Earth's surface to shake.
- An earthquake is a type of wave motion energy that travels through the earth's surface layer.
- Faulting, folding, tectonic movement, volcanic eruptions, and manmade elements like dams and reservoirs may all be to blame.
- Of all the natural disasters, earthquakes are by far the most unpredictable and severely destructive.
- Every few minutes, there are minor earth tremors brought on by moderate waves of vibration within the earth's crust, but major earthquakes, which are typically brought on by movement along faults, can be extremely destructive, especially in heavily populated places.

Earthquake Waves

- Earthquake waves are produced when energy is released during an earthquake. Body waves and surface waves are the two main categories of earthquake waves.
- **Body Waves:** They are created when energy is released at the focus and travel through the earth's body in all directions. Hence, body waves are so named. Surface waves are created when the body waves interact with the rocks on the surface.
- **Surfacing Waves:** The surface is traversed by these waves. As waves pass through various densities of materials, their velocities alter. The velocity increases with material density. When they come into contact with materials of different densities, their direction also modifies due to reflection or refraction.

There are two types of body waves

1. P-waves, also known as "primary waves," travel more quickly and are the first to reach the surface. P-waves resemble sound waves in many ways. They move through solid, liquid, and gaseous substances.
   - ✓ P-waves vibrate perpendicular to the wave's direction. In the propagation direction, this puts pressure on the material. Because of the resulting density discrepancies, the material stretches and contracts as a result.

2. **S-waves also known as secondary waves:** With some latency, S-waves or secondary waves reach the surface. They can only move through objects that are solid. This aspect of the S-waves is quite significant. It has aided scientists in their understanding of the internal structure of the earth.
   - ✓ S-waves vibrate in a direction perpendicular to the vertical direction of the wave.

- **How can seismic waves be used to better comprehend the interior of the earth?**
  - ✓ Seismographs placed in remote regions capture seismic waves.
  - ✓ The Earth's interior can be mapped thanks to variations in arrival times, waves travelling unexpected courses due to refraction, and the absence of seismic waves in some areas known as shadow zones.
  - ✓ Discontinuities in depth-dependent velocity are a sign of compositional and density variations.
  - ✓ it is possible to estimate the density and composition of the earth's interior by watching changes in velocity (change in densities greatly varies the wave velocity).
  - ✓ Wave motion discontinuities as a function of depth are a sign of phase shifts.
  - ✓ distinct strata can be recognised by watching the variations in the direction of the waves and the appearance of shadow zones.
- **The Appearance Of The P- and S-Wave Shadow Zone**
  - ✓ Liquids do not conduct S-waves.
  - ✓ The zone beyond 103 is known as the shadow zone of S-waves since the entire region does not receive S-waves. The liquid outer core was discovered as a result of this finding.
  - ✓ Between 103 and 142 from the epicentre, a band known as the shadow zone of P-waves is visible around the globe.
  - ✓ This is due to the fact that P-waves are bent as they cross the boundary between the semisolid mantle and the liquid outer core.
  - ✓ Seismographs beyond142 degrees from the epicentre, detect the arrival of P-waves but not S-waves. This provides information on the sturdy inner core.
  - ✓ Thus, it was determined that the shadow zone for both types of waves was located between 103 and 142 from the epicentre.
  - ✓ The seismographs located at any distance within 103 from the epicentre, recorded the arrival of both P and S-wave

Classification of Earthquake

1. **On basis of causative factors**

- **Natural**
  - ✓ Volcanic
  - ✓ Tectonic
  - ✓ Isostatic
  - ✓ Plutonic
  - ✓ Artificial

2. **On basis of depth of focus**
   - ✓ Moderate(0-50km)
   - ✓ Intermediate (50-250 km)
   - ✓ Deep focus (250-700 km)

3. On basis of human casualities
   - ✓ Moderate (deaths<50,oo)
   - ✓ Highly hazardous(51,000-1,00,00)
   - ✓ Most hazardous(>1,00,00)

- **Richter scale**
  1. Richter magnitude scale is the scale to measure the magnitude of energy released by an earthquake.
  2. This scale was devised by Charles. F. Richter in the year 1935.
  3. The number indicating magnitude ranges between 0 to 9

- **Mercalli Scale**
  1. The Mercalli intensity scale is a seismic scale used for **measuring the intensity** of an earthquake.
  2. It measures the effects of an earthquake
  3. The number indicating intensity **ranges between 1 to 12**

Earthquake Causes

- Earthquakes are caused mainly due to dis-equilibrium in any part of the crust of the earth. A number of causes have been assigned to caused dis-equilibrium or isostatic imbalance in the earth's crust.

A. Natural Reasons

- ✓ Volcanic eruption
- ✓ Faulting and folding
- ✓ Upwarping and downwarping
- ✓ Gaseous expansion and contraction inside the earth.
- ✓ Plate Movement
- ✓ Landslides

B. Man-Made/Anthropogenic Reasons

- ✓ Deep underground mining
- ✓ Blasting of rock by dynamites for construction purposes.
- ✓ Deep underground tunnel
- ✓ Nuclear explosion
- ✓ Reservoir Induced Seismicity (RIS) (E.g. **Koyna Reservoir witnessed Earthquake in 1967 due to RIS**)
- ✓ Hydrostatic pressure of man-made water bodies like reservoirs and lakes.

Distribution of Earthquake

- **Circum-Pacific seismic belt:** The Pacific Ocean's rim is home to the strongest earthquakes on Earth, making it the epicentre of the world's largest earthquake belt. It also goes by the name "Ring of Fire."
- **From Java to Sumatra, the Alpide seismic belt** stretches through the Himalayas, the Mediterranean, and out into the Atlantic. About 17% of the greatest earthquakes in the globe occur in this zone.
- **The submerged mid-Atlantic ridge** indicates the location of the separation of two tectonic plates (a divergent plate boundary).
- **Earthquake Prone areas in India:** India has been split into four seismic zones, namely Zones II, III, IV, and V, by Indian seismology experts. The entire Himalayan region, the states of North-East India, Western and Northern Punjab, Haryana, Uttar Pradesh, Delhi, and portions of Gujarat are all considered to be in the highest and high-risk categories, referred to as zone V and IV, respectively.
- A sizable portion of the peninsular region is in the low-risk zone, while the remaining portions of the northern plains and the western coastal areas are in the moderate risk zone.

Volcano

A volcano is a rupture in the crust of a planetary-mass object, such as Earth, that allows hot lava, volcanic ash, and gases to escape from a magma chamber below the surface. The process is called Volcanism and has been ongoing on Earth since the initial stages of its evolution over 4 billion years ago.

Volcanoes are Earth's geologic architects. They've created more than 80 percent of our planet's surface, laying the foundation that has allowed life to thrive. Their explosive force crafts mountains as well as craters.

Formation of Volcanoes

1. Most volcanoes in the world are formed near the tectonic plate boundaries, which are vast regions of our planet's lithosphere that are constantly shifting and colliding.

2. In a region known as a subduction zone, tectonic plates frequently drop far below one another when they clash.
3. Temperatures and pressures rise as the continent descends further into the Earth, causing water to be released from the rocks.
4. The water slightly lowers the melting point of the rock that lies above it, creating magma that can rise to the surface and reactivate dormant volcanoes.
5. Not all volcanoes are formed as a result of subduction; another method is hotspot volcanism.
6. In this instance, a hotspot or zone of magmatic activity in the centre of a tectonic platE
7. Although the hotspot itself is thought to be largely stationary, the tectonic plates continue their slow march, building a line of volcanoes or islands on the surface. This mechanism is thought to be behind the Hawaii volcanic chain.

Volcanic Landforms

- Depending on whether magma cools below or above the crust, volcanic landforms are classified as either extrusive or intrusive.
  - ✓ **Plutonic rocks** are those created when magma within the crust cools.
  - ✓ **Igneous rocks** are those created when lava cools above the surface.

- **Extrusive Volcanic Landforms**
  - ✓ Extrusive landforms are formed from material thrown out to the surface during volcanic activity.

- **Fissure Vent**
  - ✓ A fissure vent, also known as a volcanic fissure, is a long, narrow volcanic opening through which lava often erupts without igniting or exploding.
  - ✓ The vent may be many kilometres long and only a few metres wide.
  - ✓ In basaltic volcanism (shield type volcanoes), fissure eruptions are frequent.

- **Middle Ocean Ridges**
  - ✓ Over 70,000 km of the ocean basins are covered by the system of mid-ocean ridges.
  - ✓ There are regular eruptions in the mid-ocean ridges' core region.
  - ✓ The seabed is spreading as a result of the basaltic lava, which has less silica and is hence less viscous.

- **Composite Type**
  - ✓ They are volcanic landforms of the conical or central type.
  - ✓ Large amounts of pyroclastic debris and ashes reach the surface together with andesitic lava.
  - ✓ Layers are formed when andesitic lava and pyroclastic material gather close to vent vents, giving the mounts the appearance of a composite volcano or stratovolcano (divided into layers).
  - ✓ **Mount Stromboli (the Lighthouse of the Mediterranean)**, Mount Vesuvius, Mount Fuji are examples.

- **Shield Volcanoes**
  - ✓ The most well-known examples are the volcanoes in Hawaii.
  - ✓ The majority of the lava in these volcanoes is basaltic (very fluid).
  - ✓ It's not steep on these volcanoes.
  - ✓ If water enters the vent in any way, they become explosive; otherwise, they remain less explosive.
  - ✓ Examples include the dormant shield volcano Mauna Kea and the active shield volcano Mauna Loa in Hawaii.

- **Crater**
  - ✓ A crater is an outlet for the magma in the

form of an inverted cone. The crater is visible as a dip in the shape of a bowl while the volcano is dormant. A crater lake forms when water from rain or melting snow builds up in the crater.

- **Caldera**
  - ✓ After volcanic eruptions, the magma chamber beneath some volcanoes may be drained.
  - ✓ Calderas are formed when the volcanic material that was above a magma chamber collapses into an empty magma chamber, giving the collapsed surface the appearance of a sizable cauldron or tub.
  - ✓ A caldera lake forms when water from melted snow or rain accumulates in the crater (in general, the caldera lakes are also called crater lakes).
  - ✓ Some crater lakes only occasionally occur due to their unstable surroundings.
  - ✓ For example, Lake Toba (Indonesia) formed after its supervolcanic eruption around 75,000 years ago. It is the largest crater lake in the world

- **Intrusive Landforms**
  - ✓ Intrusive landforms are formed when magma cools within the crust.

- **Batholiths**
  - ✓ These massive granitic rock bodies were created when hot magma solidified deep within the ground.
  - ✓ Only when the underlying materials have been removed by denudation processes do they become visible on the surface.
  - ✓ Huge mountains' cores, known as batholiths, may become revealed on the surface as a result of erosion.

- **Laccoliths**
  - ✓ Large invasive bodies with a dome form that are connected by a conduit that resembles a pipe from below.
  - ✓ These are an exposed dome-like batholith's intrusive equivalents.
  - ✓ There are granite dome hills scattered throughout the Karnataka plateau. Most of these are laccoliths or batholith specimens that have exfoliated.

- **Lapolith**
  - ✓ Wherever it encounters a weak plane, a portion of the lava may tend to shift horizontally as it goes higher. It may rest in a variety of ways.
  - ✓ It is known as Lapolith if it transforms into a saucer-shaped body that is concave to the sky.

- **Phacolith**
  - ✓ Sometimes, in folded igneous layers, a wavy mass of intrusive rocks is found at the foot of synclines or the top of the anticline.
  - ✓ Such wavy materials clearly connect to their source below through magma tunnels (subsequently developed as batholiths).

- **Sills**
  - ✓ Sill refers to the almost horizontal bodies of the intrusive igneous rocks. Sheets are the ones that are thinner.

- **Dykes**
  - ✓ Lava solidifies virtually perpendicular to the ground as it flows through fissures and faults in the terrain.
  - ✓ It cools in the same location, forming a structure like a wall. These things are referred to as dykes.
  - ✓ These are the invading types that are most frequently observed in the western Maharashtra region.
  - ✓ These are thought to have served as feeders for the eruptions that produced the Deccan traps.

Location of Volcanoes

- Around the ring of fire, a 25,000-mile-long horseshoe-shaped region that spans from the southern tip of South America around the West Coast of North America, through the Bering Sea to Japan, and on to New Zealand, are located approximately 75% of the world's active volcanoes.
- The Pacific and Nazca tectonic plates' margins meet a variety of other tectonic plates in this area. Importantly, though, there is no geological link between the ring's volcanoes. To put it another way, an eruption of volcanic material in Indonesia is unrelated to one in Alaska and cannot cause the infamous Yellowstone supervolcano to erupt.

Reasons of Volcanic Eruption on Pacific Ring of Fire.

- **Plate Boundaries:** Plate tectonics is the cause of the Ring of Fire. Huge slabs of the Earth's crust called tectonic plates fit together like puzzle pieces. The mantle, a layer of solid and molten rock, is on top of the moving plates, which are not fixed. These plates can occasionally slide adjacent to one another, clash, or move apart. These geologically active zones in the Ring of Fire are where most tectonic activity takes place.
  - ✓ **Convergent Boundaries:** Tectonic plates colliding with p another create a convergent plate boundary. Subduction zones, where the heavier plate slides under the lighter plate and leaves a deep trench, are frequently found at convergence points. The dense mantle material is transformed during subduction into buoyant magma, which rises through the crust to reach the Earth's surface. A volcanic arc, which is made up of several active volcanoes, is the result of rising magma over millions of years.
  - ✓ Andes Mountains of South America run parallel to the Peru-Chile Trench, created as the Nazca Plate subducts beneath the South American Plate.
- **Divergent Boundaries:** The breaking apart of tectonic plates creates a divergent border. Rift valleys and seafloor spreading are found at divergent boundaries. Magma rising in the rift as the old crust pulls itself in opposing directions causes the seafloor to spread. The magma is cooled by the seawater, forming new crust. Over millions of years, the magma's upward flow and subsequent cooling produced high ridges on the ocean floor.
  - ✓ In the Ring of Fire, the East Pacific Rise is where the seabed is expanding most dramatically. The East Pacific Rise is situated where the Pacific Plate, the Cocos Plate, the Nazca Plate, and the Antarctic Plate divide, west of Central America, South America, and Antarctica, respectively.
  - ✓ **Transform Boundaries:** As tectonic plates pass one another horizontally, a transform boundary is created.
  - ✓ At the points where these plates connect, pieces become stuck. As the other plates continue to shift, tension rises there. Because of the stress, the rock cracks or slips, jolting the plates ahead and creating earthquakes.
  - ✓ Faults are these slippage or breakage regions. The majority of Earth's faults can be located in the Ring of Fire along transform boundaries.

- **Active Volcanoes in the Ring of Fire**
  - ✓ **Mount Ruapehu** in New Zealand
  - ✓ **Krakatau, perhaps better known as Krakatoa,** is an island volcano in Indonesia.
  - ✓ **Mount Fuji,** Japan's tallest and most famous mountain, is an active volcano in the Ring of Fire.
  - ✓ Mount St. Helens, in the U.S. state of Washington, is an active volcano in the Cascade Mountains.
  - ✓ **Positive Effects of Volcanism** New productive landforms like islands, plateaus, volcanic mountains, etc. are produced by volcanism. Consider Deccan traps.
  - ✓ For crops and orchards, the volcanic ash and dust are particularly fertile.

- ✓ When volcanic rocks weather and decay, they produce exceptionally rich soil.
- ✓ Although significant cultivation is impossible on the steep slopes of volcanoes, forestry operations on those slopes produce valuable timber resources.
- ✓ Volcanoes raise mineral deposits to the surface, especially metallic ores. The cavities of the gas bubbles can contain copper and other ores.
- ✓ The diamond-producing Kimberlite rock in South Africa is the conduit of a long-extinct volcano.
- ✓ Hot lava that comes into contact with deep waters around active volcanoes heats them up, causing springs and geysers to form
- ✓ The Puga valley in Ladakh region and Manikaran (Himachal Pradesh) are promising spots in India for the generation of geothermal electricity.
- ✓ Geothermal potential can also be used for space heating.
- ✓ As scenic features of great beauty, attracting a heavy tourist trade, few landforms outrank volcanoes.
- ✓ At several places, national parks have been set up, centred around volcanoes. E.g. Yellowstone National Park.

Geyser	Hot water spring
Along its journey, high-pressure steam or water collects in fissures, cracks, and small reservoirs. When the pressure reaches the threshold level, the steam explodes to the surface, causing the water at the mouth to become agitated. the geyser's name.	A spring is created when steam or water under high pressure condenses at the surface and travels easily to the top through the vent.
Silicate deposits at mouth give them their distinct colours.	Some springs are very colourful because of the presence of cyanobacteria of different colours.
Generally, geysers are located near active volcanic areas. Iceland is famous for its geysers.	Found all across the world

Rocks and Minerals

- Rocks make up the majority of our planet. Mineral grains mixed in diverse ways and with various qualities make up the rocks.
- Minerals are chemical substances that exist in nature and have atoms organised in three dimensions.
- Each mineral has a distinct appearance and set of qualities depending on the kind of elements present and how they are arranged.
- When organised in different ways, the same chemical elements exhibit various properties.
- A mineral is made up of at least two different elements. However, single element minerals such as sulphur, copper, silver, gold, graphite, etc. are occasionally discovered as well.
- The earth's hot magma is the fundamental source of all minerals.
- Mineral crystals form as the magma cools, and a systematic series of minerals crystallise one after the other to form rocks.
- Metal-containing minerals are referred to as metallic minerals (such as haematite), while ore refers to metallic minerals that may be mined for a profit.
- More than 2000 minerals make up the earth's crust, yet just six of them are most prevalent and contribute the most.

Some Major Minerals

- **Quartz** It is one of the most important components of sand and granite.
  - ✓ It consists of silica and it is a hard mineral virtually insoluble in water.
  - ✓ They are used in the manufacturing of radio, radar, etc.
- **Feldspar**
  - ✓ Silicon and oxygen are major elements of all types of feldspar.

- ✓ Sodium, potassium, calcium, aluminium, etc are found in specific feldspar varieties.
- ✓ **Half of the earth's crust is composed of feldspar [plagioclase (39%) and alkali feldspar (12%)].**
- ✓ It is commonly used in ceramics and glass making.

- **Pyroxene**

  - ✓ The common elements in pyroxene are Calcium, aluminium, magnesium, iron and silicon.
  - ✓ About 10% of the earth's crust is made up of pyroxene.
  - ✓ It is commonly found in meteorites.

- **Amphibole**

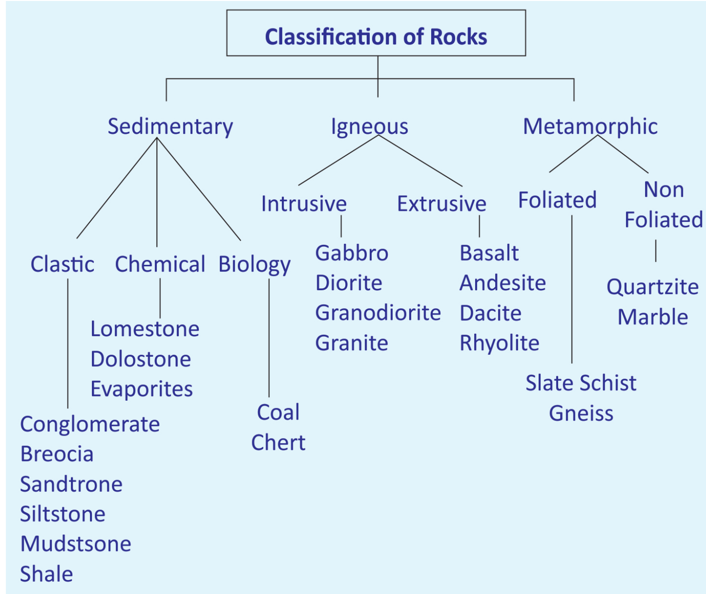
  - ✓ Aluminium, calcium, silicon, iron and magnesium are the major elements of amphiboles.
  - ✓ They form 7% of the earth's crust.
  - ✓ It is green or black in colour and is used in asbestos industries commonly.
  - ✓ Hornblende is another form of amphiboles.

- **Mica**

  - ✓ It is made up of elements like potassium, aluminium, magnesium, iron, silicon, etc.
  - ✓ It forms 4% of the earth's crust.
  - ✓ It is commonly found in igneous and metamorphic rocks.
  - ✓ Mica is widely used in electronic instruments.

Formation of Rocks

In all, there are three types of rocks: igneous, sedimentary, and metamorphic. Each type of rock has a different origin.



- **How Do Igneous Rocks Form?**

  - ✓ When melted rock cools and hardens, igneous rocks are created. When located beneath the surface of the Earth, melted rock may take the form of magma. When it is released onto the Earth's surface during a volcanic eruption, it can also take the form of lava.
  - ✓ The igneous rocks granite, scoria, pumice, and obsidian are a few examples.
  - ✓ Pumice, for instance, is created when lava, which is composed of molten rock, water, and trapped gas, is violently blasted from a volcano. Some of the contained gas escapes during the extremely quick cooling and depressurization of the expelled material, producing holes and gas bubbles on the solidified substance.

- **How do Sedimentary Rocks Form?**

  - ✓ When soil and other elements on the Earth's surface are eroded and eventually settle down, forming one layer of sediments, sedimentary rocks begin to form. New and more materials are degraded and deposit on the earlier layers as time goes on. Layer after layer is created as a result. Due to the weight of the top layers, the lower layers experience extreme pressure, eventually transforming into rocks.

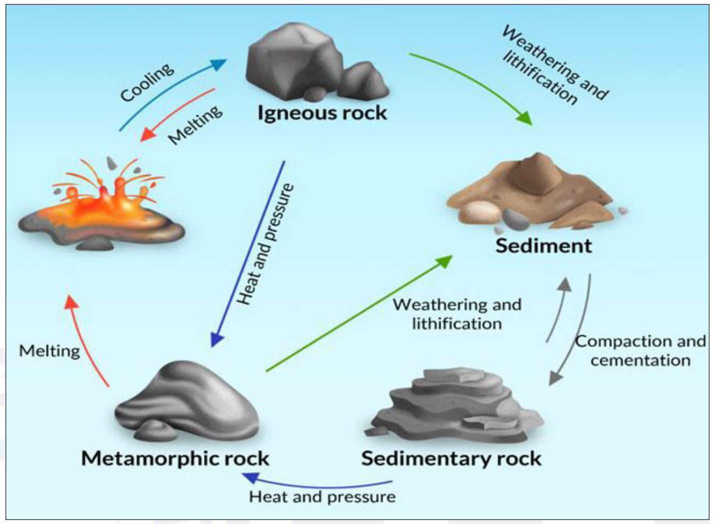
- ✓ The sedimentary rocks **sandstone, limestone, shale, conglomerate, and gypsum are a** few examples. For instance, sand from rivers and beaches is deposited as sandstone. Since deltas are where rivers enter the ocean, this is where one can usually locate them.

- **How Are Metamorphic Rocks Formed?**

- ✓ To metamorphose or simply to morph means 'to change in form'. Metamorphic rocks are actually products of rocks that have undergone changes. Thus, a metamorphic rock may have originally been an igneous, sedimentary, or even another metamorphic rock. The changes occur when the original rocks are subjected to extreme heat and pressure beneath the Earth's surface.They may also occur when the the original rocks are caught in the middle of two colliding tectonic boundaries.
- ✓ Some examples of metamorphic rocks are marble, slate, schist and gneiss. Marble, for instance is the result of the metamorphism of limestone and dolostone. When limestone metamorphoses, its calcite grains grow and interlock with one another. As such, marble is denser and harder compared to limestone.

Rock Cycle

- Different physical and chemical processes link each type of rock to the others.
- Igneous, sedimentary, and metamorphic rocks may be subject to weathering and erosion in mountains.



- Breaking free from these exposed rocks, sediment grains (or boulders!) tumble or fall downhill in a streambed as a result of gravity. The silt further degrades along this journey, eventually reaching the ocean. When sediment is dumped in an ocean basin, it is covered by further sediment, which causes it to consolidate into sedimentary rock. It can transform, turning into a metamorphic rock.

Personal Notes

CLIMATOLOGY

Evolution of Atmosphere

- The current atmosphere has gone through three stages of development.
- **Loss of the first Atmosphere:** According to theory, the solar winds swept away the early atmosphere's hydrogen and helium content.
- **Evolution of the Atmosphere:** caused by the earth's core heat. Due to the massive volcanism and degassing throughout the early life of the planet, nitrogen, sulphur, carbon dioxide, water vapour, and argon were released.
- **Alters the composition:** through the process of photosynthesis, the living world alters the composition of the atmosphere.
- Condensed water vapour caused clouds to develop, which then caused rain to wash the majority of the carbon dioxide into the oceans.
- Through the anaerobic respiration of microbes like cyanobacteria, oxygen was created (and not from degassing).
- The primary contributor to the current makeup of the earth's atmosphere is Oxygen and Nitrogen.

Atmosphere

- Life can only be found on Earth, making it a special planet.
- Among the elements required for life, air holds a unique position.
- Several gases are blended together to form the air.
- The entire earth is surrounded by air.
- The atmosphere is the term for the air that surrounds the Earth.
- A key component of our planet is its atmosphere.
- The earth's gravitational pull connects it to the planet.
- It helps to keep the appropriate temperature required for living and block harmful ultraviolet rays.
- All types of earthly life depend on the air to survive. Any type of life that does not exist cannot be envisioned. The environment is similar to a protective layer.
- Gases in the atmosphere continually move and change since it is a dynamic system. With respect to composition and temperature, these gases create a number of hazy layers surrounding Earth.
- There is no direct evidence of the early stages of earth's genesis in the gases that make up the current atmosphere. They are a byproduct of development brought about by volcanic eruptions, hot springs, chemical breakdown of solid matter, and redistribution from the biosphere.

Composition of Atmosphere

- Numerous gases are mixed together to form the atmosphere. Additionally, it contains a significant amount of aerosols, which are both liquid and solid particles.
- Quantities of other components fluctuate from time to time and from location to place. Dry air is very stable all over the planet up to an altitude of roughly 80 kilometres if the water vapour, suspended particles, and other variable gases were omitted from the atmosphere.
- Nearly 99% of the dry, air is composed of nitrogen and oxygen. About 1% of the atmosphere is made up of the other gases, which are mainly inert.
- Along with these gases, the atmosphere contains significant amounts of water vapour and dust particles. These solid and liquid particles have major climatic implications.

Gases

- **Oxygen:** The most significant gas is oxygen, while making up only 21% of the atmosphere's overall volume. All living things breathe in oxygen. Oxygen can also interact with other elements to create significant compounds like oxides. Additionally, without oxygen, burning is not feasible.

- **Nitrogen:** 78% of the entire atmospheric volume is made up of nitrogen. It is a gas that is largely inert and a crucial component of all organic molecules. Nitrogen primarily controls combustion via dilution of oxygen.
- **Carbon di oxide:** Only around 0.038% of the dry air is carbon dioxide, which is produced during burning. Through photosynthesis, green plants take carbon dioxide from the air and use it to create food and maintain other biophysical processes.
- **Argon:** Argon is the third most significant gas, however it only makes up 0.93%
- **Ozone:** Ozone (03), which is actually a form of oxygen molecule with three rather than two atoms, is another significant gas in the atmosphere. It is unevenly dispersed and makes up less than 0.00006% of the atmosphere's volume. The highest ozone concentrations are seen between 20 km and 25 km altitude. The sun's dangerous UV energy is blocked significantly by ozone.
- Neon, helium, hydrogen, xenon, krypton, methane, and other gases are also present in the atmosphere but in essentially trace amounts.

Water Vapour

- One of the most changeable gases in the atmosphere, water vapour makes up between 2% and 4% of the total volume (in cold dry and humid tropical climates respectively). Within 6 kilometres of the earth's surface, 90% of the atmosphere's moisture content may be found.
- It absorbs some of the incoming solar radiation in addition to the long-wave terrestrial radiation (heat or infrared generated by the earth at night).
- Precipitation and clouds are made of water vapour. The ultimate driving factor behind all storms, latent heat of condensation, is released upon condensation.

Solid Particles

- The Solid Sand particles (derived from worn rocks and also from volcanic ash), pollen grains, tiny creatures, soot, and ocean salts are among the particles found in the atmosphere. The top layers of the atmosphere may also contain meteorite fragments that were burnt up in the atmosphere.
- These particles aid in the absorption, reflection, and scattering of solar energy, which contributes the charmingly variegated red and orange colour during sunrise and sunset.
- The selective scattering of solar light by dust particles gives the sky its blue colour.
- Salt atoms transform into hygroscopic nuclei, which aid in the creation of water droplets, clouds, and other types of condensation and precipitation.

Greenhouse Effect

- When gases in Earth's atmosphere capture the Sun's heat, the result is a phenomenon known as the greenhouse effect.
- Earth becomes substantially warmer as a result of this process than it would be without an atmosphere.
- One factor that makes the Earth a pleasant place to live is the greenhouse effect

Structure of Atmosphere

Troposphere

- The lowest part of the atmosphere on Earth is called the troposphere. It reaches a maximum distance of 18 km near the equator, 13 km at midlatitude, and roughly 8 km at the poles.
- The troposphere contains the majority of the atmosphere's mass (about 75–80%).
- Because hot air rises to higher altitudes, the thickness is larger at the equator.

- The Tropopause marks the end of the troposphere.
- As one travels upward, the temperature in this layer drops by 5C each kilometre, reaching -45C at the poles and -80C above the equator at the Tropopause (greater fall in temperature above equator is because of the greater thickness of troposphere – 18 km).
- "Lapse rate" refers to the rate of temperature decline.
- **Tropopause:** The atmospheric boundary that separates the troposphere from the stratosphere is known as the tropopause.The temperature stays constant in this layer.

Stratosphere

- It is located above the troposphere and uniformly reaches a height of 50 km.
  - ✓ The temperature in this layer remains steady for a while before rising to a level of 0C at a height of 50 km.
  - ✓ Ozone is the cause of this increase (harmful ultraviolet radiation is absorbed by ozone).
  - ✓ The conditions are practically perfect for flying aeroplanes since this layer is almost completely devoid of clouds and related weather phenomena. Therefore, when the weather is calm, aeroplanes fly in the upper troposphere rather than the lower stratosphere.
  - ✓ At lower elevations of this layer, cirrus clouds can occasionally be found.

Mesosphere

- The mesosphere extends to about 50 to 80 kilometres.
  - ✓ In this layer, the temperature drops once again and averages -90 C at its lowest point.
  - ✓ The uniform layer reaches the mesosphere.
  - ✓ A layer of ions that extends into the other layer is present at the upper mesosphere boundary.
  - ✓ The ions or charged particles in this layer aid in telecommunication by reflecting radio waves.
- **Thermosphere:** With rising height in the thermosphere, temperature rises quite quickly.
  - ✓ This layer includes the ionosphere. It stretches 80 to 400 km.
  - ✓ In radio transmission, this layer is helpful. This layer serves to reflect radio signals back to the earth from space.
  - ✓ The incredibly low pressure of the thermosphere would prevent a person from feeling warm.
  - ✓ In this layer, satellites and the International Space Station orbit. (A human or an object in this layer doesn't feel the heat because, despite the high temperature, the atmosphere is incredibly rarified, with gas molecules hundreds of kilometres apart.)
  - ✓ In the lower portions of this stratum, auroras have been seen.

Ionosphere

- This layer is electrically charged and is situated between 80 and 400 kilometres above the surface.
  - ✓ By absorbing cosmic rays, gamma rays, X-rays, and ultraviolet rays with shorter wavelengths, charged particles are ionised.
  - ✓ As a result of friction, this layer is where meteorites and arriving spacecraft start to heat up.
  - ✓ Once more, the sun's energy causes temperatures to rise with height.

Exosphere

- This is the top layer of the atmosphere, above the ionosphere at a height of roughly 400 km.
  - ✓ The temperature progressively rises through the layer, and the air is increasingly rarefied.
  - ✓ Light gases from here, including hydrogen and helium, float towards space.

- ✓ Through the layer, temperature rises gradually. This layer corresponds with space (as it is exposed to direct sunlight).

Temperature Inversion

- Under typical circumstances, the temperature in the troposphere typically drops by 1 degree for every 165 metres of altitude. It is known as a normal lapse rate.
- But occasionally, the trends are inverted, and the temperature begins to rise rather than fall with height. The term for this is a temperature inversion.
- A temperature inversion is a reversal of the tropospheric atmosphere's typical temperature pattern. A layer of warm air is located above the cold air layer beneath this climatic occurrence.
- While sometimes it happens as a result of air moving horizontally or vertically, it is caused by static atmospheric circumstances.

Favourable Conditions For Temperature Inversion.

- **Long winter nights:** Incoming solar energy may not be enough to offset the heat loss caused by terrestrial radiation from the ground surface at night.
- **Cloudless and clear sky:** Without any clouds or other obstructions, heat loss from the earth happens more quickly.
- **Cloudless and clear sky:** This prevents heat from the planet's surface from being absorbed as much.
- **Slow movement of air:** No heat is transferred or mixed in the lower atmosphere as a result of slow air movement.
- **Snow covered ground surface:** The heat is lost the most from a snow-covered ground surface because the sun's rays are reflected off of it.

Types of Temperature Inversion

1. **Non Advectional inversion**
   - ✓ **Radiation inversion (surface temperature inversion):** The most common time for a surface temperature inversion to occur is during clear nights when the ground rapidly cools off due to radiation. Surface temperature inversions arise when air is chilled by contact with a colder surface until it becomes cooler than the surrounding atmosphere. Fog may form if the temperature of the surface air falls below its dew point.
   - ✓ In the upper latitudes, it occurs frequently. It happens during chilly nights and is destroyed throughout the day in lower and middle latitudes.

2. **Subsidence Inversion (Upper Surface Temperature Inversion)**
   - ✓ The increase in atmospheric pressure that follows the descent of a broad layer of air causes it to be compressed and heated, which lowers the temperature lapse rate.
   - ✓ A temperature inversion occurs when the air is warmer at higher altitudes than it is at lower altitudes. Subsidence inversion is the name for this kind of temperature inversion.
   - ✓ It frequently occurs across the subtropical oceans and the northern continents in winter (dry atmosphere); these areas typically have subsiding air since they are situated beneath significant high-pressure centres.
   - ✓ Because it occurs in the upper reaches of the atmosphere, it is also known as an upper surface temperature inversion.

Advectional

1. **Valley inversion** in intermontane valley: In high mountains or deep valleys, the temperature of the lower air layers can occasionally rise rather than fall with elevation.
   - ✓ Here, the surface cools more quickly than the top layers and rapidly radiates heat back to space. The effect is that the lower cold layers get heavier and condense.

- ✓ They travel towards the bottom where the cold layer settles down as a zone of low temperature while the top layers are somewhat warmer due to the sloping surface below.
- ✓ Temperature inversion describes this situation, which is the reverse of the typical vertical distribution of temperature.

2. **Frontal or Cyclonic inversion**
   - ✓ When warm and cold fronts collide, the warmer front rises while the heavier cold front descends.
   - ✓ While most inversions are almost horizontal, this one has a significant slope. It frequently occurs in the temperate zone and induces cyclonic conditions that lead to precipitation in various forms.
   - ✓ A frontal inversion is brittle and disintegrates as the weather changes.

Effect

- Temperature inversion controls precipitation, cloud types, and frost formation by causing warm air to condense as it cools.
- Due to temperature inversion, air pollutants including smoke and dust particles do not spread on the surface. Dust particles hanging in the air.
- Air movement is halted because of the atmosphere's stability, which prevents both upward and downward air movement.
- Less rain: Convection clouds are unable to move very high into the sky, resulting in less rain and no showers. Therefore, it hinders agricultural output.
- **Lower visibility:** Fog forms when warm air above and cold air below are present, which reduces visibility and disrupts traffic.
- Tornadoes and thunder storms.

Heat Budget of Earth

- The heat budget of the earth, which keeps the planet's average yearly temperature at 15 degrees Celsius, is the equilibrium between incoming solar insolation and outgoing terrestrial radiation.
- Solar insolation refers to the solar energy that the earth's surface receives.
- The Radiation from the sun towards the earth is called incoming shortwave solar radiation and from the earth towards the atmosphere is called outgoing longwave terrestrial radiation.

How it is calculated?

- Suppose incoming solar insolation is = 100 units Amount lost through scattering and reflection.
  a. Through Clouds- 27units
  b. By dust particles – 6units
  c. By Ice Caps and Glaciers- 2units

Total 35 units are reflected back into space. (known as albedo of the earth) Now, the units received by earth and its atmosphere = 100 – 35 = 65units

Budget of Earth's heat

The direct radiation that the earth receives from the sun is divided into 51 units, as follows:

i. Direct Radiation Received: 34 units
ii. Diffused day light received equals 17 units, for a total of 51 units.

Heat Budget of Atmosphere

- Heat Budget of Atmosphere Absorption by atmospheric gases in various vertical zones of atmosphere-14 units
  - ✓ Currently, 51 + 14 units = 65 units (total solar insolationreceived by earth andatmosphere)
  - ✓ Of the 51 units of solar radiation that the earth directly receives from the sun, 17 units are re-radiated back into space, while the remaining 34 units (51-17units) are absorbed by the atmosphere and released as outgoing terrestrial radiation.
  - ✓ This equals 48 units (14 plus 34).

Pressure Belts

Belts of high or low pressure define the horizontal distribution of air pressure across latitudes. This is a hypothetical model, though, as pressure belts are not always seen on earth in this form.

Type

The following pressure bands are among them

1. Equatorial Low Pressure Belt;
2. The Subtropical High Pressure Belts;
3. Betts' Subpolar Low Pressure System;
4. The Polar High-Pressure Belts

1. **Equatorial Low Pressure Belt**
   - ✓ Throughout the entire year, the sun shines practically vertically on the equator.
   - ✓ Equatorial low pressure results from warm air rising over the equatorial region as a result of this process.
   - ✓ From the equator, this belt continues to 10 N and 10 S latitudes.
   - ✓ The absence of horizontal air movement and the presence of only conventional currents are caused by the excessive heating.
   - ✓ Doldrums (the zone of stillness) is the name given to this belt as a result of the virtually nonexistent surface winds.
   - ✓ Because the winds from subtropical high pressure belts converge in these areas, they are known as the regions of convergence.
   - ✓ Another name for this band is the Inter Tropical Convergence Zone (ITCZ).

2. **The Sub-tropical High Pressure Belts**
   - ✓ In both hemispheres, the sub-tropical high pressure belts run from the tropics to roughly 35 o latitude.
   - ✓ It is known as the South sub-tropical high pressure belt in the southern hemisphere and the North sub-tropical high pressure belt in the northern hemisphere.
   - ✓ Because of the earth's rotation, these pressure belts form where the rising air from the equatorial region is diverted toward the poles.
   - ✓ It drops and piles up in these areas after growing cold and heavy. High pressure is the effect of this.
   - ✓ Here, there are calm conditions with weak, erratic winds.
   - ✓ In the past, it was challenging for ships carrying horses via these belts to sail in these calm seas.
   - ✓ They used to throw the horses in the sea in order to make the vessels lighter. Henceforth these belts or latitudes are also called 'horse latitudes'.
   - These are the regions of divergence because winds from these areas blow towards equatorial and subpolar low pressure belts.

3. **The Sub-polar low Pressure Belts**
   - ✓ In the northern hemisphere, the sub-polar low pressure belts extend between 45N and the Arctic Circle, and in the southern hemisphere, it does so between 45S and the Antarctic Circle.
   - ✓ They are referred to as the South and North Sub-polar Low Pressure Belts, respectively.
   - ✓ Here, cyclonic storms or low pressure conditions are created by the convergence of winds from the subtropical and polar high belts.
   - ✓ The term "polar front" also applies to this convergence zone.

4. **The Polar High Pressure Belts**
   - ✓ The sun never beams vertically in the polar regions.
   - ✓ Low temperatures are a result of the sun's constant slanting beams in this area.
   - ✓ Low temperatures cause air to compress, which raises its density. As a result, significant pressure is present here.

- ✓ The belt is known as the South polar high pressure belt in the southern hemisphere and the North polar high pressure belt in the northern hemisphere.
- ✓ Sub-polar low pressure belts receive wind from these belts.

Pressure belts shifting

- Actually, these pressure belts' location is not fixed.
- They move between the Tropics of Cancer and Capricorn in the months of July and January, respectively, following the shifting positions of the sun's direct rays.
- Along with moving north and south of the equator, the thermal equator—also known as the band of highest temperature—also moves.
- Pressure belts also slightly fluctuate north and south of their annual average location along with the thermal equator's seasonal shifts, which are northward in summer and southerly in winter.

Wind and Wind Types

The wind is defined as the horizontal movement of air brought on by the earth's rotation and the warmth of the sun. The following geographic processes and factors influence flow and direction:

- **Pressure gradient force:** This force provides initial flow and direction to the wind. The flow is from high pressure to low pressure and it is at right angles to isobars. The velocity of wind is directly proportional to pressure gradient force.
- **Coriolis force/deflection force:** The force that deflects the direction of the wind is called deflection force. They are deflected to the right (concerning their source) in the northern hemisphere and the left in the southern hemisphere.
- **Friction force generated by surface:** It is a restraining force on the flow of the wind. The amount of friction is an outcome of surface irregularities and the orientation of natural landforms. Friction is least above smooth oceanic surfaces. The frictional force is effective up to a height of a few thousand meters only.

Classification of Parmanent winds

- **Trade Winds**
  - ✓ In both the north and south hemispheres, these move from equatorial low-pressure belts to subtropical high-pressure belts.
  - ✓ In the northern hemisphere, these are referred to as northeast trade winds, and in the southern hemisphere, southeast trade winds.
  - ✓ In the northern hemisphere, they migrate from NE to SW, while in the southern, from SE to NW.
- **Westerlies:** Westerlies move from subpolar low-pressure belts to both the northern and southern hemispheres from subtropical high-pressure belts.
  - ✓ In the northern hemisphere, they move in a SW to NE direction, while in the southern hemisphere, they move in a NW to SE direction.
  - ✓ Westerlies are hindered by land in the northern hemisphere, which reduces their efficiency.
  - ✓ In the southern hemisphere, westerlies are strong, and because of the sound they produce, they are also known as
  - ✓ soaring forties between 40o and 50o South
  - ✓ angry fifty-somethings at 50oS latitude
  - ✓ Sixties screaming at 60oS latitudes
  - ✓ These cause rain to fall on the western shores of continents since they are on-shore during the entire year.
- **Polar Wind:** In both the north and south hemispheres, they go from polar high-pressure belts to subpolar low-pressure belts.
  - ✓ In the northern hemisphere, they migrate from NE to SW, while in the southern, from SE to NW.
  - ✓ They causes blizzards because they are stronger and more intense in the winter.

Classification of Secondary winds

These winds change their directions with the seasonal changes or periodically.

- **Monsoon Wind:** A monsoon wind is a seasonal wind that is most common in Asia and that changes direction from summer to winter. It frequently brings heavy rainfall.
  - ✓ The interaction of the planetary wind system and local conditions, both at the surface and in the high troposphere, leads to the Asiatic monsoon.

- **Land And Sea Breeze**
  - ✓ The frequency of land and sea breezes varies according to day and night, and these are the winds found along coastlines.
  - ✓ Heat transport and absorption varies between the land and the sea. The land warms up more quickly during the day and surpasses the water in temperature.
  - ✓ A low-pressure area develops over the land as the air rises, whilst the sea is generally chilly and the pressure overseas is rather high. As a result, there is a pressure gradient from the sea to the land, and a sea breeze is produced.
  - ✓ The condition is reversed throughout the night. The water is warmer, while the land loses heat more quickly. From land to sea, there is a pressure gradient, which causes land breeze.

- **Valley and Mountain Breeze**
  - ✓ The air from the valley blows up the valley to fill the ensuing gap in mountains during the day as the slopes become warm and air rises upward. Valley breeze is the term for this wind.
  - ✓ As the slopes cool off at night, the mountain wind, which is composed of thick air, flows into the valley. Katabatic wind is the name for the chilly mountain air that flows into the valley.
  - ✓ On the leeward side of mountain ranges, another kind of warm breeze can be found. The wind's moisture condenses and turns to precipitation when it travels through mountain ranges. Dry air is warmed by the adiabatic process as it falls the slope's leeward side. The snow could melt quickly in this dry air.

Tertiary or Local Wind

Name of the wind	Type	Place
Chinook (Snow eaters)	Hot, dry	The Rocky mountains
Foehn	Hot, dry	The Alps
Khamsin	Hot, dry	Egypt
Sirocco	Hot, moist	Sahara to the Mediterranean Sea
Solano	Hot, moist	Sahara to the Iberian Peninsula
Harmattan (Guinea doctor)	Hot, dry	West Africa
Loo	Hot and dry	North India and Pakistan
Norwester	Hot	New Zealand
Santa Ana	Hot	South California
Karaburun (black storm)	Hot dusty	Central Asia
Bora	Cold, dry	Blows from Hungary to North Italy
Mistral	Cold	The Alps and France
Pampero	Cold	Argentina
Punas	Cold dry	The western side of Andes Mountain
Blizzard	Cold	Tundra region
Purga	Cold	Russia
Levanter	Cold	Spain
Calima	Dust-laden dry	Saharan Air Layer across the Canary Islands
Elephanta	Moist (in monsoon)	Malabar coast

Evaporation and Condensation

Evaporation

Water changes from a liquid to a gas through the process of evaporation. Evaporation is mostly caused by heat.The saturated layer is replaced by the unsaturated layer as a result of air movement. Therefore, evaporation increases in direct proportion to air movement.

- **Factors Affecting Rate of Evaporation**
  - ✓ The volume of water
  - ✓ Temperature.
  - ✓ Relative moisture.
  - ✓ Area where moisture evaporates.
  - ✓ **Wind speed:** A strong wind blowing over an evaporating surface removes the saturated air and replaces it with dry air, which encourages more evaporation.
  - ✓ The rate of evaporation is unusually great whenever there is a confluence of high temperature, extremely low relative humidity, and strong winds. This causes soil to become dehydrated to a depth of several inches.
  - ✓ **Air Pressure:** The atmospheric pressure acting on the evaporating surface has an impact on evaporation as well. A higher rate of evaporation occurs when there is less pressure exerted on the liquid's open surface.
  - ✓ **Water composition:** The relationship between evaporation and salinity is inverse.

Condensation

- Condensation is the process by which water vapour becomes actual water.
- Condensation results from heat being lost (latent heat of condensation, opposite of latent heat of vaporization).

  When humid air is cooled, it may reach a point where it can no longer store water vapour (dew point is reached when saturation point, or 100% relative humidity, is reached).

  The extra water vapour then condenses into liquid. It is referred to as sublimation if it immediately condenses into a solid state.

- **Condensation takes Place**
  1. When the temperature of the air is reduced to dew point with its volume remaining constant (adiabatically),
  2. When both the volume and the temperature are reduced,
  3. When moisture is added to the air through evaporation,
  - ✓ After condensation the water vapour or the moisture in the atmosphere takes one of the following forms - dew, frost, fog and clouds.
  - ✓ Condensation takes place when the dew point is lower than the freezing point as well as higher than the freezing point.

Forms of Condensation

1. **Dew:** Dew is the term used to describe moisture that is deposited as water droplets on cooled solid objects like rocks, grass, and plant leaves rather than as air nuclei above the surface.

   I. Clear skies, calm winds, high relative humidity, and chilly, long nights are the optimum circumstances for its creation.

   II. The dew point must be higher than the freezing point in order for dew to occur.

2. **White Frost:** Condensation below freezing point (0 C), or when the dew point is at orbelow freezing point, causes ice to develop on cold surfaces.
   - ✓ Instead of leaving behind water droplets, the extra moisture leaves behind tiny ice crystals.

- ✓ The optimum circumstances for the development of white frost are similar to those for the development of dew, with the exception that the air temperature must be at or below freezing.

3. Fog

- ✓ An air mass that contains a lot of water vapour condenses on the fine dust particles inside of it when the temperature of the air mass suddenly drops.
- ✓ Thus, the fog is a cloud with a base that is either at or extremely close to the ground. The vision decreases to nothing due to the fog and mist.
- ✓ Smoke in urban and industrial areas produces a lot of nuclei that aid in the creation of fog and mist. Smog is the term for such a situation where smoke and fog are present The three megacities of the country are Mumbai, Delhi, and Kolkata, however Delhi has a considerably more acute air pollution issue.

4. Mist

- ✓ Mist and fog differ in that mist has a higher moisture content than fog.
- ✓ Each nucleus is covered with a thicker coating of moisture in mist.
- ✓ Mountains frequently have mists because warm air moving up the slopes meets a chilly surface.
- ✓ Water droplets can also condense into mist, but this process occurs less frequently. This indicates that mist is less dense and dissipates more quickly.
- ✓ Fogs are more common where warm air currents meet cold air currents and are drier than mist.
- ✓ Visibility is greater than one kilometre but less than two km when there is mist

5. Haze

- ✓ Haze is often an atmospheric condition where dry particles like dust, smoke, and other materials obstruct the sky's transparency (no condensation. Smog and haze are similar, but smog contains condensation.
- ✓ Agriculture (especially ploughing in dry weather), traffic, industry, and wildfires are all sources of haze particles.

6. Smog

- ✓ Smog = smoke + fog (smoky fog) caused by the burning of large amounts of coal, vehicular emission and industrial fumes (Primary pollutants).

- **Clouds**
  - ✓ A cloud is a collection of minuscule water droplets or ice crystals created when water vapour condenses in open air at high altitudes.
  - ✓ A major contributing factor to clouds is the adiabatic cooling of air below its dew point.
  - ✓ The shapes of the clouds change as they develop at a certain height above the earth's surface.
  - ✓ Clouds can be divided into four categories based on their height, expanse, density, and transparency or opaqueness: (i) cirrus; (ii) cumulus; (iii) stratus; (iv) nimbus.
  - ✓ **Cirrus Clouds:** Cirrus clouds are formed at high altitudes (8,000 – 12,000m). They are thin and detached clouds having a feathery appearance. They are always white in colour.
  - ✓ **Cumulus Clouds:** Cumulus clouds look like cotton wool. They are generally formed at a height of 4,000 -7,000 m. They exist in patches and can be seen scattered here and there. They have a flat base.
  - ✓ **Stratus Clouds:** As their name implies, these are layered clouds covering large portions of the sky.These clouds are generally formed either due to loss of heat or the mixing of air masses with different temperatures.
  - ✓ **Nimbus Clouds:** Nimbus clouds are black or dark gray. They form at middle levels or very near to the surface of the earth.
  - ✓ These are extremely dense and opaque to the rays of the sun.

- ✓ Sometimes, the clouds are so low that they seem to touch the ground.
- ✓ Nimbus clouds are shapeless masses of thick vapour.

- **A combination of these four basic types can give rise to the following types of clouds:**
  1. High clouds- cirrus, cirrostratus, cirrocumulus;
  2. Middle clouds– altostratus and altocumulus;
  3. Low clouds– stratocumulus and nimbostratus (long duration rainfall cloud)
  4. Clouds with extensive vertical development– cumulus and cumulonimbus (thunderstorm cloud)

Precipitation

Precipitation happens when small droplets of water, ice, or frozen water vapour combine to form bulky masses that are too large to remain suspended in the atmosphere.. Then, as precipitation, they fall to the ground. All liquids that fall to the ground from the atmosphere are referred to as precipitation. Rainfall, snow, hail, frost, and dew are common examples.

- **Conditions for precipitation to form**
  - ✓ The atmosphere must contain moisture and water vapour.
  - ✓ There must be sufficient nuclei present to aid condensation.
  - ✓ Weather conditions must be good for condensation of water vapour to take place.
  - ✓ The products of condensation must reach the earth.

Types of Precipitation

1. **Convectional:** Heat causes the air to lighten and ascend in convection currents. As it rises, it expands and loses heat, which causes condensation to happen and the formation of cumulous clouds. As a result of this process, latent heat of condensation is released, further heating the air and pushing it upward.
   - ✓ Convectional precipitation is substantial but transient, intensely localised, and has a minimal cloud cover. In the Congo basin, the Amazon basin, and the islands of south-east Asia, it primarily happens in the summer and frequently occurs over equatorial doldrums.

2. **Orographic:** When the saturated air mass comes across a mountain, it is forced to ascend and as it rises, it expands (because of fall in pressure); the temperature falls, and the moisture is condensed.
   - ✓ The chief characteristic of this sort of rain is that the windward slopes receive greater rainfall. After giving rain on the windward side, when these winds reach the other slope, they descend, and their temperature rises. Then their capacity to take in moisture increases and hence, these leeward slopes remain rainless and dry. The area situated on the leeward side, which gets less rainfall is known as the rain-shadow area (Some arid and semi-arid regions are a direct consequence of rain-shadow effect.

- **Example:** Patagonian Desert in Argentina, Eastern slopes of Western Ghats). It is also known as the relief rain.
  - ✓ **Example:** Mahabaleshwar, situated on the Western Ghats, receives more than 600 cm of rainfall, whereas Pune, lying in the rain shadow area, has only about 70 cm.

3. **Cyclonic or frontal:** This type of rainfall occurs along the zone of contact between a warm and cool air mass.
   - ✓ When two large air masses of different temperature meet, the warmer and hence lighter air is lifted above the cooler air.
   - ✓ Warm air then rises, cools and condenses to form rain.

- The boundary that separates cold air and warm air is called a "front".

Tropical Cyclones

Tropical cyclones are ferocious storms that develop over tropical waters before moving ashore and wreaking havoc on a huge scale with their high winds, torrential rain, and storm surges. One of the world's most deadly natural disasters is a tropical cyclone. Over warm tropical oceans, tropical cyclones develop and intensify.

- **The following are factors that favour the development and strengthening of tropical storms**
  - Large sea surface that is warmer than 27 degrees Celsius.
  - The Coriolis force's existence.
  - Discreet changes in the vertical wind speed.
  - A low-level cyclonic circulation or preexisting weak low-pressure region.
  - Higher divergence than the system at sea level.

Pressure System	Pressure Condition at the Centre	Pattern of Wind Direction	
		Northern Hemisphere	Southern Hemisphere
Cyclone	Low	Anticlockwise	Clockwise
Anticyclone	High	Clockwise	Anticlockwise

Pattern of Wind Direction in Cyclones and Anticyclones

Tropical Cyclone Formation Phases

Three stages can be used to categorise the tropical cyclone development cycle:

1. **Stage of Formation and Initial Development**
   - A cyclonic storm forms and begins to develop when heat and water vapour from the warm ocean are transferred to the air above it, primarily by evaporation from the sea surface.
   - Due to convection and condensation of rising air above the ocean's surface, it facilitates the formation of large vertical cumulus clouds.

2. **Mature stage**
   - When a tropical storm gets stronger, the air rises in ferocious thunderstorms and tends to spread out horizontally at the tropopause level. When air spreads out, a positive pressure is created at very high altitudes, which quickens the convectional motion of the air downward.
   - When subsidence is caused, air warms up through compression, creating a warm "Eye" (low-pressure center). A concentric pattern of extremely turbulent giant cumulus thundercloud bands is the primary physical characteristic of a mature tropical cyclone in the Indian Ocean.

3. **Decay and modification**
   - As soon as its source of warm, moist air starts to wane or is suddenly cut off, a tropical cyclone starts to lose strength in terms of its core low pressure, internal warmth, and extremely fast speeds.
   - This occurs when it touches down on land or when it crosses across icy waters.

- **Tropical Cyclones in India**
  - Tropical cyclones originate over the Bay of Bengal, Arabian Sea and the Indian ocean. These tropical cyclones have very high wind velocity and heavy rainfall and hit the Indian Coastal states of Tamil Nadu, Andhra Pradesh,

West Bengal, Odisha and Gujarat (These five states are more vulnerable to cyclone disasters than others in India).

- ✓ Most of these cyclones are very destructive due to high wind velocity and torrential rain that accompanies it.

Airmass

- At any given height, the attributes of an Air Mass's temperature and moisture content (humidity) are quite similar.
- Its surface area can reach hundreds of thousands of square miles.
- The air mass may only have a slight horizontal difference in temperature and moisture.
- An air mass takes on the features of the area when it stays over a uniform area for a long enough period of time. The enormous ocean surface or the vast plains are examples of homogeneous landscapes.

Fronts

A front is the boundary zone formed when two air masses with distinctly different characteristics collide.

- **There are four different front types:**
  - ✓ **Stationary front:** The surface position of this front does not move. Winds on either side of this front appear to be nearly parallel.
  - ✓ **Cold front:** The area where the cold air meets the warm air mass is known as the cold front.
  - ✓ **Warm front:** A warm front is formed when a warm air mass moves in the direction of a cold air mass.
  - ✓ **Occluded front:** An air mass is said to be occluded when it is completely elevated above the ground.
- The fronts are characterised by a sharp gradient in temperature and pressure that occur in the middle latitudes. They create sudden temperature swings and raise the air.
- Systematic evolution of front in mid-latitude regions due to convergence of polar air mass and the warm sub-tropical air mass is known as **frontogenesis**. Frontogenesis is well explained by the '**polar front theory' of V. Bjerknes**, J. Jakob. The general atmospheric circulation favours divergence of air masses in sub-tropical and Polar regions, but there is convergence of two air masses of different properties in sub-polar low-pressure region, which gives rise to fronts and temperate cyclones.

Temperate Cyclone

- A temperate cyclone, also known as an extratropical cyclone, is a large, low-pressure weather system that forms in the mid-latitudes. Temperate cyclones typically form along fronts, which are boundary zones between regions of different air masses.
- These are active in both hemispheres above the mid-latitudinal zone between 35 and 65 latitude. The movement is going from west to east, and it is more noticeable in the winter. These latitude ranges are where polar and tropical air masses collide to generate fronts.

Extratropical Cyclone Formation

- The Polar Front theory offers the most comprehensive explanation for the genesis and growth of temperate cyclones.
- This hypothesis states that a polar front forms when warm, humid air masses from the tropics collide with cold, dry air masses from the poles.
- Warm air mass is pushed upward because the cold air mass is denser and heavier.
- Instability is produced by the interaction of the cold and warm air masses, and a low pressure is established at the junction, especially where the interactions are occurring.
- As a result of the pressure being reduced, a void

is produced. A cyclone is created as a result of the surrounding air rushing in to fill this space and the earth's rotation.

- Extratropical cyclones contrast with more severe hurricanes of the tropics, which form in regions of relatively uniform temperatures.

Seasonal Occurrence of Temperate Cyclones

- The seasons that see the most temperate cyclones are winter, late autumn, and spring. They are typically connected to overcast and rainy weather.
- A large concentration of storms occurs over the Bering Strait, the United States and Russian Arctic, and the sub-Arctic zone during the summer when all the pathways of temperate cyclones travel northward. However, there are only a few temperate cyclones across the subtropics and the warm temperate zone.

- **Distribution of Temperate Cyclones**
  - ✓ Winter storms over the Baltic Sea, Mediterranean basin reaching up to Russia and even up to India in winter (called western disturbances), and Antarctic frontal zone. USA and Canada - extend over Sierra Nevada, Colorado, Eastern Canadian Rockies, and the Great Lakes region.

Jet Stream

According to the World Meteorological Organization (WMO), the term "jet stream" refers to a strong narrow current that is concentrated along a nearly horizontal axis in the upper troposphere or stratosphere, is characterised by strong vertical and lateral wind shear, and has one or more velocity maxima.

Strong, nearly horizontal upper tropospheric fluxes are known as jet streams. They develop at the boundaries of neighbouring air masses with large temperature differences and are caused by differential heating of the earth's surface.

- **The factors that influence the flow of the jet stream are the landmasses and the Coriolis effect.**
  - ✓ Due to the impact of Earth's rotation, jet streams move from west to east. In both hemispheres, the circulation is typically seen between the poles and 20 degrees latitude.
  - ✓ These are also known as circumpolar since they circle both hemispheres' poles.
  - ✓ On the trajectory, their circulation path is wavy and irregular.
  - ✓ Due to the northward shifting, the extent is smaller in the summer, however in the winter, it can reach up to 20 degrees latitude.
  - ✓ These might be up to 2-3 km deep and 40 km wide.
  - ✓ The minimum wind speed is around 120 km/h in the winter and 50 km/h in the summer, with a very high average wind speed.
  - ✓ The peak and trough of the jet stream are where wind speeds are at their highest.
  - ✓ It flows northward throughout the summer and southward along the southern Himalayan slopes during the winter (early June). Along the northern edge of the Tibetan Plateau in the late summers, between July and August.
  - ✓ The monsoon's onset and subsequent withdrawal are frequently predicted by the Jet Stream's periodic migration.
  - ✓ The subtropical stream's inclination toward the north is the first sign that the monsoon season has officially begun over India.

Characteristics of Jet streams

- **The circulation of Jet streams is from west to east due to the effect of Earth rotation. Generally, the circulation is observed between poles and 20 degrees latitude in both hemispheres.**
  - ✓ These are also called circumpolar because they move around the poles in both hemispheres.
  - ✓ Their circulation path on the trajectory is wavy and meandering.
  - ✓ The extent narrows down during the summer

season because of the northward shifting while these extend up to 20 degrees latitude during winters.

- ✓ These may range from 40 km in width and 2-3 km in depth.
- ✓ The average wind speed is very high with a lower limit of about 120 km per hour in winter and 50 km per hour in summer.
- ✓ The maximum velocity of wind is recorded in the crest and trough of the jet stream.
- ✓ In winters, it flows along the southern slopes of the Himalayas and shifts northwards in summer, flowing along the edge of the Himalayas (early June). And in late summers between July-August along the northern edge of the Tibetan Plateau.
- ✓ The periodic movement of the Jet Stream often indicates the onset and subsequent withdrawal of the monsoon.
- ✓ The northward movement of the subtropical stream is the first indication of the onset of the monsoon over India.

Types of Jet streams

- **The origin of the Jets is supported by three kinds of gradients:**
  - ✓ The thermal gradient between pole and equator
  - ✓ The pressure gradient between pole and equator
  - ✓ The pressure gradient between surface and subsurface air over the poles.

The two Major Types are

1. The subtropical jet stream.
2. The mid-latitude or polar front jet stream.

- **Subtropical Westerly Jet Stream**
  - ✓ In both hemispheres above latitudes of 30 to 35 degrees, they migrate in the upper troposphere to the north of the subtropical high-pressure belt.
  - ✓ They circulate more regularly than the polar front jet stream, from west to east.
  - ✓ It is produced by the earth's rotation and flows for the majority of the year.

- **Polar Front Jet Stream**
  - ✓ They develop above the zone of convergence between the tropical warm air mass and the polar cold air mass in latitudes between 40 and 60 degrees.
  - ✓ The convergence of two dissimilar air masses accounts for the steepness of the temperature gradient.
  - ✓ These have a more changeable position than the subtropical jet and migrate in an easterly direction.

- **Other types**
  - ✓ There is another type of upper-level jet called polar night jet which forms mainly during the winter months when the nights are much longer. It meanders through the upper stratosphere over the poles and is present in the convergence zone above the sub-polar low-pressure belt.
  - ✓ A barrier jet in the low levels forms just upstream of mountain chains, with the mountains causing the jet to be oriented parallel to the mountains.
  - ✓ Coastal low-level jets are related to a sharp contrast between high temperatures over land and lower temperatures over the sea and play an important role in coastal weather, giving rise to strong coast parallel winds. These are associated with oceanic high-pressure systems and thermal lows over land.
  - ✓ A valley exit jet is a strong, down-valley, elevated air current that flows above the intersection of the valley and its adjacent plain. They can achieve high speeds and heights.
  - ✓ The mid-level African easterly jet occurs during the summer in Northern Hemisphere between

10N and 20N above West Africa. While the nocturnal poleward low-level jet occurs in the Great Plains of East and South Africa.

- **Climatic Significance**
  - ✓ They have an immense influence on local and regional weather conditions.
  - ✓ There is a close relationship between the intensity of temperate cyclones and jet streams. Severe storms occur when Jet streams interfere with surface wind systems.
  - ✓ They also help in giving a relatively clear picture of the occurrence of the events of El Nino and La Nina
  - ✓ They are also used by aviators if they have to fly in the direction of the flow of the jet streams. But aviators avoid them when flying in the opposite direction of the jet streams because Jet streams are unpredictable can cause sudden movement even when the weather looks calm and clear.
  - ✓ The monsoon of South Asia is largely affected and controlled by Jet streams.
  - ✓ The monsoons also depend on the upper air circulation which is dominated by Sub Tropical Jet Streams. The southwest monsoon in India is related to the tropical easterly stream which is between 8-35 degrees North latitudes. The northeast monsoon in the winters is related to the subtropical westerly Jet Stream which blows between 20-35 degree latitudes in both hemispheres.

Climatic Region of World

Koeppen's scheme of Classification of Climate

- The Kppen climate classification system categorizes climate zones throughout the world based on local vegetation. Wladimir Kppen, a German botanist and climatologist, first developed this system at the end of the 19th century, basing it on the earlier biome research conducted by scientists.
- The system divides the world into five climate zones based on criteria, usually temperature, which allows for different vegetation growth.
- The distribution of vegetation and climate were shown to be closely related by Koeppen. He chose specific temperature and precipitation values, connected them to the spread of flora, and then utilised these data to categorise the climates.
- Four of the five major climatic groupings identified by Koeppen are based on temperature, while the fifth is based on precipitation.
- A, C, D, and E are capital letters that indicate humid regions, while capital B is for dry climates.
- The seasonality of precipitation and temperature features are used to further categorise the climatic groups into kinds, which are denoted by small letters.
- The little letters f, m, w, and s stand for the seasons of dryness, with f denoting no dry season, m denoting a monsoon climate, w denoting the winter dry season, and s denoting the summer dry season.
- Temperature severity is denoted by the little letters a, b, c, and d.
- Using the capital letters S for steppe or semi-arid and W for deserts, the B - Dry Climates are further split.

Group	Characteristics
A- Trpcial	Average Temperature of the coldest month is 18 C or higher
B- Dry Climates	Potential evaporation exceeds precipitation
C- Warm Temperate	The average temperature of the coldest month of the (Mid-latitude) climates years is higher than minus 3 C but below 18 C
D- Cold Snow Climates	The average temperature of the coldest month is minus 3 C or below
E- Cold Climates	Average temperature for all months is below 10 C
H- High Land	Cold due the elevation

Group	Type	Latter Code	Characteristics
A- Tropical Humid Climate	Tropical wet Tropical monsoon Tropical wet and dry	Af Am Aw	No dry season Monsoonal, short dry season Winter dry season
B - Dry Climate	Subtropical Steppe Subtropical desert Mid-latitude steppe Mid-latitude desert	BSh BWh BSk BWk	Low-latitude semi-arid or dry Low-latitude arid or dry Mid-latitude semi-arid or dry Mid-latitude arid or dry
C-Warm temperate (Mid-latitude) Climate	Humid subtropical Mediterranean Marine west coast	Cfa Cs Cfb	No dry season, warm summer Dry hot summer No dry season, warm and cool summer
D- Cold Snow forest Climates	Humid continental Subarctic	Df Dw	No dry season, severe winter Winter dry and very severe
E-Cold Climates	Tundra Polar ice cap	ET EF	No True summer Perennial ice
H-Highland	Highland	H	Highland with snow cover

Equatorial Climate

A. Distribution: The Congo-Zaire basin, the Amazon belt, and South-East Asia within 10o N-S are the main geographical areas.

- ✓ The effect of trade winds gives place to monsoonal influences as one travels further from the equator

B. Temperature: Annual range of less than 2^{0}C; consistently high and uniform throughout the year.

- ✓ The annual temperature range is less than 2C even in highlands.
- ✓ Mornings are brighter and sunnier in equatorial regions because of the intense heat there.

Distribution of Equatorial Climate

Inspite of high rainfall throughout the year there is no uniform spatial distribution of rainfall in all parts of equatorial climatic region. Though no month goes dry but definitely some months of the year receive more rainfall than the other months. Thus, the months having more rainfall are called wet months while the months receiving less rainfall are known as less wet months.

C. Rainfall: Convectional rainfall occurs in this area at 4 O'clock through cumulonimbus clouds that are associated with a thunderstorm.

- ✓ In every month, it rains.
- ✓ Rainfall has two equinoxes that are monthly peaks: March and September
- ✓ Convectional rainfall occurs during these times, and the sun is directly overhead.
- ✓ On solstices, there is least rainfall.
- ✓ Monsoon winds begin to disrupt the pattern of rainfall as one travels north from the tropical areas.
- ✓ Due to the humid and hot environment, it is bad for habitation (High incidents of malaria and other tropical diseases).

D. Vegetation: There are dense tropical rain forests, often known as selvas in the Amazon.

- ✓ Due to their extreme proximity and density, trees compete with one another for sunlight.
- ✓ Epiphytes: They are plants that grow upon other plants non-parasitically
- ✓ There are three canopy layers in a forest.
- ✓ All year long is the growing season.

- ✓ There is no specific season for sowing, flowering, or leaf-shedding.
- ✓ Numerous tree species are mixed together, and since hardwood logs float on water, commercial logging is impossible.
- ✓ dyewoods, ebony, mahogany, etc.
- ✓ Cutting and moving the hardwood is a challenging operation.
- ✓ The tropical rainforests have been removed in several places, either for shifting agriculture or logging.
- ✓ Mangrove forests can be found in brackish marshes and coastal locations.

E. **Economic Activities:** Plantation crops like bananas, coconuts, sugar, coffee, tobacco, and spices are among the main crops, as are rubber (SE Asia), cocoa (Ghana and Nigeria), and banana.

- ✓ Belukar is a secondary forest that is developing in Malaysia as a result of activities related to shifting farming.
- ✓ Agriculture and other developmental endeavours are challenging because when a forest is cut, thick grass and undergrowth immediately sprout.

Tropical Monsoon Climate

- **Distribution**
  - ✓ North Australia, as well as South and South-East Asia.
  - ✓ Outside of this area, the onshore trade winds influence the climate, and the amount of rainfall is more equally spread throughout the year (tropical marine climate)

- **Due to its location close to the tropics, it has warm to hot summers.**
  - ✓ While the maximum temperature can rise to 45°C during the summer, the average monthly temperature is above 18°C.
  - ✓ The summertime temperature ranges from 30-45°C, with an average of around 30°C.
  - ✓ The average wintertime temperature is about 25°C, with a range of 15 to 30°C.

- **Seasons:** Seasons are chief characteristics of monsoon climate.
  - ✓ Cool, dry winters (October – February).
  - ✓ Hot, dry summers (March – June).
  - ✓ Rainy season (June-September).
  - ✓ Orographic rainfall

- **The Cool Dry Season (October to February)**
  - ✓ The Indian subcontinent receives little or no rain from the North-East Monsoon (outward-blowing dry winds).
  - ✓ The Northeast Monsoons, which blow over the Bay of Bengal and pick up moisture, bring rains to the south-eastern portions of the Indian peninsula during the months of November and December. However, only a minor quantity of rain occurs in Punjab from cyclonic causes (Western Disturbances).

- **The hot dry season (March to mid-June)**
  - ✓ Temperatures rapidly increase as the sun moves from the Tropic of Cancer to the north.
  - ✓ Sea breezes and little rain provide some relief to coastal areas.

- **The rainy season (mid-June to September)**
  - ✓ With the South-West's "burst," torrential rainstorms deluge the entire nation.
  - ✓ This rainy season is when the majority of the year's rainfall occurs (this concentrated heavy rainfall in summer is a chief characteristic of the Tropical Monsoon Climate).

- **Vegetation**
  - ✓ Due to a distinct dry season when leaves fall, the tree is deciduous.

- ✓ Forests are often harvested, however the vegetation changes depending on the amount of rain.
- ✓ Hardwood trees with broad leaves.
- ✓ There are much fewer species and the forests are less dense and luxuriant than those in the tropical zone.

- **Economic activities**
  - ✓ The area can support a dense population.
  - ✓ Farming for subsistence is the primary activity (crops grown with an intention to secure food for the season and not sold as the production is very low).
  - ✓ In areas with irrigation systems, intensive farming is common.
  - ✓ In South-East Asia and North-East India, shifting farming is common.
  - ✓ Rice, sugar, jute (or hemp in Manilla), and cotton are the main crops. Brazil is where coffee is grown. Tea requires moderate temperatures (15 to 20 oC), significant rainfall (150 cm), and slopes with good drainage.
  - ✓ Although raising cattle and sheep is done for both home and commercial reasons, the livestock sector is not as lucrative as it is in temperate climates.

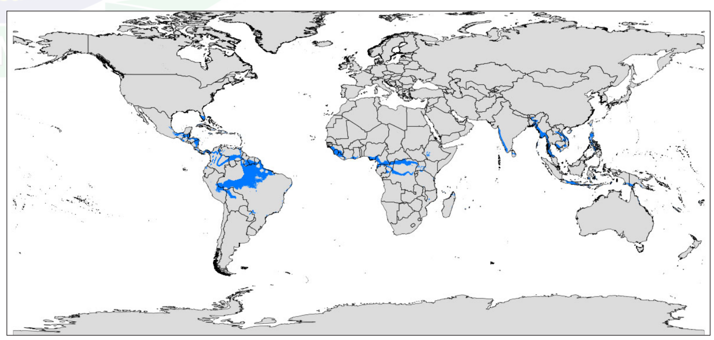
- **Shifting Cultivation**
  - ✓ The farming method is "slash and burn." In order to provide for their family, farmers clear a plot of land and grow cereals and other food crops. Farmers move to a different location and prepare a new plot of land for cultivation as the soil fertility declines. Due to the absence of modern inputs like fertilisers or other modern inputs, this type of shifting enables Nature to replenish the soil's fertility through natural processes, resulting in low land productivity. In various sections of the nation, it is known by various names.

Region	Name of Shifting Cultivation
Malaysia	Lacking
Burma	Taungya
Thailand	Tamrai
Philippines	Caingin
Java	Humah
Sri Lanka	Chena
Africa and Central America	Milpa
North-east India	Jhum

Tropical Marine Climate

- **Distribution**
  - ✓ Occurs on the eastern coasts in tropics under the influence of trade winds. Philippines, Central America, NE Australia, Madagascar, East Africa and East Brazil.

- **Rainfall:** It is both orographic and convectional. It is maximum in summer season but without any distinct dry season.
  - ✓ It is prone to **severe tropical storms and typhoons.**



Desert Climate

- **Distribution**
  - ✓ Areas having less than 25 cm of annual precipitation known as deserts (whether hot or cold).
  - ✓ Major hot deserts are located on the western side of tropics (i.e. on 15*-30* latitude range of continent).

- **Hot Desert**
  - ✓ The aridity of hot deserts is mainly due to offshore trade winds.
  - ✓ Lie in the horse latitude belt where the air is subsiding – a condition least favourable to precipitation. Further winds blow from cooler to hotter regions, hence the lack of water content.

- **Cold Deserts**
  - ✓ The aridity of cold deserts is because of offshore westerlies or leeward side effects.
  - ✓ Cold deserts are also generally located on high plateaus.
  - ✓ Atacama/Peruvian desert (driest place on earth) is the driest of all deserts (< 1.25 cm p.a.).
  - ✓ Cold currents have the effect of cooling the air. When this comes in contact with the hot air on the land mass, relative humidity drops further.

- **Rainfall**
  - ✓ Whatever occurs, occurs mostly because of convectional rainfall and thunderstorms.
  - ✓ In cold deserts in Asia, whatever rainfall happens occurs because of occasional western disturbances and in form of snow.

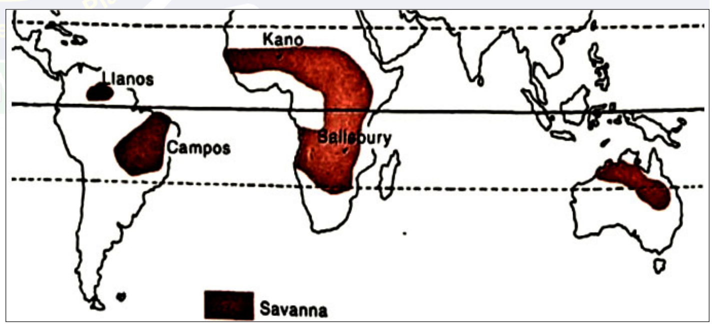
- **Temperature**
  - ✓ Temperature is high throughout the year (due to clear cloudless sky, intense insolation, and high rate of evaporation). No winter.
  - ✓ The average temperature is around 30-35C.
  - ✓ The diurnal and annual range is high.
  - ✓ Coastal deserts generally have less temperature than interiors due to cold currents. Ranges are also high in interiors.
  - ✓ The annual range of temperature is higher in cold deserts compared to hot deserts (because they are mostly located in mid-latitudes where variation in insolation is highest and because they are located deep inside continents)

- **Vegetation**
  - ✓ Vegetation is xerophytes / drought resistant scrubs (like cactus)
  - ✓ Shrubs remain dormant for years waiting for rainfall. They also have long roots, modified leaves and stems. Seeds have thick tough skins and lie dormant until it rains.
  - ✓ High evaporation means salts are brought upwards and they accumulate on the surface forming hard pans. Soil is also deficient in humus.

- **Minerals**
  - ✓ Gold is mined in Australia, diamonds and copper in Kalahari Desert, copper and nitrates in Atacama Desert.

Tropical Savanna / Sudan Climate

- **Distribution**
  - ✓ It is found between equatorial forests and the trade wind hot deserts.
  - ✓ The grasses are called llanos in Orinoco basin and campos in Brazil.



- **Seasons**
  - ✓ Distinct rainy and dry seasons with a wide variation of temperatures during the day.
  - ✓ wet and hot season (May-September in Northern hemisphere, October-March in Southern hemisphere).
  - ✓ From the equator to the pole and toward the edges of the desert, the amount of rainfall and the length of the rainy season diminish.

- ✓ When trade winds reach the interior of continents, they are dry but bring rain to the eastern coasts.

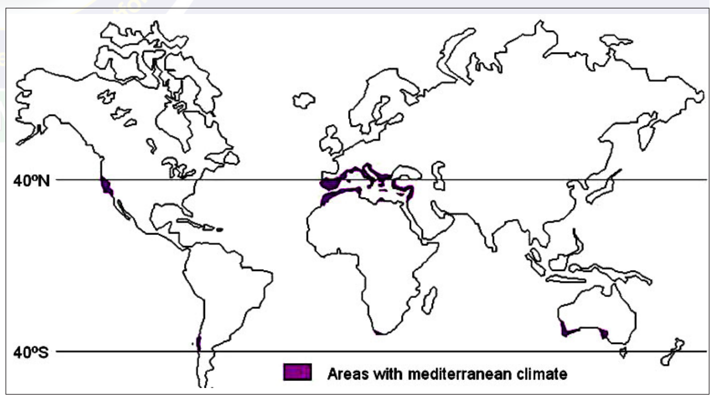
- **Dry, Cool weather**
  - ✓ The annual temperature range is roughly 10oC, and as we travel toward the poles, the range widens.
  - ✓ The highest temperatures occur right before the start of rain rather than during the time when the sun is at its heaviest.
  - ✓ Sudan is where these characteristics are best developed, which is why this sort of climate is named Sudanese.

- **Local Winds**
  - ✓ The north-eastern trade winds that originate in interior Africa and blow toward Guinea's Atlantic coast are known as harmattan (the doctor). They are from arid regions where the humidity is rarely higher than 30%. Since it protects against moist sea winds, it is known as the doctor.

- **Vegetation**
  - ✓ Long savanna grasses (elephant grass). Grasses are rooted deeply. Throughout the cool, dry season, it is dormant.
  - ✓ Poleward, trees become less dense and taller.
  - ✓ Some deciduous trees lose their leaves during the cool, dry season to stop water loss.
  - ✓ Some trees have broad trunks that contain water-holding structures (like Acacia tree).
  - ✓ A thin margin of several umbrella-shaped trees is exposed to the wind.
  - ✓ The nutrients in the soil are completely washed away when there is a lot of rain during a hot, humid season.
  - ✓ Animal domestication is common in Australia.
  - ✓ Grass fires that happen during the dry season also burn tree seeds that are about to sprout.

- **Animal of Savanna**
  - ✓ Due to the frequency of hunting, the savanna is known as "big game country" and is home to a wide diversity of animals.
  - ✓ There are essentially two categories of creatures in the savanna, one is the grass-eating herbivorous animals and second is the fleshing-eating carnivorous species.
  - ✓ Zebras, antelopes, giraffes, gazelles, deer, and elephants are all herbivores.
  - ✓ Lion, tiger, leopard, hyena, panther, jaguar, jackal, etc. are examples of carnivorous animals.
  - ✓ **Warm Temperate/ Mediterranean Climate**

- **Distribution**
  - ✓ It is confined between 30 - 45* latitudes on the western margins of the continents.
  - ✓ It is caused by shifting of pressure belts and comes under the effect of trade winds during summers (continental trades and hence dry) and westerlies during winters (onshore winds and hence wet).



- **Temperature**
  - ✓ Highest temperatures are experienced as we move inland away from maritime influence.
  - ✓ Climate is not extremebecause of cooling effect by water bodies.

- **Rainfall**
  - ✓ Cyclonic rainfall is prevalent from westerlies.

The rain comes as heavy showers and only on few days with bright sunny intervening days.

- ✓ The region experiences dry warm summers and wet cold winter.
- ✓ Dry, warm summers with offshore Tradewinds
- ✓ In the Northern Hemisphere, the Summer Solstice occurs when the sun is directly above the Tropic of Cancer, usually June 21. In the Southern Hemisphere, the Summer Solstice occurs when the sun is directly above the Tropic of Capricorn, usually December 21.The belt of influence of the Westerlies is shifted a little polewards. Rain bearing winds are therefore not likely to reach the Mediterranean lands.
- ✓ Hence the regions are practically rainless in summers and remain dry.
- ✓ The heat is intense, and the days are excessively warm.
- ✓ In the interiors, prolonged droughts are common. The relative humidity is generally low.
- ✓ Wet, cold winters with on-shore Westerlies:
- ✓ The Westerlies belt shifts equatorward in the winter and the Mediterranean regions are under the influence of on-shore Westerlies.
- ✓ Hence, these lands receive almost all of their precipitation during the winter months.
- ✓ The rain comes in heavy downpours and causes floods in the months of September and October in Mediterranean Europe

- **Local Winds**
  - ✓ **Sirocco:** They are the south-westerlies blowing from Sahara Desert into the mediterranean climate. They are hot and dry and remain dry even after passing above Mediterranean Sea. It is most frequent during spring and is bad for crops.
  - ✓ **Mistral:** It is a cold wind from north in Alps region which rushes down in winter into the valleys to fill the low pressure towards the sea.It is fast and may take the temperature below the freezing point.
  - ✓ Bora: In the Adriatic coast, the cold winds blowing from the continent to the sea in winters are called Bora. They are very fast.

- **Vegetation**
  - ✓ **Mediterranean evergreen forests:** They are found in regions of high rainfall. Cork oak trees are common in Europe while eucalyptus are grown in Australia.
  - ✓ **Evergreen coniferous forests:** They are found in highlands.
  - ✓ **Mediterranean shrubs:** They are the dominant vegetation.
  - ✓ **Orchard farming:** Fruit trees have long roots enabling them to fetch water in hot summer season as well. The thick leathery skin of the fruits also prevents transpiration.

Agriculture

- Summer is dry hence monsoon crops are not grown.
- This region is not suitable for agriculture, but some regions do cultivate using irrigation methods.
- Citrus fruits are mostly grown and viticulture (wine making) is mostly done here.

Temperate Continental Grasslands / Steppe Climate

Name of the Temperate Grassland	Region
Pustaz	Hungary and surrounding regions
Prairies	North America (between the foothills of the Rockies and the Great Lakes)
Pampas	Argentina and Uruguay (Rain-shadow effect)]
Bush-veld (more tropical)	Northern South Africa
High Veld (more temperate)	Southern South Africa
Downs	Australia (Murray-Darling basin of southern Australia)
Canterbury	New Zealand

- **Distribution (30° – 45°)**
  - ✓ They border the deserts and lie in the interiors of the continents in Northern hemisphere and near the oceans in Southern hemisphere. Though they lie in the westerly belt, they are far removed from the maritime influence.
  - ✓ Mostly they are grassland / treeless because of absence of maritime influence. They are extensive in northern hemisphere.
  - ✓ Grasslands in Southern hemisphere are less continental due to proximity to oceans. They have less extreme temperatures (milder winters and less annual range) and rainfall is higher as well.

- **Temperature (Continental Climate)**
  - ✓ Warm summers and cold winters. Extreme variation of temperature.
  - ✓ Wetter and cooler than Savannah.
  - ✓ Annual range is very high in northern hemisphere.
  - ✓ Southern hemisphere climate is never severe (effect of ocean).

- **Rainfall**
  - ✓ Annual precipitation (conventional sources) is light with maximum rainfall in summers. Winters get occasional rains from western disturbances and in the form of snow.
  - ✓ Annual precipitation is higher in Southern hemisphere due to proximity to ocean and warm ocean currents.

- **Local Winds**
  - ✓ **Chinooks:** In the cold winter months of regions east of the Rocky Mountains, a strong, dry, warm wind sometimes blows from the mountains across the land. These winds, known as Chinook winds, can bring quick temperature changes.

- **Vegetation**
  - ✓ Nutritious grasses (No trees).
  - ✓ Complete grasslands are converted into agricultural lands.
  - ✓ Truck farming is done (mostly in prairies).
  - ✓ Heavily mechanised farming (Aeroplane used for dropping fertilizers).
  - ✓ Per person productivity is high, per acre productivity is low (because of absence of intense farming).
  - ✓ The grasses lie dormant in the winters and become active in the spring when the temperature is hot enough. In summers they get scorched but in autumn they grow again.
  - ✓ Polewards, an increase in precipitation gives way to coniferous trees while equatorward they merge with desert shrubs.

- **Economic Development**
  - ✓ Prairies would have wheat, cotton, maize cultivation
  - ✓ Steppes are one of the major producers of wheat
  - ✓ Pampas region would have wheat cultivation, animal husbandry livestock ranching (alfa-alfa a nutritious grass is found here).
  - ✓ Downs of Australia would have sheep rearing (Marino sheep famous for wool).
  - ✓ Veldts are famous for sheep rearing (agora goat is famous for wool production).

- **Warm Temperate/China Climate/ Natal Type /Gulf Type**

- **Distribution**
  - ✓ Eastern margin in warm temperate zone (30^0- 45^0)

- **China Type**
  - ✓ East and central China.
  - ✓ Rainfall throughout the year.
  - ✓ Trade winds take the warm current moist air

inside and causes rain in summers. Typhoons are carried in by the trades in late summers.
- ✓ In winters, however there is a reversal of wind direction due to cooling of Asian land mass and temperatures plummet (rain through moisture gain by Siberian plateau wind while passing yellow). So annual range of temperature is high.

- **Gulf Type**
  - ✓ SE USA, Gulf of Maxico.
  - ✓ The monsoonal characteristics are less here as the pressure gradient between continental North America and the Atlantic Ocean is never high enough to reverse the wind direction completely.
  - ✓ Rainfall in summer is maximum.
  - ✓ In winter season this type will experience temperate cyclone while in late summers they experience tropical cyclones (hurricane).

- **Natal Type Climate**
  - ✓ In southern hemisphere like South Africa (Natal province), Eastern Australia, Southern Brazil.
  - ✓ These lands have no monsoonal climate due to thinness of the land masses which is not sufficient to cause any wind change.
  - ✓ More dominance of maritime climate. So annual range of temperature is less, rainfall is more and distributed throughout the year.

- **Rainfall & Temperature**
  - ✓ It has more rainfall than Mediterranean climates for same latitude because of influence of warm currents. They are under the influence of trade winds.
  - ✓ Summers are warm and winters are cool. Rainfall varies from 60-150 cm.

- **Natural Vegetation**
  - ✓ The region supports luxurious vegetation due to heavier rainfall.
  - ✓ There are perennial plants, a well-suited condition for the rich variety of plant life.
  - ✓ The lowlands carry both evergreen broad-leaved forests and deciduous trees, like tropical monsoon forests.
  - ✓ The highlands carry various important softwoods species of conifers such as pines and cypresses.
  - ✓ Eastern Australia = Eucalyptus
  - ✓ South-Eastern Brazil, eastern Paraguay, north-eastern Argentina = Parana pine, the quebracho, wild yerba mate trees.
  - ✓ Natal = palm trees

- **Economic Development**
  - ✓ These regions are the most productive part of the middle latitudes due to the adequate rainfall; no prolonged drought and the cold season is warm.
  - ✓ This shows almost continuous growing season.
  - ✓ The temperate monsoon regions are the most intensively tilled parts of the world.

Agriculture Development

Country	Economic Activity
China	Rice, Tea, Cotton, Maize, Mulberry
Natal	Sugarcane
South America	Coffee and Maize
USA	Maize Region- Cotton- Tobacco (Virginia Tobacco)

- **Cool Temperate Western Margin / British Climate**

- **Distribution**
  - ✓ Located to the western margin in cool temperate zone (45-65) North and South.
  - ✓ They are under the influence of westerlies all through the year, but westerly influence is blocked by Rockies and Andes in N and S America, respectively.

- ✓ Britain, Northern France, Northern Germany, Norway, Western Canada (Vancouver provinces) Tasmania and New Zealand, Southern Chile.
- ✓ British type will experience four seasons

- **Temperature & Precipitation**
  - ✓ Cool moderate climate.
  - ✓ Low annual range of temperature. Moderate temperature best suited for human habitation. Summers are never very warm.
  - ✓ Rainfall is throughout the year with winter or autumn maximum because of cyclonic conditions.
  - ✓ Rainfall from westerlies in summer.
  - ✓ Western coast receives most rainfall and rain decreases towards interior.
  - ✓ Temperature have much oceanic influence, mostly warm ocean currents

- **Natural Vegetation**
  - ✓ Deciduous forests are found, and they shed their leaves in autumn to prepare for the cold season.
  - ✓ Tall trees with good canopy cover, mostly give softwood.
  - ✓ Trees are social species and are in pure stand, multiple species are not found (hence commercially viable).
  - ✓ Example – Oak, Birch, Beech, Elm

- **Economic Activities**
  - ✓ Lumbering (cutting of trees for commercial purpose) in systematic way. Winter cutting is done where they would make wood logs float on frozen river.
  - ✓ Market gardening is a type of agricultural practice

- **Cool Temperate Eastern / Laurentian Climate**

- **Distribution**
  - ✓ It is the intermediate types and has both maritime and continental traits.
  - ✓ It is extended in cool temperate eastern margin (45-65) of northern hemisphere.
  - ✓ It extends in eastern Canada (Newfoundland), North-East USA (new England states) regions, Korea, Northern Japan present beyond 40 latitude).
  - ✓ It also extends in Eastern Siberia, North china, Manchurian regions.
  - ✓ In southern hemisphere this climatic type is absent (land is not present beyond 40 latitude).

- **Rainfall and Temperature**
  - ✓ Winters are cold and dry while summers are warm and wet. Summers would be warmer but for the cold continental winds.
  - ✓ Rainfall throughout the year.
  - ✓ In summer, westerlies bring rain fall in North America region because they catch moisture from great lakes. In winter, gulf stream increases moisture content which results in rainfall from polar easterly wind.
  - ✓ In china, we have summer maximum rainfall because of intense heating of land leading winds penetration come from pacific (south-east monsoon). In winter, anti cyclonic conditions in central Asia exists hence cold wind blows out and create some rainfall (Borrowing moisture from Yellow Sea).

- **Natural Vegetation**
  - ✓ Mixed forestry (coniferous and deciduous).
  - ✓ Deciduous would spread below 50 latitude, Coniferous would spread above 50 latitude.
  - ✓ Oak, birch beech maple are principle trees.
  - ✓ Agriculture: potatoes, oats, barley, soya beans (mostly china) are grown.
  - ✓ Nova Scotia of Canada is famous for apple farming.

- **Economic activities**

- Lumbering and its associated timber, paper and pulp industries are the most important economic activity.
- Fishing is also an important economic activity.
- Agriculture is less important because of long and severe winters.
- Farmers are engaged in dairy farming in the North American region.

- **Boreal Climate/Taiga Climate/Siberian Climate / Cool Temperate Continental Climate / Continental Sub-Polar Climate**

- **Distribution**
  - It has tundra towards the north and steppes towards the south. Taiga is the Russian name.
  - It stretches along a continuous belt across central Canada, some parts of Scandinavian Europe and most of central and southern Russian (50 to 70 N).
  - Found only in the northern hemisphere (due to great east-west extent).
  - Absent in the southern hemisphere (Because of the narrowness in the high latitudes. Also, the strong oceanic influence reduces the severity of the winter).

- **Temperature**
  - Summers are brief and warm reaching whereas winters are long and brutally cold.
  - Annual temperature range of the Siberian Climate is the greatest (Almost 50-60°C in Siberia).
  - In North America, the extremes are less severe, because of the continent's lesser east-west stretch.
  - Occasionally cold, northerly polar local winds such as the Blizzards of Canada and Buran of Eurasia blow violently.
  - Permafrosts (a thick subsurface layer of soil that remains below freezing point throughout the year) are generally absent as snow is a poor conductor of heat and protects the ground from the severe cold above

- **Precipitation**
  - Rainfall annually is not high as maritime influence in the interiors is absent.
  - Frontal disturbances might occur in winter.
  - It is quite well distributed throughout the year, with a summer maximum (convectional rain in mid-summer – 15°C to 24°C).
  - In winter, the precipitation is in the form of snow as mean temperatures are well below freezing all the time.

- **Natural Vegetation**
  - The predominant type of vegetation is evergreen coniferous forest.
  - The conifers are best suited to this type of sub-Arctic climate as they require little moisture
  - Juniper, spruce, fir, pine are example species of coniferous
  - The greatest single band of the coniferous forest is the taiga(a Russian word for coniferous forest) in Siberia.
  - These coniferous belts are rich source of softwood (used in furniture, construction, paper making industries).

- **Tundra Climate / Polar Climate / Arctic Climate**

- **Distribution**
  - Found in regions north of the Arctic Circle and south of Antarctic Circle.
  - The icecaps are confined to highlands and high latitude regions of Greenland and Antarctica.
  - In the southern hemisphere, Antarctica is the greatest single stretch of ice-cap.
  - The lowlands - coastal strip of Greenland, the barren grounds of northern Canada and Alaska and the Arctic seaboard of Eurasia, have tundra climate.

- **Temperature**
  - ✓ The tundra climate is characterized by a very low mean annual temperature (most of the year below freezing point).
  - ✓ Temperatures are as low as 40-50 C below freezing in mid-winter whereas summers are relatively warmer.

- **Precipitation**
  - ✓ Precipitation is mainly in the form of snow and sleet.
  - ✓ Frequent blizzards reaching a velocity of 130 miles an hour.
  - ✓ Convectional rainfall is generally absent.

- **Natural Vegetation**
  - ✓ There are no trees in the tundra due to Frozen ice beneath the surface soil (permafrost) restricts root growth.
  - ✓ Lowest form of vegetation like mosses, lichens etc. are found in patches.
  - ✓ Climatic conditions along the coastal lowlands are a little favourable.
  - ✓ Coastal lowlands support hardy grasses and reindeer moss which provide the only pasturage for reindeers.
  - ✓ Berry-bearing bushes and Arctic flowers bloom in the brief summer.
  - ✓ In the summer, Birds migrate north to prey on the numerous insects which emerge when the snow thaws.
  - ✓ ResidingMammals = Wolves, foxes, muskox, Arctic hare and lemmings.
  - ✓ Penguins live only in Antarctic.

- **Human Activities**
  - ✓ People live a semi-nomadic life and largely confined to the coast.
  - ✓ In Greenland, northern Canada and Alaska live the Eskimos.
  - ✓ During winter they live in igloos.
  - ✓ Fish, seals, walruses, and polar bears are their major food.

Personal Notes

OCEANOGRAPHY

Bottom Relief Features

- Water covers over 71% of the earth's surface.
- The earth's continent is completely encircled by oceans, which are one single, big, continuous body of water.
- They make up 45% of the Southern Hemisphere and 35% of the Northern.
- They hold 97.2% of the water in the entire earth.
- The world's five major oceans are divided mostly by their geographic locations.
- These are the Pacific Ocean, the Indian Ocean, the Atlantic Ocean, and the Arctic Ocean. These four seas are considered to include all other seas, including inland seas and oceanic arms.
- The National Geographic Society for the first time named the Southern Ocean as the newest of Earth's five oceans as of June 2021.

Divisions of The Ocean Floor

Continental Shelf

- It stretches typically 70 kilometres into the ocean at a 1 angle and a depth of 120–150 metres. The continental shelf is mostly nonexistent on the west coast of South America, however this varies greatly. On North America's east coast, it is 120 kilometres broad. It is also fairly wide in the Bay of Bengal.
- Depth = In some places, it can be as shallow as 30 metres, while in others, it can be 600 metres deep.
- The shelf break, often known as the end of the shelf, is typically an extremely steep slope.
- Together, the continental shelves of all the oceans account for 5% of their combined surface area.
- Sediments that have been deposited by rivers, glaciers, etc. cover the continental shelves to varying degrees of thickness.

Continental Slope

- The slope between the deep ocean floor and the continental shelf is known as a continental slope.
- Many places on the continental slope are carved by undersea canyons.
- The continental shelf's seaward boundary is marked by the continental slope.
- The slope region has a gradient that ranges from 2 to 5 degrees.
- It spans from 180 to 3600 metres below the surface.
- The continental slope can reach enormous depths in some locations, including off the coast of the Philippines.
- Continental slopes have extremely few sediment deposits on them, mostly because of their steepness and growing separation from the land.
- The amount of sea life is also much lower here than on the shelf.

Continental Rise

- With depth, the slope of the continent gradually becomes less steep.
- The term "continental rise" is used to describe the slope when it reaches a level of between 0.5 and 1.
- The slope virtually flattens out and blends into the abyssal plain as depth increases.
- Deep Sea Plain or Abyssal Plain
- Ocean basins have gently sloping regions called deep sea planes.

- These are the world's flattest and smoothest areas because the irregular topography is covered by terrigenous and shallow water sediments. Terrigenous is a term for marine sediment that has been eroded off land.
- It covers around 40% of the ocean's surface.
- Between 3,000 and 6,000 m is the range of depths.
- Fine-grained sediments like clay and silt are present across these plains.
- In the midst of oceans, it has vast submerged plateaus, ridges, tunnels, beams, and oceanic islands that rise above sea level.

Oceanic Deeps or Trenches

- The trenches are narrow basins with rather steep sides (Depressions). The deepest regions of the ocean are found here.
- They are generated during ocean-ocean convergence and ocean-continent convergence and are tectonically derived.
- They are three to five kilometres deeper than the nearby ocean floor.
- The trenches are located in the bottoms of continental slopes and around island arcs, on the edges of the deep-sea plain.
- The island chains or the bordering-fold mountains are parallel to the ditches.
- The Pacific Ocean has many trenches, which create a nearly continuous ring along its western and eastern edges.
- The Mariana The deepest trench, at a depth of more than 11 kilometres, is located in the Pacific Ocean off the Guam Islands.
- Mindanao Deep, among other ocean depths (35000 feet)
- Japanese trenches are shorter than the Tonga trench (31000 feet) (all 3 in the Pacific Ocean)
- They are linked to both powerful earthquakes and active volcanoes (Deep Focus Earthquakes like in Japan). Because of this, they are crucial to the study of plate movement.

Minor Ocean Relief Features

- In addition to the principal relief features of the ocean floor outlined above, several ocean regions are characterised by other, smaller but equally important features.
- Ridges, hills, seamounts, guyots, trenches, canyons, break zones, island arcs, atolls, coral reefs, submerged volcanoes, and sea-scarps.

Mid-Oceanic Ridges

- A seafloor mountain system created by plate tectonics is known as a mid-ocean ridge.
- It normally sinks to a depth of 2,600 metres and rises to a height of 2,000 metres above an ocean basin's deepest point.
- Along a divergent plate border, this feature is where seafloor spreading occurs.

Seamount

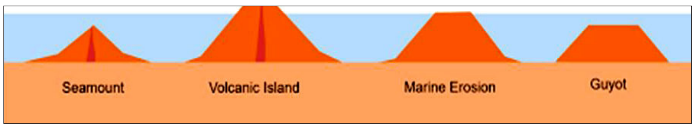
- A seamount is a volcanically produced mountain beneath the sea.
- The ocean's surface is not reached by seamounts.
- These have a potential height range of 3,500–4,500 metres.
- A notable example is Emperor Seamount, a Hawaiian Island extension in the Pacific Ocean.

Submarine Canyons

- A submarine canyon is a steep-sided valley that has been dug into the seabed of the continental slope; it can occasionally extend well over the continental shelf, have virtually vertical walls, and occasionally have canyon walls that are up to 5 km high, like the Great Bahama Canyon.
- The Hudson Canyon is the world's most well-known undersea canyon.
- **Guyots:** Guyot, also referred to as a tablemount, is an uninhabited underwater volcanic mountain

with a flat top that is located more than 200 metres beneath the ocean's surface.

- ✓ These mountains have flat tops from progressive subsidence that occurred throughout time.
- ✓ More than 10,000 seamounts and guyots are thought to be present in the Pacific Ocean alone.



- **Atoll**
  - ✓ An atoll, sometimes referred to as a coral atoll, is a ring-shaped coral reef that has a coral rim that partially or entirely encircles a lagoon.
- On the rim, there could be coral cays or islands. Atolls are islands that are situated in warm, tropical or subtropical waters where coral can flourish.

- **Bank**
  - ✓ These maritime structures were created by erosional and depositional processes.
  - ✓ An elevation with a flat top that is part of the continental edge is called a bank.
  - ✓ Although there is little water depth here, it is sufficient for navigation.
  - ✓ Famous examples are the Dogger Bank in the North Sea and the Grand Bank in Newfoundland's northwest Atlantic.
  - ✓ Some of the world's most prosperous fisheries can be found along the banks.

- **Shoal**
  - ✓ A shoal is a detached elevation with shallow depths. Since they project out of water with moderate heights, they are dangerous for navigation.

- **Reef**
  - ✓ A reef is a mostly biological deposit that takes the appearance of a mound or rocky elevation resembling a ridge and is produced by live or dead organisms.
  - ✓ The Pacific Ocean is known for its coral reefs, which are often seen in conjunction with seamounts and guyots.
  - ✓ Off the Australian Queensland coast is where you may find the world's largest reef. [Coral reefs will be discussed in later posts]
  - ✓ The possibility of the reefs rising above the water's surface makes them generally hazardous for navigation.

- **Studying oceanic relief's importance**
  - ✓ The movement of seawater is governed by ocean relief.
  - ✓ In turn, the oceanic motion in the form of currents results in numerous fluctuations in the oceans and the atmosphere.
  - ✓ Navigation and fishing are also impacted by the ocean's bottom relief.

- **Marginal Seas**
  - ✓ A marginal sea is an area of the ocean that is only partially surrounded by islands, archipelagos, or peninsulas.
  - ✓ The Arabian Sea, Baltic Sea, Bay of Bengal, Bering Sea, Black Sea, Gulf of California, Gulf of Mexico, Mediterranean Sea, Red Sea, and the four Siberian Seas are a few of the larger marginal seas (Barents, Kara, Laptev, and East Siberian).
  - ✓ The depth and proximity to landmasses are the main distinctions between marginal seas and open oceans.
  - ✓ The fact that marginal seas are typically shallower than open oceans means that human activity, river runoff, climate, and water circulation all have a greater impact on them.

- **Arctic Ocean-** Barents Sea ,The Irish Sea

- **Atlantic Ocean-** Argentine Sea, Caribbean Sea, English Channel, Gulf of Mexico, Hudson Bay, Irish Sea, Labrador Sea, Mediterranean Sea ,North Sea , Norwegian Sea
- **Indian Ocean-** Andaman Sea, Arabian Sea, Bay of Bengal, Java Sea, Persian Gulf, Red Sea, Sea of Zanj.

Bays, Gulfs, Straits, and Isthmus

- Water bodies like bays, gulfs, and straits are confined within a larger body of water close to shore.

  ✓ Conflicts with neighbours and the natural world are frequent because these three water bodies are frequently found near key areas of human activity.

- **Bays**
  ✓ A bay is a body of water that has land on three sides and an open entrance to the ocean on the fourth (In Gulfs, the mouth is narrow).
  ✓ In comparison to a gulf, a bay is typically more open and smaller.
  ✓ Example: Bay of Bengal, Hudson Bay (Canada), etc.
  ✓ New York Bay, near the mouth of the Hudson River, is an illustration of a bay at a river's mouth (Hudson Estuary).

- **Gulfs**
  ✓ A gulf is a broad body of water with a potentially tiny outlet that is almost entirely encircled by land.
  ✓ The Gulf of Mexico is the biggest gulf in the world.
  ✓ Other examples include the Gulf of California, the Persian Gulf (between Saudi Arabia and Iran), the Gulf of Mannar, and the Gulf of Aden (between the Red Sea and the Arabian Sea).

- **Straits**
  ✓ A strait is a constrained waterway that separates two geographical masses (continents or islands).
  ✓ A body of water, such as a strait, is referred to as a "choke point" when it can be obstructed or even closed to regulate traffic movements.

- **Isthmus**
  ✓ A strait's land equivalent is an isthmus. a small area of land that connects two larger land masses.
  ✓ Examples are the Suez and Panama straits.

Polymetallic Nodules (PMNs)

- Polymetallic nodules, commonly known as manganese nodules, are mineral lumps that range in size from millimetres to tens of centimetres that are found in the deep sea.
- In varying amounts, they contain lead, cadmium, vanadium, molybdenum, titanium, nickel, copper, cobalt, and other elements. Nickel, cobalt, and copper are thought to be of strategic and economic importance.
- They can be found in great numbers covering the deep sea floors of the world's oceans.
- India was the first nation to be recognised as a pioneer investor in the study and application of PMNs.
- In 1987, the United Nations (UN) granted it exclusive use of a region in the Central Indian Ocean Basin.
- National Institute of Ocean Technology (NIOT) will launch 'Samudrayaan project' by 2021-22 to explore the deep sea region. It is pilot project of Union Ministry of Earth Sciences as part the 'Deep Ocean mission' for deep ocean mining of rare minerals.
- Samudrayaan Project
- It proposes to send indigenously developed submersible vehicle with three persons to a depth of about 6000 metres to carry out deep underwater studies.

- **Significance of Polymetallic Nodules**
  - ✓ They contain metals and rare earth elements that are crucial to high-tech businesses.
  - ✓ About 20% of the copper held in land-based reserves worldwide is thought to be present in the CCZ nodules.
  - ✓ These rare earth elements are regarded as a significant source of priceless minerals like gold, silver, and zinc.
  - ✓ At the moment, China is in charge of about 95% of the rare earth metals. India's exploration will counteract China's growing influence.

UN Convention on Laws of Seas

Decides deep sea mining, environment protection, maritime boundary and dispute settlement. **UNCLOS sections the oceans into**

Territorial waters

- **12 nautical miles from the starting point**
  - ✓ Nations are allowed to enact laws and utilise their resources as they see fit.
  - ✓ Other than the "Innocent Passage," foreign vessels are not granted full rights of passage.
  - ✓ passing through waters that don't threaten the safety and peace of the world.
  - ✓ Nations have the authority to halt the harmless passage.
  - ✓ A submarine must navigate on the surface and display its flags while in another nation's territorial seas.

Contiguous Zone

- Beyond the territorial waters, a distance of 12 nautical miles (i.e. 24 Nautical Miles from the baseline limit).
  - ✓ Only four laws, namely those governing immigration, taxation, and pollution, can be enforced by a nation.

Exclusive Economic Zones

- Area that extends 200 nautical miles from the baseline from the margin of the territorial sea.
- All natural resources are exclusively subject to national exploitation rights.
- The main objective of the EEZ was to put an end to disputes over oil and fishing rights.
- Foreign ships are allowed to navigate and fly freely, subject to the coastal governments' regulations.
- Submarine pipelines and cables can be laid by foreign nations.

Ocean Currents

- Oceanic currents resemble river flow. They show a consistent flow of water travelling in a specific path and direction.
- There are two different types of forces that affect ocean currents: primary forces that cause water to move and secondary factors that cause currents to flow.
- The main factors affecting currents include the Coriolis force, wind, gravity, and solar heating.
- Temperature and salinity differences are the secondary forces that affect the currents.

Primary Forces Responsible For Ocean Currents

Influence of Sunlight (Insolation)

- Water expands as a result of heating by the sun. Because of this, the level of ocean water is around 8 cm higher near the equator than it is at middle latitudes.
- Water tends to flow down the slope as a result of the extremely little gradient that is created. Typically, the flow runs from east to west.

Influence of wind (atmospheric circulation)

- The ocean's surface is blown by wind, which causes the water to move. The movement of the water body throughout its route is impacted by friction between the wind and the water surface.

- The amplitude and direction of ocean currents are determined by winds, with Coriolis force also having an impact on direction. For instance, the yearly reversal of ocean currents in the Indian Ocean is caused by monsoon winds.
- The earth's atmospheric circulation pattern and the ocean's circulation pattern roughly match.
- In the middle latitudes, the Sub-tropical High Pressure Belt dominates the anticyclonic air circulation over the oceans (more pronounced in the southern hemisphere than in the northern hemisphere due to differences in the extent of landmass). The pattern of oceanic circulation also lines up with this.

Influence of Gravity

- Gravity tends to pull the water down to pile and create gradient variation.

Effect of Coriolis force

- The water is forced to travel to the right in the northern hemisphere and to the left in the southern hemisphere by the Coriolis force.
- Gyres are the name given to these significant water clumps and the flow that surrounds them. All of the ocean basins experience the resulting huge circular currents. The Sargasso Sea is one such circular flow.
- Secondary Forces Responsible for Ocean Currents
- The secondary forces are temperature differential and salinity difference.
- Ocean currents' vertical motion is impacted by variations in the density of water (vertical currents).
- As the cold water is denser than warm water, the water with high salinity is denser than the water with low salinity.
- Water that is substantially lighter and denser has a tendency to rise.
- Cold water at the poles dips and slowly drifts towards the equator, creating cold water ocean currents.
- To replace the cold water that is sinking, warm water currents move away from the equator and towards the poles.

Types of Ocean Currents

Based on depth

Depending on their depth, **ocean currents** can be divided into surface currents and deep-water currents:

1. About 10% of the ocean's total water, or the top 400 metres, is made up of surface currents;
2. The remaining 90% of the ocean's water is made up of deep ocean currents.

✓ Due to changes in gravity and density, these waters travel around the ocean basins.

✓ High latitudes, when the temperatures are frigid enough to enhance the density, allow deep waters to sink into deep ocean basins.

- **Based on temperature**
  - ✓ According to their temperature, ocean currents are divided into warm and cold currents.

1. **Cold currents** transport cold water [from high latitudes to low latitudes] into warm water regions. These currents are typically found on the west coast of the continents in the low and middle latitudes (true in both hemispheres), and on the east coast in the higher latitudes in the Northern Hemisphere; Currents flow in a clockwise direction in the northern hemisphere and an anti-clockwise direction in the southern hemisphere;

2. **Warm currents**, which are typically seen on the east coast of continents in the low and middle latitudes and transport warm water into cold water areas [low to high latitudes] (true in both hemispheres). They can be found in significant concentrations on the west coasts of continents in the northern hemisphere.

- **General Characteristics of Ocean Currents**
  - ✓ In general, the currents flow counterclockwise in the southern hemisphere and clockwise in the northern hemisphere.
  - ✓ This is caused by the deflective Coriolis force, which obeys Ferrel's law.
  - ✓ In the northern Indian Ocean, a major exception to this tendency may be observed when the current flow modifies its course in response to the seasonal shift in the direction of monsoon winds.

- **The warm currents originate near the equator and move towards the pole while the cold ocean currents originate near the poles and move towards the equator.**
- In lower latitudes, warm currents flow along the eastern coastlines and cold currents flow along the western sides.
  - ✓ On the contrary, in higher latitudes, this scenario is inverted asthe cold currents flow along the eastern shoreline, while the warm currents flow along the western shore.

1. Warm and cold currents collide in a **convergence** and the sites of convergence of ocean currents are considered as suitable fishing grounds
2. **Divergence** is the splitting of one current into several smaller currents that move in separate direction.

- **The shape and position of coasts play an important role in guiding the direction of currents.**
  - ✓ The currents are present both above and below the sea's surface (due to salinity and temperature difference).
  - ✓ For instance, the Mediterranean Sea's deep surface water descends and flows as a subsurface current beyond Gibraltar to the west.

Pacific Ocean Currents

- **Equatorial Pacific Ocean Currents**
  - ✓ Under the influence of prevailing trade winds [tropical easterlies], the north equatorial current and the south equatorial current start from the eastern pacific (west coast of Central America) and traverse a distance of 14,500 km moving from east to west.

- **Counter equatorial current**
  - ✓ This oceanic current raises the level of western pacific (near Indonesia and Australia) ocean by few centimeters. The **counter-equatorial** current flows between the north equatorial current and the south equatorial current in **west-east** direction.

- **Three factors aid the formation of Counter-Equatorial current**
  - ✓ Trade winds have caused water to accumulate in the western Pacific.
  - ✓ The narrow areas with quiet (lower) air conditions are known as doldrums. they exist in an area of low pressure in the equatorial region, between the north and south equatorial currents. Such circumstances facilitate the piled-up waters of the western Pacific's retrograde migration.
  - ✓ Due to the earth's rotation, water is accumulating in the western region of the oceans.

- **Kuroshio Current**
  - ✓ The Kuroshio current is created when the north equatorial current turns northward off the

Philippines. Its northern portion is influenced by westerlies, and the majority of it is located in the subtropical high-pressure zone.

- **Oyashio and Okhotsk Current**
  - ✓ There are two more cold currents in the northern Pacific: the Okhotsk current, which crosses the Sakhalin Islands before merging with the Oyashio current off Hokkaido.This Oyashio current travels through the east coast of the Kamchatka Peninsula before merging with the warmer waters of Kuroshio (Northern Japanese Island) current.

- **North-Pacific Current**
  - ✓ With the merger of Kuroshio and oyashio currents, North-Pacific current originates at the south-east coast of Japan and flows eastward under the influence of the dominant westerlies until it reaches the west coast of North America, when it splits into two branches, the Alaskan current and the California current.

- **Alaska Current**
  - ✓ The northern branch, also referred to as the Alaska current, travels counterclockwise around the British Columbian and Alaskan coasts. In comparison to the nearby waters in this zone, the water of this current is quite warm.

- **California Current**
  - ✓ The Californian current refers to the southern branch of the North-Pacific current, which travels as a cold current down the west coast of the USA. To complete the circuit, the Californian current combines with the North Equatorial Current.

- **East Australian current**
  - ✓ Following the pattern in the northern hemisphere, the south equatorial current flows from east to west and turns southwards as the East Australian current. It then meets the South pacific current near Tasmania which flows from west to east.

- **Peru current or Humboldt Current**
  - ✓ When it reaches South America's southwest coast, the Peru current turns northward. The vast circuit is completed when this cold current feeds the south equatorial current.
  - ✓ Additionally, a crucial fishing zone is where the warm equatorial ocean waters and the Peru Cold current meet.

Atlantic Ocean Currents

Because of their impact on the climates of North-Western Europe, North-Western Africa, and fisheries in the Grand Banks region, these Atlantic Ocean Currents are considered highly significant.

- **Equatorial Atlantic Ocean Currents**
  - ✓ The north equatorial current and the south equatorial current start from the eastern Atlantic ocean (the west coast of Africa), flowing from east to west, under the influence of the easterlies.
  - ✓ This adds a few centimetres to the elevation of the western Atlantic Ocean (north of the Brazil bulge). Due to this, a counter-equatorial current develops that moves in a west-to-east direction between the north and south equatorial currents.

- **Antilles Current**
  - ✓ The south equatorial current splits into two forks near the Cape de Sao Roque (Brazil).
  - ✓ While the majority of the current travels down the eastern edge of the West Indies as the Antilles current, a portion of it also flows into the Caribbean Sea via the Mexican Gulf and the north equatorial current.

- The Mississippi River, as well as branches of the north and south equatorial currents, have delivered enormous amounts of water to the Mexican Gulf, raising the water level.

- **Gulf Stream and North Atlantic Drift**
  - Gulf stream originates from the convergence of the North Atlantic Equatorial Current bringing tropical water from the east, and the Florida Current which brings warm water from the Mexican gulf. The Gulf Stream merges with the cold Labrador and East Greenland currents at the Grand Banks to form the North Atlantic Drift, that migrate westward under the influence of westerlies.

- **Norwegian Current**
  - When the **North Atlantic drift** reaches the eastern section of the ocean, it splits into two branches.
  - The primary current travels through the British Isles before turning into the Norwegian current that flows towards the Arctic Ocean.
  - The Norwegian current is crucial because being a warm current, it moderates climatic extremes and helps keep the ocean to Norway's north partially free of ice. Russia is able to transport merchandise through the Arctic Ocean in the summer due of this current (Barents Sea).
  - As part of the cold **Canary current**, the southerly branch travels between Spain and the Azores.
  - The North Atlantic circuit is fully completed when this current merges with the North Equatorial Current.
  - The Sargasso Sea, lying within this circuit, is full of large quantities of seaweed and is an important geographical feature. It is bounded on the west by the **Gulf Stream**; in the north, by the North Atlantic Current; in the east by the Canary Current; south by the **North Atlantic Equatorial Current.**

- **Brazil Current**
  - In the South Atlantic Ocean, close to Cape de Sao Roque (or cape of saint Roch), the south equatorial current, which flows from east to west, breaks into two branches (Brazil).
  - While the southern branch turns southward and flows down the South American coast as the Brazil current which is a warm ocean current.
  - Due to the influence of westerlies, the south-flowing Brazil current swings eastward at roughly latitude 35S and joins the West Wind Drift or Antarctic circumpolar current.
  - Falkland cold current is the name of a tiny branch of West Wind Drift that runs between the Argentinian coast and the Falkland Islands. At Brazil's southernmost point, it combines with the warm Brazil current.

- **Benguela Current**
  - A branch of the South Atlantic current splits at the southern tip of Africa and flows along the west coast of South Africa as a cold ocean current called Benguela current. It joins the south equatorial current to complete the circuit.

Indian Ocean Currents

- Due to the fact that the Indian Ocean is "half of an ocean", its currents behave differently from those of the Atlantic and Pacific Oceans.
- Additionally, the monsoon winds in the Northern Indian Ocean are unique to the area and have a direct impact on the flow of the ocean's surface water [North Indian Ocean Currents].
- The currents in the northern portion of the Indian Ocean change their direction from season to season in response to the **Seasonal Rhythm of the Monsoons.** The effect of winds is comparatively more pronounced in the Indian Ocean.

Winter Circulation

- The north equatorial current and the south equatorial current begin from the south of Indonesian islands and move from east to west under the influence of easterly trade winds.
- This adds a few centimetres to the elevation of the western Indian Ocean (south-east of the horn of Africa). And as a result, a counter-equatorial current develops that moves from west-to-east between the north and south equatorial currents.
- The Bay of Bengal experiences an anticlockwise water circulation caused by the north-east monsoons.
- Similar to this, the water in Arabian Sea along the western coast of India also moves counterclockwise.

- **Summer Circulation - North Equatorial Current Counter-Equatorial Current are Absent**
  - ✓ A strong current flows from west to east during the summer, completely obliterating the north equatorial current as a result of the strong south-west monsoon's effects and the absence of the north-east trades. As a result, there is also no counter-equatorial current.
  - ✓ Therefore, during this season, the water flows clockwise in the northern part of the ocean.

- **Southern Indian Ocean Currents – Agulhas current, Mozambique current, West Australian current**
  - ✓ The southern Indian Ocean's general pattern of circulation is very reminiscent of the southern Atlantic and Pacific oceans. Seasonal changes have less of an impact.
  - ✓ The Pacific Ocean's corresponding current helps the south equatorial current move from east to west.
  - ✓ It divides into two branches: the Agulhas current, which flows west of Madagascar; and the Mozambique current, which flows along the western coast of Madagascar.
  - ✓ These two branches combine at Madagascar's southernmost point to form the Agulhas current and which joins the West Wind Drift.
  - ✓ The West Wind Drift, flowing across the ocean in the higher latitudes from west to east, reaches the southern tip of the west coast of Australia.
  - ✓ One of the branches of this cold current turns northwards along the west coast of Australia. This is known as the West Australian current. It flows northward to feed the south equatorial current.

Ocean Temperature

- The study of ocean temperature is crucial to determine the kind and distribution of marine biodiversity at different oceanic depths, climate of coastal regions, and the movement of of water invertical and horizontal ocean currents.
- Ocean temperature is mostly driven by insolation (Incoming Solar Radiation).
- The specific heat of water is more than that of the land, therefore it warms slowly in comparison to land.
- Therefore, oceans are known to play a crucial for regulating the earth's energy and temperature .

Factors Affecting Temperature Distribution

- **Latitude**
  - ✓ The average temperature of ocean surface water is around 27°C and it gradually decreases from equator to poles.
  - ✓ The tropics experience maximum temperature because sun rays fall perpendicular in this region. However, when one moves towards the pole, the insolation reach the earth in a slanted manner.
  - ✓ Thus, insolation per unit area decreases when one moves from equator to the pole.
  - ✓ The rate at which the temperature decreases with increasing latitudes is usually 0.5°C per latitude.

- **Unequal distribution of landmass**
  - ✓ Water and land are not distributed equally between both the hemispheres.
  - ✓ Due to the northern hemisphere's enormous land mass, it is warmer than the southern one (because high specific heat of water results in its slower heating).

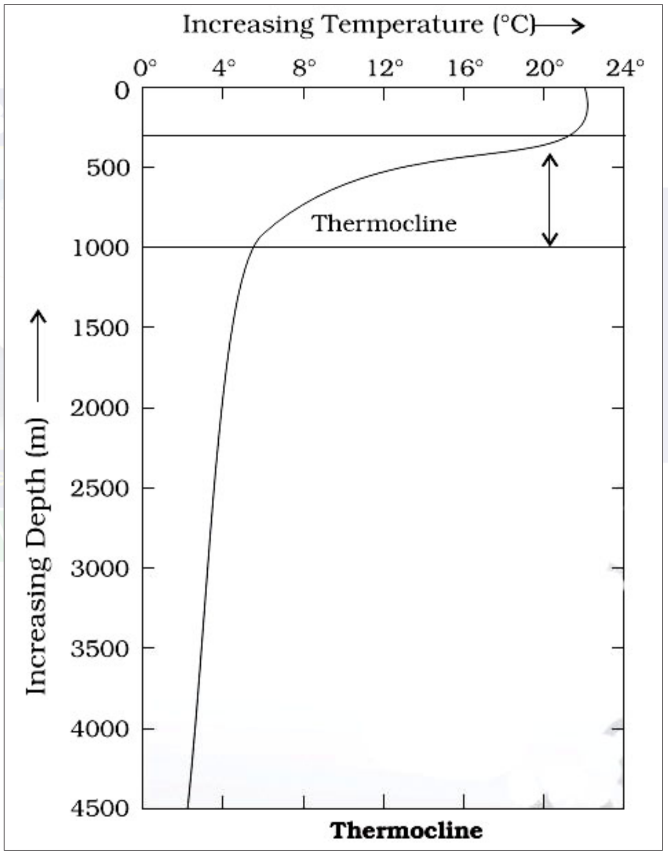
- **Prevailing winds (Longitudinal variation of temperature)**
  - ✓ Offshore winds, which originate on land and blow towards the ocean, push warm surface water away.
  - ✓ As a result, cold water rises up from beneath the surface to replace the area from where water is displaced.

- **Ocean currents**
  - ✓ The flow of water from one place to another is referred to as an oceanic current. These ocean currents play a significant role in maintaining the temperature of an area.

- **Enclosed and open sea**
  - ✓ Lower latitude temperatures are higher in enclosed seas than in open seas.
  - ✓ Higher latitude temperatures are lower in enclosed seas than in open seas.

- **Variation in ocean temperature**
  - ✓ At the equator, Earth's surface receives nearly four times as much solar radiation on average as it does at the pole. Due to the transparency of water, radiation can travel quite a distance beneath the surface.
  - ✓ Greater depth is reached by shorter wavelength radiations with higher energy. Due to turbulent mixing by the waves and winds, heat is transferred to deeper depths of the ocean.
  - ✓ Due to the high specific heat of water, daily and seasonal temperature variations in water are generally less pronounced than on the land.

- **Vertical variation in oceanic temperature**
  - ✓ Water motions induced by density regulate the vertical distribution of temperature in the deep ocean.
  - ✓ Ocean surface temperatures are always at their highest due to sun energy's direct incidence.
  - ✓ Only a limited amount of heat is transmitted downward by this method since heat conduction moves exceedingly slowly on its own.
  - ✓ Convection is how the heat is transferred from the upper ocean layers to the lower ones.



Thermocline

- **Horizontal Variation in oceanic temperature**
  - ✓ The ocean's surface water has an average temperature of roughly 27C
  - ✓ From the equator to to the poles, the average temperature progressively drops.
  - ✓ The oceans of the southern hemisphere has lower temperatures than the northern hemisphere.

- ✓ The distribution of land and water in the northern and southern hemisphere is the reason for this anomaly.
- ✓ The highest temperature is measured slightly to the north of the equator.

Salinity

- Sea water's salinity is an essential characteristic. It is calculated using the quantity of salt (in gm) dissolved in one kilogram's worth of saltwater, or 1,000 gm.

- Highest salinity in water bodies
- lake Van in Turkey (330/),
- Dead sea (238/),
- Great Salt Lake (220/),

Dissolved Salts in Sea Water (gm of Salt per kg of Water)	
Chlorine	18.97
Sodium	10.47
Sulphate	2.65
Magnesium	1.28
Calcium	0.41
Potassium	0.38
Bicarbonate	0.14
Bromine	0.06
Borate	0.02
Strontium	0.01

- The unit of measurement is parts per thousand ($^{o}/_{oo}$) or ppt.
- Salinity levels of 7 $^{o}/_{oo}$ have traditionally been used as the criterion for defining "brackish water."
- The water cycle and ocean circulation can be significantly impacted by even slight changes in the ocean surface salinity (i.e., concentration of dissolved salts).

Factors that affect the salinity of the oceans can be broadly grouped into two categories

1. **Factors that increase salinity**
   - ✓ Evaporation from the ocean's surface waters removes water molecules, leaving the salt behind.
   - ✓ Ice formation as freezing of ice leaves salt in the water.
   - ✓ Advection of more saline water
   - ✓ Mixing with more saline deep water(Due to the ocean currents)
   - ✓ Solution of salt deposits

2. **Factors that decrease salinity**
   - ✓ **Precipitation** on the ocean surface waters adds water molecules.
   - ✓ **Melting of ice** which dilutes the concentration of salt in the water.

- **Advection** of less saline water
- **Mixing** with less saline deep water(Due to the ocean currents)
- **Inflow** of fresh water from land

Distribution of Salinity

- **Vertical (Change with depth)**
  - ✓ Although salinity varies with depth, the manner in which it varies depends on the sea's location.
  - ✓ Assuming all other variables remain fixed, seawater's density rises as its salinity rises. Seawater with high salinity typically dips below water with low salinity. Salinity stratification arises as a result of this.
  - ✓ Salinity rises sharply in a unique region known as the halocline (contrast thermocline).

- **Horizontal**
  - ✓ Near the tropics, salinity levels are highest.
  - ✓ Towards the pole and equator, it declines
  - ✓ Equator = Incorporation of freshwater due to more rainfall

- ✓ Poles = Less evaporation keeps water molecules from being removed from the surface.

Relationship Between Salinity, Temperature, and Density

- **Density and temperature are inversely related.**
  - ✓ The salinity lowers when temperature rises because more space exists between water molecules as a result of volume expansion.
  - ✓ Only up to a certain degree does water's density rise when its temperature drops.
  - ✓ Pure water reaches its greatest density, or peak density, at a temperature of 4C. As it cools further, it expands and becomes less dense than the surrounding water, which is why water floats when it freezes at 0C.
  - ✓ When the temperature, density or salinity of a layer changes rapidly, this region is referred to as a cline.
  - ✓ Thermoclines are areas of rapid change in temperature. Areas of rapid change in density are **pycnoclines** and areas of rapid change in salinity are **haloclines**.

Oceanic Movement

- Ocean water is dynamic, and factors like temperature, salinity, density, and outside forces like the sun, moon, and winds all affect how it moves.
- Ocean water bodies frequently move in both the horizontal and vertical directions.
- The waves and currents of the ocean are described by the horizontal motion.
- Through ocean currents, water travels from one location to another. While the water inside the waves does not move, the wave trains do.
- The term "vertical motion" relates to upwelling and tides, which are the rise and fall of water in the oceans and seas.
- The ocean water rises and falls twice daily as a result of the sun's and moon's attraction.

Tides

- The term "tide" refers to the daily or twice-daily cyclic rise and fall of the sea level, which is primarily caused by the moon's and sun's gravitational pull.
- Surges are water movement brought on by meteorological factors (winds, changes in air pressure, etc). (storm surge during cyclones).
- Due to the significant fluctuations in frequency, size, and height of tides, studying them requires a tremendous deal of geographical and temporal complexity.
- The main drivers of tides are, to a large degree, the gravitational pull of the moon and, to a lesser extent, the gravitational pull of the sun.
- A further aspect is centrifugal force, which works in opposition to the earth's gravitational attraction.
- All these elements must be in harmony for tides to occur.
- The difference between these two forces-the moon's gravitational pull and the centrifugal force-is known as the "tide-generating" force.
- The pull or attraction force of the moon is larger than the centrifugal force closest to the surface of the earth, resulting in a net force that causes a bulge towards the moon.
- As the earth is farther from the moon on the other side, the attracting pull is weaker and the centrifugal force takes over. There is a net force away from the moon as a result. The second bulge away from the moon is produced by it.

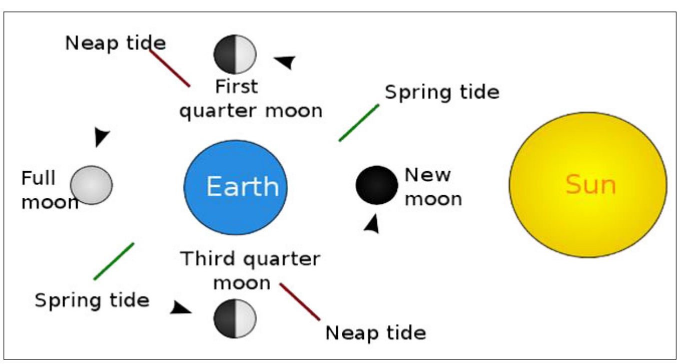
Factors Controlling the Nature and Magnitude of Tides

- The moon's motion with respect to the earth.
- changes in the sun's and moon's relative positions to the earth.
- Water is distributed unevenly over the world.
- irregularities in the way the oceans are arranged.

- The tidal bulges are produced on the surface of the earth by horizontal tide-generating forces rather than vertical forces.
- On broad continental shelves, the tidal bulges are higher. Tides become low when they reach the mid-oceanic islands.
- A coastline's bays and estuaries can have an impact on how strong the tides are.

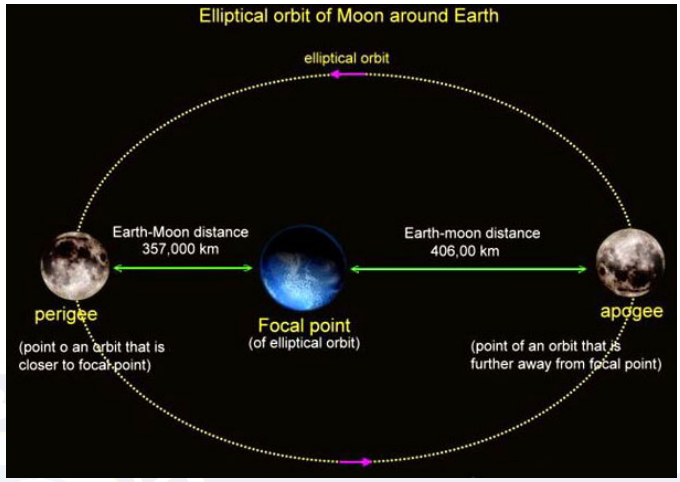
Tides based on the Sun, Moon and the Earth Positions

- **Spring Tides:** The moon's position in relation to the earth, as well as the sun's, directly affects the height of the tide.
    - ✓ The height of the tide will be greater when the earth, moon, and sun are in a straight line.
    - ✓ Two of these events per month, one during the full moon and the other at the new moon, are referred to as "spring tides."
- **Neap tides:** The time between spring tides and neap tides is usually seven days.
    - ✓ The forces of the sun and moon tend to balance one another at this time since they are at a right angle to one another.
    - ✓ Despite being more than twice as powerful as the sun, the Moon's attraction is lessened by the sun's gravitational pull.
    - ✓ These tides also happen twice a month, just as spring tides.



Unusual high and low tides happen once a month when the moon is at its **perigee**, its closest point to the earth. The tidal range is wider than usual at this time.

- The moon's gravitational pull is restricted two weeks later, at its furthest point from Earth **(apogee)**, and the tidal ranges are lower than usual.



Importance of Tides

1. **Navigation:** Navigation is aided by high tides. Near the coastlines, they boost the water level. This makes it easier for ships to dock at the harbour.
    - ✓ In general, tides contribute to some rivers becoming passable for ocean-going vessels. Due to the tidal character of the mouths of the Thames and Hooghly, respectively, London and Calcutta [Tidal Ports] have grown to be significant ports.
2. **Fishing:** The high tides are beneficial for fishing. When the tide is high, a lot more fish approach the shore. This enables fishermen to catch a sizable amount of fish.
3. **Desilting:** Tides are also helpful in desilting the sediments and in removing polluted water from river estuaries.

El Nino

- The term "El Nio," which translates to the Christ Child, was used by fisherman along the coastlines of Ecuador and Peru to characterise the warming of the central and eastern Pacific.

- El Nio is the term used to describe the sporadic development of warm ocean surface waters along the coasts of Ecuador and Peru. El Nio incidents happen irregularly every 2–7 years, on average once every 3–4 years.
- The typical upwelling of cool, nutrient-rich deep ocean water is greatly less when this warming takes place.
- Around Christmas, El Nio typically starts and typically lasts for a few weeks to a few months.
- Occasionally, a really heated event might arise and endure for significantly longer periods of time. Strong El Nios occurred twice in the 1990s, from fall 1997 to spring 1998 and from 1991 to 1995.

El Nino Year

- Air pressure decreases over substantial portions of the central Pacific and the South American coast during El Nio years.
- In the western Pacific, a weak high replaces the typical low-pressure system (the southern oscillation). Reduced trade winds as a result of this change in the pressure pattern = Weak Walker Cell. Walker Cell may even reverse itself occasionally.
- Due to the equatorial countercurrent's (current in the doldrums) decline, warm ocean water can now gather along Peru and Ecuador's shores.

Normal Conditions

- An area of surface low pressure typically forms across northern Australia and Indonesia, whereas an area of high pressure typically forms off the coast of Peru. Trade winds blow strongly from east to west over the Pacific Ocean as a result.
- Warm surface waters are transported westward by the trade winds' easterly movement, bringing convective storms (thunderstorms) to Indonesia and coastal Australia. Warm water is pulled to the west, and along Peru's coast, cold bottom, nutrient-rich water wells up to the surface to replace it.

Walker Circulation (Occurs during Normal Years)

The pressure gradient force resulting from a high pressure system over the eastern Pacific Ocean and a low pressure system over Indonesia leads to the Walker circulation (walker cell).

El Nino's Effects

- The marine life off the coasts of Peru and Ecuador was severely harmed by the warmer waters.
- Fish catches off the South American coast were fewer than they were in a typical year (Because there is no upwelling).
- Australia, Indonesia, India, and southern Africa all experience severe droughts.
- California, Ecuador, and the Gulf of Mexico all had heavy rains.

Impact on Indian Monsoon.

- El Nino and the Indian monsoon have the opposite relationship.
- El Nino droughts have caused six of India's most notable droughts since 1871, including the most recent ones in 2002 and 2009.
- However, not every El Nino year resulted in an Indian drought. For instance, although 1997–1998 experienced a significant El Nino, there was no drought (Because of IOD).
- On the other side, one of the greatest droughts was brought on by a moderate El Nino in 2002.
- The agrarian economy of India is directly impacted by El Nino because it tends to reduce the output of summer crops including rice, sugarcane, cotton, and oilseeds.
- The end result is high inflation and slow development in the gross domestic product, as agriculture makes up around 14% of the economy.

El Nino Southern Oscillation

- The Southern Oscillation, a pattern of atmospheric pressure circulation in the Pacific Ocean, is related to the development of an El Nio [Circulation of Water].
- In oceanography and climatology, the Southern Oscillation is a pronounced inter-annual variation in atmospheric pressure over the tropical Indo-Pacific area.
- Since El Nino and the Southern Oscillation frequently coincide, the phenomenon is known as ENSO, or El Nino Southern Oscillation.

The El Nino Modoki

- A combined ocean-atmosphere phenomenon known as El Nio Modoki occurs in the tropical Pacific.
- It differs from El Nio, a related linked event in the tropical Pacific.
- Strong abnormal warmth in the eastern equatorial Pacific is a characteristic of a traditional El Nio.
- While El Nio Modoki is linked to significant anomalous cooling in the eastern and western tropical Pacific and severe anomalous warming in the central tropical Pacific.

La Nina

- The weather typically returns to normal following an El Nio occurrence.
- The central and eastern Pacific may experience an unusual buildup of cold water in some years, when the trade winds can become unusually powerful. La Nia refers to this occurrence.
- Scientists think that the summer drought that affected central North America in 1988 may have been caused by a strong La Nia that year. The hurricane seasons of 1998 and 1999 during this time in the Atlantic Ocean were particularly active.
- In the past 100 years of record keeping, Hurricane Mitch, one of the developing hurricanes, was the fiercest hurricane to ever form in October.

Effects of La Nina

- Lower-than-average air pressure across the western Pacific is a defining feature of La Nia. More rain is a result of these low-pressure areas.
- monsoons in India and Southeast Asia that are unusually heavy, cool and rainy winter conditions in southeastern Africa, wet weather in eastern Australia, a chilly winter in western Canada and the northwestern United States, and a winter drought in the south of the country.
- The Southwest monsoon rainfall is enhanced by la nina conditions, whereas the Northeast monsoon rainfall is negatively impacted.
- In Southeast Asia, the summer monsoon often brings more rain than usual, particularly in Bangladesh and northwest India. The Indian economy, which depends on the monsoon for agriculture and industries, gains from this generally.
- Catastrophic floods have been linked to strong La Nia episodes in northern Australia.
- Rainfall that is above average is another effect of La Nia occurrences over northern Brazil and southeastern Africa.
- Along the Gulf Coast of the United States, the pampas region of southern South America, and the west coast of tropical South America, drier-than-normal conditions have been noted.

Coral Reef

- Thousands of small creatures called "polyps" of coral, which are linked to anemones and jellyfish, construct and make up coral reefs.
- In shallow water, polyps are organisms with a soft body and a calcareous skeleton. To create these sturdy skeletons, the polyps draw calcium salts from the seawater.
- The colonies of polyps are anchored to the stony ocean floor.
- As a cemented calcareous stony mass known as corals, the tube skeletons expand outward and upward.

- In order for new coral polyps to form, the coral polyps that have already died shed their coral skeleton.
- Over many millions of years, the cycle is repeated, resulting in the accumulation of layers of corals [reef is the name given to the shallow rock formed by these depositions].
- At various phases, these layers give rise to distinct maritime landforms. Coral reef is an excellent example of such a landform.
- Over time, coral reefs change or develop into coral islands (Lakshadweep).
- The types of salts or components the corals are formed of determine the shapes and colours that they take.
- Algae, which are tiny marine plants, also deposit calcium carbonate, which helps corals grow.

Fringing Reefs (Shore Reefs)

- Reefs that grow out from a beach are known as fringing reefs . In between the shore and the main reef body, they frequently form a shallow lagoon because of their close proximity to land.
- A narrow strip (1-2 km wide) is formed by a fringing reef. With the seaward side sloping sharply into the deep sea, this form of reef develops from the deep sea floor. The sudden and significant depth increase prevents coral polyps from growing outward.
- The bordering reef is the most prevalent of the three main types of coral reefs, and there are several examples of it in all of the major areas where coral reefs have developed.
- The New Hebrides Society islands, located off the coast of Australia and Florida's southern coast, both have fringing reefs.

Barrier Reefs

- Large linear reef complexes known as "barrier reefs" run parallel to a beach and are set apart from it by a lagoon. This reef is the longest of the three (in terms of length, not width), stretches across hundreds of kilometres, and is at least several kilometres broad. It encircles the shoreline or an island in the form of a crooked, asymmetrical ring that runs nearly parallel to it.
- While instances can be found in both the tropical Atlantic and the Pacific, barrier reefs are much less numerous than bordering reefs or atolls.
- The world's largest example of this type of reef is the 1200-mile-long Great Barrier Reef off the NE coast of Australia.
- As opposed to what its name suggests, the GBR is a fairly sizable complex made up of numerous reefs.

Atolls

- An atoll is an oceanic reef system that is broadly circular (annular) and surrounds a sizable (and frequently deep) centre lagoon.
- A number of channels that cross the reef allow the lagoon, which is 80 to 150 metres deep, to be connected to the ocean.
- Atolls are situated far from deep sea platforms, where features beneath the surface, like a submerged island or a volcanic cone that may reach a level suitable for coral growth, may contribute to the formation of atolls.
- There are three different types of atolls that can exist:
- A real atoll is either an island-dotted atoll or a circular reef enclosing a lagoon without an island.
- a coral island or an atoll island that is actually an atoll reef, constructed by the process of wave erosion and deposition with island crowns erected on them. An atoll encircling a lagoon with an island.
- In comparison to other oceans, the Pacific has by far the most atolls. Atolls like the Funafuti atoll in the Ellice/Island and the Fiji atoll are well recognised. The Lakshadweep Islands also contain a significant number of atolls.

- Most atolls in the South Pacific are found in the middle of the ocean. French Polynesia, the Caroline and Marshall Islands, Micronesia, and the Cook Islands all have examples of this type of reef.

Coral Bleaching or Coral Reef Bleaching

- Coral reef bleaching is a typical coral stress reaction to several of the many stressors.
- When the concentration of photosynthetic pigments within zooxanthellae decreases or the densities of zooxanthellae decrease, bleaching results. It is no longer helpful to coral, and coral will bleach it.
- When corals bleach, they frequently lose 60–90% of their zooxanthellae, and each zooxanthellae could lose 50–80% of their pigments used for photosynthetic activity.
- The afflicted corals typically regain their symbiotic algae within a few weeks or months if the stress-causing bleaching is not too severe and if it lessens over time.

- **Temperature**
  - ✓ Coral species can get bleached due to unusually low or high sea temperatures. Corals aren't found on the west coast of tropical temperate continents because of the cold currents.
  - ✓ Events of bleaching happen when there are sharp temperature reductions together with severe upwelling occurrences (like El Nino) and seasonal cold-air outbreaks.
  - ✓ The majority of reefs have recovered, with modest levels of coral mortality, although some have suffered catastrophic damage.

- **Sub aerial Exposure**
  - ✓ Reef flat corals that are suddenly exposed to the atmosphere during conditions like extremely low tides, sea level drops caused by ENSO, or tectonic uplift may experience bleaching.
  - ✓ Consequences of this loss of zooxanthellae, such as exposure to extreme heat or cold, increased solar radiation, desiccation, and dilution of sea water by heavy rains, may all contribute to coral death.

- **Fresh Water Dilution**
  - ✓ Coral reef bleaching has been shown to be caused by the rapid dilution of reef waters by storm-generated precipitation and runoff.
  - ✓ In general, these bleaching incidents are uncommon and limited to rather small, near coast locations.

- **Inorganic Nutrients**
  - ✓ An rise in ambient elemental nutrient concentrations (such as ammonia and nitrate) does not result in coral reef bleaching; rather, it raises zooxanthellae numbers by two to three times.
  - ✓ Eutrophication may have indirect negative impacts, such as decreased coral resistance and increased vulnerability to disease, even though it is not directly responsible for the loss of zooxanthellae.

- **Consequences of global coaral bleaching**
  - ✓ Despite covering less than 0.1% of the ocean's surface, 25% of all marine animals find food and shelter in coral reef ecosystems.
  - ✓ Around 500 million people worldwide rely on the fish stocks that they support.
  - ✓ In a matter of months, mass bleaching can transform a coral-dominated reef into one dominated by algae; it may take decades or more to reverse this process.

Personal Notes

BIOGEOGRAPHY

Soil

- Soil is the loose, granular material that covers the surface of the earth, whether it is thin or.
- In varying amounts, soil also contains minerals from the lithosphere, water from the hydrosphere, and air from the atmosphere. Organic materials, such as humus and microorganisms, come from the biosphere.
- These substances act as a medium for developing organisms and as fertilisers for plants.
- The correct proportions of air, water, minerals, and organic matter create for productive soil.
- In addition to organisms like mice, worms, insects, and snacks, soil also benefits from the presence of plants and germs like fungi, bacteria, and algae.

Composition of Soil

- In soil, minerals make up 45% of the average makeup.
- 10% Organic matters
- 50 percent air and water
- **Soil Genesis:** The process of turning rocky terrain into usable farmland is known as "soil formation" or "soil genesis."
- The weathering of the parent rock is the first step in the formation of soil. Materials that have weathered experience several chemical and biological alterations depending on the climate.

- **Five Factors are**
  - ✓ Parent Rock
  - ✓ Climatic Factors
  - ✓ Relief
  - ✓ Flora, Fauna, and Micro Organism
  - ✓ Time

- **Five Processes are:**
  - ✓ Lateralization and bacterization
  - ✓ Calcification
  - ✓ Salinization
  - ✓ Podzolization
  - ✓ Gleization

- **Parent Rock**
  - ✓ Parent rock could be sedimentary, metamorphic, or igneous.
  - ✓ It controls the soil's minerals, chemical makeup, colour, and texture.
  - ✓ Sand, silt, and clay are transferred to soil from parent rock.
  - ✓ Black soil, for instance, is composed of basaltic volcanic rock that has weathered.
  - ✓ igneous rock makes up red soil.

- **Climatic Variables**
  - ✓ Significant climate factors like temperature and precipitation have an impact on how soil is formed.
  - ✓ For instance, extreme temperatures and very little precipitation caused soil in the desert to calcify.
  - ✓ Semi-arid regions originated as a result of capillary action-induced calcification [when evaporation exceeds precipitation].
  - ✓ In locations with waterlogging, peaty soil formed by the gleization process in chilly, humid circumstances.
  - ✓ Fe and Al descend during the Podozolization process, creating acidic soil.
  - ✓ Heavy rainfall and equatorial climate conditions led to the development of laterite soils.

- **Relief**
  - ✓ The slope and altitude also affect the soil's thickness or thinness. While steep terrain contains thin soils, plain areas are covered in dense soil.

- ✓ Animals, plants, and microorganisms:
- ✓ Due to the richness of flora, animals, and microorganisms, humus is abundant in forest areas but deficient in arid ones.

- Because of the existence of microorganisms, the laterite soils also lack humus content.
- **Time:** Time determines the thickness of the soil profile.

The following are five processes involved in the soil genesis after the weathering process:

- **Lateralization and bacterization:** In hot, humid tropical and equatorial settings, the processes of lateralization and bacterization are widespread.
  - ✓ Low humus content in the upper section of the soil is a result of an increase in bacterization caused by high temperatures and frequent rain.
  - ✓ Leaching of dissolved minerals from the top layer to the soil profile's "layer B" occurs as a result of heavy rainfall.
  - ✓ The B layer of soil in laterite soil is hence mineral-rich.
  - ✓ Bigger trees do better in soil that is laterite.

- **Salinization/alkalization:** In scorching desert regions with relatively little precipitation and high temperatures, the salinization process frequently takes place.
  - ✓ The subterranean salts are brought to the surface by intense evaporation.
  - ✓ This is also occurring in low-rainfall regions' irrigated areas.
  - ✓ For instance, in certain regions of Punjab and Rajasthan.

- **Calcification:** The Savana climate (about 35 C and 75 cm of precipitation) is where the calcification process takes place.
  - ✓ Because soil nutrients were introduced to the earth's surface at a lower level, grass can grow there but trees cannot.

- **Podzolization:** This occurred in a cool and humid climate where bacteria activity is low. In this region, the thick dark organic surface having organic compounds can be translocated by heavy rainfall.
  - ✓ Podzolization process happens in Taiga Forest, Coniferous soil, and Boreal forest.

- **Gleying:** Anaerobic and soggy conditions were present during this process. Some specialised bacteria thrive on organic materials, which causes a decrease in iron and aluminium compounds and increases the acidity of the soil.
  - ✓ Peaty soil and marshy soil are two examples.

Soil profile

- The topsoil and subsoil are the two primary layers that make up most soil profiles.
- As you descend the soil profile, layers of soil are called soil horizons. The ability to discern between soil horizons in a soil profile might vary.

- **Typically, soils have three primary horizons:**
  - ✓ A horizon, nutrient-rich topsoil with high levels of organic matter and biological activity (i.e. most plant roots, earthworms, insects and micro-organisms are active). Because of the organic compounds, the A horizon is typically darker than other horizons.
  - ✓ Clay-rich subsoil in **horizon B**. While holding more moisture than the topsoil, this horizon is frequently less fruitful. Compared to the A horizon, it often has a lighter colour and less biological activity. The texture can also be more dense than the A horizon.
  - ✓ Underlying weathered rock in **the C horizon** (from which the A and B horizons form).

- ✓ Additionally, some soils contain an **O horizon,** which is primarily made up of plant debris that has accumulated on the soil's surface.
- ✓ The characteristics of horizons are used to identify various soil types and assess potential for land use.

Soil Classification

Soil can be categorised into sand, clay, silt, peat, chalk and loam types of soil based on the dominating size of the particles within a soil.

1. **Sandy Soil**
   - ✓ Light, warm, and dry sand has a tendency to be acidic and deficient in nutrients.
   - ✓ Due to their high sand content and low amount of clay, sandy soils are frequently referred to as "light soils" (clay weighs more than sand).
   - ✓ It is the construction material that is most frequently used.
   - ✓ It is made up of rock fragments and hard minerals like silicon dioxide.
   - ✓ They are the biggest kind of dirt particles, and each one can be seen with the human eye.
   - ✓ The big, generally stable sand particle size promotes drainage in compacted soils, increases soil aeration, and produces tilt, which supports plant growth.
   - ✓ Fine sand has a particle size range of 0.075 to 0.425 mm, medium sand of 0.425 to 2 mm, and coarse sand of 2 to 4.75 mm.
   - ✓ The particle shape might be sub-angular, angular, flat, rounded, or elongated.
   - ✓ It has a rough, smooth, or polished texture.
   - ✓ These soils are simple to work with and have quick water drainage.
   - ✓ By enhancing the soil's ability to store nutrients and water, the addition of organic matter can assist in providing plants with an additional boost of nutrients.

2. **Silt Soil**
   - ✓ A soil type with a high fertility rating, silt Soil is light and moisture-retentive.
   - ✓ Silt soils are well drained and retain moisture well because they are composed of medium sized particles.
   - ✓ The fineness of the particles makes them susceptible to compacting and to being washed away by rain.
   - ✓ A sedimentary substance having a size between sand and clay is called silt.
   - ✓ It creates a fertile deposit on the valley floor when carried by floodwaters.
   - ✓ Silt has particles between 0.002 to 0.06 mm in size.
   - ✓ Due to its fineness, silt soil creates a smooth mud when wet, which you can easily mould into balls or other shapes with your palm. When silt soil is really wet, it melds with water to create thin, powdery particles.
   - ✓ By adding organic matter, the silt particles can be bound into more stable clumps.

3. **Clay Soil**
   - ✓ High nutrient levels are advantageous for clay soil, a heavy soil type.
   - ✓ In the summer, clay soils become dry while remaining wet and chilly in the winter.
   - ✓ Being smaller than 0.002 mm in size, clay particles are the smallest of all soil particles.
   - ✓ It is made up of microscopic and submicroscopic rock-decomposition-related particles.
   - ✓ A cohesive, fine-grained soil is clay.
   - ✓ They generate a sticky or glue-like feel when wet or dry and quickly adhere to one another.

- ✓ More than 25% of these soils are composed of clay, and clay soils have a high water-holding capacity due to the gaps between its particles.
- ✓ When in touch with water, clay expands and contracts as it dries out.
- ✓ Compared to sand particles, which are generally round, clay particles are thin, flat and covered with tiny plates.
- ✓ Organic clay is highly compressible and its strength is very high when dry, which is why it is used in construction as mud mortar.

4. Peat Soil

- ✓ Peat soil has a high level of organic matter and holds a lot of moisture.
- ✓ Rarely found in gardens, this sort of soil is sometimes imported in order to give the best soil foundation for plants.

5. Loam Soil

- ✓ Sand, silt, and clay are combined to create loam soil in order to counteract the drawbacks of each type.
- ✓ These soils have high drainage, are rich, and are simple to work with. They can be either sandy or clay loam, depending on what makes up the majority of their composition.
- ✓ Although considered to be a gardener's best friend because of their ideal particle balance, soils nonetheless benefit from being supplemented with extra organic matter.

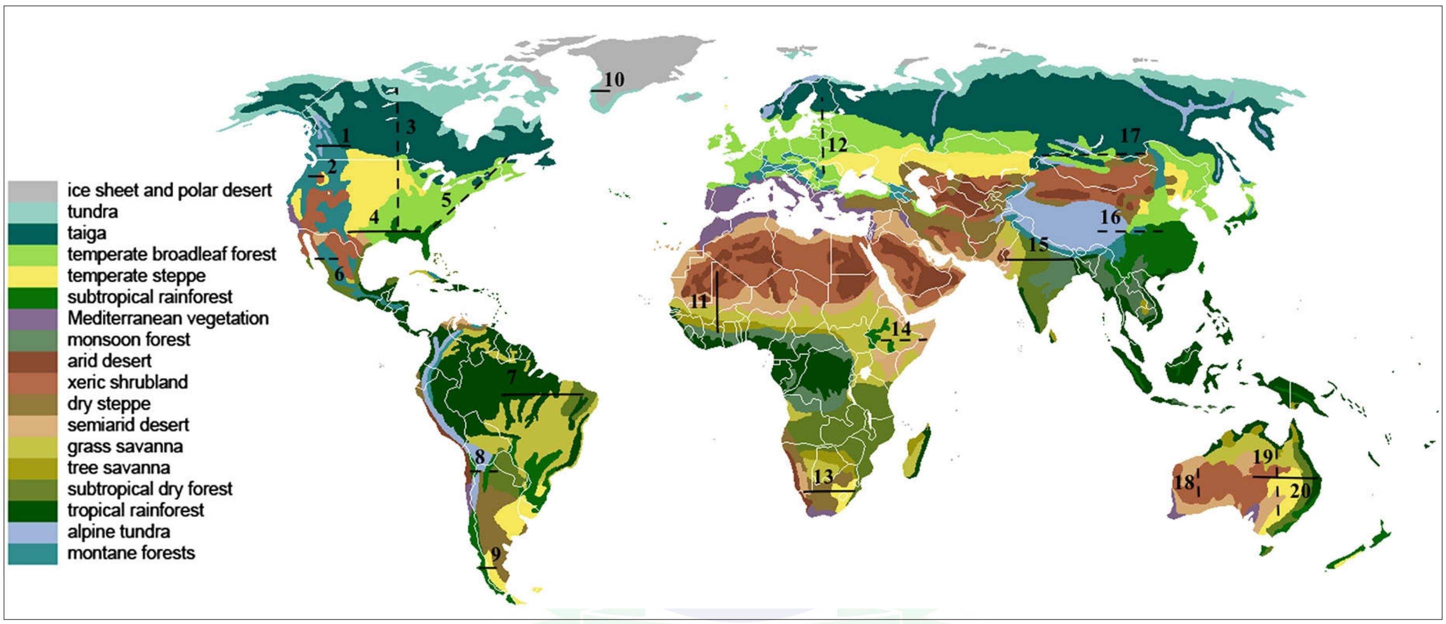
Biomes

- The term "biome" is a shortened version of "biological home."
- The concept and classification of a biome are not agreed upon by all scientists.
- A biome is a significant natural eco-system where we may investigate the entire assemblage of plant and animal communities.
- Here, all of the biota share a minimum set of traits, and all of the biome regions are characterised by more or less consistent environmental factors.
- Though there are animal and plant communities inside a biome, the dominant vegetation that makes up the majority of the biomass is typically used to identify and define a biome.

Factors Affecting Biome

A biome's size, location, and characteristics are influenced by a number of factors. The following are significant factors:

- Daylight and nighttime hours. The duration of photosynthesis is primarily caused by this.
- Average temperature and temperature differential. differences (both daily and yearly) to identify extreme circumstances
- Growth season length.
- Precipitation, including the overall amount, changes over time, and intensity.
- Speed, direction, duration, and frequency of wind flow.
- kinds of soil
- Slope
- Drainage
- Other types of plants and animals



Classification of biomes.

A biome's size, location, and characteristics are influenced by a number of factors. The following are significant factors:

(a) Based on climate, with a focus on the moisture's availability

- According to this basis , the amount of moisture available to plants on a scale ranging from abundant (forest biome) to practically scarce (arid biome) defines the biome (desert biome).
- The temperature conditions, however, vary greatly within each biome from low to high latitudes and from low to high elevations.
- **There is a need to further categorise each biome into subtypes as a result.**
- However, there are four main categories of biomes according to this classification:
  - ✓ Biome of forests
  - ✓ Biome of savanna
  - ✓ Biome of grassland
  - ✓ The arid biome

(b) On the basis of climate and vegetation

- As the vegetation and climate have intimate relationship the world is divided into various types on the basis of climates.
- Further, these climate based biomes are divided into various sub-types on the basis of vegetation

Classification of Biomes on the Basis of Climate and Vegetation		
Biomes of the first ordery (based on Climatic Zones)	**Biomes of the Second order (Based on Vegetation)**	**Biomes of the Third order (Combination of Climate and Vegetation)**
1. Tropical Biome	(i) Tropical Forest Biome	(a) Evergreen Rain- Forest Biome (b) Semi-evergreen Forest Biome (c) Deciduous Forest Biome (d) Semi-deciduous Forest Biome (e) Monanne Forest Biome (f) Swamp Forest Biome
	(ii) Savana Biome	(a) Savanna Forest Biome (b) Savanna Grassland Biome
	(iii) Desert Biome	(a) Dry and Arid Desert Biome
2. Temperate Biome	(i) Boreal Forest Biome (Temperate Forest Biome)	(a) North American Biome (b) Asiatic Biome (c) Mountain Forest Biome
	(ii) Temperate Deciduous Forest Biome	(a) North American Biome (b) European Biome
	(iii) Temperate Grassland	(a) Saviet Steppe Biome (b) North-American Prarise Biome Pampa Biome
	(iv) The Mediterranean	(i) Austration Grassland Biome (ii) Southern Hemisphere Biome
	(v) Temperate Rainfores Biome	
3. Tundra Biome	(i) Aretic Tundra Biome (ii) Alpine Tundra Biome	

Terrestrial Biomes

1. Tropical Evergreen Rainforests Biome

- It covers the area of Amazon low land of south America, Congo basin of equatorial Africa and South Eastern Asian Islands extending from Sumatra to New Guinea.

- **Climate**

  ✓ With a range of only 20C, this region has hot temperatures all year long.

  ✓ The daily temperature range, however, is substantially greater than the annual temperature range.

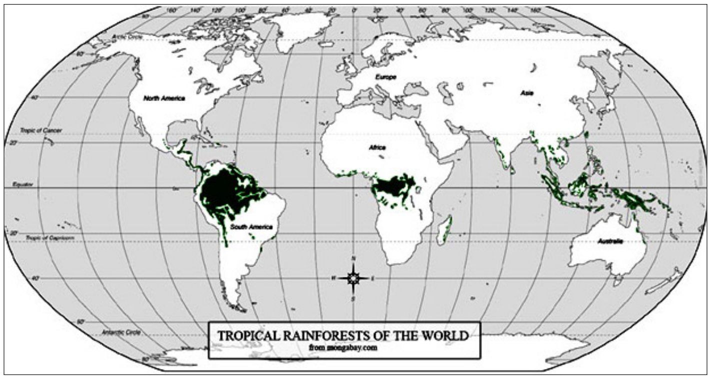
  ✓ Between 150 cm and 250 cm of rain fall in this region each year.

  ✓ It is spread out over the course of the year.

  ✓ The afternoon is when it rains virtually every day.

  ✓ This also occurs as a result of a significant volume of water vapour entering the atmosphere as a result of the high temperature.

  ✓ Since both temperature and rainfall are high throughout the entire year, this region is therefore thought to have an equable climate.



- **Natural Vegetation**
  There are three levels to the evergreen rainforest.

a. Between roughly 20 and 50 metres is the canopy, or higher level, where trees are located. The majority of them are hard wood trees, including cinchona, ebony, mahogany, rosewood, and sandalwood.

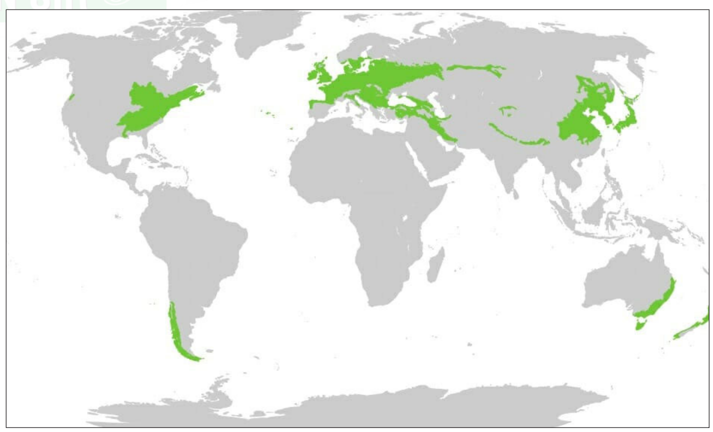
b. The second intermediate level is where the trees are, and it is between 10 and 20 metres high. Palm trees are the most significant plant in this genus. In addition to palm trees, this layer also contains epiphytic and parasitic species.

c. The third level, or lower level, is located between ground level and a height of around 10 metres. This category includes a wide range of plants, including herbs, bananas, pineapples, ferns, mosses, orchids, and more. The lowest level or surface was unable to receive sunlight due to tall, dense plants with broad leaves.

- **Animal Life**
  - ✓ Jaguars, lemurs, orangutans, elephants, and others are among the important creatures of this biome. Some significant birds found here are the toucan, sloth, and macaw parrot.
  - ✓ The majority of birds are colourful.
  - ✓ With alligators, tadpoles, fish, frogs, Hippopotamuses, and other animals, the water bodies in the tropical regions are also abundant in animal life.
  - ✓ The majority of insects, birds, and other animals live on the branches of trees due to the impenetrability and strong vegetation growth in the lower area.
  - ✓ The world's highest productivity can be found in the tropical rainforest biome.
  - ✓ It should be noted that while the rainforest biome only makes up 13% of the world's total geographic area, it is responsible for 40% of the world's biodiversity.

2. Tropical Deciduous Forests Biome (Monsoon Forests)

- ✓ **Distribution:** The tropical deciduous woodland biome is divided into main regions:
- ✓ The West Indies, the Neotropics,
- ✓ Eastern Africa, northern Australia, and the Indo-Malaysian Zone (mostly in south and south-east Asia, with the exception of equatorial evergreen rainforest areas).
- ✓ In addition to these significant regions, tropical deciduous forest biomes can also be found in South Africa, Southern Brazil, the South-Eastern United States of America, Formosa (Taiwan), southern China, and Japan.



- **Climate**
  - ✓ Two different seasons, the moist season and the dry season, characterise this tropical deciduous forest biome.
  - ✓ There are three primary seasons in a year in

India and nearby monsoonal regions like Pakistan, Bangladesh, etc.: Dry warm summer season (March to June), Warm humid summer season (July to October), and Dry winter season (November to February).

- ✓ The maximum temperature between May and June fluctuates between 38C and 48C, but the average warm, dry summer season ranges between 27C and 32C.
- ✓ The length of the dry season has a greater impact on the vegetation in the tropical deciduous forest biome than the total amount of precipitation.
- ✓ The mean annual rainfall is approximately 1500 mm on average, but there are significant temporal and regional variability.
- ✓ Even the temporal distribution of rainfall within a single year is highly variable because more than 80 percent of mean annual rainfall is received within 3 wet months of summer season (July, August and September).

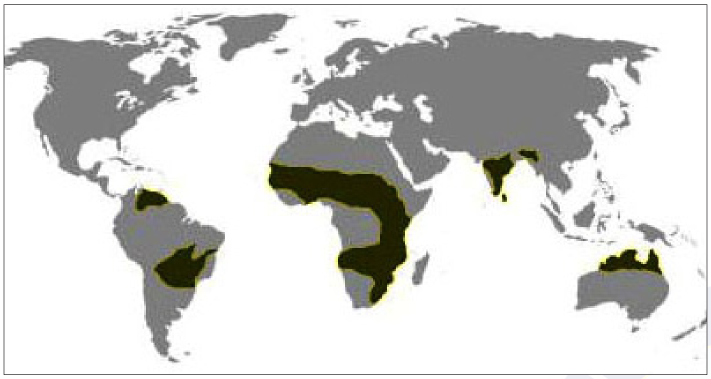
- **Natural Vegetation**
  - ✓ The tropical deciduous forest biome has fewer plant species than the tropical evergreen rainforest biome.
  - ✓ Since there is less competition for sunlight among the plants in this biome than in the rainforest biome, plant density is likewise lower in this biome.
  - ✓ Most of the trees are between 12 and 30 metres tall.
  - ✓ The tropical deciduous forests have a vertical structure made up of four strata or layers. Trees make up the top and second strata; shrubs make up the third; and herbaceous plants make up the bottom and fourth strata, often known as the ground stratum.
  - ✓ While the plants in the third stratum are evergreen, the majority of the trees are deciduous.
  - ✓ Bamboo is another important member of the Indian deciduous forests.
  - ✓ Besides, there are numerous trees, climbers, shrubs and grasses which have spatial variations from one region of the tropical deciduous forests to the other region.

- **Animal Life**
  - ✓ It is an important ecological principle that the number of animal species, their overall population, and species diversity will increase as a biome's vertical pattern of vegetation stratifies and the number of plant species increases.
  - ✓ The tropical evergreen rainforest biome is a superb example of this ecological principle in action.
  - ✓ However, compared to the rainforest biome, the monsoon deciduous forest has a lower number of animal species due to less animal species diversification and, consequently, less vertical stratification.
  - ✓ In other words, the seasonal pattern in animal reproduction, migration, and breeding has been caused by the seasonal nature of the monsoon deciduous woods.
  - ✓ For instance, during each of the two seasons of the year, birds in east Africa breed twice. Typically, Indian dogs procreate just once a year, usually at the end of the wet monsoon season (during October-November).
  - ✓ Because of the growth of agriculture, this biome contains the most domesticated mammals.
  - ✓ The majority of the world's population of humans live in this biome.

- **Savanna Biome**
  - ✓ Open grassland regions with few trees make up the savanna biome, which is a variety of grassland biome. Savannas can be classified as either tropical or semi-tropical.

- **Distribution**
  - ✓ Except for Antarctica, all continents have grasslands.

- ✓ The largest savannas are found close to the equator in Africa.
- ✓ Serengeti National Park in Tanzania, which is well-known for its enormous wildebeest and zebra populations, is one of the most well-known African savannas. Along with these animals, the park is also home to gazelles, elephants, hippos, and lions.



- ✓ Other savanna locations include:
- ✓ **Africa:** South Africa, Namibia, Zimbabwe, Botswana, and
- ✓ Australia:
- ✓ Honduras and Belize are in Central America.
- ✓ Colombia and Venezuela are in South America.
- ✓ South Asia

- **Climate**
  - ✓ Seasonal variations can be found in the savanna's climate.
  - ✓ A savanna can receive up to 50 inches of rain during the warm, humid wet season.
  - ✓ However, the temperature can get very hot during the dry season, and there will only be four inches of rain every month.
  - ✓ Savannas are ideal for grass and brush fires during their dry seasons due to their mix of high temperatures and minimal precipitation.

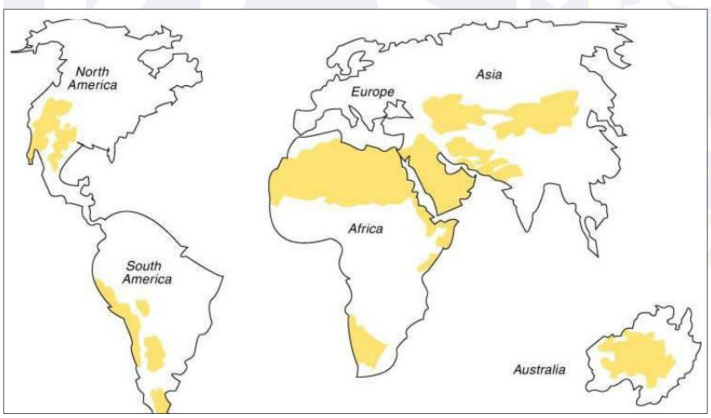
- **Natural Vegetation**
  - ✓ The savanna biome is defined as a region of grassland with scattered trees or groups of trees.
  - ✓ Tall plants like trees find it challenging to flourish in the savanna due to its lack of water.
  - ✓ Savanna grasses and trees have evolved to survive in the arid conditions and high temperatures.
  - ✓ Grasses, for instance, grow swiftly when water is abundant during the wet season and turn brown during the dry season to save water.
  - ✓ Some trees only produce leaves in the rainy season and retain water in their roots all year round.
  - ✓ Because there are so many fires, the grasses are short and near to the ground, and some plants can withstand fire.
  - ✓ Wild grasses, shrubs, baobab trees, and acacia trees are a few types of savanna vegetation.

- **Animal life**
  - ✓ The savanna is home to many large land mammals, including elephants, giraffes, zebras, rhinoceroses, buffalo, lions, leopards, and cheetahs.
  - ✓ Other animals include baboons, crocodiles, antelopes, meerkats, ants, termites, kangaroos, ostriches, and snakes.
  - ✓ Many of the savanna biome animals are grazing herbivores that migrate through the region.
  - ✓ They rely on their herd numbers and speed for survival, as the vast open areas provide little means of escape from quick predators.
  - ✓ If the prey is too slow, it becomes dinner. If the predator is not fast enough, it goes hungry.
  - ✓ Camouflage and mimicry are also very important to animals of the savanna.

- **Desert Biome**
  - ✓ Some of the most common yet unknown biomes are deserts.

- ✓ They are present in 60 countries around the world and make up around one-third of the earth's surface.
- ✓ Over 3.5 million square miles or 9 million square kilometres, the subtropical Sahara is the world's largest hot desert ecosystem.
- ✓ However, the Antarctica, a polar desert, is the world's largest desert.
- ✓ The vast majority of people believe that deserts are incapable of supporting any kind of life, although they actually contain over 4,000 different plant and animal species.
- ✓ Due to the low annual precipitation in desert biomes, both plants and animals must endure extremely harsh circumstances.
- ✓ A desert biome is a group of habitats that grow in arid (dry) settings as a result of little to no rainfall (less than 50 cm annually).

Distribution



- **Climate**
  - ✓ Desert evenings are often frigid because there isn't much moisture in the air to absorb and hold onto the heat produced by the high daytime temperatures.
  - ✓ The desert biome is an extremely difficult land mass to live in due to the combination of high temperature variations and exceedingly limited water availability.
  - ✓ Due to the lack of moisture in the atmosphere to screen off the sun's beams, temperatures are extremely high during the day.
  - ✓ This indicates that the energy from the sun is absorbed by the ground.
  - ✓ The air around the ground then becomes warmer.
  - ✓ The exact reverse occurs as night falls.
  - ✓ Heat absorbed during the day is returned to the environment via the heated ground and hot air, resulting in rapid drop in temperature.

- **Precipitation**
  - ✓ Precipitation in hot and dry deserts is a lot different from precipitation in cold deserts.
  - ✓ Hot and cold deserts typically receive very little rainfall, an average of 15 cm per year.
  - ✓ Cold deserts, on the other hand, experience a lot of snow and receive rain in spring, an average of 15-26 cm, to be exact.
  - ✓ **Seasons:** Desert biomes experience significant seasonal climate variations.
  - ✓ Temperatures in the summertime range from 30 to 49 degrees Celsius. Precipitation levels are low or nonexistent throughout the summer.
  - ✓ Additionally, precipitation usually occurs at a faster pace than evaporation.
  - ✓ Temperatures in the winter range from 10 to 20 degrees Celsius. During these summer months, there is a lot of precipitation.

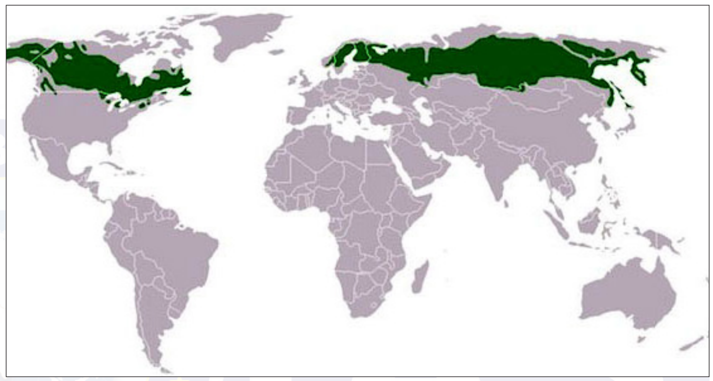
- **Natural Vegetation**
  - ✓ The high daily temperature swings and extremely low rainfall that are common in desert biomes make life challenging for plants.
  - ✓ Cacti, tiny shrubs, succulents, and grasses are the most typical plants that flourish in desert biomes.
  - ✓ Desert plants have evolved special adaptations to survive in these challenging environmental circumstances.

- ✓ In order to reduce water loss, common adaptations include storing water in stems and leaves, coating leaves with wax, and dropping leaves.
- ✓ Particularly the cactus plant, which may grow up to 20 feet tall and live for over 200 years since it has successfully adapted to the extreme climatic conditions of desert biomes.
- ✓ Because of its shallow roots, which help it to take up water, the Giant Saguaro cactus in particular has been able to flourish in this harsh biome.

- **Animal Life**
  - ✓ These animals have evolved special cooling and water-saving characteristics to help them stay cool.
  - ✓ For instance, a well-known desert animal like the camel may survive without food and water for days thanks to the fat that is stored in its hump. In order to protect itself from the worst of winter, it also possesses thick fur and underwool. It has the ability to seal its nostrils to block sand blowing inside. A camel has large hooves to keep it from sliding into the sand and two rows of eyelashes to protect its eyes from the sun and wind.
  - ✓ Other animals in the desert biome include Bobcats, Coyotes, Javelina, Desert Tortoise, Cactus Wren, Desert Kangaroo Rat, Sonoran Desert Toad, Thorny Devil, Desert Bighorn Ship, Armadillo Lizard, Sonoran Pronghorn Antelope, and so on.

- **Boreal Forest (Taiga) Biome**
  - ✓ The boreal forest, which spans a vast 20 million hectares over Europe, Asia, and North America, is the second-largest biome on the earth.
  - ✓ The name "Taigaor the Snow Forest" is another name for the area.
  - ✓ Coniferous forest, including larches, spruces, birches, aspens, firs, and pines, makes up the majority of the area.
  - ✓ Most of the forest is covered in dense, close-cropped trees that create a canopy with moss undergrowth.
  - ✓ But in some places, the trees are spaced away from one another, creating what is known as lichen woodland.
  - ✓ The forest also has diverse climatic patterns and different species of organisms.

- **Distribution**



  - ✓ This biome is only located in Northern Hemispheres at latitudes between 60^0 and 50^0 North.
  - ✓ **Forest Cover in Northern America:** From Labrador on the east coast to Alaska on the west coast, northern America is covered in a boreal forest. From the North side of the continent to the South, 2,000 kilometres are thought to have been travelled. While just 11% of the boreal forest is present in America, 24% of it is covered by Canada.
  - ✓ **Boreal Forest Cover in Europe and Asia:** The boreal forest cover in Europe and Asia runs from Siberia on the east to Scandinavia on the west. Asia is where the forest is the widest when measured from North to South; there, it stretches for 3,000 kilometres. Only 4% of the boreal forest is covered in nations like Sweden, Finland, and Norway, whereas Russia alone has a coverage of 58%.

Climate

- **Temperatures**
  - ✓ Typically, temperatures below the arctic tundra are very cold.
  - ✓ Boreal forest temperatures, which can last up to eight months from October to May and are found beneath the tundra region, are extremely cold.
  - ✓ -30F to -65F is thought to be the range for the average temperature.
  - ✓ Additionally, throughout the winter, the forest receives an average snowfall of 16 to 39 inches.
  - ✓ The powerful winds that blow through the forest slow down the snowmelting process between storms.
  - ✓ Summertime brings about a significant shift in temperature, which can get a little warm. An average increase of 20F to 70F is possible.
  - ✓ 80 degrees Fahrenheit is the highest temperature ever logged. The words "short, cool, and damp" best describe summers.

- **Precipitation**
  - ✓ The boreal forest experiences precipitation in the form of snowfall in the winter and rain throughout the brief summer season.
  - ✓ The wide spongy moss undergrowth that soaks up the surplus water causes certain portions of the forest to be constantly frozen, while it causes other areas to be moist.
  - ✓ The majority of the rains and snowmelt travel to wetlands where they are caught and stored.
  - ✓ Permafrost is a condition where the ground freezes over permanently and prevents plant growth.

- **Microclimates**
  - ✓ It's possible that certain parts of the forest are more wet, dry, warm, chilly, windy, or shaded than other parts.
  - ✓ The fallen leaves and twigs from the forest trees are left on the forest floor, where they gradually decompose to produce a habitat for a variety of insects.
  - ✓ The little creatures are protected from the elements by crevices and bark that has fallen from the trees.
  - ✓ Additionally, the snow cover is an excellent insulator and can offer the animals below it with a sufficient amount of warm shelter.
  - ✓ The wind would have substantially decreased the climatic temperatures within the forest, but the hanging tree branches and dense tree cover block the wind.

- **Seasons**
  - ✓ The Cree, a race of people that inhabit these forests, recognise the six seasons in the boreal forest. Spring, break-up, summer, autumn, freeze-up, and winter are the different seasons.
  - ✓ The freeze-up period in October is when the lakes freeze over and the trees begin to lose their foliage.
  - ✓ Following fall, this time frame finishes as winter officially begins.
  - ✓ The snowmelt season is the other time frame.
  - ✓ The earth appears to be bare at this time. The break-up season may continue for several months or until all of the lake's ice has melted.

- **Natural Vegetation**
  - ✓ **Coniferous trees:** Coniferous evergreen trees like spruces, pines, and larches dominate the boreal forest.
  - ✓ In order to make the most of the available sunlight and to begin photosynthesis as soon as possible, these trees preserve their green tint.
  - ✓ In order to ensure that they lose as little water as possible in the summer and spring, conifers produce distinctive waxy needle-like leaves.
  - ✓ The needle-like leaves of the majority of conifers typically fall off after every two to

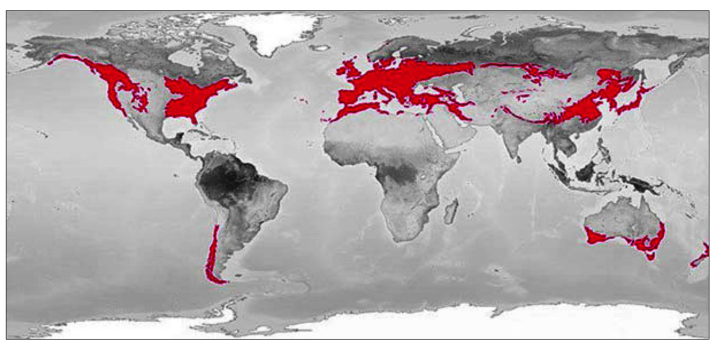
three years, while others, like the spruce, retain them for about eight to nine years.
- ✓ Others, including the Larch and Tamarack, shed their needle-like leaves each year.
- ✓ **Deciduous Trees:** The severe conditions of the boreal woodlands prevent the majority of deciduous trees from growing. Some do, however, succeed in expanding.
- ✓ To save energy for the chilly winter months, deciduous trees shed their leaves throughout the autumn season.
- ✓ Some of its branches can snap because to the heavy snowfall that occurs during the winter.
- ✓ Birch, poplar, and aspen are examples of broad-leaved deciduous trees, while blueberries, willow, and alder are considered **shrubs**.
- ✓ **Fungi:** Fungi such as mushrooms are found in large quantity in the boreal forest.
- ✓ The fungi are saprophytes and get enough nutrients from the many dead branches and trees found within the forest.
- ✓ **Lichen:** Algae and fungus in a symbiotic interaction form lichens.
- ✓ They form an expansive undergrowth in the forest and can also be found on rocks and tree branches.
- ✓ **MosS:** They are part of the undergrowth in the boreal forest.
- ✓ Moss is feathery in shape and is mostly found in moist places.
- ✓ They grow well in acidic soils such as the one that is found within the forest because of the fallen coniferous needles that lower the pH of the soil.

Animal Life

- **Mammals:** The mammals found in the boreal forest are herbivores such as the moose, caribou, deer, elk, voles, muskrat, beaver, hare, mice and the snowshoe.
  - ✓ The herbivores are well adapted to survive in harsh environments such as hibernation.
  - ✓ They are also well adapted to survive against attacks from carnivores through camouflage.
  - ✓ The carnivores found in the forest are the fox, lynx, marten, grizzly bear, coyote, black bear, otter, shrews, cougar, ermine and the least weasel.

Temperate Deciduous Forests

- **Distribution**
  - ✓ Everywhere in the planet, including in the Northern and Southern Hemispheres, there are deciduous forests.
  - ✓ North America, Europe, and portions of Russia, China, and Japan are often home to the largest deciduous forests in the globe.
- **Climate:** The characteristic that distinguishes deciduous forests from other types is that their trees shed their leaves annually with the change of the seasons. Deciduous forests are also sometimes referred to as temperate broadleaf deciduous forests, which implies that they are frequently found in temperate climate zones.
  - ✓ From chilly winters to scorching, arid summers, the weather changes.
  - ✓ Each fall, the leaves of these trees lose their moisture. The nutrients included in the leaves are absorbed by the soil when the leaves decompose. Fall, winter, and spring are the times when the leaves change colour.
  - ✓ Even while deciduous woods are primarily located in four-season temperate zones, they can also be found in tropical, subtropical, and savanna areas.



- ✓ **Temperature:** Trees in these forests lose their leaves once a year, the average temperature of a deciduous forest is typically around 50 degrees Fahrenheit (10 degrees Celsius), with winters dropping much colder.
- ✓ **Precipitation:**Rain falls around the year in deciduous forests, and in some locations, snowfall is common for winter precipitation.
- ✓ Typically, the average rainfall for a deciduous forest is in the range of 30 to 60 inches annually.

- **Natural Vegetation**
  - ✓ The plant species in temperate deciduous woods are very diverse.
  - ✓ The majority have three plant layers.
  - ✓ On the forest floor, you can find lichen, moss, ferns, wildflowers, and other small plants.
  - ✓ The third level is made up of hardwood trees including maple, oak, birch, magnolia, sweet gum, and beech, while the middle level is made up of shrubs.
  - ✓ Along with the hardwood trees, this biome contains conifers including spruce, fir, and pine trees.
- **Animal Life:** The ability to adjust to seasonal changes is necessary for animals that dwell in temperate deciduous forests. In the winter, some creatures in this biome migrate or hibernate.
  - ✓ Red-crowned cranes, owls, hawks, squirrels, sable, black bears, wolves, leopards, lynx, siberian tigers, otters, and red pandas are among the animal species.

- **Temperate Grassland**
  - ✓ One of the most crucial biomes to comprehend is temperate grasslands. They are crucial to our survival. They are crucial in managing climate change, as well.
  - ✓ The Northern Hemisphere contains temperate grasslands.
  - ✓ They are also referred to as steppes or prairies.
  - ✓ The seasons of growth and dormancy in temperate grasslands are clearly defined.
  - ✓ Temperatures in temperate grasslands can vary greatly throughout the year.
- **Location:** Locations of temperate grasslands include:
  - ✓ Argentina, Uruguay - pampas
  - ✓ Australia - downs
  - ✓ Central North America - plains and prairies
  - ✓ Hungary - puszta
  - ✓ New Zealand - downs
  - ✓ Eurasia-Russia, Ukraine-Asia – steppes
  - ✓ South Africa – veldts

  - ✓ **Climate:** Even though the temperatures in emperate grasslands are generally moderate, there are different seasons there.
  - ✓ Cold winters and sweltering summers are common.
  - ✓ It gets between 10 and 35 inches of precipitation a year, most of it snow in the winter, in the late spring and early summer.
- **Temperature:** In tropical grasslands, seasonal temperature variations may be minimal, but in temperate grassland regions, variations may reach 40^{0}C (72^{0}F).
  - ✓ Summertime highs can reach over 100 degrees Fahrenheit. The mercury can fall to 40 degrees below zero throughout the winter.
  - ✓ While the corresponding figures in July are 18^{0}C (64^{0}F) and 28^{0}C (82^{0}F), the mean temperatures in January range from 18^{0}C (0^{0}F) in the north to 10^{0}C (50^{0}F) in the south.
  - ✓ The most northern regions of the North

American grassland zone have mean annual temperatures that are below $0^{0}C$ ($32^{0}F$).

- **Precipitation and soil:** The eastern US prairies, the pampas of South America, and the steppes of Ukraine and Russia are the world's most productive soil.
  - ✓ In the grassland regions of North America, the average annual rainfall ranges from 300 to 600 millimetres.
- **Vegetation:** The temperate grasslands are dominated by grasses.
  - ✓ Plants such as:
  - ✓ Low and mid-range grass types
  - ✓ Small succulents and ground shrubs
  - ✓ Small trees
  - ✓ Grains
  - ✓ The various species of grasses include: Blue grama, Gallet, Blue-eyed grass, Purple needle grass, Buffalo grass, Ryegrass, Foxtail.
- **Animals**
  - ✓ The large herbivores include bison, gazelles, zebras, rhinoceroses, and wild horses.
  - ✓ The natural carnivores, like lions, wolves, cheetahs, leopards, coyotes, red-tailed hawks, owls, and opossums, are also found in temperate grasslands and prey on big and small animals.
  - ✓ Omnivores such as badgers also thrive in this biome. These kinds of animals eat rodents, snakes, frogs, insects, fruits, and roots.

Mediterranean Biome

- **Distribution**

- ✓ The Mediterranean biome has grown in both hemispheres' western portions of the continents between 30^{0} and 40^{0} latitudes, and occasionally up to 45^{0}.
- ✓ THis biome includes the western Turkey, Syria, western Israel, and Lebanon, as well as the central and southern California of the United States, central Chile of South America, the far southwest of South Africa, and the coastal regions of western and southern Australia. It also includes the northwestern coastal lands of Africa bordering the Mediterranean Sea.

Climate

- ✓ Three prominent characteristics of the Mediterranean climate lend this biome's sclerophyll characteristics to its vegetation:
- ✓ While summers are dry, winters are chilly and wet. The majority of the year's rainfall falls during the wet winter months.
- ✓ Winters are generally chilly, while summers are warm and dry.
- ✓ All seasons receive enough sunlight, but summer has more of it.
- ✓ Mean annual rainfall ranges between 370mm and 650mm, the most portions of which is received during winter season.
- ✓ The winter rainfall is received through the cyclonic storms associated with the westerlies.
- ✓ The summer season is almost dry.

- **Natural Vegetation:** The sclerophyll plant formation classes that make up the Mediterranean vegetation community range from Mediterranean mixed evergreen forests (on the coastal plains directly abutting the seas and oceans) through woodland, dwarf forest, and scrubs.
  - ✓ Trees and bushes make up the majority of the vegetative community.
  - ✓ The names of the shrubs vary depending on where they are found in the Mediterranean

biome, for example, maquis or garrigue in southern Europe, chaparral in California, fymbos or fymbosch in South Africa, and mallee scrub in Australia.

- ✓ In order to survive in arid conditions, Mediterranean biome plants have developed a number of physical traits.
- ✓ Some trees have thorny leaves (such as succulent cactus family).
- ✓ The plants of the Mediterranean biome have also developed special types of root systems in accordance with the regional environmental conditions mainly the availability of moisture.

- **Animal Life**
  - ✓ Mule deer, ground squirrels, and wood rats rule the mammal kingdom. The other significant animals include a variety of rodent species, such as rabbits, as well as other predators like lizards and snakes and a variety of raptorial birds, such as kites, falcons, and hawks.
  - ✓ Due to the enormous clearing of forests by European immigrants, the majority of the original native animals of the South African Mediterranean biome have since gone extinct or are extremely rare.
  - ✓ For instance, the once-significant quagga type of zebra is now completely extinct, whereas the bontebok type of antelope has been driven to isolated areas and has become a rare species.

Personal Notes

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Karol Bagh Office

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Phone No.: +91 1149 052 928, +91 9205 777 818

Mukherjee Nagar Office

704, Ground Floor, Main Road Front of Batra Cinema
Mukherjee Nagar, Delhi - 110009
Phone No.: +91 1143 017 512, +91 9205 777 817