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GNANADHARE ACADEMY

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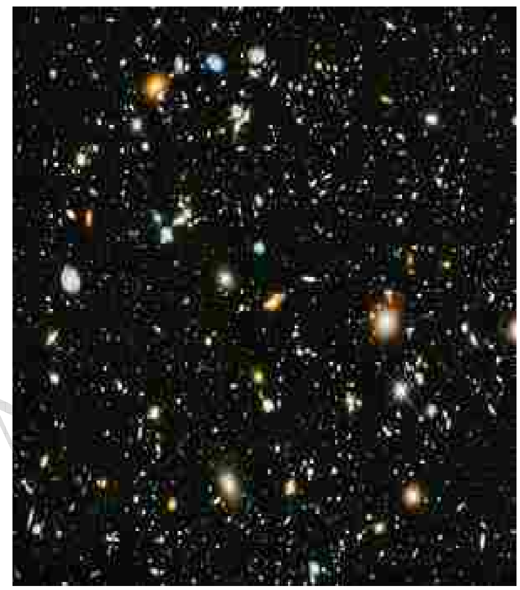
- **PHYSICAL GEOGRAPHY**
- **INDIAN AND WORLD GEOGRAPHY**

PHYSICAL GEOGRAPHY

➢ UNIVERSE



The **Universe** is all of space and time and their contents, including planets, stars, galaxies, and all other forms of matter and energy. While the spatial size of the entire Universe is still unknown, it is possible to measure the observable universe.

The earliest scientific models of the Universe were developed by ancient Greek and Indian philosophers and were **geocentric**, placing Earth at the centre of the Universe. Over the centuries, more precise astronomical observations led Nicolaus Copernicus to develop the **heliocentric model** with the Sun at the centre of the Solar System. In developing the law of universal gravitation, Sir Isaac Newton built upon Copernicus' work as well as observations by Tycho Brahe and Johannes Kepler's laws of planetary motion.

Further observational improvements led to the realization that the Sun is one of hundreds of billions of stars in the **Milky Way**, which is one of at least hundreds of billions of galaxies in the Universe. Many of the stars in our galaxy have planets. At the largest scale galaxies are distributed uniformly and the same in all directions, meaning that the Universe has neither an edge nor a center. At smaller scales, galaxies are distributed in clusters and superclusters which form immense filaments and voids in space, creating a vast foam-like structure. Discoveries in the early 20th century have suggested that the Universe had a beginning and that space has been expanding since then, and is currently still expanding at an increasing rate.

The **Big Bang theory** is the prevailing cosmological description of the development of the Universe. Under this theory, space and time emerged together 13.799±0.021 billion years ago with a fixed amount of energy and matter that has become less dense as the Universe has expanded. After an initial accelerated expansion at around 10^{-32} seconds, and the separation of the four known fundamental forces, the Universe gradually cooled and continued to expand, allowing the first subatomic particles and simple atoms to form. Dark matter gradually gathered forming a foam-like structure of filaments and voids under the influence of gravity. Giant clouds of hydrogen and helium were gradually drawn to the places where dark matter was most dense, forming the first galaxies, stars, and everything else seen today. It is possible to see objects that are now further away than 13.799 billion light-years because space itself has expanded, and it is still expanding today. This means that objects which are now up to 46 billion light years away can still be seen in their distant past, because in the past when their light was emitted, they were much closer to the Earth.

From studying the movement of galaxies, it has been discovered that the universe contains much more matter than is accounted for by visible objects; stars, galaxies, nebulas and interstellar gas. This unseen matter is known as **dark matter** (*dark* means that there is a wide range of strong indirect evidence that it exists, but we have not yet detected it directly). The **CDM model** is the most widely accepted model of our universe. It suggests that about 69.2%±1.2% [2015] of the mass and energy in the universe is a cosmological constant (or, in extensions to CDM, other forms of dark energy such as a scalar field) which is responsible for the current expansion of space, and about 25.8% [2015] is dark matter. Ordinary ("baryonic") matter is therefore only 4.9% [2015] of the physical universe. Stars, planets, and visible gas clouds only form about 6% of ordinary matter, or about 0.3% of the entire universe.

There are many competing hypotheses about the ultimate fate of the universe and about what, if anything, preceded the Big Bang, while other physicists and philosophers refuse to speculate, doubting that information about prior states will ever be accessible. Some physicists have suggested various **multiverse hypotheses**, in which the Universe might be one among many universes that likewise exist.

THE BIG BANG THEORY

The Big Bang theory is an effort to explain what happened at the very beginning of our universe. Discoveries in astronomy and physics have shown beyond a reasonable doubt that our universe did in fact have a beginning. Prior to that moment there was nothing; during and after that moment there was something: our universe. The big bang theory is an effort to explain what happened during and after that moment.

According to the **standard theory**, our universe sprang into existence as "singularity" around 13.7 billion years ago.

What is a "singularity" and where does it come from? Well, to be honest, we don't know for sure. Singularities are zones which defy our current understanding of physics. They are thought to exist at the core of "black holes." Black holes are areas of intense gravitational pressure. The pressure is thought to be so intense that finite matter is actually squished into infinite density (a mathematical concept which truly boggles the mind). These zones of infinite density are called "singularities." Our universe is thought to have begun as an infinitesimally small, infinitely hot, infinitely dense, something - a singularity. Where did it come from? We don't know. Why did it appear?We don't know.

After its initial appearance, it apparently inflated (the "Big Bang"), expanded and cooled, going from very, very small and very, very hot, to the size and temperature of our current universe. It continues to expand and cool to this day and we are inside of it: incredible creatures living on a unique planet, circling a beautiful star clustered together with several hundred billion other stars in a galaxy soaring through the cosmos, all of which is inside of an expanding universe that began as an infinitesimal singularity which appeared out of nowhere for reasons unknown. This is the Big Bang theory.

Big Bang Theory - Common Misconceptions

There are many misconceptions surrounding the Big Bang theory. For example, we tend to imagine a giant explosion. Experts however say that there was no explosion; there was (and continues to be) an expansion. Rather than imagining a balloon popping and releasing its contents, imagine a **balloon expanding**: an infinitesimally small balloon expanding to the size of our current universe.

Another misconception is that we tend to image the singularity as a **little fireball** appearing somewhere in space. According to the many experts however, space didn't exist prior to the Big Bang. Back in the late '60s and early '70s, when men first walked upon the moon, "three British astrophysicists, Steven Hawking, George Ellis, and Roger Penrose turned their attention to the Theory of Relativity and its implications regarding our notions of time. In 1968 and 1970, they published papers in which they extended Einstein's Theory of General Relativity to include measurements of time and space.[1, 2] According to their calculations, time and space had a finite beginning that corresponded to the origin of matter and energy."[3] The singularity didn't appear *in* space; rather, space began inside of the singularity. Prior to the singularity, *nothing* existed, not space, time, matter, or energy - nothing. So where and in what did the singularity appear if not in space? We don't know. We don't know where it came from, why it's here, or even where it is. All we really know is that we are inside of it and at one time it didn't exist and neither did we.

Big Bang Theory - Evidence for the Theory

What are the major evidences which support the Big Bang theory?

- First of all, we are reasonably certain that the universe had a beginning.
- Second, galaxies appear to be moving away from us at speeds proportional to their distance. This is called "**Hubble's Law**," named after Edwin Hubble (1889-1953) who discovered this phenomenon in 1929. This observation supports the expansion of the universe and suggests that the universe was once compacted.
- Third, if the universe was initially very, very hot as the Big Bang suggests, we should be able to find some remnant of this heat. In 1965, Radio astronomers Arno Penzias and Robert Wilson discovered a 2.725 degree Kelvin (-454.765 degree Fahrenheit, -270.425 degree Celsius) Cosmic Microwave Background radiation (CMB) which pervades the observable universe. This is thought to be the remnant which scientists were looking for. Penzias and Wilson shared in the 1978 Nobel Prize for Physics for their discovery.
- Finally, the abundance of the "light elements" Hydrogen and Helium found in the observable universe are thought to support the Big Bang model of origins.

Big Bang Theory - The Only Plausible Theory?

Is the standard Big Bang theory the only model consistent with these evidences? No, it's just the most popular one. Internationally renowned Astrophysicist George F. R. Ellis explains: "People need to be aware that there is a range of models that could explain the observations….For instance, I can construct you a spherically symmetrical universe with Earth at its center, and you cannot disprove it based on observations. You can only exclude it on philosophical grounds. In my view there is absolutely nothing wrong in that. What I want to bring into the open is the fact that we are using philosophical criteria in choosing our models. A lot of cosmology tries to hide that."[4]

In 2003, Physicist Robert Gentry proposed an attractive alternative to the standard theory, an alternative which also accounts for the evidences listed above.[5] Dr. Gentry claims that the standard Big Bang model is founded upon a faulty paradigm (the Friedmann-lemaitre expanding-spacetime paradigm) which he claims is inconsistent with the empirical data. He chooses instead to base his model on Einstein's static-spacetime paradigm which he claims is the "genuine cosmic Rosetta." Gentry has published several papers outlining what he considers to be serious flaws in the standard Big Bang model.[6] Other high-profile dissenters include Nobel laureate Dr. Hannes Alfvйn, Professor Geoffrey Burbidge, Dr. Halton Arp, and the renowned British astronomer Sir Fred Hoyle, who is accredited with first coining the term "the Big Bang" during a BBC radio broadcast in 1950.

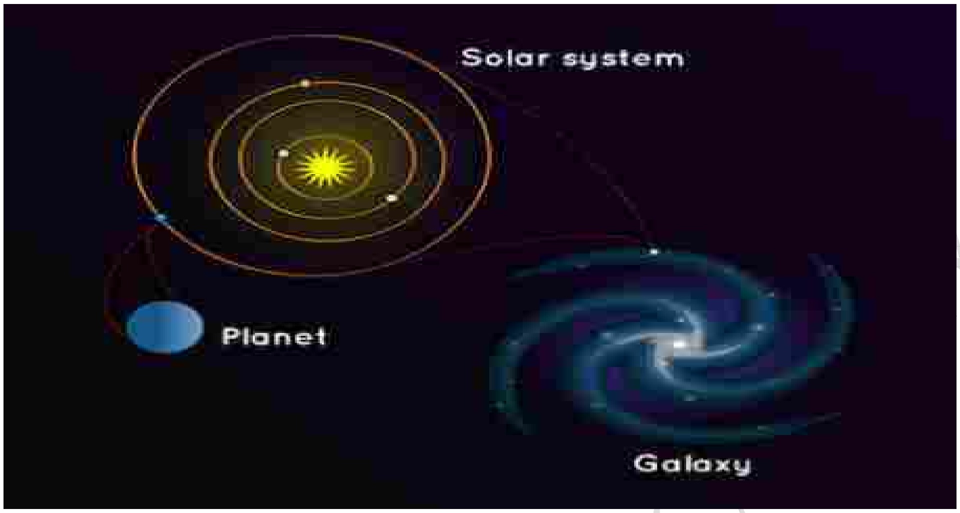
GALAXIES AND ITS TYPES

We live on a planet called Earth that is part of our solar system. But where is our solar system? It's a small part of the Milky Way Galaxy.

A **galaxy** is a huge collection of gas, dust, and billions of stars and their solar systems. A galaxy is held together by gravity. Our galaxy, the Milky Way, also has a super massive black hole in the middle.

Types of Galaxies

Galaxies are classified into three main types: **spiral galaxies, elliptical galaxies, and irregular galaxies.**



Spiral galaxies, such as the Milky Way, consist of a flat disk with a bulging center and surrounding spiral arms. The galaxy's disk includes stars, planets, dust, and gas—all of which rotate around the galactic center in a regular manner.

This spinning motion, at speeds of hundreds of kilometers per second, may cause matter in the disk to take on a distinctive spiral shape like a cosmic pinwheel. Some spiral galaxies obtain even more interesting shapes that earn them descriptive names, such as sombrero galaxies.
Older stars reside in the bulge at the center of the galactic disk. Many new stars also form in spiral systems, and their disks are surrounded by a halo, which scientists believe is rich with mysterious dark matter.

Elliptical galaxies are shaped as their name suggests. They are generally round but stretch longer along one axis than along the other. They may be nearly circular or so elongated that they take on a cigar like appearance.

Elliptical galaxies **contain many older stars**, up to one trillion, but little dust and other interstellar matter. Their stars orbit the galactic center, like those in the disks of spiral galaxies,

but they do so in more random directions. Few new stars are known to form in elliptical galaxies.
The universe's largest known galaxies are giant elliptical galaxies, which may be as much as two million light-years long. Elliptical galaxies may also be small, in which case they are dubbed dwarf elliptical galaxies.

Galaxies that are not spiral or elliptical are called **irregular galaxies**. Irregular galaxies appear misshapen and lack a distinct form, often because they are within the gravitational influence of other galaxies close by.

Galactic Mergers

Some galaxies occur alone or in pairs, but they are more often parts of larger associations known as groups, clusters, and superclusters.
Galaxies in such groups often interact and even merge together in a dynamic cosmic dance of interacting gravity. Mergers cause gases to flow towards the galactic center, which can trigger phenomena like rapid star formation.

Our own Milky Way may someday merge with the Andromeda galaxy—just two million light-years away and visible to the naked eye from Earth's Northern Hemisphere.
These intergalactic processes may be part of natural evolution by which irregular galaxies transform into one of the other shapes, and by which spiral galaxies eventually become elliptical galaxies—as scientists believe they must.

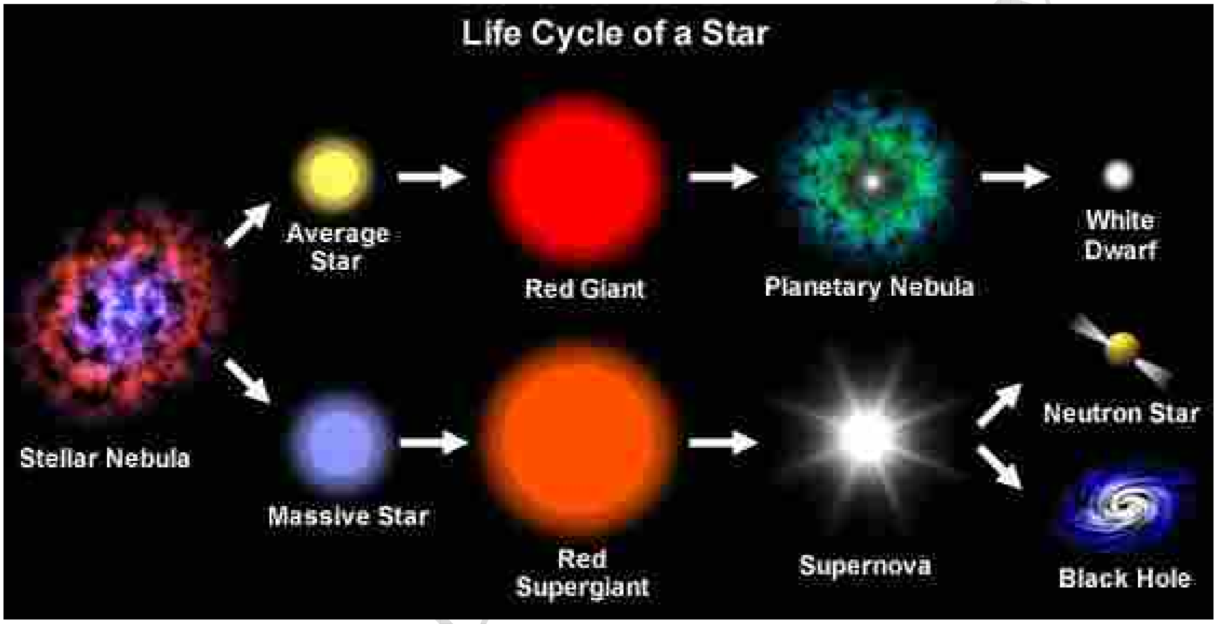
THE MILKY WAY GALAXY

The Milky Way Galaxy is our home galaxy in the universe. It is a fairly typical barred spiral with four major arms in its disk, at least one spur, and a newly discovered outer arm. The galactic centre, which is located about 26,000 light-years from Earth, contains at least one supermassive black hole (called Sagittarius A*), and is crossed by a bar. The Milky Way began forming around 12 billion years ago and is part of a group of about 50 galaxies called the Local Group. The Andromeda Galaxy is part of this group as are numerous smaller galaxies, including the Magellanic Clouds. The Local Group itself is part of a larger gathering of galaxies called the Virgo Supercluster of galaxies.

However, will last for several billion years, because they **burn their fuel much more slowly**. Eventually, however, the **hydrogen fuel** that powers the nuclear reactions within stars will begin to run out, and they will enter the final phases of their lifetime. Over time, they will expand, cool and change colour to become **red giants**. The path they follow beyond that depends on the **mass** of the star.

Small stars, like the **Sun**, will undergo a relatively peaceful and beautiful death that sees them pass through a **planetary nebula** phase to become a **white dwarf**, this eventually cools down over time leaving a **brown dwarf**.

Massive stars, on the other hand, will experience a most **energetic and violent** end, which will see their remains scattered about the cosmos in an enormous explosion, called a **supernova**. Once the dust clears, the only thing remaining will be a very dense star known as a **neutron star**, these can often be rapidly spinning and are known as **pulsars**. If the star which explodes is especially large, it can even form a **black hole**.



➢ SOLAR SYSTEM

The Solar system consists of the Sun; the eight official planets, at least three "dwarf planets", more than 130 satellites of the planets, a large number of small bodies (the comets and asteroids), and the interplanetary medium.

The eight bodies officially categorized as planets are often further classified in several ways:

Do you know?

Pluto is classified as a dwarf planet.

By Composition:

Terrestrial or Rocky planets: Mercury, Venus, Earth and Mars. The terrestrial planets are composed primarily of **rock and metal** and have relatively high densities, slow rotation, solid surfaces, no rings and few satellites.

Jovian or Gas planets: Jupiter, Saturn, Uranus and Neptune. The gas planets are composed primarily of **hydrogen and helium** and generally have low densities, rapid rotation, deep atmospheres, rings and lots of satellites.

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

(a) The terrestrial planets were formed in the close vicinity of the parent star where it was too warm for gases to condense to solid particles. Jovian planets were formed at quite a distant location.

(b) The **solar wind** was most intense nearer the sun; so, it blew off lots of gas and dust from the terrestrial planets. The solar winds were not all that intense to cause similar removal of gases from the Jovian planets.

(c) The terrestrial planets are smaller and their **lower gravity** could not hold the escaping gases.

By Size:

Small planets: Mercury, Venus, Earth and Mars. The small planets have diameters less than 13000km.

Giant planets: Jupiter, Saturn, Uranus and Neptune. The giant planets have diameters greater than 48000 km. The giant planets are sometimes also referred to as gas giants.

By Position Relative to the Sun:

Inner planets: Mercury, Venus, Earth and Mars.
Outer planets: Jupiter, Saturn, Uranus and Neptune.

The asteroid belt between Mars and Jupiter forms the boundary between the inner solar system and the outer solar system.

By position Relative to the Earth:

Inferior planets: Mercury and Venus. These are closer to the Sun than Earth. The inferior planets show phases like the Moon's when viewed from Earth.

Superior planets: Mars, Jupiter, Saturn, Uranus and Neptune. Farther from the Sun than Earth. The superior planets always appear full or nearly so.
All the planets were formed in the same period sometime **about 4.6 billion years ago**.

Theories of Evolution of the Earth/Solar system

All the theories are part of:

1) Open System: Catastrophic theories
2) Closed System: Non-Catastrophic theories

I. Open system theories visualize catastrophic events

(a) **Dynamic encounter theory / Collisional theory:** It is the theory for the historical origin of the planets as a result of a near **collision of the sun and a comet**. This theory was first proposed by Georges Leclerc, **Comte de Buffon** (1707-1788), director of the royal botanical collection in Paris. Later Buffon disassociated himself from his own views, giving up his **theory of the formation of the planets**.

(b) **Gaseous Tidal Theory:** The tidal theory was proposed by James Jeans & Harold Jeffreys in 1918. They proposed that a huge tidal wave, raised to the sun by a passing star was drawn into a long filament and became detached from the principal mass. As the gaseous material was condensed, it seperated into masses and took the formation of the planets.

(c) **Planetesimal Theory:** This is a theory of the origin of the solar system. It was proposed by **Forrest R. Moulton and Thomas C. Chamberlin** about 1900. The theory states that the planets were formed by the accumulation of extremely small bits/chunks of matter planetesimals that revolved around the sun.

(d) **Double Star Theory:** This theory was proposed by **Lyttleton** and of **Russell** states that "A passing star crushed the companion of the sun, and out of its debris planets were formed".

(e) **Supernova Theory:** This theory was proposed by Fred Hoyle. *Theoretical* studies indicate that most *supernovae* are triggered by one of two basic mechanisms: the sudden re-ignition of nuclear fusion in a degenerate star or the sudden gravitational collapse of a massive star's core.

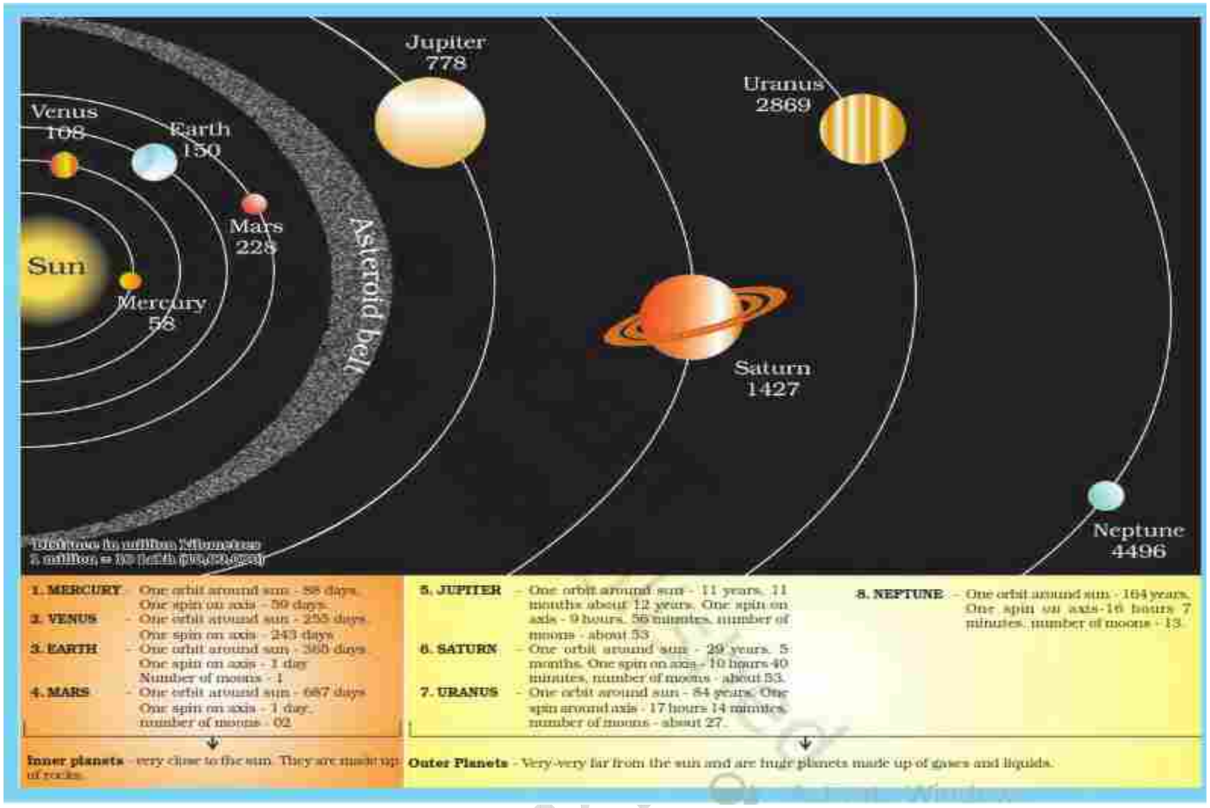
II. Closed System

(a) **Nebular Theory:** It explains three observable facts. The first is that the planets all **rotate in the same direction**. The second is that they all orbit within **6 degrees of a common plane**. The third is that all the terrestrial planets, which are those within the orbit of the Asteroid Belt, are rocky, while those outside it are gaseous. The theory also explains the existence of the **Kuiper Belt** -- a region on the fringes of the solar system with a high concentration of comets.

(b) **Dust Cloud Theory:** The Embryonic **Dust Cloud theory** attempts to explain how a planetary system is formed. It is defined as a **cloud** of Gas and **Dust**, which orbits a parent star. Within the **cloud** of Gas and **Dust**, planets form (from the **dust** itself). This is thought to occur through **gravitational forces**.

(c) **Protoplanet Theory:** The floccules / **protoplanet theory**. In **1960, McCrea** suggested a **theory** that linked planetary formation with the production of a stellar cluster and also explained the slow rotation of the Sun. **Protoplanet**, in astronomical **theory**, a hypothetical eddy in a **whirling cloud of gas or dust** that becomes a planet by **condensation** during formation of a solar system.

(d) **Meteoric Theory:** This theory was proposed by **G Kuiper.** According to this theory, Sun is already present begins to capture elements present in interstellar space. Lower specific gravities body are far away from sun and give birth to planets.



THE SUN

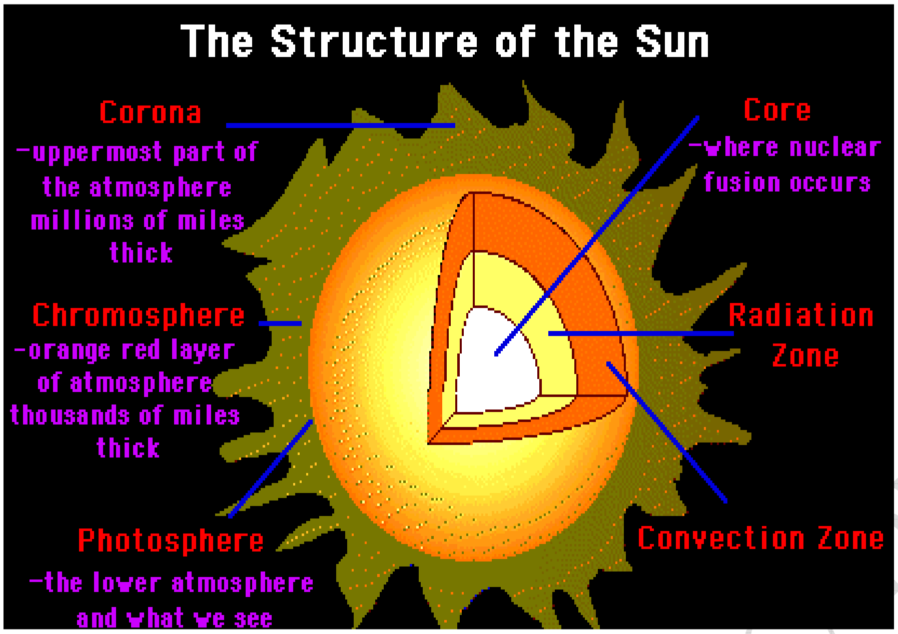
Sun is a star with a diameter of 109 times of earth and a mass of 3.30 lakh times of Earth, roughly accounting for 99.9% of total mass of the Solar system. Sun is mostly made of **Hydrogen and Helium** and is a main sequence **yellow dwarf**. It was formed some **4.6 billion years ago** and is expected to deplete its hydrogen in next 5-6 billion years to turn into a red giant at the end of its life.

Composition of sun

Hydrogen → 74.9%
Helium → 23.8%
Metals → 1.3%

Structure of Sun

The Sun has a core at its center; a radiative zone surrounding the core; a convective zone surrounding the radiative zone; a thin photosphere at its surface; and a Chromosphere and corona that extends beyond the photospheric surface.



Solar

Spots → Temporary dark spots formed when the magnetic field bursts through the surface. It can slow down the flow of energy from the inside of the Sun – that's what makes the sun spots cooler & darker than the surrounding photosphere.

- **Core**

Solar energy is produced at the core of the sun where temperatures reach 15 million °C by **nuclear fusion**. This enormous energy makes the sun shine.

- **Radiative Zone**

The Sun's radiative zone is the section of the solar interior between the innermost core and the outer convective zone. In the radiative zone, energy generated by nuclear fusion in the core moves outward as **electromagnetic radiation.**

- **Convective zone**

In this zone the density of plasma is low. This zone transports hot and light density fluids from the core region of high energy & temperature to the outer region of low energy & temperature.

- **Photosphere**

This is the **first visible layer of the Sun**. The temperature here is around 6000 degree Kelvin (5370 degree Celsius). The solar spots are formed on this layer. The temperature of a **solar spot** is around 4500 degrees.

- **Chromosphere**

Chromosphere literally mean as 'sphere of colour'. This layer is dominated by emission lines.

- **Corona**

This is the outermost layer of the Sun. High temperature in this region gives it an unusual spectral feature of a highly ionised ion. Chromosphere & corona are visible only during formation of Diamond Ring during Solar eclipse.

MERCURY

Mercury is closest planet to Sun. Due this much proximity, mercury's orbit is very much stretched into a long elliptical shape.

Important facts about mercury are as follows:

- Mercury takes **88 Earth days** to complete one **revolution** around sun, however, it takes **59 Earth days** to complete one **rotation**.
- It's surface is covered with deep craters, separated by plains and huge banks of cliffs.
- Mercury's most notable surface feature is an ancient crater called the **Caloris Basin**, which is a huge pit for such a small planet.
- Mercury's very thin atmosphere is made primarily of **sodium, potassium, helium, and hydrogen.**
- On its day side (the side facing the Sun), temperatures reach 430°C ; on its night side, the heat escapes through the negligible atmosphere, and temperatures plunge to **-170°C.**
- Mercury is so close to the Sun, the glare of the Sun makes it difficult to observe Mercury from Earth. Mercury is therefore visible only periodically, when it is just above the horizon, for at most an hour or so before sunrise and after sunset.
- It also moves more quickly across the sky than the other planets. Even when Mercury is visible, the sky is often so bright that it is hard to distinguish it from the background sky.
- THE NASA's Mercury-orbiting **probe, Messenger**, has confirmed a vast amount of ice at the North Pole on Mercury, the closest planet to the Sun. Mercury's North Pole is always in shadows. The South pole is also believed to harbor ice but there is little data to support it. Messenger which was launched in 2004 orbits much closer to the north pole than the south.

Morning Star

Morning star is a name given to the planet **Venus** whit appears in the east before sunrise (as though heralding the coming of the morning). **Less commonly**, Morning Star can refer to the **planet Mercury** when it appears in the **east before sunrise**.

Evening Star

The planet **Venus** when it appears in the west (evening sky) after sunset. Less commonly, the planet **Mercury** when it appears in the west (evening sky) after sunset.

VENUS

Venus is similar to Earth in many ways and is closer in distance to Earth than any other planet, and it has a similar **size and composition**.

Key facts about Venus are as follows:

- A Venus **year** is equal to **225 days** while a Venus **day** is equal to **243 days.** Thus, a day on Venus is longer than a year.
- Venus rotates on its **polar axis backwards** compared to Earth, so a Venus sunrise occurs in the west and sunset in the east.
- Venus is blanketed by a thick atmosphere nearly 100 times denser than Earth; it is made mostly of **carbon dioxide** along with some nitrogen and trace amounts of water vapor, acids, and heavy metals**. No terrestrial life is possible on Venus.**
- Venus's clouds are laced with **poisonous sulphur dioxide**, and its surface temperature is 500°C. Interestingly, this is **even hotter than Mercury**, which is much closer to the Sun. These hostile conditions are because of a runaway **greenhouse effect** on Venus.
- Since Venus is closer to the Sun than Earth, it is never up in the sky at midnight. Rather, Venus is visible in the sky either just after dark or just before sunrise, depending on the season, so it is called **Morning or Evening Star.**
- Further, due to highly reflective clouds on Venus, its **albedo is much higher** and it looks as third brightest object in the sky, after the Sun and the Moon.
- Through a small telescope, it is possible to see Venus undergo phases, just like the Moon. This occurs because, from our point of view on Earth, we see only the parts of Venus that are illuminated by sunlight at any given time. However, unlike the Moon, though, Venus is usually brighter to our view in its crescent phase than in its full phase.
- The **magnetic field** of Venus is far **weaker** than that of Earth because it is assumed that the core of Venus is less convective and may have already solidified.

MARS

Mars is known as the **red planet** because it looks red from Earth. The reddish color comes from the high concentration of **iron oxide compounds**—that is, rust—in the rocks of the Martian surface.

Some key facts about Mars are as follows:

- Martian year is of 687 days and Martian day is 24h 37m.
- Martian atmosphere is very thin—only about 7000th the density of Earth's atmosphere. The atmosphere is mostly carbon dioxide, with tiny fractions of oxygen, nitrogen, and other gases.

- At the equator, during the warmest times of the Martian summer, the temperature can reach nearly –18°C at the poles, during the coldest times of the Martian winter, temperatures drop to -85°C and beyond.
- Mars is known for fascinating geologic features on its surface; it is covered with all sorts of mountains, craters, channels, canyons, highlands, lowlands, and even polar ice caps. Scientific evidence strongly suggests that once, billions of years ago, Mars was much warmer than it is now, and was an active, dynamic planet.

Geological features of Mars:

- Mars has a rich variety of geological features: huge craters, broad plains, tall mountains, deep canyons, and much more, all with colorful names.
- The tallest mountain in the solar system, the extinct volcano Olympus Mons, rises 24 kilometers above the Martian surface.
- A massive canyon called the Vallis Marineris (Mariner Valley) cuts across the northern hemisphere of Mars for more than 3,200 kilometers; it is three times deeper than the Grand Canyon, here on Earth.
- On the southern hemisphere of Mars is Hellas, an ancient canyon that was probably filled with lava long ago and is now a large, light area covered with dust.

Moons of Mars – Phobos and Deimos

- Phobos and Deimos are irregularly shaped rocky objects. They look very much like asteroids. Phobos is about 10 miles and Deimos is about half that size.
- Phobos and Deimos look like small asteroids. The proximity of Mars to the asteroid main belt, suggests that they were indeed once asteroids whose orbits took them close to Mars. The orbital conditions were just right for Mars to capture them with its gravity, causing them to enter into stable orbits around Mars.

JUPITER

Jupiter is the **largest planet** in solar system, twice as massive as all the other planets, moons and asteroids in solar system put together. More than 90 percent of Jupiter's mass consists of **swirling gases**, mostly **hydrogen and helium**; in this incredibly thick, dense atmosphere, storms of incredible magnitude rage and swirl. The largest of these storms is the **Great Red Spot**, which is often visible from Earth through even a small telescope.

Other notable facts about Jupiter are as follows:

- A day on Jupiter is only 9 hours 56 minutes which makes it fastest rotating planet / body in solarsystem.
- Jupiter is 1,300 times Earth's volume and 320 times Earth's mass. Jupiter has a rocky core made of material thought to be **similar to Earth's crust and and mantle.** Around this core, in these extreme conditions, it is likely that a thick layer of compressed hydrogen is present; the hydrogen in this layer probably acts like metal, and may be the

cause of Jupiter's intense magnetic field, which is five times greater than even that of the Sun.

- As of now , there are **67 known moons of Jupiter**; many of which are only a few miles across. However, four of them —Io, Europa, Ganymede, and Callisto—are about the size of Earth's Moon or larger.

Atmosphere of Jupiter

- Jupiter's upper atmosphere is composed of about 88–92% hydrogen and 8–12% helium by percent volume or fraction of gas molecules.
- There are also traces of carbon, ethane, hydrogen sulfide, neon, oxygen and sulphur. The outermost layer of the atmosphere contains crystals of **frozen ammonia.**

The Great Red Spot at Jupiter

- The Great Red Spot on Jupiter is a huge windstorm more than 14,000 kilometers wide and 26,000 kilometers long. The storm that perpetuates the Spot is apparently powered by the upwelling of hot, energetic gases from deep inside Jupiter's atmosphere which produce winds that blow counter clockwise around the Spot at 400 kilometers per hour. Its red colour may be because of **Sulphur or Phosphorus**.
- Jupiter is the archetypal gas giant planet—so much so that gas giants are often called **Jovian planets.**

Important Moons of Jupiter

- **Io –** the most geologically **active body in solar system**. Io, the **closest** of the Galilean moons to Jupiter, is affected so strongly by the gravitational tides exerted on it by Jupiter and the other moons that it is the most geologically active body in our solar system.
- **Europa** - is the second closest to Jupiter of the four Galilean moons. Its surface is covered with frozen water ice.
- **Ganymede -** is the **largest moon** in the solar system, about one-and-a-half times as wide as Earth's Moon. It has a very thin atmosphere and its own magnetic field.
- **Calisto –** is, the furthest away from Jupiter of the four Galilean moons, is scarred and pitted by ancient craters. Its surface may be the oldest of all the solid bodies in the solar system.

SATURN

Saturn is similar to Jupiter, although about one-third the mass. A day on Saturn is only **10 hours and 39 minutes long**; it spins so fast that its diameter from pole to pole. However, its **day is longer than that of Jupiter.**

Saturn has a solid core likely made of rock and ice, which is thought to be many times the mass of Earth. Covering this core is a layer of **liquid metallic hydrogen**, and on top of that are layers of **liquid hydrogen and helium**. These layers conduct strong electric currents that, in turn, generate Saturn's powerful magnetic field.

Saturn's Moons

Saturn has 62 confirmed moons, and its largest moon is Titan, which is larger than Earth's own moon and has a thick, opaque atmosphere. Also like Jupiter, many of these are small moons that are likely to be asteroids captured in Saturn's gravitational field.

- **Mimas** - has a diameter of 396 kilometers. It is the smallest known body in the solar system that became round because of its own gravitation.
- **Enceladus -** was recently (2005) detected as having geysers of water shooting out from its surface, suggesting the presence of liquid water deep in its core.The craters of Enceladus have been named Alibaba and Alladin.
- **Titan -** is largest moon of Saturn and perhaps the most complex moon in the entire solar system. This is the only moon in solar system with a **dense atmosphere**.

NEPTUNE

Neptune is the eighth major planet in our solar system, 17 times more massive than Earth and about four times its diameter.

- The most remote of the four gas giant planets in our solar system, Neptune takes **165 Earth years** to orbit the Sun once.
- A "day" on Neptune, however, is only 16 Earth hours.
- Similar to Uranus, Neptune's cloud-top temperature is a frosty –210°C.

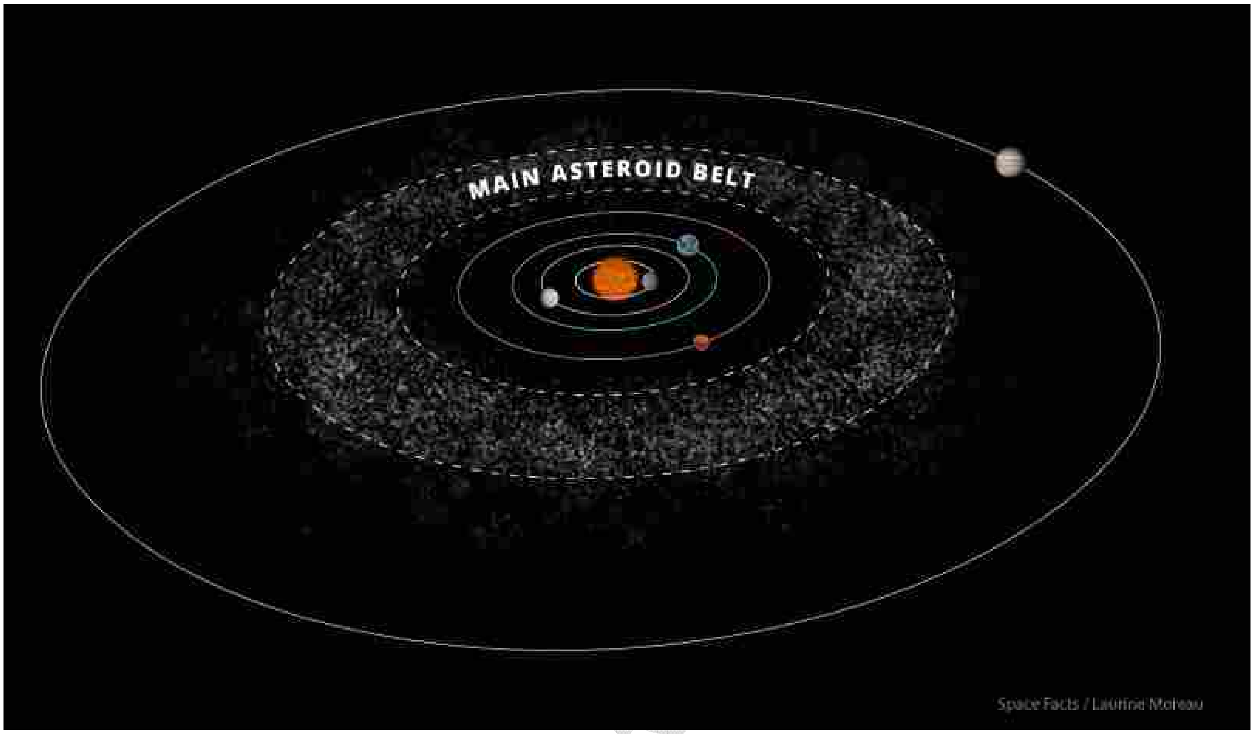
Neptune is **bluish-green** in color, which might seem fitting for a planet named after the **Roman god of the sea**. However, the color does not come from water; it is due to the gases in Neptune's atmosphere reflecting sunlight back into space. Neptune's atmosphere consists mostly of **hydrogen, helium, and methane**. Below the atmosphere, scientists think there is a thick layer of ionized water, ammonia, and methane ice, and deeper yet is a rocky core many times the mass of Earth.

The Solar System

	Mercury	*Venus*	*Earth*	*Mars*	*Jupiter*	*Saturn*	*Uranus*	*Neptune*	*Pluto*
Distance*	0.387	0.723	1.000	1.524	5.203	9.539	19.182	30.058	39.785
Density@	5.44	5.245	5.517	3.945	1.33	0.70	1.17	1.66	0.5-0.9
Radius#	0.383	0.949	1.000	0.533	11.19	9.460	4.11	3.88	-0.3
Satellites	0	0	1	2	16	about 18	about 17	8	1

* Distance from the sun in astronomical unit i.e. average mean distance of the earth is 149,598,000 km = 1
@ Density in gm/cm³
\# Radius: Equatorial radius 6378.137 km = 1

ASTEROID BELT



What is The Asteroid Belt?

The vast majority of asteroids in the solar system are found in a region of the solar system out **beyond Mars.** They form the Asteroid Belt. Others orbit in near-Earth space and a few migrate or are thrown out to the outer solar system by **gravitational interactions.** The four largest asteroids in the belt are **Ceres, Vesta, Pallas, and Hygiea. They contain half the mass of the entire belt**. The rest of the mass is contained in countless smaller bodies. There was a theory once that if you combined all the asteroids they would make up the missing “Fifth” rocky planet.

Facts about The Asteroid Belt

What other fascinating things do we know about the Asteroid Belt?

- Asteroid Belt objects are **made of rock and stone**. Some are solid objects, while others are orbiting “rubble piles”.
- The Asteroid Belt contains **billions and billions of asteroids**.
- Some asteroids in the Belt are quite large, but most range in size down to pebbles.
- The **asteroid 1/Ceres** is also designated as a **dwarf planet**, the largest one in the inner solar system.
- We know of at least 7,000 asteroids.

- The Asteroid Belt may contain many objects, but they are spread out over a huge area of space. This has allowed spacecraft to move through this region without hitting anything.
- Asteroids get their names from suggestions by their discoverers and are also given a number.
- The formation of Jupiter disrupted the formation of any worlds in the Asteroid Belt region by scattering asteroids away. This caused them to collide and break into smaller pieces.
- **Gravitational** influences can move asteroids out of the Belt.
- The Asteroid Belt is often referred to as the "**Main Belt**" to distinguish it from other groups of asteroids such as the **Lagrangians and Centaurs**.

There are 5 officially recognised dwarf planets in our solar system, they are **Ceres, Pluto, Haumea, Makemake and Eris**. With the exception of **Ceres, which is located in the asteroid belt**, the other dwarf planets are found in the outer solar system. Of the dwarf planets only 2 have been visited by space probes, in **2015 NASA's Dawn** and **New Horizons missions** reached **Ceres and Pluto respectively.**

What Is Dwarf Planet?

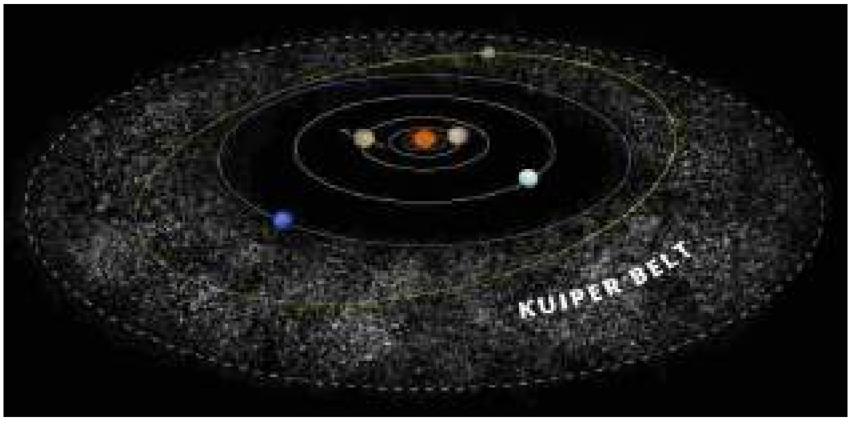
Dwarf planets share many of the **same characteristics as planets** though there is **one significant difference**. The International Astronomical Union's definition of a dwarf planet is:
A "dwarf planet" is a celestial body that

In early 1801, Ceres was the first object considered to be an asteroid

- is in orbit around the Sun
- has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape
- has not cleared the neighbourhood around its orbit, and
- is not a satellite.

The key difference is that a planet has cleared other objects in the area of its orbit while a dwarf planet has not.

Kupier Belt

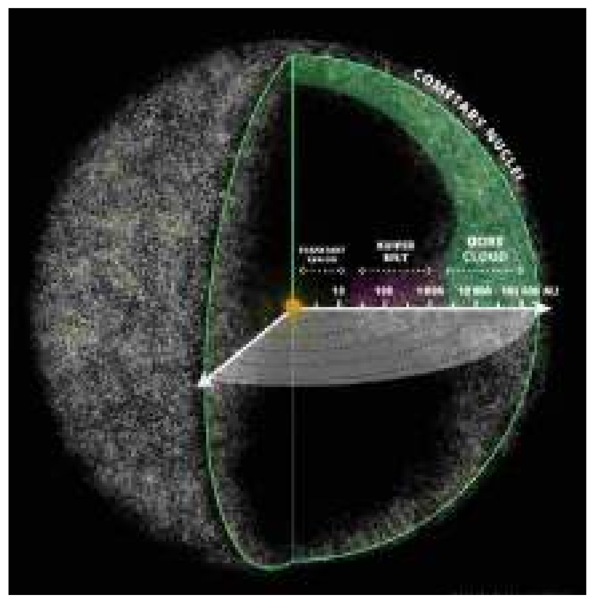


Where is the asteroid Belt located?

The Asteroid Belt is located in an area of space between the orbits of Mars and Jupiter

The Kuiper Belt (also known as the **Edgeworth–Kuiper belt**) is a region of the Solar System that exists **beyond the eight major planets**, extending from the orbit of Neptune (at 30 AU) to approximately 50 AU from the Sun. It is similar to the asteroid belt, in that it contains many small bodies, all remnants from the Solar System's formation. But unlike the Asteroid Belt, it is **much larger – 20 times as wide and 20 to 200 times as massive.**

It contains small solar system bodies made **mostly of ices.** The ices are frozen volatiles (gases) such as methane, ammonia, nitrogen and water. It also is home to the known dwarf planets **Pluto, Haumea and Makemake**. Some of the Solar System's moons, such as Neptune's **Tritton** and Saturn's **Phoebe**, are also believed to have originated in the region.



OORT CLOUD

Oort Cloud

The Oort Cloud is an extended **shell of icy objects** that exist in the **outermost reaches of the solar system**. It is named after astronomer **Jan Oort**, who first therorised its existence. The Oort Cloud is roughly **spherical**, and is thought to be the origin of most of the long-period comets that have been observed.

THE EARTH

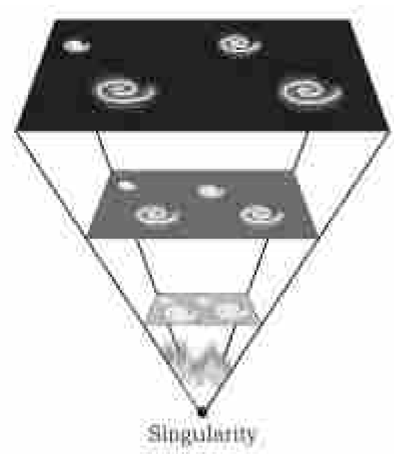
ORIGIN OF THE EARTH

Early Theories

A large number of hypotheses were put forth by different philosophers and scientists regarding the origin of the earth. 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. 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. Sir James Jeans and later Sir Harold Jeffrey supported this argument. At a later date, the arguments considered of a companion to the sun to have been coexisting. These arguments are called ***binary theories***. 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 heliumalong 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.

Modern Theories

However, scientists in later period took up the problems of origin of universe rather than that of just the earth or the planets. The most popular argument regarding the origin of the universe is the ***Big Bang Theory***. It is also called ***expanding universe hypothesis***. Edwin Hubble, in 1920, provided evidence that the universe is expanding. As time passes, galaxies move further and further apart. You can experiment and find what does the expanding universe mean. Take a balloon and mark some points on it to represent the galaxies. Now, if you start inflating the balloon, the points marked on the balloon will appear to be moving away from each other as the balloon expands. Similarly, the distance between the galaxies is also found to be increasing and thereby, the universe is considered to be expanding. However, you will find that besides the increase in the distances between the points on the balloon, the points themselves are expanding. This is not in accordance with the fact. Scientists believe that though the space between the galaxies is increasing, observations do not support the expansion of galaxies. So, the balloon example is only partially correct.



THE BIG BANG

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

- In the beginning, all matter forming the universe existed in one place in the form of a "tiny ball" (singular atom) with an unimaginably small volume, infinite temperature and infinite density.
- At the Big Bang the "tiny ball" exploded violently. This led to a huge expansion. It is now generally accepted that the event of big bang took place 13.7 billion years before the present. The expansion continues even to the present day. As it grew, some energy was converted into matter. There was particularly rapid expansion within fractions of a second after the bang. Thereafter, the expansion has slowed down. Within first three minutes from the Big Bang event, the first atom began to form.
- Within 300,000 years from the Big Bang, temperature dropped to 4,500K and gave rise to atomic matter. The universe became transparent.

The expansion of universe means increase in space between the galaxies. An alternative to this was Hoyle's concept of ***steady state***. It considered the universe to be roughly the same at any point of time. However, with greater evidence becoming available about the expanding universe, scientific community at present favours argument of expanding universe.

The Star Formation

The distribution of matter and energy was not even in the early universe. These initial density differences gave rise to differences in gravitational forces and it caused the matter to get drawn together. These formed the bases for development of galaxies. A ***galaxy*** contains a large number of stars. Galaxies spread over vast distances that are measured in thousands of ***light-year***s. The diameters of individual galaxies range from 80,000-150,000 light years. A galaxy starts to form by accumulation of hydrogen gas in the form of a very large cloud called ***nebula***. Eventually, growing nebula develops localised clumps of gas. These clumps continue to grow into even denser gaseous bodies, giving rise to formation of stars. The formation of stars is believed to have taken place some 5-6 billion years ago.

NOTE: A light year is a measure of distance and not of time. Light travels at a speed of 300,000 km/second. Considering this,the distances the light will travel in one year is taken to be one light year. This equals to **9.461×10km**. The mean distance between the sun and the earth is 149,598,000 km. In terms of light years, it is 8.311 minutes of a year.

Formation of Planets

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

(i) The stars are localised lumps of gas within a nebula. The gravitational force within the lumps leads to the formation of a core to the gas cloud and a huge rotating disc of gas and dust develops around the gas core.

(ii) In the next stage, the gas cloud starts getting condensed and the matter around the core develops into small rounded objects. These small-rounded objects by the process of cohesion develop into what is called ***planetesimals***. Larger bodies start forming by collision, and gravitational attraction causes the material to stick together. Planetesimals are a large number of smaller bodies.

(iii) In the final stage, these large number of small planetesimals accrete to form a fewer large bodies in the form of planets.

The Moon

The moon is the only natural satellite of the earth. Like the origin of the earth, there have been attempts to explain how the moon was formed. In 1838, Sir George Darwin suggested that initially, the earth and the moon formed a single rapidly rotating body. The whole mass became a **dumb-bell-shaped** body and eventually it broke. It was also suggested that the material forming the moon was separated from what we have at present the depression occupied by the Pacific Ocean. However, the present scientists do not accept either of the explanations. It is now generally believed that the formation of moon, as a satellite of the earth, is an outcome of 'giant impact' or what is described as "**the big splat**". A body of the size of one to three times that of mars collided into the earth sometime shortly after the earth was formed. It blasted a large part of the earth into space. This portion of blasted material then continued to orbit the earth and eventually formed into the present moon about 4.44 billion years ago.

Evolution of the EARTH

Do you know that the planet earth initially was a barren, rocky and hot object with a thin **atmosphere of hydrogen and helium**. This is far from the present day picture of the earth. Hence, there must have been some events– processes, which may have caused this change from rocky, barren and hot earth to a beautiful planet with ample amount of water and conducive atmosphere favouring the existence of life. In the following section, you will find out how the period, between the 4,600 million years and the present, led to the evolution of life on the surface of the planet. The earth has a layered structure. From the outermost end of the atmosphere to the centre of the earth, the material that exists is not uniform. The atmospheric matter has the least density. From the surface to deeper depths, the earth's interior has different zones and each of these contains materials with different characteristics. We shall discuss in detail the properties of each of this layer in the next chapter.

Origin of Life

The last phase in the evolution of the earth relates to the origin and evolution of life. It is undoubtedly clear that the initial or even the atmosphere of the earth was not conducive for the development of life. Modern scientists refer to the origin of life as a kind of chemical reaction, which first generated complex organic molecules and assembled them. This assemblage was such that they could duplicate themselves converting inanimate matter into living substance. The record of life that existed on this planet in different periods is found in rocks in the form of fossils. The microscopic structures closely related to the present form of blue algae have been found in geological formations that are much older than these were some 3,000 million years ago. It can be assumed that life began to evolve sometime **3,800 million years ago**. The summary of evolution of life from unicellular bacteria to the modern man is given in the Geological Time Scale.

Geological Time Scale

Eons	*Era*	*Period*	*Epoch*	*Age/ Years Before Present*	*Life/ Major Events*
	Cenozoic (From 65 million years to the present times)	Quaternary	Holocene	0 - 10,000	Modern Man
			Pleistocene	10,000 - 2 million	Homo Sapiens
		Tertiary	Pliocene	2 - 5 million	Early Human Ancestor
			Miocene	5 - 24 million	Apes; Flowering Plants and Trees
			Oligocene	24 - 37 Ma	Anthropoid Apes
			Eocene	37 - 58 Million	Rabbits and Hare
			Paleocene	57 - 65 Million	Small Mammals : Rats – Mice
	Mesozoic: 65 - 245 Million Mammals	Cretaceous		65 - 144 Million	Extinction of Dinosaurs
		Jurassic		144 - 208 Million	Age of Dinosaurs
		Triassic		208 - 245 Million	Frogs and turtles
	Palaeozoic: 245 - 570 Million	Permian		245 - 286 Million	Reptile dominate-replace amphibians
		Carboniferous		286 - 360 Million	First Reptiles; Vertebrates: Coal beds Amphibians
		Devonian		360 - 408 Million	
		Silurian		408 - 438 Million	First trace of life on land: Plants
		Ordovician		438 - 505 Million	First Fish
		Cambrian		505 - 570 Million	No terrestrial Life : Marine Invertebrate
Proterozoic	Pre-Cambrian 570 Million - 4,800 Million			570 - 2,500 Million	Soft-bodied arthropods
Archean				2,500 - 3,800 Million	Blue green Algae; Unicellular bacteria
Hadean				3,800 - 4,800 Million	Oceans and Continents form – Ocean and Atmosphere are rich in Carbon dioxide
Origin of Stars	5,000 - 13,700 Million			5,000 Million	Origin of the sun
Supernova				12,000 Million	Origin of the universe
Big Bang				13,700 Million	

INTERIOR OF THE EARTH

The configuration of the surface of the earth is largely a product of the processes operating in the interior of the earth. **Exogenic** as well as **endogenic** processes are constantly shaping the landscape. A proper understanding of the physiographic character of a region remains incomplete if the effects of endogenic processes are ignored. Human life is largely influenced by the physiography of the region. Therefore, it is necessary that one gets acquainted with the forces that influence landscape development. To understand why the earth shakes or how a tsunami wave is generated, it is necessary that we know certain details of the interior of the earth. In the previous chapter, you have noted that the earth-forming materials have been distributed in the form of layers from the **crust to the core**. It is interesting to know how scientists have gathered information about these layers and what are the characteristics of each of these layers. This is exactly what this chapter deals with.

SOURCES OF INFORMATION ABOUT THE INTERIOR

The earth's **radius is 6,370 km**. No one can reach the centre of the earth and make observations or collect samples of the material. Under such conditions, you may wonder how scientists tell us about the earth's interior and the type of materials that exist at such depths. Most of our knowledge about the interior of the earth is largely based on estimates and inferences. Yet, a part of the information is obtained through direct observations and analysis of materials.

1) Direct Sources

The most easily available solid earth material is surface rock or the rocks we get from mining areas. Gold mines in South Africa are as deep as 3 - 4 km. Going beyond this depth is not possible as it is very hot at this depth. Besides mining, scientists have taken up a number of projects to penetrate deeper depths to explore the conditions in the crustal portions. Scientists world over are working on two major projects such as "**Deep Ocean Drilling Project**" and "**Integrated Ocean Drilling Project**". **The deepest drill at Kola**, in **Arctic Ocean**, has so far reached a depth of 12 km. This and many deep drilling projects have provided large volume of information through the analysis of materials collected at different depths. **Volcanic eruption** forms another source of obtaining direct information. As and when the molten material (magma) is thrown onto the surface of the earth, during volcanic eruption it becomes available for laboratory analysis. However, it is difficult to ascertain the depth of the source of such magma.

2) Indirect Sources

Analysis of properties of matter indirectly provides information about the interior. We know through the mining activity that temperature and pressure increase with the increasing distance from the surface towards the interior in deeper depths. Moreover, it is also known that the density of the material also increases with depth. It is possible to find the rate of change of these characteristics. Knowing the total thickness of the earth, scientists have estimated the values of temperature, pressure and the density of materials at different depths.

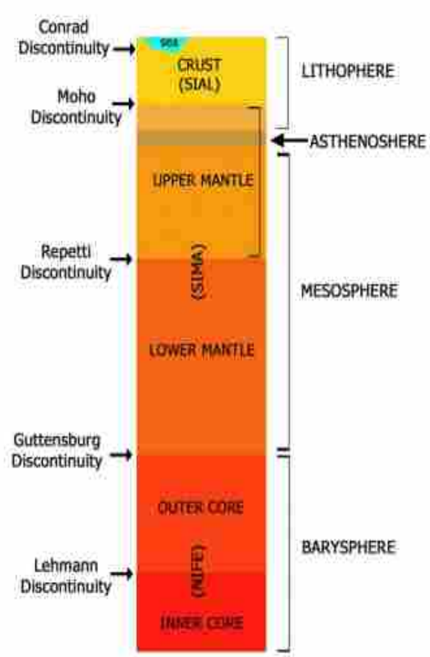
Another source of information are the meteors that at times reach the earth. However, it may be noted that the material that becomes available for analysis from **meteors**, is not from the interior of the earth. The material and the structure observed in the meteors are similar to that of the earth. They are solid bodies developed out of materials same as, or similar to, our planet. Hence, this becomes yet another source of information about the interior of the earth.

The other indirect sources include **gravitation**, **magnetic field**, and **seismic activity**. The gravitation force (**g**) is not the same at different latitudes on the surface. It is greater near the poles and less at the equator. This is because of the distance from the centre at the equator being greater than that at the poles. The gravity values also differ according to the mass of material. The uneven distribution of mass of material within the earth influences this value. The reading of the gravity at different places is influenced by many other factors. These readings differ from the expected values. Such a difference is called **gravity anomaly**. **Gravity anomalies** give us information about the distribution of mass of the material in the crust of the earth. **Magnetic surveys** also provide information about the distribution of magnetic materials in the crustal portion, and thus, provide information about the distribution of materials in this part. **Seismic activity** is one of the most important sources of information about the interior of the earth. Hence, we will discuss it in some detail.

STRUCTURE OF THE EARTH

The Crust

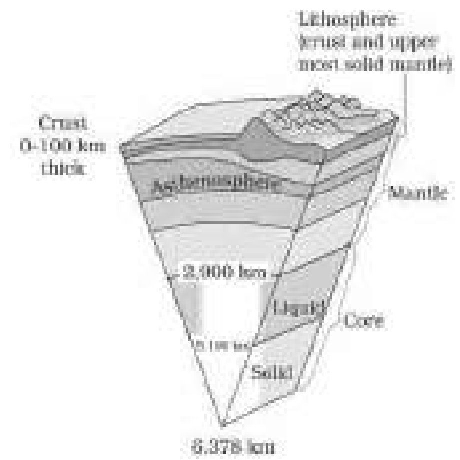
It is the outermost solid part of the earth. It is brittle in nature. The thickness of the crust varies under the **oceanic and continental areas**. Oceanic crust is thinner as compared to the continental crust. The mean thickness of oceanic crust is 5 km whereas that of the continental is around 30 km. The continental crust is thicker in the areas of major mountain systems. It is as much as 70 km thick in the Himalayan region. It is made up of heavier rocks having density of 3 g/cm. This type of rock found in the oceanic crust is basalt. The mean density of material in oceanic crust is 2.7 g/cm3. Major constituent elements of crust are **Silica (Si) and Aluminium (Al)** and thus, it is often termed as **SIAL** (Sometimes SIAL is used to refer Lithosphere, which is the region comprising the crust and uppermost solid mantle, also). The discontinuity between the hydrosphere and crust is termed as the **Conrad Discontinuity**.



STRUCTURE OF THE EARTH

The Mantle

The portion of the interior beyond the crust is called the mantle. The mantle extends from **Moho's discontinuity** to a depth of 2,900 km. The upper portion of the mantle is called **asthenosphere**. The word astheno means weak. It is considered to be extending upto 400 km. It is the main source of magma that finds its way to the surface during volcanic eruptions. It has a density higher than the crust's (3.4 g/cm). The crust and the uppermost part of the mantle are called **lithosphere**. Its thickness ranges from 10-200 km. The lower mantle extends beyond the asthenosphere. It is in solid state. The major constituent elements of the mantle are **Silicon and Magnesium** and hence it is also termed as **SIMA**. The discontinuity between the crust and mantle is called as the **Mohorovich Discontinuity or Moho discontinuity.**



INTERIOR OF THE EARTH

The Core

As indicated earlier, the earthquake wave velocities helped in understanding the existence of the core of the earth. The core mantle boundary is located at the depth of 2,900 km. The outer core is in liquid state while the inner core is in solid state. The density of material at the mantle core boundary is around 5 g/cm and at the centre of the earth at 6,300 km, the density value is around 13g/cm3. The core is made up of very heavy material mostly constituted by nickel and iron. It is sometimes referred to as the **nife** layer. The core is separated from the mantle by **Guttenberg's Discontinuity**. The discontinuity between the upper core and the lower core is called as **Lehmann Discontinuity**.

EARTHQUAKE

The study of seismic waves provides a complete picture of the layered interior. An earthquake in simple words is shaking of the earth. It is a natural event. It is caused due to release of energy, which generates waves that travel in all directions.

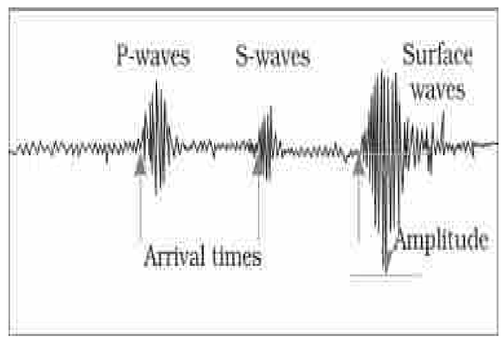
Why does the earth shake?

The release of energy occurs along a fault. A fault is a sharp break in the crustal rocks. Rocks along a fault tend to move in **opposite directions**. As the overlying rock strata press them, the friction locks them together. However, their tendency to move apart at some point of time overcomes the friction. As a result, the blocks get deformed and eventually, they slide past one another abruptly. This causes a release of energy, and the energy waves travel in all directions. The point where the energy is released is called the **focus** of an earthquake, alternatively, it is called the **hypocentre**. The energy waves travelling in different directions reach the surface. The point on the surface, nearest to the focus, is called **epicentre**. It is the first one to experience the waves. It is a point directly above the focus.

Convectional activity causes the plates to move. The edges of plates are called **plate margins**. There are three types of plate margins. At a **destructive boundary** the plates move together, but at a **constructive boundary** the plates move apart. At a **conservative boundary** the plates move side by side (As discussed in earlier chapter).

Earthquake Waves

All natural earthquakes take place in the lithosphere. You will learn about different layers of the earth later in this chapter. It is sufficient to note here that the lithosphere refers to the portion of depth up to 200 km from the surface of the earth. An instrument called '**seismograph'** records the waves reaching the surface. A curve of earthquake waves recorded on the seismograph is given in the below Figure . Note that the curve shows three distinct sections each representing different types of wave patterns. Earthquake waves are basically of two types — **body waves** and **surface waves**. Body waves are generated due to the release of energy at the focus and move in all directions travelling through the body of the earth. Hence, the name body waves. The body waves interact with the surface rocks and generate new set of waves called surface waves. These waves move along the surface. The velocity of waves changes as they travel through materials with different densities. The denser the material, the higher is the velocity. Their direction also changes as they reflect or refract when coming across materials with different densities.



Earthquake Wave

There are two types of body waves. They are called P and S-waves.

(a) P-waves move faster and are the first to arrive at the surface. These are also called **'primary waves'**. The P-waves are similar to sound waves. They travel through **gaseous, liquid and solid materials**.
(b) S-waves arrive at the surface with some time lag. These are called **'secondary waves'**. An important fact about S-waves is that they can travel only through **solid materials**. This characteristic of the S-waves is quite important. It has helped scientists to understand the structure of the interior of the earth. Reflection causes waves to rebound whereas refraction makes waves move in different directions. The variations in the direction of waves are inferred with the help of their record on seismograph. The surface waves are the last to report on seismograph. These waves are **more destructive**. They cause displacement of rocks, and hence, the collapse of structures occurs.

Propagation of Earthquake Waves

Different types of earthquake waves travel in different manners. As they move or propagate, they cause vibration in the body of the rocks through which they pass. P-waves vibrate parallel to the direction of the wave. This exerts pressure on the material in the direction of the propagation. As a result, it creates density differences in the material leading to stretching and squeezing of the material. Other three waves vibrate perpendicular to the direction of propagation. The direction of vibrations of **S-waves is perpendicular to the wave direction in**

the vertical plane. Hence, they create troughs and crests in the material through which they pass. Surface waves are considered to be the most damaging waves.

Emergence of Shadow Zone

Earthquake waves get recorded in seismographs located at far off locations. However, there exist some specific areas where the waves are not reported. Such a zone is called the **'shadow zone'.** The study of different events reveals that for each earthquake, there exists an altogether different shadow zone. Figure (a) and (b) show the **shadow zones of P and S-waves**. It was observed that seismographs located at any distance within 105 degree from the epicentre, recorded the arrival of both P and S-waves. However, the seismographs located beyond 145 degree from epicentre, record the arrival of P-waves, but not that of S-waves. Thus, a zone **between 105 degree and 145 degree** from epicentre was identified as the **shadow zone** for both the types of waves. The entire zone beyond 105 degree does not receive S-waves. **The shadow zone of S-wave is much larger than that of the P-waves**. The shadow zone of P-waves appears as a band around the earth between 105 degree and 145 degree away from the epicentre. The shadow zone of S-waves is not only larger in extent but it is also a little over 40 per cent of the earth surface. You can draw the shadow zone for any earthquake provided you know the location of the epicentre.

Types of Earthquakes

1. The most common ones are the **tectonic earthquakes**. These are generated due to sliding of rocks along a fault plane.
2. A special class of tectonic earthquake is sometimes recognised as **volcanic earthquake.** However, these are confined to areas of active volcanoes
3. In the areas of intense mining activity, sometimes the roofs of underground mines collapse causing minor tremors. These are called **collapse earthquakes**.
4. Ground shaking may also occur due to the explosion of chemical or nuclear devices. Such tremors are called **explosion earthquakes**.
5. The earthquakes that occur in the areas of large reservoirs are referred to as **reservoir induced earthquakes**.

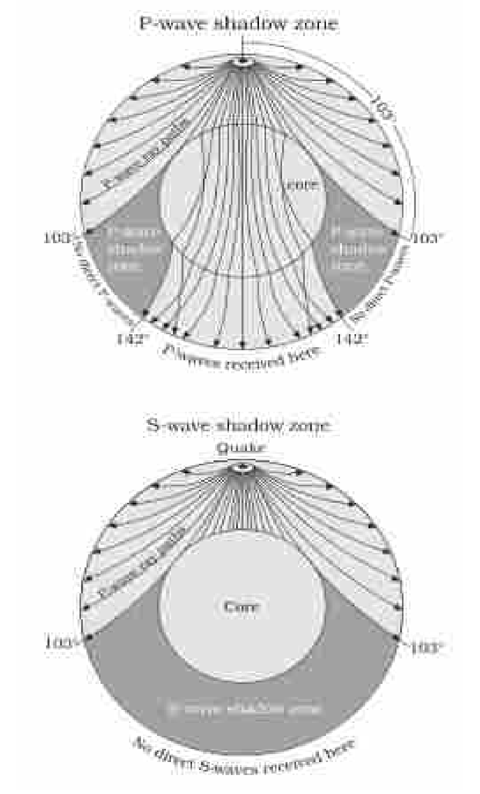


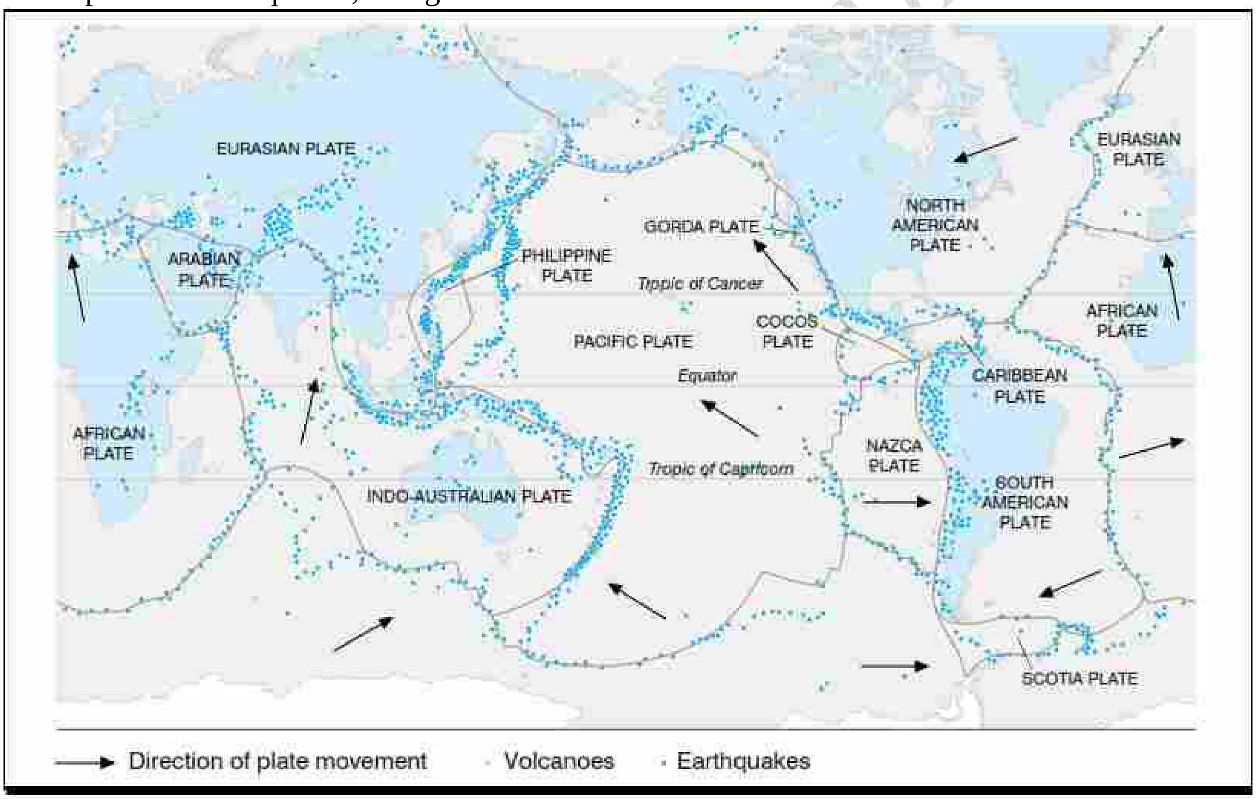
Fig (a) & (b): Shadow Zones

Measuring Earthquakes

The earthquake events are scaled either according to the magnitude or intensity of the shock. The magnitude scale is known as the **Richter scale**. The magnitude relates to the energy released during the quake. The magnitude is expressed in absolute numbers, 0-10. The intensity scale is named after **Mercalli**, an Italian seismologist. The intensity scale takes into account the visible damage caused by the event. The range of intensity scale is from 1-12.

The Distribution of Earthquakes

The world's distribution of earthquakes coincides very closely with that of volcanoes. Regions of greatest seismicity are **Circum-Pacific areas**, with along the '**Pacific Ring of Fire'**. It is said that as many as 70 percent of earthquakes occur in the Circum-Pacific belt. Another 20 percent of earthquakes take place in the **Mediterranean-Himalayan belt** including Asia Minor, the Himalayas and parts of north-west China. Elsewhere, the earth's crust is relatively stable and is less prone to earthquakes, though nowhere can be said to be immune to earth tremors.



Major lithospheric plates and distribution of earthquakes and volcanoes

Effects of Earthquakes

Earthquake is a natural hazard. The following are the immediate hazardous effects of earthquake:

(a) Ground Shaking
(b) Differential ground settlement
(c) Land and mud slides
(d) Soil liquefaction
(e) Ground lurching
(f) Avalanches
(g) Ground displacement
(h) Floods from dam and levee failures
(i) Fires
(j) Structural collapse
(k) Falling objects
(l) Tsunami

The first six listed above have some bearings upon landforms, while others may be considered the effects causing immediate concern to the life and properties of people in the region. The effect of tsunami would occur only if the epicentre of the tremor is below oceanic waters and the magnitude is sufficiently high. **Tsunamis** are waves generated by the tremors and not an earthquake in itself. Though the actual quake activity lasts for a few seconds, its effects are devastating provided the magnitude of the quake is more than 5 on the Richter scale.

VOLCANOES AND VOLCANIC LANDFORMS

A volcano is a place where gases, ashes and/or molten rock material – lava – escape to the ground. A volcano is called an active volcano if the materials mentioned are being released or have been released out in the recent past. The layer below the solid crust is mantle. It has higher density than that of the crust. The mantle contains a weaker zone called **asthenosphere**. It is from this that the molten rock materials find their way to the surface. The material in the upper mantle portion is called **magma**. Once it starts moving towards the crust or it reaches the surface, it is referred to as **lava**. The material that reaches the ground includes lava flows, pyroclastic debris, volcanic bombs, ash and dust and gases such as nitrogen compounds, sulphur compounds and minor amounts of chlorene, hydrogen and argon.

Volcanoes

Volcanoes are classified on the basis of **nature of eruption** and **the form developed at the surface**. Major types of volcanoes are as follows:

Shield Volcano

Shield Volcanoes

Barring the basalt flows, the shield volcanoes are the largest of all the volcanoes on the earth. The Hawaiian volcanoes are the most famous

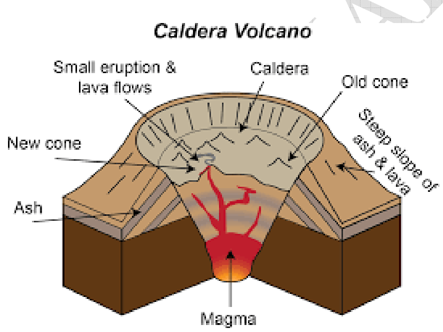
Examples: These volcanoes are mostly made up of **basalt**, a type of lava that is very fluid when erupted. For this reason, these volcanoes are not steep. They become explosive if somehow water gets into the vent; otherwise, they are characterised by **low-explosivity**. The upcoming lava moves in the form of a fountain and throws out the cone at the top of the vent and develops into cinder cone.

Composite Volcano

Composite Volcanoes

These volcanoes are characterised by eruptions of cooler and more viscous lavas than basalt. These volcanoes often result in explosive eruptions. Along with lava, large quantities of pyroclastic material and ashes find their way to the ground. This material accumulates in the vicinity of the vent openings leading to formation of layers, and this makes the mounts appear as composite volcanoes.

Caldera

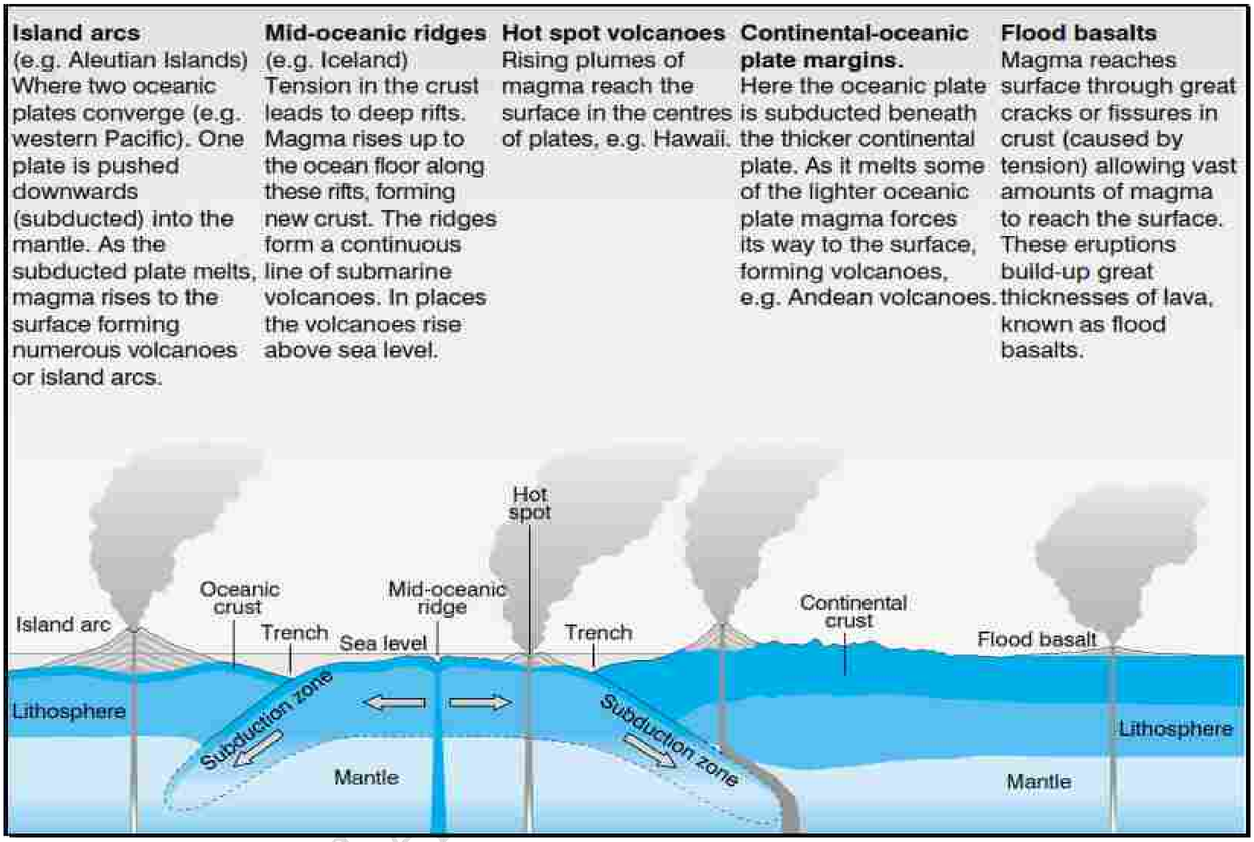


These are the **most explosive** of the earth's volcanoes. They are usually so explosive that when they erupt they tend to collapse on themselves rather than building any tall structure. The collapsed depressions are called calderas. Their explosiveness indicates that the magma chamber supplying the lava is not only huge but is also in close vicinity.

Flood Basalt Provinces

These volcanoes outpour highly fluid lava that flows for long distances. Some parts of the world are covered by thousands of sq. km of thick basalt lava flows. There can be a series of flows with some flows attaining thickness of more than 50 m. Individual flows may extend for hundreds of km. The ***Deccan Traps*** from India, presently covering most of the Maharashtra plateau, are a much larger flood basalt province. It is believed that initially the trap formations covered a much larger area than the present.

Mid-Ocean Ridge Volcanoes

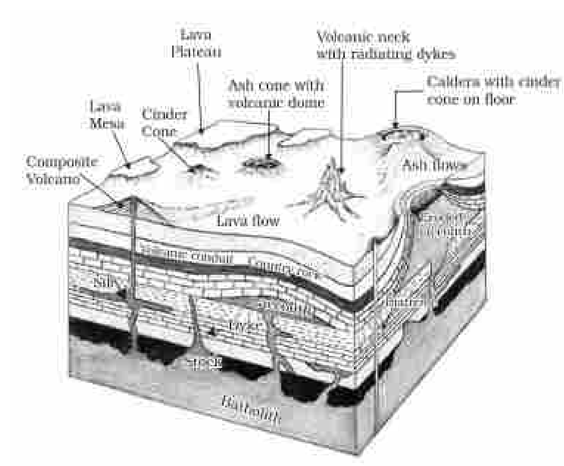


These volcanoes occur in the oceanic areas. There is a system of mid-ocean ridges more than 70,000 km long that stretches through all the ocean basins. The central portion of this ridge experiences frequent eruptions.

Volcanic landforms

Intrusive Forms

The lava that is released during volcanic eruptions on cooling develops into **igneous rocks**. The cooling may take place either on reaching the surface or also while the lava is still in the crustal portion. Depending on the location of the cooling of the lava, igneous rocks are classified as **volcanic rocks** (cooling at the surface) and **plutonic rocks** (cooling in the crust). The lava that cools within the crustal portions assumes different forms. These forms are called **intrusive forms**. Some of the forms are shown in Figure.



Batholiths

A large body of magmatic material that cools in the deeper depth of the crust develops in the form of large domes. They appear on the surface only after the denudational processes remove the overlying materials. They cover large areas, and at times, assume depth that may be several km. These are granitic bodies. Batholiths are the cooled portion of magma chambers.

Lacoliths

These are large dome-shaped intrusive bodies with a level base and connected by a pipe-like conduit from below. It resembles the surface volcanic domes of composite volcano, only these are located at deeper depths. It can be regarded as the localised source of lava that finds its way to the surface. The Karnataka plateau is spotted with domal hills of granite rocks. Most of these, now exfoliated, are examples of lacoliths or batholiths.

Lapolith, Phacolith and Sills

As and when the lava moves upwards, a portion of the same may tend to move in a horizontal direction wherever it finds a weak plane. It may get rested in different forms. In case it develops into a saucer shape, concave to the sky body, it is called **lapolith**. A wavy mass of intrusive rocks, at times, is found at the base of synclines or at the top of anticline in folded igneous country. Such wavy materials have a definite conduit to source beneath in the form of magma chambers (subsequently developed as batholiths). These are called the phacoliths. The near horizontal bodies of the intrusive igneous rocks are called **sill** or **sheet**, depending on the thickness of the material. The thinner ones are called sheets while the thick horizontal deposits are called sills.

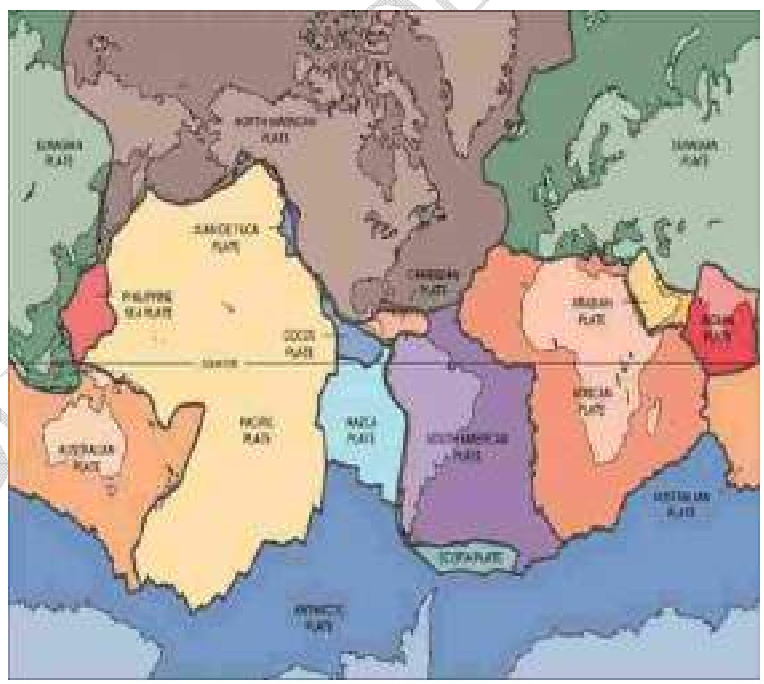
Dykes

When the lava makes its way through cracks and the fissures developed in the land, it solidifies almost perpendicular to the ground. It gets cooled in the same position to develop a wall-like structure. Such structures are called dykes. These are the most commonly found intrusive forms in the western Maharashtra area. These are considered the feeders for the eruptions that led to the development of the Deccan traps.

➢ DISTRIBUTION OF OCEANS AND CONTINENTS

CONTINENTAL DRIFT: THEORY & DEFINITION

Continental drift was a theory that explained how continents shift posit- ion on Earth's surface. Set forth in **1912** by **Alfred Wegener**, a geophysicist and meteorologist, contin-ental drift also explained why look-alike **animal and plant fossils, and similar rock formations,** are found on different continents.



The theory of continental drift

According to **Wegener**, all the continents formed a single continental mass, a mega ocean surrounded by the same. The super continent was named **PANGAEA**, which meant all earth. The mega-ocean was called **PANTHALASSA**, meaning all water. He argued that, around 200 million years ago, the super continent, Pangaea, began to split. Pangaea first broke into two large continental masses as **Laurasia** and **Gondwanaland** forming the northern and southern components respectively. Subsequently, Laurasia and Gondwanaland continued to break into various smaller continents that exist today. A variety of evidence was offered in support of the continental drift. Some of these are given below.

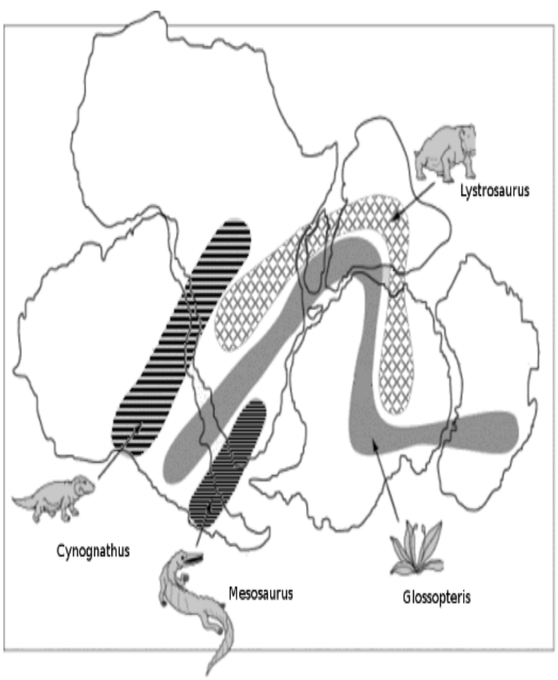
Evidence in Support of the Continental Drift

➢ The Matching of Continents (Jig-Saw-Fit)

The **shorelines of Africa and South America** facing each other have a remarkable and unmistakable match. It may be noted that a map produced using a computer programme to find the best fit of the Atlantic margin was presented by Bullard in 1964. It proved to be quite perfect. The match was tried at 1,000 fathom line instead of the present shoreline.

➢ Rocks of Same Age Across the Oceans

The radiometric dating methods developed in the recent period have facilitated correlating the rock formation from different continents across the vast ocean. The belt of ancient rocks of 2,000 million years from Brazil coast matches with those from western Africa. The earliest marine deposits along the coastline of South America and Africa are of the Jurassic age. This suggests that the ocean did not exist prior to that time.



Tillite

It is the **sedimentary rock formed out of deposits of glaciers**. The Gondawana system of sediments from India is known to have its counter parts in six different landmasses of the Southern Hemisphere. At the base the system has thick tillite indicating extensive and prolonged glaciation. Counter parts of this succession are found in **Africa, Falkland Island, Madagascar, Antarctica and Australia besides India.** Overall resemblance of the Gondawana type sediments clearly demonstrates that these landmasses had remarkably similar histories. The glacial tillite provides **unambiguous evidence of palaeoclimates** and also of drifting of continents.

Placer Deposits

The occurrence of rich placer **deposits of gold in the Ghana coast** and the absolute absence of source rock in the region is an amazing fact. The gold bearing veins are in **Brazil** and it is obvious that the gold deposits of the Ghana are derived from the Brazil plateau when the two continents lay side by side.

Distribution of Fossils (Refer above figure)

When identical **species of plants and animals** adapted to living on land or in fresh water are found on either side of the marine barriers, a problem arises regarding accounting for such distribution. The observations that Lemurs occur in **India, Madagascar and Africa** led some to consider a contiguous landmass "**Lemuria**" linking these three landmasses. **Mesosaurus** was a small reptile adapted to shallow brackish water. The skeletons of these are found only in two localities: the **Southern Cape** Province of South Africa and **Iraver** formations of Brazil. The two localities presently are 4,800 km apart with an ocean in between them.

Force for Drifting

Wegener suggested that the movement responsible for the drifting of the continents was caused by **pole-fleeing force and tidal force**. The polar-fleeing force relates to the **rotation of the earth**. You are aware of the fact that the earth is not a perfect sphere; it has a **bulge at the equator**. This bulge is due to the rotation of the earth. The second force that was suggested by Wegener—the tidal force—is due to the **attraction of the moon and the sun** that develops tides in oceanic waters. Wegener believed that these forces would become effective when applied over many million years. However, **most of scholars considered these forces to be totally inadequate.**

Post-Drift Studies

It is interesting to note that for continental drif, most of the evidence was collected from the continental areas in the form of **distribution of flora and fauna or deposits like tillite.** A number of discoveries during the post-war period added new information to geological literature. Particularly, the information collected from the ocean floor mapping provided new dimensions for the study of distribution of oceans and continents.

Convectional Current Theory

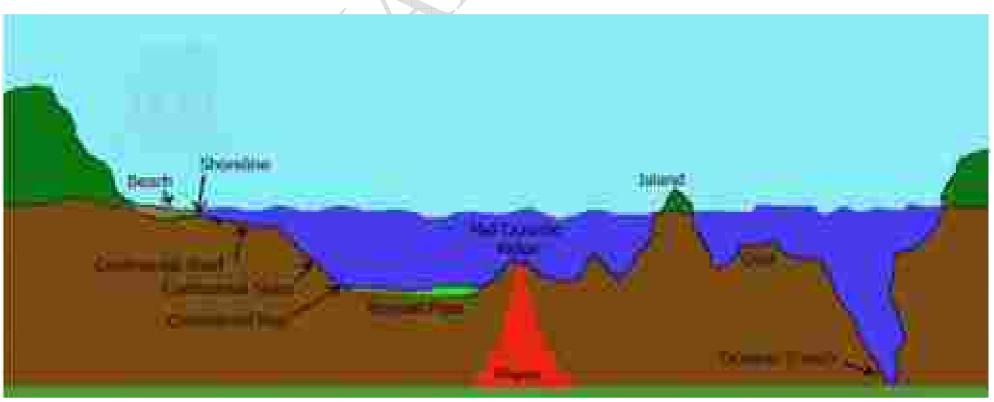
Arthur Holmes in 1930s discussed the possibility of convection currents operating in the mantle portion. These currents are generated due to radioactive elements causing thermal differences in the mantle portion. Holmes argued that there exists a system of such currents in the entire mantle portion. This was an attempt to provide an explanation to the issue of force, on the basis of which contemporary scientists **discarded the continental drift theory.**

Mapping of the Ocean Floor

Detailed research of the ocean configuration revealed that the ocean floor is not just a vast plain but it is **full of relief**. Expeditions to map the oceanic floor in the post-war period provided a detailed picture of the ocean relief and indicated the existence of submerged mountain ranges as well as deep trenches, mostly located closer to the continent margins. The mid-oceanic ridges were found to be most active in terms of volcanic eruptions. The dating of the rocks from the oceanic crust revealed the fact that the latter is much younger than the continental areas. Rocks on either side of the crest of oceanic ridges and having equidistant locations from the crest were found to have remarkable similarities both in terms of their constituents and their age.

Ocean Floor Configuration

In this section we shall note a few things related to the ocean floor configuration that help us in the understanding of the distribution of continents and oceans. The ocean floor may be segmented into three major divisions based on the **depth as well as the forms of relief**. These divisions are **continental margins, deep-sea basins and mid-ocean ridges.**



Continental Margins

These form the **transition between continental shores and deep-sea basins**. They include **continental shelf, continental slope, continental rise and deep-oceanic trenches**. Of these, the deep-sea trenches are the areas which are of considerable interest in so far as the distribution of oceans and continents is concerned.

Abyssal Plains

These are extensive plains that lie **between the continental margins and mid-oceanic ridges.** The abyssal plains are the areas where the continental sediments that move beyond the margins get deposited.

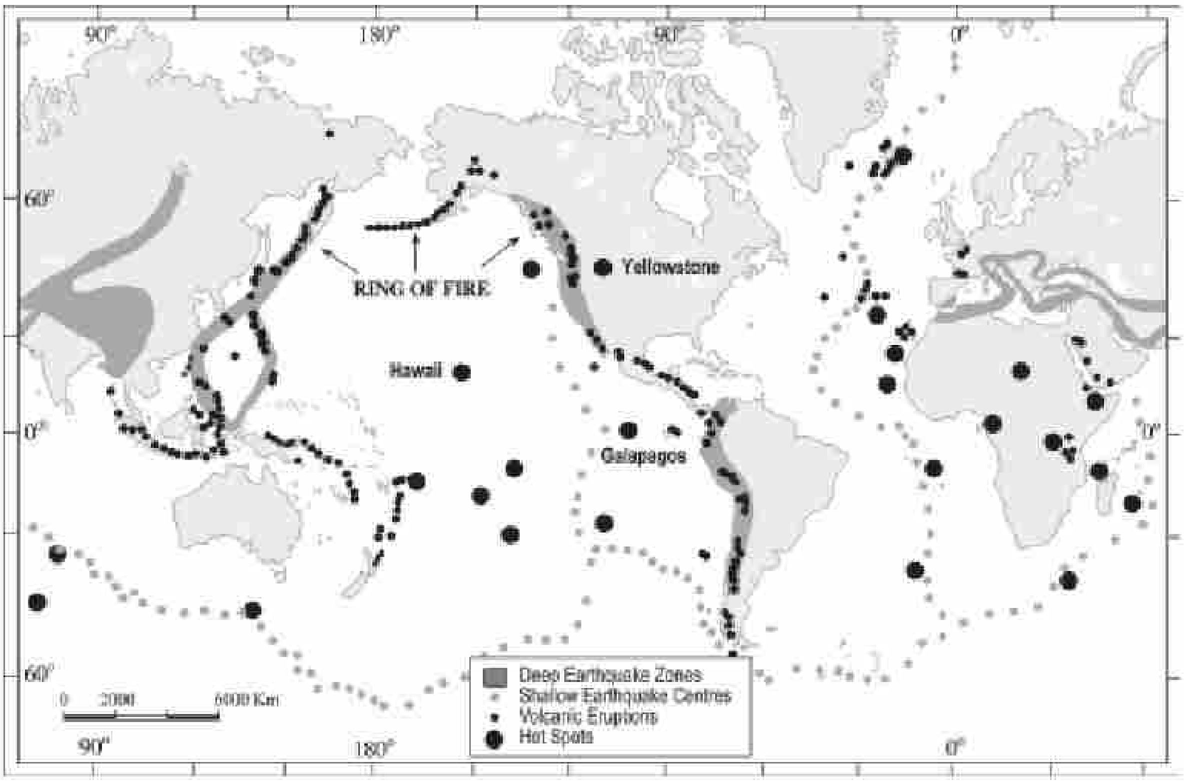
Mid-Oceanic Ridges

This forms an **interconnected chain of mountain system** within the ocean. It is the longest mountain-chain on the surface of the earth though submerged under the oceanic waters. It is characterized by a central rift system at the crest, a fractionated plateau and flank zone all along its length. The rift system at the crest is the **zone of intense volcanic activity**.

Distribution of Earthquakes and Volcanoes

Study the maps showing the distribution of seismic activity and volcanoes given in below figure. You will notice a **line of dots** in the central parts of the Atlantic Ocean almost parallel to the coastlines. It further extends into the Indian Ocean. It bifurcates a little south of the Indian subcontinent with one branch moving into East Africa and the other meeting a similar line from Myanmar to New Guiana.

You will notice that this line of dots coincides with the midoceanic ridges. The shaded belt showing another area of concentration coincides with the **Alpine-Himalayan system** and the **rim of the Pacific Ocean**. In general, the foci of the earthquake in the areas of mid-oceanic ridges are at shallow depths whereas along the Alpine-Himalayan belt as well as the rim of the Pacific, the earthquakes are deep-seated ones. The map of volcanoes also shows a similar pattern. The rim of the Pacific is also called rim of fire due to the **existence of active volcanoes in this area.**



Distribution of earthquakes and volcanoes

CONCEPT OF SEA FLOOR SPREADING

As mentioned above, the post-drift studies provided considerable information that was not available at the time Wegener put forth his concept of continental drift. Particularly, the mapping of the ocean floor and palaeomagnetic studies of rocks from oceanic regions revealed the following facts :

(a) It was realised that all along the mid-oceanic ridges, volcanic eruptions are common and they bring huge amounts of lava to the surface in this area.
(b) The rocks equidistant on either sides of the crest of mid-oceanic ridges show remarkable similarities in terms of period of formation, chemical compositions and magnetic properties. Rocks closer to the mid-oceanic ridges are normal polarity and are the youngest. The age of the rocks increases as one moves away from the crest.
(c) The ocean crust rocks are much younger than the continental rocks. The age of rocks in the oceanic crust is nowhere more than 200 million years old. Some of the continental rock formations are as old as 3,200 million years.
(d) The sediments on the ocean floor are unexpectedly very thin. Scientists were expecting, if the ocean floors were as old as the continent, to have a complete sequence of sediments for a period of much longer duration. However, nowhere was the sediment column found to be older than 200 million years.

(e) The deep trenches have deep-seated earthquake occurrences while in the midoceanic ridge areas, the quake foci have shallow depths.

These facts and a detailed analysis of magnetic properties of the rocks on either sides of the mid-oceanic ridge led Hess (1961) to propose his hypothesis, known as the **"sea floor spreading".** Hess argued that constant eruptions at the crest of oceanic ridges cause the rupture of the oceanic crust and the new lava wedges into it, pushing the oceanic crust on either side. The ocean floor, thus spreads. The younger age of the oceanic crust as well as the fact that the spreading of one ocean does not cause the shrinking of the other, made Hess think about the consumption of the oceanic crust. He further maintained that the ocean floor that gets pushed due to volcanic eruptions at the crest, sinks down at the oceanic trenches and gets consumed. The basic concept of sea floor spreading has been depicted in below figure.

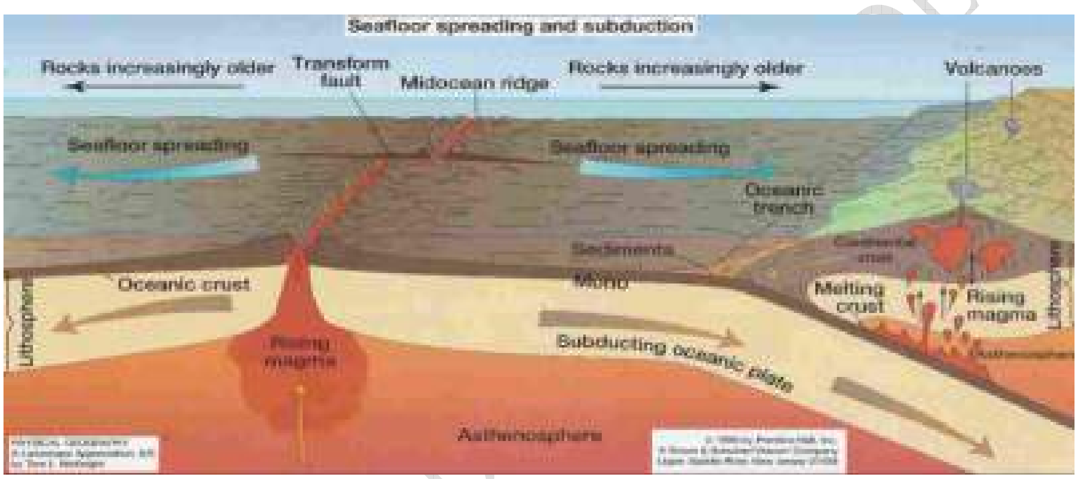


PLATE TECTONICS

Since the advent of the concept of sea floor spreading, the interest in the problem of distribution of oceans and continents was revived. It was in 1967, McKenzie and Parker and also Morgan, independently collected the available ideas and came out with another concept termed **Plate Tectonics**.

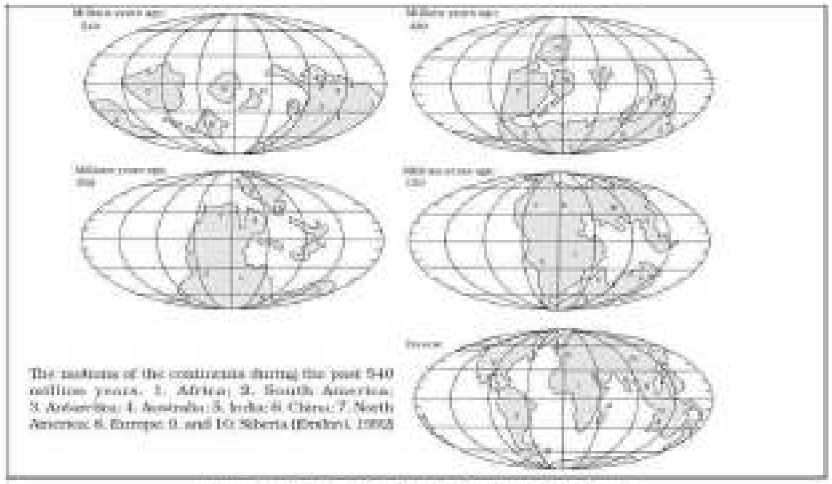
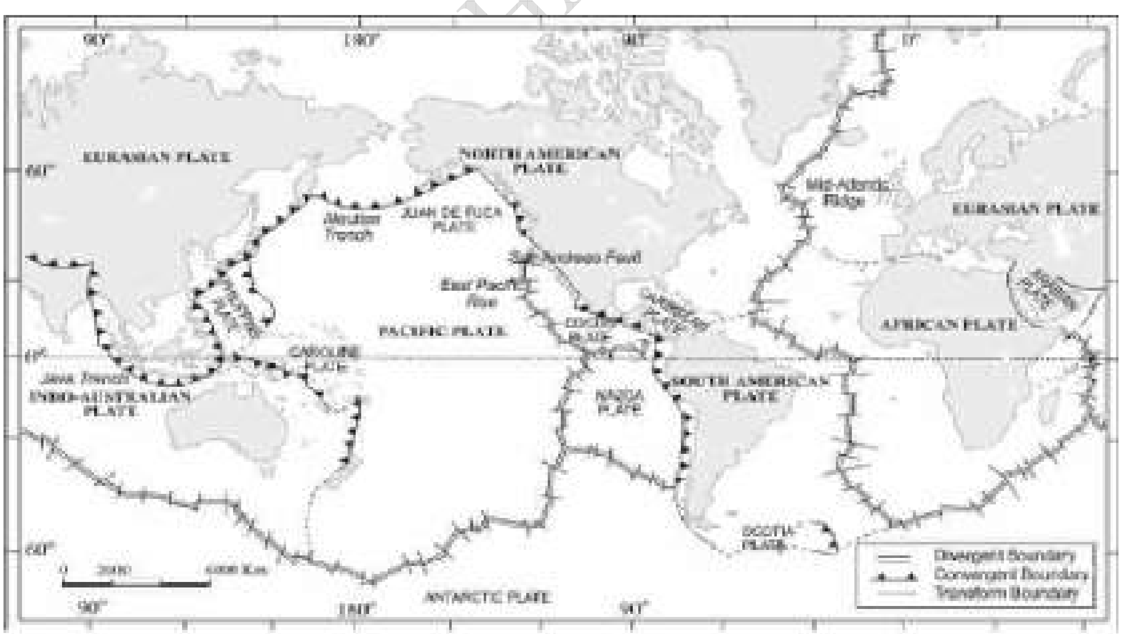


Figure 4.4 : Position of continents through geological past

A tectonic plate (also called lithospheric plate) is a massive, irregularly-shaped slab of solid rock, generally composed of both continental and oceanic lithosphere. Plates move **horizontally** over the asthenosphere as rigid units. The lithosphere includes the crust and top mantle with its thickness range varying between 5-100 km in oceanic parts and about 200 km in the continental areas. A plate may be referred to as the continental plate or oceanic plate depending on which of the two occupy a larger portion of the plate. **Pacific plate** is largely an **oceanic plate** whereas the **Eurasian plate** may be called a **continental plate**. The theory of plate tectonics proposes that the earth's lithosphere is divided into **seven major** and some minor plates. Young Fold Mountain ridges, trenches, and/or faults surround these major plates **(Below figure).**



Major and minor plates of the world

The major plates are as follows:

(a) Antarctica and the surrounding oceanic plate
(b) North American (with western Atlantic floor separated from the South American plate along the Caribbean islands) plate
(c) South American (with western Atlantic floor separated from the North American plate along the Caribbean islands) plate
(d) Pacific plate
(e) India-Australia-New Zealand plate
(f) Africa with the eastern Atlantic floor plate
(g) Eurasia and the adjacent oceanic plate.

Some important minor plates are listed below:

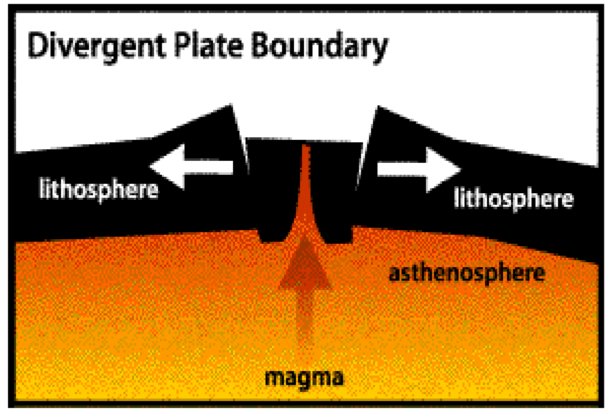
(a) **Cocos plate** : Between Central America and Pacific plate
(b) **Nazca plate** : Between South America and Pacific plate
(c) **Arabian plate** : Mostly the Saudi Arabian landmass
(d) **Philippine plate** : Between the Asiatic and Pacific plate
(e) **Caroline plate** : Between the Philippine and Indian plate (North of New Guinea)
(f) **Fuji plate** : North-east of Australia.

These plates have been constantly moving over the globe throughout the history of the earth. It is not the continent that moves as believed by Wegener. Continents are part of a plate and what moves is the plate. Moreover, it may be noted that all the plates, without exception, have moved in the geological past and shall continue to move in the future period as well. Wegener had thought of all the continents to have initially existed as a super continent in the form of Pangaea. However, later discoveries reveal that the continental masses, resting on the plates, have been wandering all through the geological period, and Pangaea was a result of converging of different continental masses that were parts of one or the other plates. Scientists using the palaeomagnetic data have determined the positions held by each of the present continental landmass in different geological periods. Position of the Indian sub-continent (mostly Peninsular India) is traced with the help of the rocks analysed from the Nagpur area.

There are three types of plate boundaries:

- **Divergent plate boundaries**: the two plates move away from each other.
- **Convergent plate boundaries**: the two plates move towards each other.
- **Transform plate boundaries**: the two plates slip past each other.

AFRICA CONTINENT



DIVERGENT PLATE BOUNDARY

The type of plate boundary and the type of crust found on each side of the boundary determines what sort of geologic activity will be found there.

Ocean-to-continent convergence

1) Divergent Plate Boundaries

Plates move apart at mid-ocean ridges where new seafloor forms. Between the two plates is a rift valley. Lava flows at the surface cool rapidly to become basalt, but deeper in the crust, magma cools more slowly to form gabbro. So the entire ridge system is made up of igneous rock that is either extrusive or intrusive. Earthquakes are common at mid-ocean ridges since the movement of magma and oceanic crust results in crustal shaking. The vast majority of mid-ocean ridges are located deep below the sea. As divergence occurs, shallow earthquakes can occur along with volcanoes along the rift areas (set of linear cracks). When the process begins, a valley will develop such as the Great Rift Valley in Africa. Over time that valley can fill up with water creating **linear lakes**. If divergence continues, a sea can form like the Red Sea and finally an ocean like the Atlantic Ocean. Check out the eastern half of Africa and notice the lakes that look linear. Eastern Africa is tearing apart from these linear lakes, to the Great Rift Valley, and up to the Red Sea. The ultimate divergent boundary is the Atlantic Ocean, which began when Pangea broke apart.

2) Convergent Plate Boundaries

When two plates converge, the result depends on the type of lithosphere the plates are made of. No matter what, smashing two enormous slabs of lithosphere together results in the creation of magma and earthquakes. **Ocean-to-continent convergence** occurs when oceanic crust converges with continental crust, forcing the denser oceanic plate to plunge beneath the

Continental-to-continental Convergence

continental plate. This process called **subduction**, occurs along oceanic trenches called **subduction zones** where lots of intense earthquakes and volcanic eruptions can occur. The denser, subducting plate begins to heat up under extreme pressure near the mantle and melts to create causes melting in the volcanoes. These coastal volcanic mountains are found in a line above the subducting plate. The volcanoes are known as a **continental arc**. The movement of crust and magma causes earthquakes. The magma will cool slowly to form granite or granodiorite. These large bodies of intrusive igneous rocks are called batholiths, which may someday be uplifted to form a mountain range. Examples are the Philippine Islands, and the Aleutian Islands of Alaska.

An **oceanic-to-oceanic plate boundary** occurs when two oceanic plates converge, causing the older, denser plate will subduct into the mantle. An ocean trench marks the location where the plate is pushed down into the mantle. The line of volcanoes that grows on the upper oceanic plate is an island arc. The Ring of Fire is a ring around the Pacific Ocean of subduction zones, which most are oceanic-to-oceanic convergence. Along these subduction zones, volcanic islands (also called volcanic arcs) form. Examples of these regions include Japan, Indonesia, and the Aleutian Islands.

When two continental plates converge, instead of subduction, the two similar tectonic plates will buckle up to create large mountain ranges like a massive car pile-up. This is called **continental-to-continental convergence**, and geologically creates intense folding and faulting rather than volcanic activity. Examples of mountain ranges created by this process are the **Himalayan mount-** ains as India is colliding with Asia, the Alps in Europe, and the Appalacian mountains in the United States as the North American plate collided with the African plate when Pangea was forming. The Kashmir India earthquake of 2005 that killed over 80,000 people occurred because of this process. And, the 2008 earthquake in China which killed nearly 85,000 people before the Summer Olympics was because of this tectonic force. The Appalachian Mountains are the remnants of a large mountain range that was

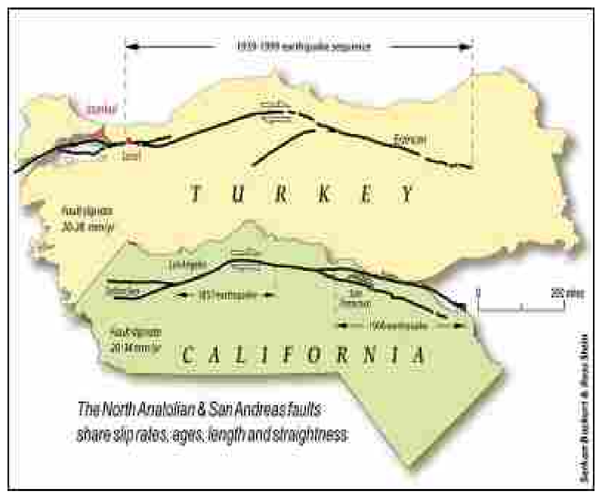
Oceanic-to-oceanic convergence

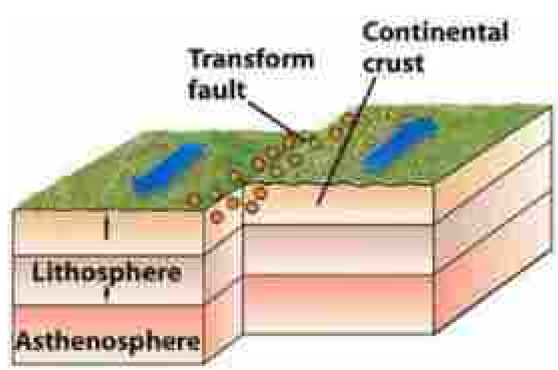
created when North America rammed into Eurasia about 250 million years ago.

Intraplate Boundaries

3) Transform plate boundaries

It occurs when two tectonic plates slide (or grind) past parallel to each other. The most famous **transform boundary** is the **San Andreas Fault** where the Pacific plate that Los Angeles and Hawaii are on is grinding past the North American plate that San Francisco and the rest of the United States is on at the rate of 3 inches a year. Recently, geologists have stated that San Francisco should expect another disastrous earthquake in the next 30 years. Another important transform boundary is the **North Anatolian Fault in Turkey**. This powerful fault last ruptured in 1999 in Izmit, Turkey which killed 17,000 people in 48 seconds.





Transform plate Boundaries

♣ Do you know this?

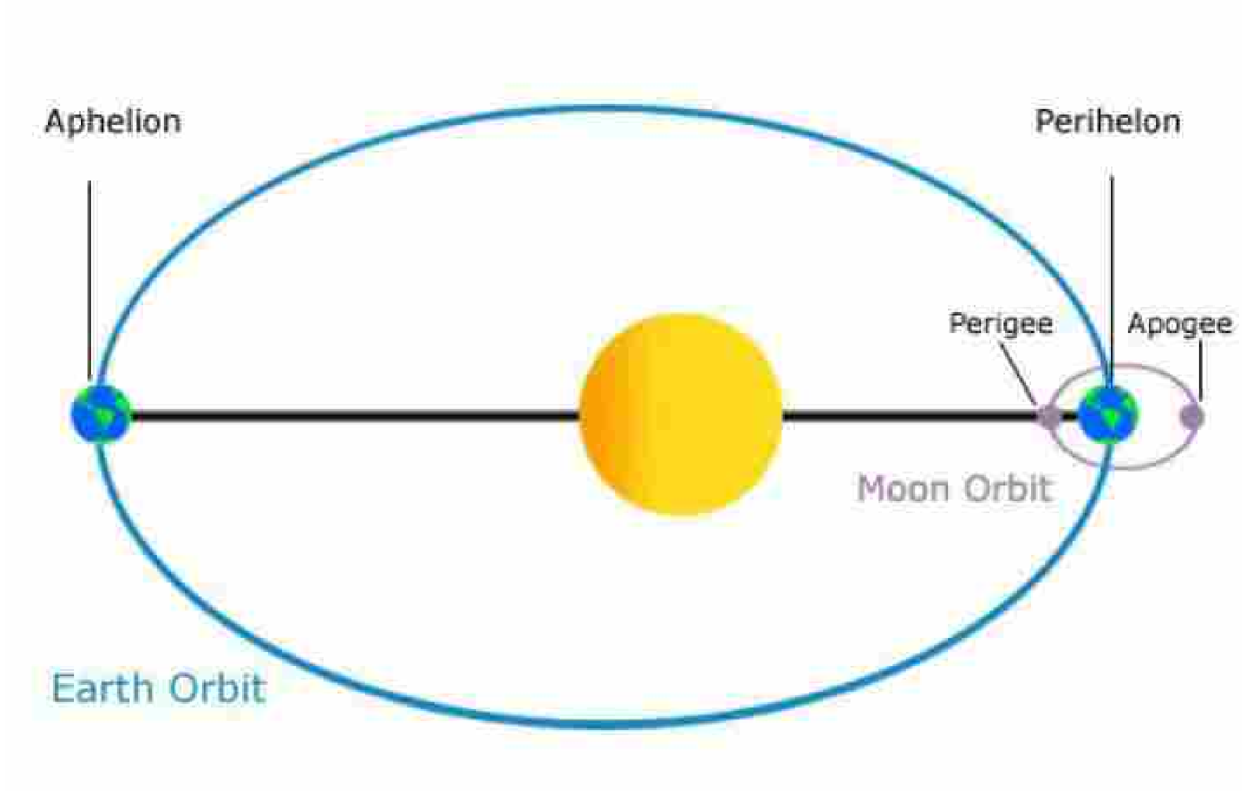
Intraplate Boundaries

A small amount of geologic activity, known as **intraplate activity**, does not take place at plate boundaries but **within a plate instead**. Mantle plumes are pipes of hot rock that rise through the mantle. The release of pressure causes melting near the surface to form a **hotspot**. Eruptions at the hotspot create a volcano. Hotspot volcanoes are found in a line.

Can you figure out why?

Hint: The youngest volcano sits above the hotspot and volcanoes become older with distance from the hotspot. Geologists use some hotspot chains to tell the direction and the speed a plate is moving. Hotspot magmas rarely penetrate through thick continental crust. One exception is the Yellowstone hotspot.

Perihelion and Aphelion



The closest point to the Sun in a planet's orbit is called **perihelion**. The furthest point is called **aphelion**. The planet moves **fastest at perihelion** and slowest at aphelion.

The planets in our Solar System orbit the Sun. The orbits of some planets are almost perfect circles, but others are not. Some orbits are shaped more like ovals, or "stretched out" circles. Scientists call these oval shapes "**ellipses**". If a planet's orbit **is** a circle, the Sun is at the center of that circle. If, instead, the orbit is an ellipse, the Sun is at a point called the "focus" of the ellipse, which is not quite the same as the center.

Since the Sun is not at the center of an elliptical orbit, the planet moves closer towards and further away from the Sun as it orbits. The place where the planet is closest to the Sun is called **perihelion**. When the planet is furthest away from the Sun, it is at **aphelion**. The words "aphelion" and "perihelion" come from the Greek language. In Greek, "helios" mean Sun, "peri" means near, and "apo" means away from.

When Earth is at perihelion, it is about 147 million km (91 million miles) from the Sun. When it is at aphelion, it is 152 million km (almost 95 million miles) from the Sun. Earth is about 5 million km (more than 3 million miles) further from the Sun at aphelion than at perihelion.

Some planets have very "stretched out" orbits. Pluto, for example, is much further from the Sun at aphelion than it is at perihelion. Astronomers say that a "stretched out" orbit has a **high eccentricity**, which means it is **long and skinny, not round like a circle**. Asteroids, many comets, and some spacecraft also travel around the Sun in elliptical orbits. They all have perihelion and aphelion points along their orbits. Anything following an elliptical orbit moves fastest at perihelion and slowest at aphelion.

If an object orbits something other than the Sun, we don't use the terms perihelion and aphelion. Satellites orbiting Earth (including the Moon!) have a close point called **perigee** and a far point called **apogee**.

NOTE THIS FACT!

Some people think that this is why we have seasons, but they are wrong. Earth reaches perihelion, its closest approach to the Sun and when you might think it should be warmest, in January - the middle of winter in the Northern Hemisphere! The difference in distance is **not** the cause of our seasons. Instead, seasons are caused by the **tilt of Earth's axis**.

➢ LOCATION OF PLACES ON THE GLOBE

It is difficult to describe the location of a point on a sphere like the earth. Now the question arises as to how to locate a place on it? We need certain points of reference and lines to find out the location of places.

You will notice that a needle is fixed through the globe in a tilted manner, which is called its **axis**. Two points on the globe through which the needle passes are two poles – **North Pole and South Pole**. The globe can be moved around this needle from west to east just as the earth moves. But, remember there is a major difference. The real earth has no such needle. It moves around its axis, which is an **imaginary line**.

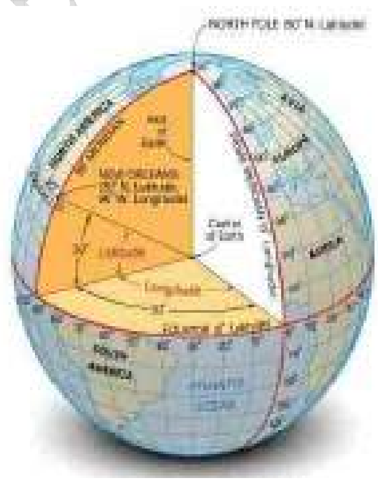
Another imaginary line running on the globe divides it into **two equal parts**. This line is known as the **equator**. The northern half of the earth is known as the **Northern Hemisphere** and the southern half is known as the **Southern Hemisphere**. They are both equal halves. Therefore, the equator is an **imaginary circular line** and is a very important reference point to locate places on the earth. All parallel circles from the equator up to the poles are called parallels of latitudes. Latitudes are measured in degrees.

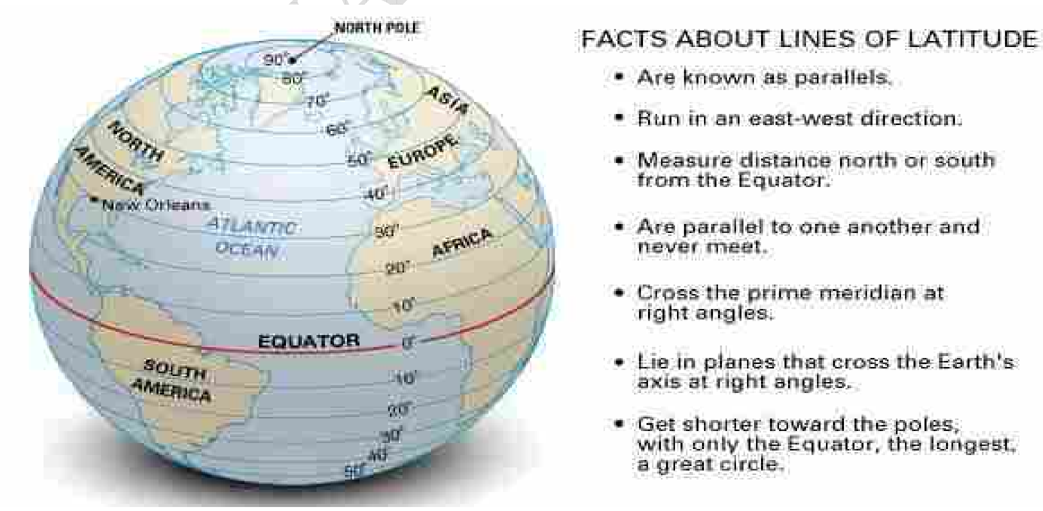
The equator represents the **zero degree latitude.** Since the distance from the equator to either of the poles is one-fourth of a circle round the earth, it will measure ¼th of 360 degrees, i.e. 90°. Thus, 90 degrees north latitude marks the North Pole and 90 degrees south latitude marks the South Pole. As such, all parallels north of the equator are called **'north latitudes'**. Similarly all parallels south of the equator are called **'south latitudes'.**

The value of each latitude is, therefore, followed by either the word north or south. Generally, this is indicated by the letter **'N' or 'S'**. For example, both Chandrapur in Maharashtra (India) and Belo Horizonte in Brazil (South America) are located on parallels of about 20° latitude. But the former is 20° north of the equator and the latter is 20° south of it. We, therefore, say that Chandrapur is situated at 20° N latitude and Belo Horizonte is situated at 20° S latitude. We see in Figure that as we move away from the equator, the size of the parallels of latitude decreases.

WHAT ARE LATITUDES?

Latitude is the angular distance of a point on the earth's surface, measured in degrees from the centre of the earth as shown in below figure. It is parallel to a line, the equator, which lies midway between the poles. These lines are therefore **called parallels of latitude**, and on a globe are actually circles, becoming smaller pole wards. The equator represents 0° and the North and South Poles are 90° N and 90°S.





Important parallels of Latitudes

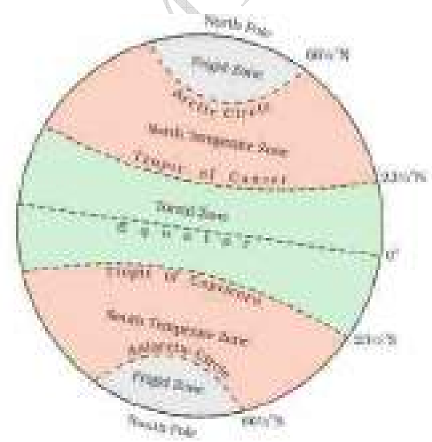
Besides the equator (0°), the North Pole (90°N) and the South Pole (90° S), there are four important parallels of latitudes–

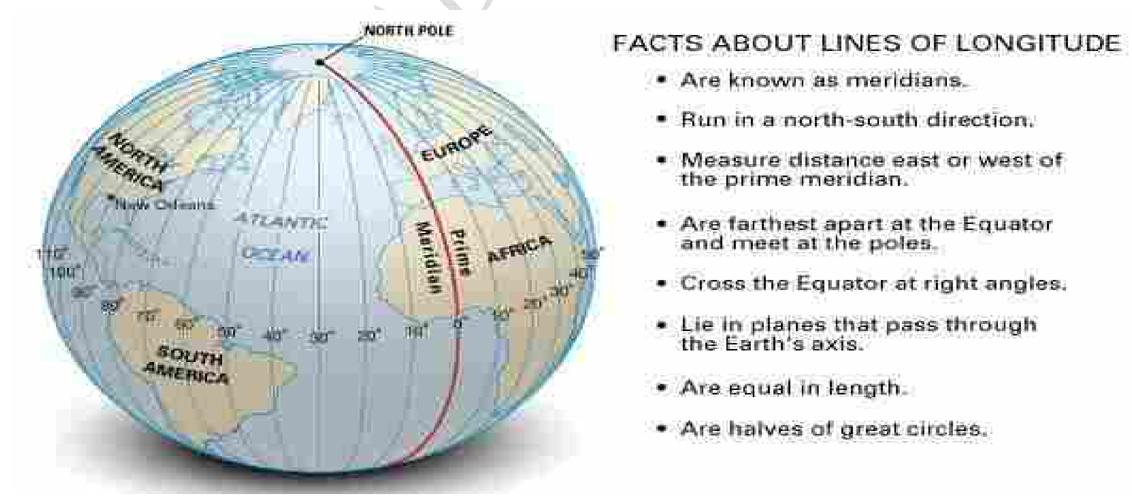
(a) Tropic of Cancer (23½° N) in the Northern Hemisphere.
(b) Tropic of Capricorn (23½° S) in the Southern Hemisphere.
(c) Arctic Circle at 66½° north of the equator.
(d) Antarctic Circle at 66½° south of the equator.

Latitude lines are also sometimes called parallels because they are parallel and equidistant from each other. Each degree of latitude is **about 69 miles (111 km) apart.**

WHAT ARE LONGITUDES?

To fix the position of a place, it is necessary to know something more than the latitude of that place. You can see, for example, that Tonga Islands (in the Pacific Ocean) and Mauritius Islands (in the Indian Ocean) are situated on the same latitude (i.e., 20° S). Now, in order to locate them precisely, we must find out how far east or west these places are from a given line of reference running from the North Pole to the South Pole. These lines of references are called the **meridians of longitude**, and the distances between them are measured in **'degrees of longitude'.** Each degree is further divided into minutes, and minutes into seconds. They are semicircles and the distance between them decreases steadily polewards until it becomes zero at the poles, where all the meridians meet.





Unlike parallels of latitude, **all meridians are of equal length**. Thus, it was difficult to number the meridians. Hence, all countries decided that the count should begin from the meridian which passed through **Greenwich**, where the **British Royal Observatory is located**. This meridian is called the **Prime Meridian**. Its value is **0° longitude** and from it we count 180° eastward as well as 180° westward. The Prime Meridian and 180° meridian divide the earth into two equal halves, the Eastern Hemisphere and the Western Hemisphere. Therefore, the longitude of a place is followed by the letter E for the east and W for the west. It is, however, interesting to note that **180° East and 180° West meridians are on the same line**.

Now look at the grid of the parallels of latitude and meridians of longitude on the globe (**Grid figure**). You can locate any point on the globe very easily if you know its latitude and longitude.

For example, **Dhubri in Assam** is situated at **26° N latitude and 90° E longitude**. Find out the point where these two lines cut each other. That point will be the location of Dhubri.

Longitude and Time

The best means of measuring time is by the movement of the earth, the moon and the planets. The sun regularly rises and sets every day, and naturally, it is the best time-keeper throughout the world. Local time can be reckoned by the shadow cast by the sun, which is the shortest at noon and longest at sunrise and sunset.

When the **Prime Meridian of Greenwich** has the sun at the highest point in the sky, all the places along this meridian will have mid-day or noon.

As the earth rotates from west to east, those places **east of Greenwich will be ahead of Greenwich time and those to the west will be behind it (Below Figure).** The rate of difference can be calculated as follows. The earth rotates 360° in about 24 hours, which **means 15° an hour or 1° in four minutes**. Thus, when it is 12 noon at Greenwich, the time at 15° east of Greenwich will be 15 × 4 = 60 minutes, i.e., 1 hour ahead of Greenwich time, which means 1 p.m. But at 15° west of Greenwich, the time will be behind Greenwich time by one hour, i.e., it will be 11.00 a.m. Similarly, at 180°, it will be midnight when it is 12 noon at Greenwich.

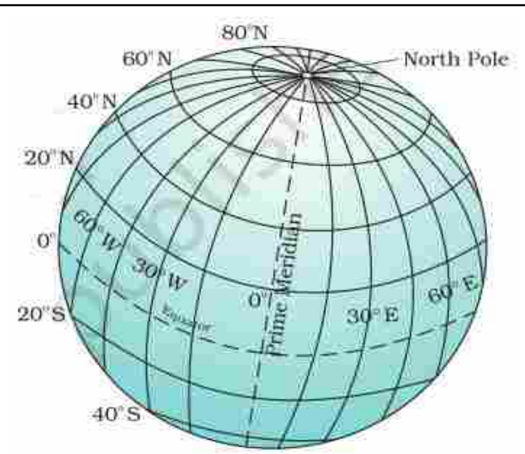
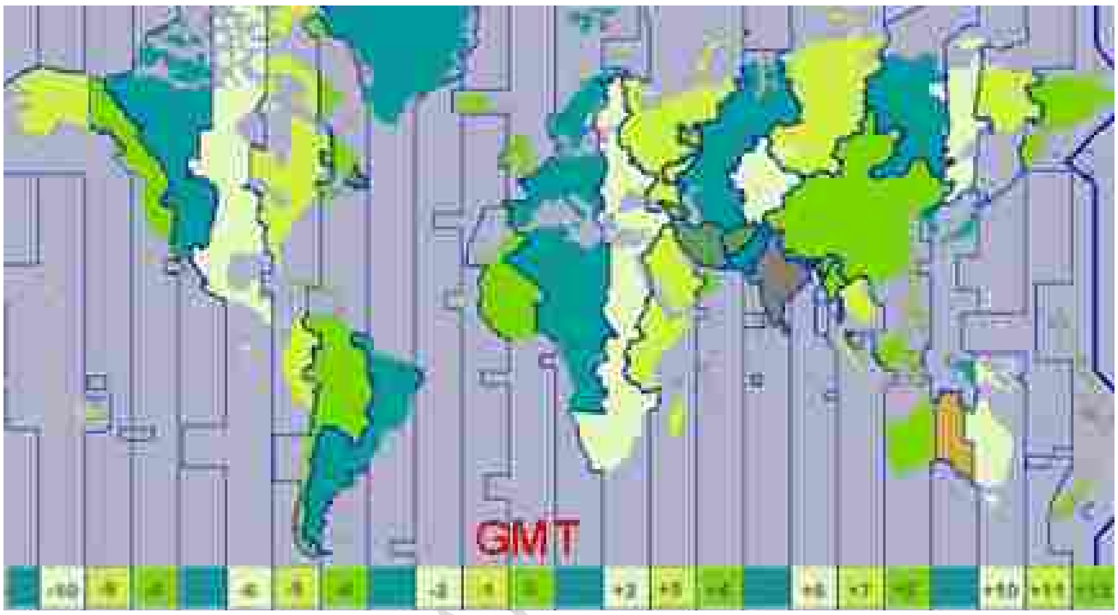


Figure : Grid

At any place a watch can be adjusted to read 12 o'clock when the sun is at the highest point in the sky, i.e., when it is mid-day. The time shown by such a watch will give the local time for that place. You can see that all the places on a given meridian of longitude have the same local time.

Longtiude & time



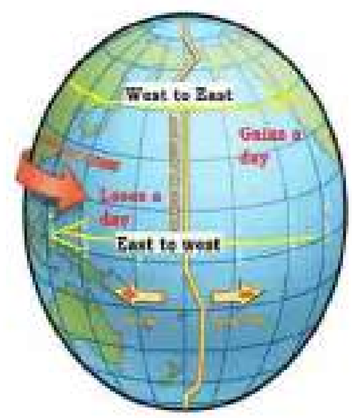
Standard Time and Time Zones

If each town were to keep the time of its own meridian, there would be much difference in local time between one town and the other. Travelers going from one end of the country to the other would have to keep changing their watches if they wanted to keep their appointments. This is impractical and very inconvenient. To avoid all these difficulties, a **system of standard time** is observed by all countries.

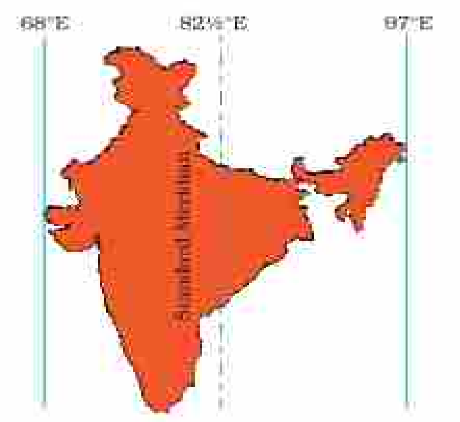
Most countries adopt their standard time from the central meridian of their countries. In larger countries such as **Canada, U.S.A., China, and Russia**, it would be inconvenient to have single time zone. So these countries have **multiple time zones**. Both **Canada and U.S.A.** have **five time zones**—the Atlantic, Eastern, Central, Mountain and Pacific Time Zones. The difference between the local time of the Atlantic and Pacific coasts is nearly five hours. USSR had eleven time zones before its disintegration. **Russia** now has **nine time zones.**

Why do we have Standard Time?

The local time of places which are on different meridians are bound to differ. For example, it will be difficult to prepare a time-table for trains which cross several longitudes. In India, for instance, there will be a difference of about **1 hour and 45 minutes in the local times of Dwarka in Gujarat and Dibrugarh in Assam**. It is, therefore, necessary to adopt the local time of some central meridian of a country as the standard time for the country. In India, the longitude of **82½° E (82° 30' E) is treated as the standard meridian**. The local time at this meridian is taken as the standard time for the whole country. It is known as the **Indian Standard Time (IST).**



International Date Line



Indian Standard Meridian

The International Date Line

A traveler going eastwards gains time from Greenwich until he reaches the meridian 180°E, when he will be 12 hours ahead of G.M.T. Similarly in going westwards, he loses 12 hours when he reaches 180°W. There is thus a total difference of 24 hours or a whole day between the two sides of the 180° meridian.

This is the International Date Line where the date changes by exactly one day when it is crossed. A traveler crossing the date line from east to west loses a day (because of the loss in time he has made); and while crossing the dateline from west to east he gains a day (because of the gain in time he encountered).

The International Date Line in the mid-Pacific curves from the normal 180° meridian at the **Bering Strait, Fiji, Tonga** and other islands to prevent confusion of day and date in some of the island groups that are cut through by the meridian. Some of them keep Asiatic or New Zealand standard time, others follow the American date and time.

Why is the international dateline drawn in a zigzag manner?

Some groups of Islands (**Polynesia, Melanesia, Micronesia**) fall on either of the dateline. So if the dateline was straight, then two regions of the same Island Country or Island group would fall under different date zones. Thus to avoid any confusion of date, this line is drawn through where the sea lies and not land. Hence, the IDL is drawn in a zig-zag manner.

MOTIONS OF THE EARTH

Rotation & Revolution

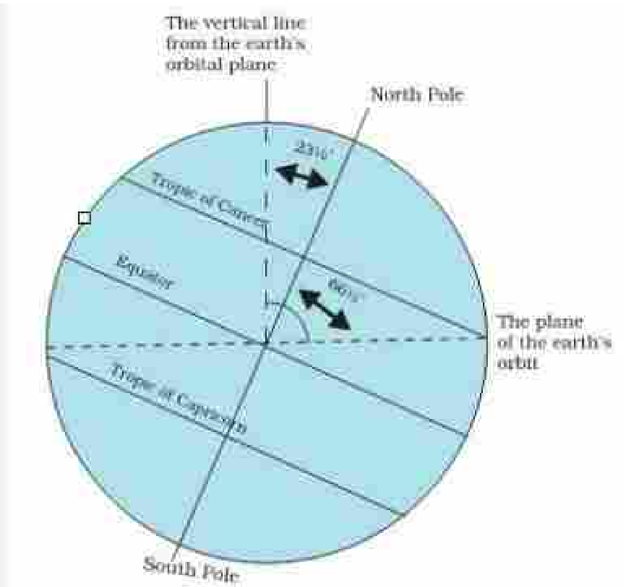


Figure 1 : Inclination of the Earth's axis and the orbital plane

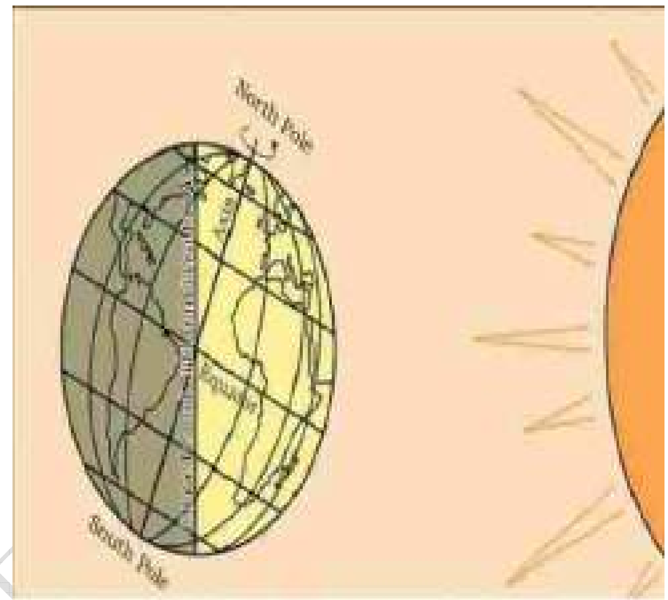


Figure 2 : Day and Night on the Earth due to rotation

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 axis of the earth which is an imaginary line, makes an angle of 66½° with its orbital plane. The plane formed by the orbit is known as the orbital plane. The earth receives light from the sun. Due to the **spherical shape of the earth**, only half of it gets light from the sun at a time (Figure 1). The portion facing the sun experiences day while the other half away from the sun experiences night. The circle that divides the day from night on the globe is called the **circle of illumination**. This circle does not coincide with the axis as you see in the (Figure 2). The earth takes about 24 hours to complete one rotation around its axis. The period of rotation is known as the **earthday**. This is the daily motion of the earth.

Revolution takes 365¼ days (one year) to revolve around the sun. We consider a year as consisting of 365 days only and ignore six hours for the sake of convenience. Six hours saved every year are added to make one day (24 hours) over a span of four years. This surplus day is added to the month of February. Thus every fourth year, February is of 29 days instead of 28 days. Such a year with 366 days is called a leap year.

From the **below figure**, it is clear that the earth is going around the sun in an **elliptical orbit**. Notice that throughout its orbit, the earth is inclined in the same direction. A year is usually divided into summer, winter, spring and autumn seasons. Seasons change due to the **change in the position of the earth around the sun.**

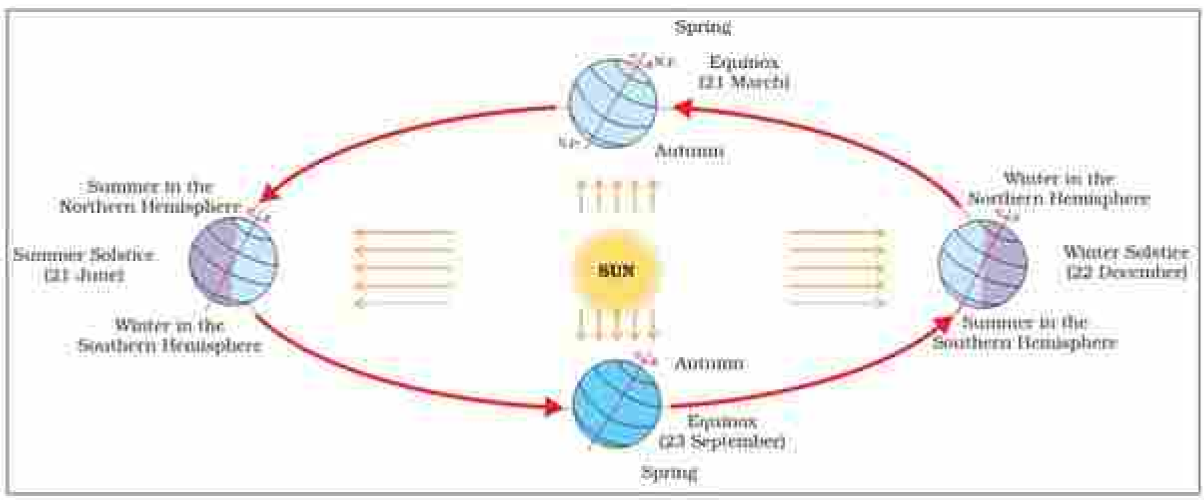


Figure : Revolution of the Earth and Seasons

Summer & Winter Solstice

Look at the **above figure**. You will see that on **21st June**, **the Northern Hemisphere is tilted towards the sun.** The rays of the sun fall directly on the **Tropic of Cancer**. As a result, these areas receive more heat. The areas near the poles receive less heat as the rays of the sun are slanting. The **North Pole** is inclined towards the sun and the places beyond the Arctic Circle experience continuous **daylight for about six months**. Since a large portion of the Northern Hemisphere is getting light from the sun, it is summer in the regions north of the equator. The longest day and the shortest night at these places occur on 21st June. At this time in the **Southern Hemisphere** all these conditions **are reversed**. It is **winter season** there. The nights are longer than the days. This position of the earth is called the **Summer Solstice.**

On **22nd December**, the **Tropic of Capricorn** receives direct rays of the sun as the **South Pole** tilts towards it. As the sun's rays fall vertically at the Tropic of
Capricorn (23½° S), a larger portion of the Southern Hemisphere gets light. Therefore, it is summer in the Southern Hemisphere with longer days and shorter nights. The reverse happens in the Northern Hemisphere. This position of the earth is called the **Winter Solstice**.

Equinox

On **21st March** and **September 23rd**, direct rays of the sun fall on the **equator**. At this position, neither of the poles is tilted towards the sun; so, the whole earth experiences equal days and equal nights. This is called an **equinox**.

On **23rd September**, it is **autumn season [season after summer and before the beginning of winter]** in the northern hemisphere and **spring season [season after winter and before the beginning of summer]** in the southern hemisphere. The opposite is the case on **21st March**, when it is spring in the northern hemisphere and autumn in the southern hemisphere.

- Thus, you find that there are **days and nights and changes in the seasons because of the rotation and revolution of the earth respectively**.
- *Rotation === Days and Nights.*
- *Revolution === Seasons.*

Why are days always longer than nights at the equator?

If there was **no atmosphere**, there would be **no refraction** and the daytime and nighttime would be near equal at the equator, at least during **equinoxes**. But due to atmosphere, the **sun's rays gets refracted (bending of light)**. Refraction is particularly stronger during the morning and the evening time when the sun's rays are slant. Even though the **actual sun is below the horizon**, its apparent image would appear above the horizon due to refraction. This makes the days longer than nights at the equator.

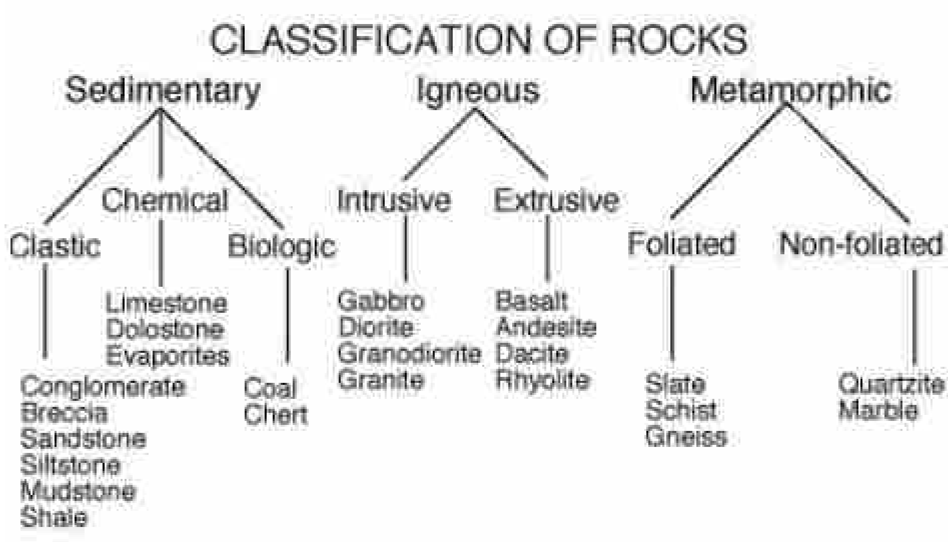
➢ ROCKS

The Earth's crust is composed of rocks. They form within the Earth and make up a large part of our planet.

What Is a Rock?

To geologists, a rock is a natural substance composed of solid crystals of different minerals that have been fused together into a solid lump.
The minerals may or may not have been formed at the same time. What matters is that natural processes glued them all together.

Classification of Rocks



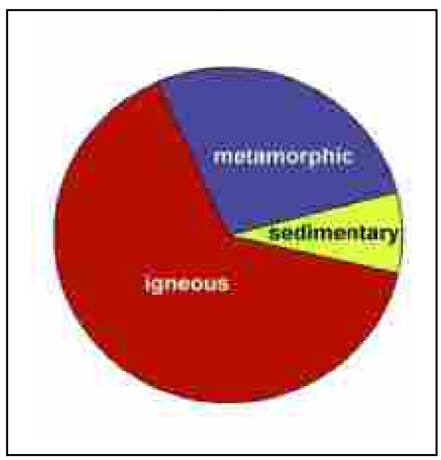
On the basis of mode of formation, rocks may be classified into three:

1. Igneous Rocks
2. Sedimentary Rocks
3. Metamorphic Rocks

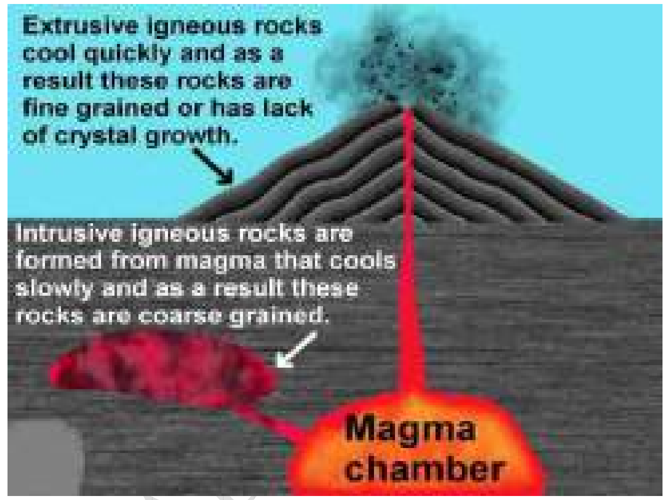
Petrology is science of rocks. A petrologist studies rocks in all their aspects viz., mineral composition, texture, structure, origin, occurrence, alteration and relationship with other rocks.

Igneous Rocks

As igneous rocks form out of magma and lava from the interior of the earth, they are known as **primary rocks**. The igneous rocks (Ignis – in Latin means 'Fire') are formed when magma cools and solidifies. When magma in its upward movement cools and turns into solid form it is called **igneous rock**. The process of cooling and solidification can happen in the earth's crust or on the surface of the earth.



Igneous rocks are classified based on **texture**. Texture depends upon size and arrangement of grains or other physical conditions of the materials. If molten material is cooled slowly at great depths, mineral grains may be very large. Sudden cooling (at the surface) results in small and smooth grains. Intermediate conditions of cooling would result in intermediate sizes of grains making up igneous rocks. Granite, gabbro, pegmatite, basalt, volcanic breccia and tuff are some of the examples of igneous rocks.



On the basis of their mode of occurrence, igneous rocks can be classified as **Intrusive and Extrusive Igneous Rocks**.

1. INTRUSIVE IGNEOUS ROCKS

- They are formed when magma solidifies **below the earth's surface**.
- The rate of cooling below the earth's surface is very slow which gives rise to the formation of large crystals in the rocks.
- That is, the mineral grains of intrusive igneous rocks are very large.
- Deep-seated intrusive igneous rocks are called as **Plutonic rocks** and shallow depth intrusive igneous rocks are called as **Hypabyssal Rocks**.
  Eg: Granite, dolerite, etc.

2. EXTRUSIVE IGNEOUS ROCKS

- They are formed by the cooling of the lava **on the earth's surface**.
- As lava cools very rapidly on the surface, the mineral crystals forming extrusive igneous rocks are very fine.
- These rocks are also called as **Volcanic Rocks**.
  Eg: Gabbro, Basalt, etc.

On the basis of chemical properties, igneous rocks can be classified as Acid and Basic Igneous rocks.

They are formed as a result of solidification of acidic (high viscous) or basic lava (low viscous).

(a) **Acidic igneous rocks** are composed of 65% or more of silica. They are coloured, hard and very strong (Eg: Granite).

(b) **Basic igneous rocks** contain less than 55% of silica and have more iron and magnesium. They are dark in colour, weak enough for weathering (Eg: Basalt, Gabbro).

Sedimentary Rocks

The word 'sedimentary' is derived from the Latin word **sedimentum**, which means settling. Rocks (igneous, sedimentary and metamorphic) of the earth's surface are exposed to **denudational agents**, and are broken up into various sizes of fragments. Such fragments are transported by different exogenous agencies and deposited. These deposits through compaction turn into rocks. This process is called **lithification**. In many sedimentary rocks, the layers of deposits retain their characteristics even after lithification. Hence, we see a number of layers of varying thickness in sedimentary rocks like sandstone, shale etc.

Depending upon the **mode of formation**, sedimentary rocks are classified into three major groups:

1. Mechanically formed/ Clastic Sedimentary Rocks

They are formed by the consolidation of sediments under excessive pressure and cementation.
Eg: Conglomerate, Breccia, Sandstone, Shale, etc.

2. Organically/ Biologically formed Sedimentary Rocks

The consolidation of organic matters derived from plants and animals form this type of rocks.
Eg: Coal, limestone, chalk, chert, etc.

3. Chemically formed Sedimentary Rocks

They are formed by various chemical reactions.
Eg: Gypsum, rock salt, limestone, etc.

Metamorphic Rocks

The word metamorphic means 'change of form'. These rocks form under the action of **pressure, volume and temperature (PVT) changes**. Metamorphism occurs when rocks are forced down to lower levels by tectonic processes or when molten magma rising through the crust comes in contact with the crustal rocks or the underlying rocks are subjected to great amounts of pressure by overlying rocks.

Metamorphism is a process by which already consolidated rocks undergo **recrystallisation** and **reorganisation** of materials within original rocks.

Mechanical disruption and reorganization of the original minerals within rocks due to breaking and crushing without any appreciable chemical changes is called **dynamic metamorphism**. The materials of rocks chemically alter and recrystallise due to thermal metamorphism.
There are two types of thermal metamorphism — contact metamorphism and regional metamorphism.

(a) In **contact metamorphism** the rocks come in contact with hot intruding magma and lava and the rock materials recrystallise under high temperatures. Quite often new materials form out of magma or lava are added to the rocks.
(b) In regional metamorphism, rocks undergo recrystallisation due to deformation caused by tectonic shearing together with high temperature or pressure or both.

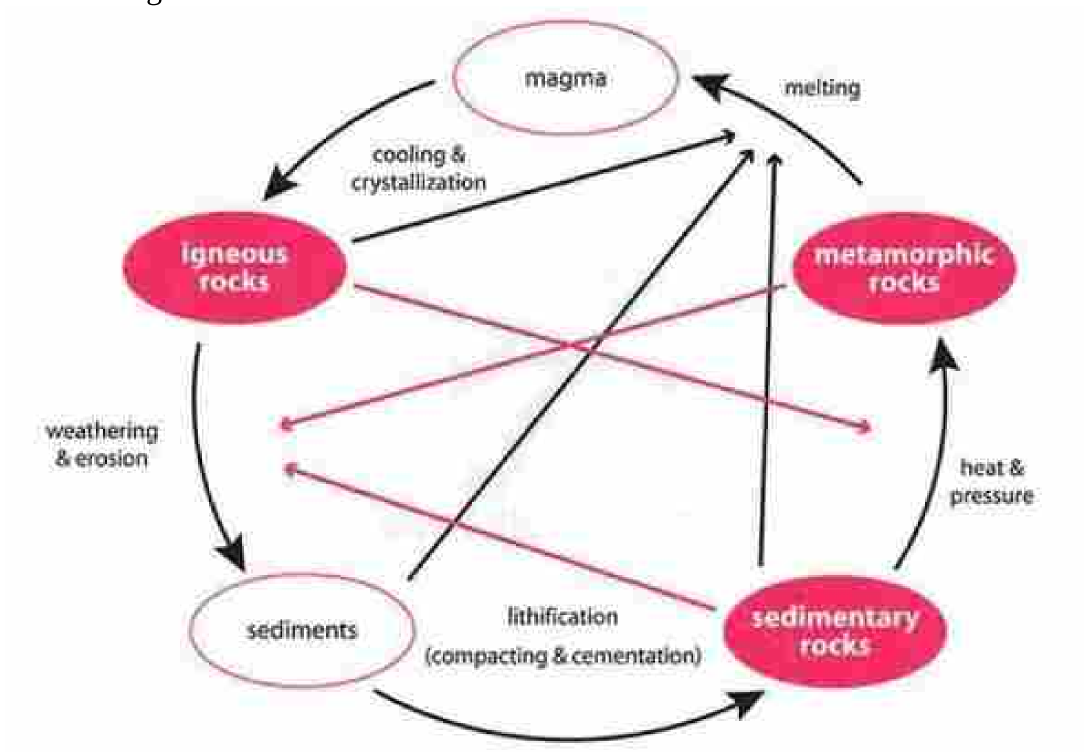
In the process of metamorphism in some rocks grains or minerals get arranged in layers or lines. Such an arrangement of minerals or grains in metamorphic rocks is called **foliation** or **lineation**.

Sometimes minerals or materials of different groups are arranged into alternating thin to thick layers appearing in light and dark shades. Such a structure in metamorphic rocks is called **banding** and rocks displaying banding are called **banded rocks**.

Types of metamorphic rocks depend upon original rocks that were subjected to metamorphism. Metamorphic rocks are classified into two major groups — foliated rocks and non-foliated rocks. Gneissoid, granite, syenite, slate, schist, marble, quartzite etc. are some examples of metamorphic rocks.

ROCK CYCLE

Rocks do not remain in their original form for long but may undergo transformation. Rock cycle is a continuous process through which old rocks are transformed into new ones. Igneous rocks are primary rocks and other rocks (sedimentary and metamorphic) form from these primary rocks. Igneous rocks can be changed into metamorphic rocks. The fragments derived out of igneous and metamorphic rocks form into sedimentary rocks. Sedimentary rocks themselves can turn into fragments and the fragments can be a source for formation of sedimentary rocks. The crustal rocks (igneous, metamorphic and sedimentary) once formed may be carried down into the mantle (interior of the earth) through subduction process (parts or whole of crustal plates going down under another plate in zones of plate convergence) and the same melt down due to increase in temperature in the interior and turn into molten magma, the original source for igneous rocks.



A CLASSIFICATION OF FORCES AFFECTING THE LANDFORMS

Landforms

There are many forms of land on the surface of the earth. Continents, oceans, mountains, plateaus, valleys, deltas, etc., are some of the examples of landforms. Landforms can be divided into three orders.

First Order landforms are continents and oceans.
The Second Order Landforms are mountains, plateaus and plains.
The Third Order Landforms include mountain sections hills, valleys, deltas, etc. All these landforms change with time. The areas where there is now land was once sea.
For example, 200 million years ago there was a sea called Tethys in the areas where the splendid

Himalayas with their sky touching peaks presently exists. Besides these slow changes, there are some violent changes in the form of explosions of volcanoes and of earthquakes.
In 1872, a hill 7 metre high, was formed in **Obens Valley** (California) due to an earthquake. Similarly, a 14.3 metre high hill was suddenly formed in the **Gulf of Yakutsh (Alaska)** in 1899.
Usually the landforms change at a very slow pace. Sometimes the changes are violent and fast but these changes are comparatively less important than the slow changes. The Forces Affecting Changes in the Landforms can be divided into the Following Two Categories-
(1) **Endogenetic Forces**- These forces are generated in the interior of the earth and cause mountains, plateaus, etc. These forces cause the parts of earth to rise or subside.
(2) **Exogenetic Forces**- These forces are produced and act on the surface of the earth. Wind, water and snow are such forces which erode the surface of the earth or make depositions on it. These external (exogenetic) forces are also called processes.

Endogenetic Forces (Tectonic Forces)

These forces are known as earth building forces (origin-'ends' within, 'genera' -origin). We have no direct knowledge of the generation of these forces because the field of their activities is in the interior parts of the earth. Some scientists think that these forces are caused by contraction of earth on cooling, change in the rotation of the earth or due to the action of the radioactive elements. On the Basis of Intensity, these Forces can be Divided into Two Subgroups-

(i) **Sudden Endogenetic Forces**
The main forces in this sub-group are volcanic or of earthquake. Landscape **suddenly undergoes disintegration**.
For example, production of deep fissures in plain areas, the sudden changes in the routes of river, the formation of small hills, etc. are some of the effects of these forces.
(ii) **Diastrophic Forces**

These forces act **very slowly**. Their effect becomes discernible after thousands of years.
For example, the coast of the Baltic sea rises by 1.3 metres in a century. There are a large number of places where the coast is either rising or sinking. The diastrophic forces from the point of view of areal distribution can be divided into two further sub-groups.

(a) **Vertical Movements** - Vertical movements originate from the **centre of the earth and affect its surface**. Consequently large scale uplift or subsidence of a part of the earth's surface takes place. These movements are slow and wide spread and do not bring changes in the horizontal rock strata. These movements are mainly associated with the **formations of continents and plateaus,** hence these are also known as continent building or plateau building movements. Besides, these movements are also called **epeirogenetic** movements. 'Epeiros' in Greek language means 'continent'. The sedimentary rocks are deposited and formed in the oceans and seas. The presence of these sedimentary rocks is wide-spread in continents. This clearly shows that these were uplifted or raised to form continents. Contrary to the above, there are countless evidences of submerged buildings, river -valleys and cities due to subsidence into the sea. Some of such examples include the submerged ancient buildings in Mediterranean in its Crete Island and the ancient city of Dwaraka in Saurashtra, India. These changes clearly point out the downward movement of the Earth's surface.

(b) **Horizontal Movements** - There are forces which act on the earth's crust **from side to side** i.e. horzontally or tangentially. Naturally, they cause a lot of disruption in the horizontal layer of strata as they do involve a good deal of compression and tension of the preexisting rocks since these forces act horizontally or tangentially to the earth's spherical surface. These are known as horizontal or tangential movements.

Structures Produced by Endogenetic Forces

Endogenetic forces create deformation in the earth's crust. This distortion takes place more **in sedimentary and metamorphic rocks than in igneous rocks**. As the former rocks are usually horizontal, a little deformation becomes easily discernible. **Weathering** and **erosion** smoothens away the deformation over the crust after some time but the deformation produced in the interior areas are not affected by the exogenetic forces (wind, water, ice, etc.). Hence, the deformation created by the endogenetic forces in the interior part of the crust is more distinct than on the upper part of the crust.

The deformations created by the endogenetic forces can be grouped into two divisions:-
(1) Crustal Bending
(2) Crustal Fracture
Both of them are responsible for creating a variety of landscape which are immediately subjected to **exogenetic forces**.

(1) Crustal Bending

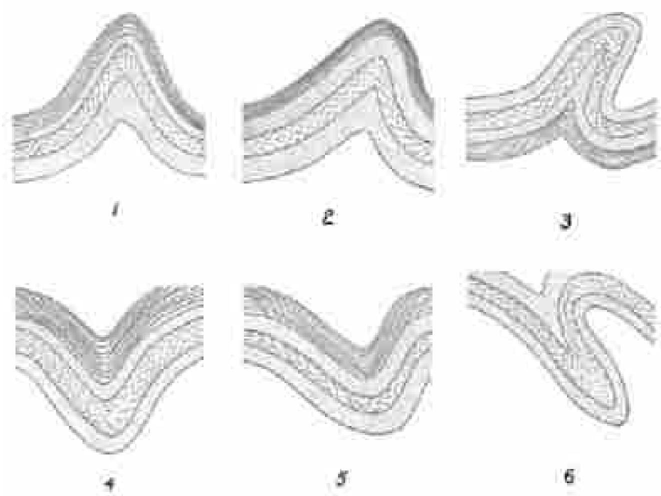


Figure 11. Various types of Folds. 1. Symmetric Anticline. 2. Asymmetric Anticline. 3. Overturned Anticline. 4. Symmetric Syncline. 5. Asymmetric Syncline. 6. Overturned Syncline.

Diastrophic forces raise an area at a place. Broad domes are created in this process. The diameters of these domes range from 160 to 325 km. The process of dome formation is known as **warping**. Domes are formed by slow warping. Water, wind, ice, etc., begin to work on them as soon as the domes begin to rise. After some time, the raised portion of the domes is eroded away but the harder rocks which resist erosion appear in a circular from. When the endogenetic forces, instead of raising the area force it down, the rocks become concave and a broad basin is formed. These basins are thus formed by a process which is opposite to dome formation. These basins are filled in by sediment. If warping makes a broad sedimentary area to subside down, the subsided area of the sedimentary rocks is known as **Geosyncline**. In the ancient times there was a great geosyncline situated between the Gondwana land and the Angara land. The Appalachian and the Alpines were born in this geosyncline.

Fold- When compression takes place on the crust due to endogenetic forces, a part of the crust is raised up in the form of folds. The Area is contracted in this process. Due to the forces acting upon it, the crust takes a wave like form. The up-fold part is known as **anticline**. The down fold-part between two anticlines is called **syncline**.

Types of Folds- According to shape, the folds are of many types:-

- **Symmetrical Folds**- These are ordinary folds. The limbs of the folds are equally inclined on either sides.
- **Asymmetrical Fold**- One of the limbs is more inclined than the other.
- **Monoclinal Fold**- In this fold, one limb makes a right angle with the surface but the other limb is ordinarily inclined.
- **Isoclinal Fold**- The two limbs are so much inclined in such a way that they appear equally inclined and parallel to each other.
- **Recumbent Fold**- In this fold the two limbs are so much inclined that they become horizontal.

(2) Crustal Fracture

The crust is being acted upon by **tension, compression, rotation, etc**., which cause the fracture of the crust. If these forces are weak, only cracks are formed. If the forces are strong, joints and faults are formed. Tension is more active than compression in breaking down the crust of the earth. The joints and faults are usually attributed to tension.

(a) Cracks-Tension and compression produce cracks. Due to tension the volume of rocks is reduced and the rocks shifts to left or right. Cracks are formed where ever there are **weak areas**. Cracks are only seen on the upper part of the crust. They are not deep. The evaporation of water in sedimentary rocks creates contraction of the layers and consequently produces cracks. Contraction due to cold of winter also produces cracks even in the igneous rocks.

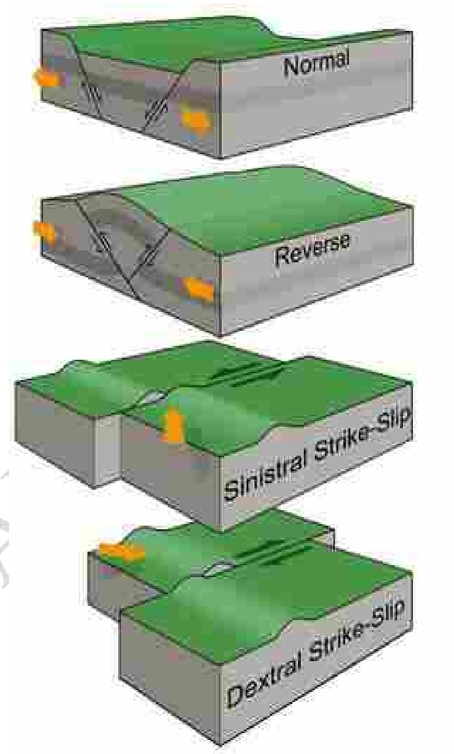
(b) Joints-When a rock is subjected to great pressure, it breaks down. The place where it breaks down is called Fracture. If the broken blocks do not have any displacement parallel to the fracture, the fracture is called a Joint. In fact there is no joint which is without any absolute displacement but if the movement is negligible the fracture is called a joint. Usually, there are parallel joints is rocks. Many types of joints intersect one another at different angles. The group of these joints are known as Joint-System. If one type of joints arc more distinct than those of other types, the joint system is called **Master Joint.**

(c) Faults-If the blocks along the surface of fracture have significant movement, the feature is called Fault. The surface of fracture where movement takes place is called Fault Plane. When the fault plane becomes smooth on account of movement of blocks, it is called Slicken side. If the movement of blocks produces scratches on the fault plane, the scratches are known as Fault Strike. A study of these scratches gives an idea of the direction of movement. Sometimes the scratches are found in different directions and at different depths. This shows that the blocks had different movements in different directions at different times.

Different types of Faults

A close look at faults helps geologists to understand *how* the tectonic plates have moved relative to one another. Types of movement of crustal blocks that can occur along faults during an earthquake:

1) Where the crust is being pulled apart, **normal faulting** occurs, in which the overlying (hanging-wall) block moves down with respect to the lower (foot wall) block.
2) Where the crust is being compressed, **reverse faulting** occurs, in which the hanging-wall block moves up and over the footwall block – reverse slip on a gently inclined plane is referred to as thrust faulting.
3) Crustal blocks may also move sideways past each other, usually along nearly-vertical faults. This **'strike-slip'** movement is described as sinistral when the far side moves to the left, and dextral, when the far side moves to the right.
4) An **oblique slip** involves various combinations of these basic movements, as in the 1855 Wairarapa Fault rupture, which included both reverse and dextral movement.



Faults can be as short as a few metres and as long as 1000km. The fault rupture from an earthquake isn't always a straight or continuous line. Sometimes there can be short offsets between parts of the fault, and even major faults can have large bends in them.

Work of Exogenetic Forces

What are Exogenic Forces?

- The forces which derive their strength from the earth's exterior or originate within the earth's atmosphere are called as exogenic forces or external forces.
- The action of exogenic forces results in wearing down and hence they are considered as **land wearing forces.**

Exogenic Processes or Denudation

- The processes which occur on earth's surface due to the influence of exogenic forces are called as exogenic processes or exogenic geomorphic processes.
- **Weathering, mass wasting, erosion, and deposition** are the main exogenic processes.
- All the exogenic processes are covered under a general term- **denudation**, which means strip off or uncover.

- The elements of nature capable of doing these exogenic processes are termed as geomorphic agents (or exogenic geomorphic agents). E.g. the wind, water, waves etc.
- Note: A process is a force applied on earth materials affecting the same. An agent is a mobile medium (like running water, moving ice, winds, waves etc) which removes, transport and deposits earth materials.
- Geomorphic processes and geomorphic agents especially exogenic, unless stated separately, are one and the same.
- **Gravity and gradients** are the two things which make these agents mobile.
- All the movements either within the earth or on the surface of the earth occur due to **gradients**– from higher levels to lower levels, from high pressure to low pressure etc.
- The exogenic forces derive their energy from atmosphere determined by the ultimate energy from the sun and also the gradient created by tectonic factors. We have already discussed in previous articles that slopes on earth surface are mainly created by tectonic factors or earth movements due to endogenic forces.
- We know that force applied per unit area is called as stress. Stress is produced in a solid by pushing or pulling.
- The gravitational force acts upon all earth materials having sloping surface and tends to produce movement of matter in the down-slope direction. This creates stress and induces deformation to the particles.

Weathering

Weathering is the action of elements of **weather** and **climate** over earth material. It can be defined mechanical disintegration and chemical decomposition of rocks through the actions of various elements of weather and climate. When rocks undergo weathering, some minerals are removed through chemical/ physical leaching by ground water and thereby the concentration of remaining (valuable) minerals increase.

Weathering can be classified as – physical, chemical and biological:

(1) Physical / Mechanical weathering

- Physical or mechanical weathering processes depend on some applied forces.
- The applied forces could be: (i) gravitational forces such as overburden pressure, load, and shearing stress; (ii) expansion force due to temperature changes, crystal growth or animal activity; (iii) water pressure controlled by wetting and drying cycles.
- **Causes:** Most of the physical weathering are caused by thermal expansion and pressure.

- **UNLOADING AND EXPANSION:**

Removal of overlying rock load because of continued erosion causes vertical pressure release. Thus, the upper layers of the remaining rock expand to produce disintegration of rock masses. Fractures will develop roughly parallel to the ground surface. In areas of curved ground surfaces, arched fractures tend to produce massive sheets or **exfoliated slabs.** Exfoliation is a result but not a process. Flaking off of more or less curved sheets of shells from over rocks or bedrocks results in smooth and rounded surfaces. So, unloading and expansion create large, smooth rounded domes called **exfoliation domes**

EXFOLIATED DOMES

- **TEMPERATURE CHANGES AND EXPANSION:**

With rising in temperature, every mineral expands and pushes against its neighbor and as the temperature falls, a corresponding contraction takes place. Due to differential heating and the resulting expansion and contraction of surface layers and their subsequent exfoliation from the surface results in smooth rounded surfaces in rocks. In rock like granites, smooth surfaced and rounded small to big boulders called **tors** form due to such exfoliation.

TORS

- **FREEZING, THAWING AND FROST WEDGING:**

Cycles of freezing and thawing (the weather becomes warmer and causes snow and ice to melt) causes frost weathering. It is most effective **at high elevations in mid-latitude** where freezing and melting is often repeated. Rapid freezing of water causes its sudden expansion and high pressure. The resulting expansion affects joints, cracks, and small intergranular fractures to become wider and wider till the rock breaks apart.

- **SALT WEATHERING:**

Salts in rocks expand due to thermal action, hydration and crystallization. Many salts like calcium, sodium, magnesium, potassium and barium have a tendency to expand. The expansion depends on temperature and their thermal properties. High temperature ranges **between 30-50 ^{0}C** of surface temperatures in desert favours such salt expansions. Salt crystallization is the most effective of all salt weathering processes. It is favoured in areas of alternative wetting and drying conditions.

(2) Chemical weathering

Chemical weathering can be due to solution, carbonation, hydration or oxidation/reduction.

- ### SOLUTION:

When something is dissolved in water or acids, the water or acid with dissolved content is called as a solution. This process involves removal of solids in solution and depends upon the solubility of a mineral in water or weak acids. When coming contact with water, many solids disintegrate and mix up as a suspension in water. Soluble rock forming minerals like nitrates, sulphates, potassium etc are affected by this process. This kind of weathering mainly occurs in a rainy. Minerals like calcium carbonate and magnesium bicarbonate present in limestone are soluble in water containing carbonic acid (formed with the addition of carbon dioxide in water) and are carried away in water as a solution. Common salt is also a rock forming mineral and is susceptible to this process of solution.

- ### CARBONATION:

Carbonation is the reaction of **carbonate and bicarbonate** with minerals and is common process helping to break down of feldspar and carbonate minerals. Carbon dioxide from the atmosphere and soil air is absorbed by water to form carbonic acid that acts as a weak acid. Calcium carbonates and magnesium carbonates are dissolved in carbonic acid and are removed in a solution without leaving any residue resulting in cave formation.

- ### HYDRATION:

Hydration is the chemical addition of water. Minerals take up water and expand; this expansion causes an increase in the volume of the material itself or rock. The process is reversible and long, continued repetition of this process causes fatigue in the rocks and may lead to their disintegration. Eg: calcium sulphate takes in water and turns to gypsum, which is more unstable than calcium sulphate.

- ### OXIDATION AND REDUCTION:

In weathering, oxidation means a **combination of a mineral with oxygen to form oxides or hydroxides**. Minerals most commonly involved in this are iron, manganese, sulphur etc. The red colour of the iron upon oxidation turns to brown and yellow. In this process of oxidation, rock breakdown occurs due to the disturbance caused by the addition of oxygen. When oxidized minerals are placed in an environment where oxygen is absent, reduction takes place.

(3) Biological weathering

This kind of weathering is caused by several **biological activities** like growth or movements of organisms. They also bring conditions for physical or chemical weathering. Grazing of animals, ploughing by human beings etc are examples of biological weathering.

Mass Movements

- These movements transfer the mass of rock debris down the slope under the **direct influence of gravity**.
- Mass movements are very active over weathered slopes rather than over unweathered slopes.
- Usual geographic agents like running water, glaciers, wind, waves etc do not have much role to play in mass movements, and it is the gravity, which is the main driving force.
- Mass movements are classified into slow movements and rapid movements.

SOLIFLUCTION

(1) Slow movements:

- **CREEP:**

It occurs on moderate steep, soil-covered slopes (doesn't need to be lubricated with water as in solifluction). The movement is **extremely slow and imperceptible** except through extended observation. We might notice that some of the electric posts in our region which are posted in sloppy areas deviated from their horizontal linearity. This is an effect of creep.

- **SOLIFLUCTION:**

It is the process of slow down slope flowing of soil mass or fine-grained rock debris saturated or **lubricated with water**. It can be said as a type of creep with lubricated water influences the movement. It mainly occurs in permafrost regions as the layers of ground water are occupied in between permanently frozen soil and rocks.

(2) Rapid movements

- **EARTHFLOW:**

Movement of water-saturated clayey or silty earth materials down low angle terraces or hillsides is called earth flow.

- **MUDFLOW:**

In the absence of vegetation and cover and with heavy rainfall, thick layers of weathered materials get saturated with water and either slow or rapidly flow down along definite channels is called as mudflow.

EFFECT DUE TO CREEP

- **DEBRIS AVALANCHE:**

It is more in humid regions with or without vegetation. It occurs in narrow tracks on sleep slopes and is similar to snow avalanche.

- **LANDSLIDES:**

In landslides, the materials involved are relatively dry irrespective of the above said rapid mass movements**.** Landslides can be classified into slump, debris slide, rock slide etc

  - **Slump**: It is a type of landslide in which slipping of several units of rock debris occurs with a backward rotation with respect to the slope over which the movement takes place.
  - **Debris slide**: In this type of landslide, there is no backward rotation. The fall is almost vertical.
  - **Rock slide**: It is nothing but the slide of individual rock masses.

Erosion and Deposition

- Erosion is the acquisition and transportation of rock debris by geomorphic agents like running water, the wind, waves etc.
- Though weathering aids erosion, it is not a pre-condition for erosion to takes place. (i.e., erosion can take place in unweathered conditions also)

- Deposition is a consequence of erosion. The erosional agents loose their velocity and energy on gentle slopes and materials carried by them start to settle themselves.
- Note: Deposition is not the work of any agents. It is just the end result of erosion.

➢ EROSION AND DEPOSITION

Action of Running Water and Groundwater

What does Running Water do?

- Running water, which doesn't need any further explanation, has two components: one is overland flow on the general land surface as a sheet and the other is linear flow as streams and rivers in valleys.
- The overland flow causes **sheet erosion** and depending upon the irregularities of the land surface, the overland flow may concentrate into narrow to wide paths.
- During the sheet erosion, minor or major quantities of materials from the surface of the land are removed in the direction of flow and gradual small and narrow **rills** will form.
- These rills will gradually develop into long and wide **gullies**, the gullies will further deepen, widen and lengthen and unite to give rise to a network of **valleys**. (Note: A valley can be formed in various ways like faulting, but here we are dealing only with the formation by means of exogenic geomorphic agent).
- Once a valley is formed, it later develops into a **stream** or **river**.

Courses of a river

A river, which is the best example of the linear flow of running water through a valley, can be divided into three, on the basis of its course – upper course, middle course and lower course.

Upper Course / Stage of Youth (Erosion dominates):

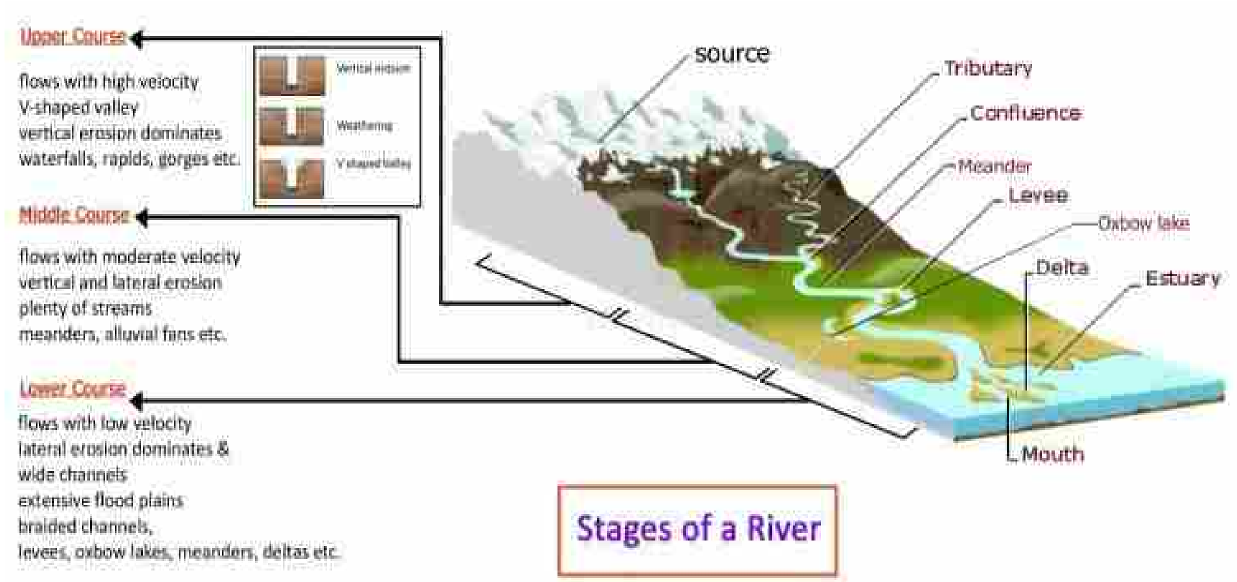
- It starts from the source of the river in **hilly or mountainous areas.**
- The river flows down the steep slope and, as a result, its velocity and eroding power are at their **maximum**.
- Streams are few, with poor integration.
- As the river flows down with high velocity, vertical erosion or downward cutting will be high which results in the formation of **V-Shaped Valleys.**
- Waterfalls, rapids, and gorges exist where the local hard rock bodies are exposed.

Middle Course/ Stage of Maturity (Transportation dominates):

- In this stage, vertical erosion slowly starts to replace with lateral erosion or erosion from both sides of the channel.
- Thus, the river channel causes the gradual disappearance of its V-shaped valley (not completely).
- Streams are plenty at this stage with good integration.
- Wider flood plains start to visible in this course and the volume of water increases with the confluence of many tributaries.
- The work of river predominantly becomes transportation of the eroded materials from the upper course (little deposition too).
- Landforms like alluvial fans, piedmont alluvial plains, meanders etc. can be seen at this stage.

Lower Course/ Stage of Old (Deposition dominates):

- The river starts to flow through a broad, level plain with heavy debris brought down from upper and middle courses.
- Vertical erosion has almost stopped and lateral erosion still goes on.
- The work of the river is mainly deposition, building up its bed and forming an extensive flood plain.
- Landforms like braided channels, floodplains, levees, meanders, oxbow lakes, deltas etc. can be seen at this stage.



Running water: erosion, transportation and deposition

- Erosion occurs when overland flow moves soil particles down slope.
- The rock materials carried by erosion are the load of the river.
- This load acts as a grinding tool helping in cutting the bottom and sides of the river bed, resulting in deepening and widening of the river channel.

Erosion Types

The work of river **erosion is accomplished in different ways**, all of which may operate together. They are corrasion, corrosion, hydraulic action etc.

1. **Corrasion or Abration:** As the rock particles bounce, scrape and drag along the bottom and sides of the river, they break off additional rock fragments. This form of erosion is called corrasion or abration. They are two types: vertical corrosion which acts downward and lateral corrosion which acts on both sides.
2. **Corrosion or Solution:** This is the chemical or solvent action of water on soluble or partly soluble rocks with which the river water comes in contact.
3. **Hydraulic Action:** This is the mechanical loosening and sweeping away of material by the sheer force or river water itself. No load or material is involved in this process.

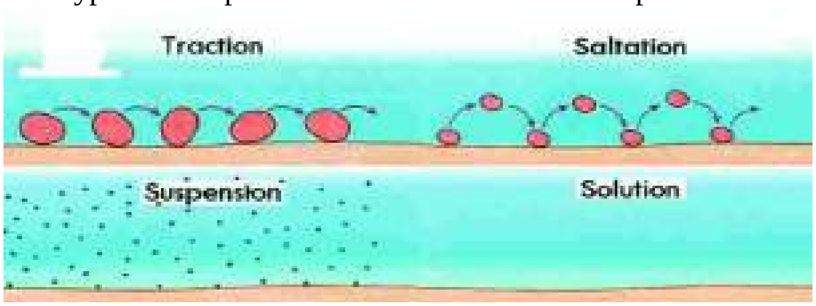
Transportation types

After erosion, the eroded materials get transported with the running water. This **transportation of eroded materials is carried in four ways**:

1. **Traction:** The heavier and larger rock fragments like gravels, pebbles etc are forced by the flow of the river to roll along its bed. These fragments can be seen rolling, slipping,

bumping and being dragged. This process is called as traction and the load transported in this way are called traction load.

2. **Saltation:** Some of the fragments of the rocks move along the bed of a stream by jumping or bouncing continuously. This process is called as saltation.
3. **Suspension:** The holding up of small particles of sand, silt and mud by the water as the stream flows is called suspension.
4. **Solution:** Some parts of the rock fragments dissolved in the river water and transported. This type of transportation is called solution transportation.



When the stream comes down from the hills to plain areas with the eroded and transported materials, the absence of slope/gradient causes the river to lose it energy to further carry those transported materials. As a result, the load of the river starts to settle down which is termed as deposition. Erosion, transportation, and deposition continue until the slopes are almost completely flattened leaving finally lowland of faint relief called **peneplains** with some low resistant remnants called **monadnocks**.

Erosional Landforms due to Running Water

1. Valleys, Gorges, Canyon

As we discussed above, valleys are formed as a result of running water. The rills which are formed by the overland flow of water later develop into gullies. These gullies gradually deepen and widen to form valleys. A **gorge** is a deep valley with very steep to straight sides. A **canyon** is characterized by steep step-like side slopes and may be as deep as a gorge. A gorge is almost equal in width at its top as well as bottom and is formed in hard rocks while a **canyon is wider** at its top than at its bottom and is formed in horizontal bedded sedimentary rocks.

2. Potholes, Plunge pools

Potholes are more or less circular depressions over the rocky beds of hills streams. Once a small and shallow depression forms, pebbles and boulders get collected in those depressions and get rotated by flowing water. Consequently, the depressions grow in dimensions to form potholes. Plunge pools are nothing but large, deep potholes commonly found at the foot of a waterfall. They are formed because of the sheer impact of water and rotation of boulders.

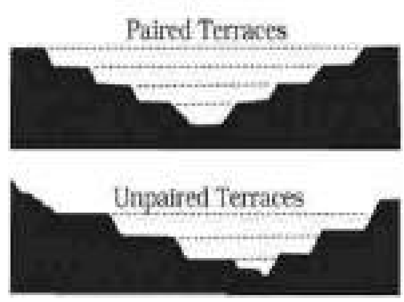
3. Incised or Entrenched Meanders

ENTRENCHED MEANDERS

They are very deep wide meanders (loop-like channels) found cut in hard rocks. In the course of time, they deepen and widen to form gorges or canyons in hard rock. The difference between a normal meander and an incised/entrenched meander is that the latter found on hard rocks.

4. River Terraces

They are surfaces marking old valley floor or flood plains. They are basically the result of vertical erosion by the stream. When the terraces are of the same elevation on either side of the river, they are called as paired terraces. When the terraces are seen only on one side with none on the other or one at quite a different elevation on the other side, they are called as unpaired terraces.



Depositional Landforms due to Running Water

1. Alluvial Fans

They are found in the middle course of a river at the foot of slope/ mountains. When the stream moves from the higher level break into foot slope plain of low gradient, it loses its energy needed to transport much of its load. Thus, they get dumped and spread as a broad low to the high cone-shaped deposits called an alluvial fan. The deposits are not roughly very well sorted.

2. Deltas

Deltas are like an alluvial fan but develop at a different location. They are found in the mouth of the river, which is the final location of depositional activity of a river. Unlike alluvial fans, the deposits making up deltas are very well sorted with clear stratification. The coarser material settle out first and the finer materials like silt and clay are carried out into the sea.

3. Flood Plains, Natural Levees

Deposition develops a flood plain just as erosion makes valleys. A riverbed made of river deposits is the active flood plain and the flood plain above the bank of the river is the inactive flood plain. Natural levees are found along the banks of large rivers. They are low, linear and parallel ridges of coarse deposits along the banks of a river. The levee deposits are coarser than the deposits spread by flood water away from the river.

4. Meanders and oxbow lakes

Meanders are loop-like channel patterns develop over the flood and delta plains. They are actually not a landform but only a type of channel pattern formed as a result of deposition. They are formed basically because of three reasons:

- Propensity of water flowing over very gentle gradient to work laterally on the banks;
- Unconsolidated nature of alluvial deposits making up the bank with many irregularities;
- Coriolis force acting on fluid water deflecting it like deflecting the wind.

MEANDERS & OXBOW LAKES

The concave bank of a meander is known as cut-off bank and the convex bank is known as a slip-off. As meanders grow into deep loops, the same may get cut-off due to erosion at the inflection point and are left as oxbow lakes. For large rivers, the sediments deposited in a linear fashion at the depositional side of a meander are called as **Point Bars or Meander Bars.**

5. Braided Channels

When selective deposition of coarser materials causes the formation of a central bar, it diverts the flow of river towards the banks, which increases lateral erosion. Similarly, when more and more such central bars are formed, braided channels are formed. **Riverine Islands** are the result of braided channels.

BRAIDED CHANNELS

What does Groundwater do?

- The part of rain or snow-melt water which accumulates in the rocks after seeping through the surface is called underground water or simply groundwater.
- The rocks through which water can pass easily are called as permeable rocks while the rocks which do not allow water to pass are called as impermeable rocks.
- After vertically going down to some depth, the water under the ground flows horizontally through the bedding planes, joints or through the materials themselves.
- Although the amount of groundwater varies from place to place, its role in shaping the surface features of the earth is quite important.
- The works of groundwater are mainly seen in rocks like limestone, gypsum or dolomite which are rich in calcium carbonate.
- Any limestone, dolomite or gypsum region showing typical landforms produced by the action of groundwater through the process of solution and deposition is called as **Karst Topography** (Karst region in the Balkans)
- The zones or horizons of permeable and porous rocks which are fully filled with water are called as the **Zones of Saturation.**
- The marks which show the upper surface of these saturated zones of the groundwater are called as the **Water Tables.**
- And these rocks, which are filled with underground water, are called as
- The water table is generally higher in the areas of high precipitation and also in areas bordering rivers and lakes.
- They also vary according to seasons. On the basis of variability, water tables are of two types: (i) Permanent water table, in which the water will never fall below a certain level and wells dug up to this depth provide water in all seasons; (ii) Temporary water tables, which are seasonal water tables.
- **Springs:** They are the surface outflow of groundwater through an opening in a rock under hydraulic pressure.
- When such springs emit hot water, they are called as **Hot Springs.** They generally occur in areas of active or recent volcanism.
- When a spring emits hot water and steam in the form of fountains or jets at regular intervals, they are called as geysers.

- In a geyser, the period between two emissions is sometimes regular (Yellowstone National Park of USA is the best example).

Erosional Landforms due to Groundwater

Sinkholes and caves are erosional landforms formed due to the action of ground water.

1. Sinkholes

Small to medium sized rounded to sub-rounded shallow depressions called swallow holes forms on the surface of rocks like limestone by the action of the solution. A sinkhole is an opening more or less circular at the top and funnel-shaped towards the bottom. When as sinkhole is formed solely through the process of solution, it is called as a **solution sink**. Some sinkhole starts its formation through the solution process but later collapse due to the presence of some caves or hollow beneath it and becomes a bigger sinkhole. These types are called as **collapse sinks**. The term **Doline** is sometimes used to refer collapse sinks. Solution sinks are more common than collapse sinks. When several sink holes join together to form valley of sinks, they are called as **Lapies** are the irregular grooves and ridges formed when most of the surfaces of limestone are eaten by solution process.

SINKHOLES

2. Caves

In the areas where there are alternative beds of rocks (non-soluble) with limestone or dolomite in between or in areas where limestone are dense, massive and occurring as thick beds, cave formation is prominent. Caves normally have an opening through which cave streams are discharged. Caves having an opening at both the ends are called tunnels.

CAVES

Depositional Landforms of Groundwater

1. Stalactites and stalagmites

They are formed when the calcium carbonates dissolved in groundwater get deposited once the water evaporates. These structures are commonly found in limestone caves.

Stalactites are calcium carbonate deposits hanging as icicles while **Stalagmites are calcium carbonate deposits** which rise up from the floor. When a stalactite and stalagmite happened to join

together, it gives rise to **pillars** or **columns** of different diameters.

Erosion and Deposition: Action of Glaciers

What is a Glacier?

- Glaciers are a **mass of ice moving under its own weight**. They are commonly found in the snow-fields.
- We know that the landmass on the earth is not entirely the same as we see around. Some areas are covered by thick green forests, some with dry hot deserts, some with permanent ice covers etc. Among these varied landmasses, the permanently ice-covered regions on the earth surface are called as snow-fields. The lowest limit of permanent snow or snow-field is called as the snowline.
- A Glacier forms in areas where the accumulation of snow exceeds its ablation (melting and sublimation) over many years, often centuries.
- They form features like **crevasses, seracs** etc. A **crevasse** is a deep crack, or fracture, found in an ice sheet or glacier, as opposed to a crevice that forms in rock. A **serac** is a block or column of glacial ice, often formed by intersecting crevasses on a glacier.
- ***Ogives*** are alternating wave crests and valleys (troughs) that appear as dark and light bands of ice on glacier surfaces. They are linked to seasonal motion of glaciers; the width of one dark and one light band generally equals the annual movement of the glacier.
- Glaciers cover about 10 percent of Earth’s land surface and they are the largest freshwater reservoirs on earth.

On the basis of the location of the glacier, they can be classified as:

1. **Continental Glacier/Piedmont Glacier**: they move outward in all directions
2. **Valley/Mountain Glaciers**: Move from higher elevation to lower

Erosional landforms due to Glaciers

1. Cirque or Corris

They are deep, long and wide troughs or basins with very steep concave to vertically dropping high walls at its head as well as sides. They are simply a bowl-shaped depression formed due to the erosional activity of glaciers. When these depressions are filled with water, they are called as **Cirque lake or Corrie Lake or Tarn Lakes**.

2. Hanging Valleys or U-shaped Valleys, Fjords/fiords

The Glacier doesn't create a new valley like a river does but deepens and widens a pre-existing valley by smoothening away the irregularities. These valleys, which are formed by the glacial erosions assume the shape of letter 'U' and hence are called as U-shaped Valleys or Hanging Valleys.

A **fjord** is a very deep glacial trough filled with sea water and making up shorelines. A fjord is formed when a glacier cuts a U-shaped valley by ice segregation and abrasion of the surrounding bedrock and this valley gradually gets filled with the seawater (formed in mountains nearby sea).

HANGING VALLEY & FJORDS/FIORDS

3. Horns and Aretes

Horns are sharp pointed and steep-sided peaks. They are formed by headward erosion of cirque wall. When the divide between two cirque walls gets narrow because of progressive erosions, it results in the formation of a saw-toothed ridge called **Arete**.

HORNS AND ARETES

Depositional Landforms due to Glaciers

Glacial deposits are of two types:

- **Glacial Till –** unassorted coarse and fine debris;
- **Outwash –** assorted roughly stratified deposits.

1. Moraines

Moraines are long ridges of deposits of glacial till. When these deposits are at the end of a glacier, they are called as **Terminal moraines** and when they are deposited on both sides, they are called as **Lateral moraines**. When lateral moraines of two glaciers join together, they form **Medial moraines**. When the lateral moraines of both sides of a glacier join together, it forms a horse-shoe shape. Ground moraines are deposits left behind in areas once covered by glaciers.

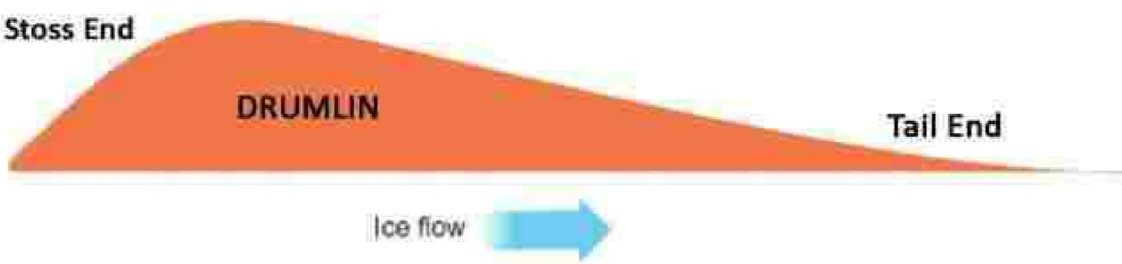
ESKERS

2. Eskers

When glaciers melt in summer, the water which formed as a result of melting accumulates beneath the glacier and flows like streams in channels beneath that ice. Very coarse material like **boulders, blocks and some minor fractions of rock debris** are carried away by these streams. They later get deposited in the valleys itself and once the ice melts completely, they are visible to the surface as sinuous ridges. These ridges are called as Eskers.

3. Drumlins

They are smooth oval-shaped ridge-like structures composed mainly of glacial till. It shapes like an inverted spoon with the highest part is called as **Stoss End** and the lowest narrow part is called as **Tail End.** They are formed as a result of glacial movement over some minor obstruction like small surface rocks. The glacial till gets deposited in those obstructions and the movement of glacier shapes these deposits like an inverted spoon.



Erosion and Deposition: Action of Wind and Waves

Action of Winds:

- The wind is the main geomorphic agent in the hot deserts.
- Winds in hot deserts have greater speed which causes erosional and depositional activities in the desert.
- The landforms which are created by erosional and depositional activities of wind are called as **Aeolian Landforms.**
- This process is not unique to the Earth, and it has been observed and studied on other planets, including Mars.
- An **erg** (also known as **sand sea / dune sea / sand sheet** if it lacks dunes) is a broad, flat area of desert covered with wind-swept sand with little or no vegetative cover. It is defined as a desert area that contains more than 125 square kilometres of aeolian or wind-blown sand and where sand covers more than 20% of the surface. Smaller areas are known as "dune fields". The largest hot desert in the world, the Sahara, contains several ergs.

Erosional Landforms due to Wind

1. Pediplains

When the high relief structures in deserts are reduced to low featureless plains by the activities of wind, they are called as Pediplains.

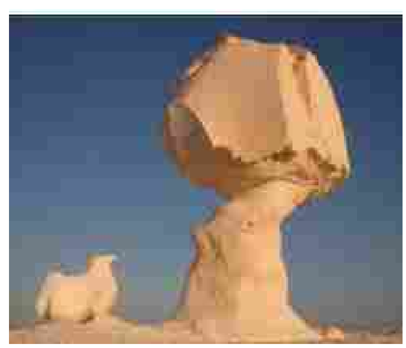
DEFLATION HOLLOWS

2. Deflation Hollows

Deflation is the removal of loose particles from the ground by the action of wind. When deflation causes a shallow depression by persistent movements of wind, they are called as deflation hollows.

3. Mushroom Tables

Ventifacts are rocks that have been abraded, pitted, etched, grooved, or polished by wind-driven sand or ice crystals. These geomorphic features are most typically found in arid environments where there is little vegetation to interfere with aeolian particle transport, where there are frequently strong winds, and where there is a steady but not overwhelming supply of sand. **Mushroom Tables / Mushroom rocks** are Ventifacts in the shape of a mushroom. In deserts, a greater amount of sand and rock particles are transported close to the ground by the winds which cause more bottom erosion in overlying rocks than the top. This result in the formation of rock pillars shaped like a mushroom with narrow pillars with broad top surfaces.

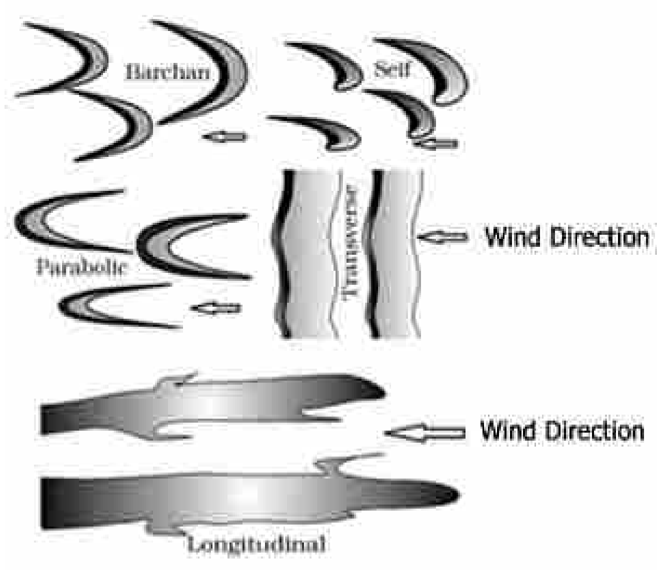


MUSHROOM TABLES

Depositional Landforms of Wind

1. Sand dunes

Dry hot deserts are good places for sand dune formation. According to the shape of a sand dune, there are varieties of sand dune forms like Barchans, Seifs etc. The **crescent-shaped dunes** are called as **Barchans** and they are the most common one. **Seif** is similar to Barchans but has only one wing or point.



2. Loess

In several large areas of the world, the surface is covered by deposits of wind-transported silt that has settled out from dust storms over many thousands of years. These depositions are called as Loess.

Action of Waves:

- Coastal processes are the most dynamic and hence most destructive.
- Some of the changes along the coast take place very fast. Storm waves and tsunami waves can cause far-reaching changes in short period of time than normal breaking waves.
- The coastal landforms in the world can be classified into **two categories:**

1. High Rocky Coast/ Submerged Coast/ Retreating Coast

In these types of coasts, the sea will be very close to the land without any coast or sometimes a narrow coast. The shores of these high rocky coasts do not show any depositional landforms. Erosional feature dominates here. Wave-cut platforms, cliffs, sea caves etc are common here. Most of the west coasts of the Indian Peninsula belong to this category.

RETREATING COAST

2. Low Sedimentary Coast/ Emerging Coast/ Advancing Coast

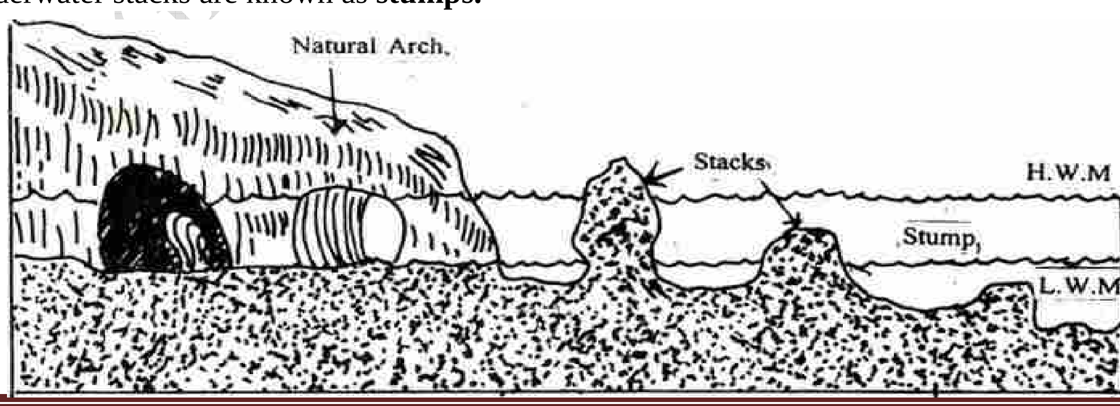
The rivers in these coasts extend the length of the coast by building coastal plains and deltas. Thus, depositional features are dominant here. Bars, Barriers, spits, lagoons etc are common on these coasts. Most of the east coasts of the India Peninsula are of this category.

EMERGING COAST

Erosional Landforms due to Waves

1. Cliffs, Terraces, Caves, Stacks and Stumps

Cliffs are common on the high rocky coasts. At the foot of such cliffs, there may be flat or gently sloping platform covered by rock debris derived from the sea cliff behind. Such platforms occurring at an elevation above the average height of waves is called as a wave-cut terrace. When the upper part of a coastal rock is hard and the lower part is soft, the erosion will not be uniform. The lower part erodes easily which results in the formation of a hollow part. This hollow part, by frequent wave action, gradually develops into a **sea-cave.** Sea arches are also formed in the same manner. **Sea stacks** are nothing but the isolated standing rocks in the sea which were once a part of the cliff. These stacks look will like small islands in the sea. Small underwater stacks are known as **stumps.**



Depositional Landforms due to Waves

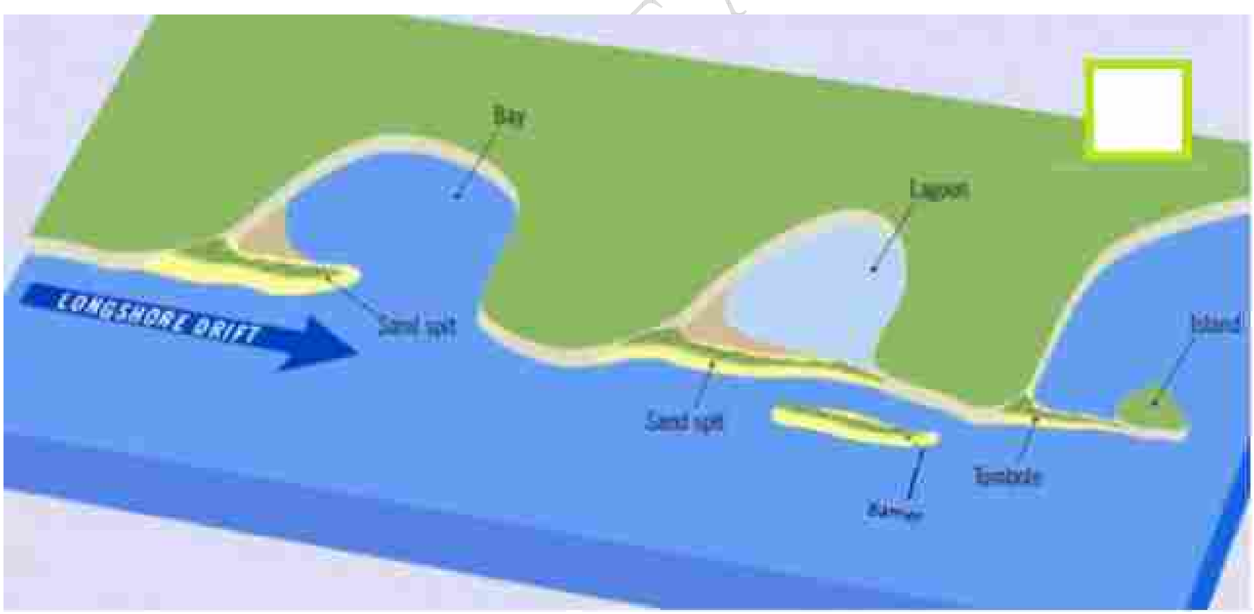
1. Beaches and dunes

Beaches are characteristics of shorelines that are dominated by deposition. Beaches are temporary features which are made up of sand-sized materials. Beaches which contain excessively small pebbles and even cobbles are called as **Shingle Beaches.** Sand dunes are formed just behind the beaches as long ridges parallel to the coastline.

2. Bars, spits, and Lagoons

Bars are deposits of sand and gravel laid down by waves and currents which separate the shoreline from the sea. They act as a barrier between the mainland and the sea.
When one end of such bar is attached to the coast and other extends into the sea, it is called as a **spit**. **Tombolo** is a deposition landform in which an island is attached to the mainland by a narrow piece of land such as a spit or bar. Sometimes due to deposition of waves and currents, both ends of the bar join to enclose a part of sea water between the coast and the bar. This enclosed part of the sea forms a lake of saline water called as **Lagoon**.

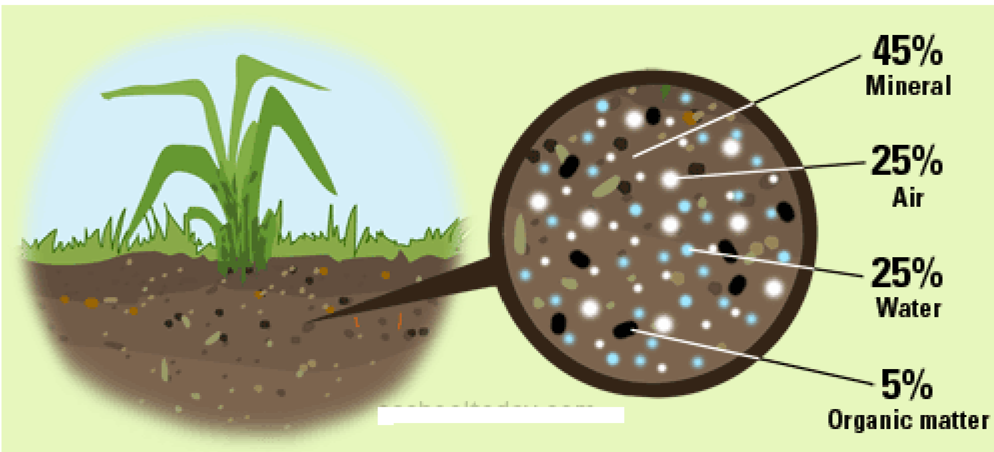
A **lagoon** is generally connected with the sea through a narrow passage. **Chilika and Pulicat lakes are examples of Lagoon Lake.**



➢ SOILS

What is a Soil?

Soils are the loose mineral or organic materials found on the earth's surface, usually (or averagely) made up of **about 25% air, 25% water, 45% mineral and 5% organic matter** (humus, tiny living organisms and sometimes plant residue).



It is the stuff that supports rooted plants in a natural environment. There are soils practically on every land that is not covered by water.

There are many types of soils, usually placed in classes (types) based on their **color, profile, texture, composition or structure**. Each soil type is formed differently and can be found in specific places on the earth's immediate surface, mid and deep under the surface. Soils on the surface (a few millimeters deep) are usually exposed to direct climatic and environmental factors, and are easily blown away by wind, washed away by water or even broken down by temperature changes, human and animal activity. There are also soils found deep down the earth, often protected from climatic and environmental factors.

Because soils are formed from a variety of ways and in infinite conditions, it is hard to give a number for the types of soils we have on earth. However, they can be grouped using the stuff that they are made of.

One important subject that many farmers and soils scientists look out for is soil chemistry. This includes **soil pH (the acidity of the soil), nutrient level, its organic content and the chemical composition of the minerals found in it**. This is partly because different soils are used for different things and it is important to know something about the soils you choose.

These are usually determined by the geographic location of the soils, the types of plants growing in them, and even the environmental factors (water and air) that the soil is exposed to.

The study of soils as naturally occurring phenomena is called **pedology**, and a person who studies soils (soil scientist) is called a **pedologist**.

Soil Profile

If one could dig a massive trench (hole), about 50-100ft vertically downwards into the ground, you will notice that you would have cut through various layers of soil types. A look at the layers from a distance gives one a cross-section view of the ground (beneath the surface) and the kind of soils and rocks it is made up of.

This cross-section view is called a **Soil Profile**. The profile is made up of **layers, running parallel to the surface, called Soil Horizons.**

Each horizon may be slightly or very different from the other above or below it. Each horizon tells a story about the **makeup, age, texture and characteristics of that layer**.
Most soils have three major horizons. These are A Horizon, B Horizon and C Horizon. Aside from these three, there are also the O, E and R horizons.

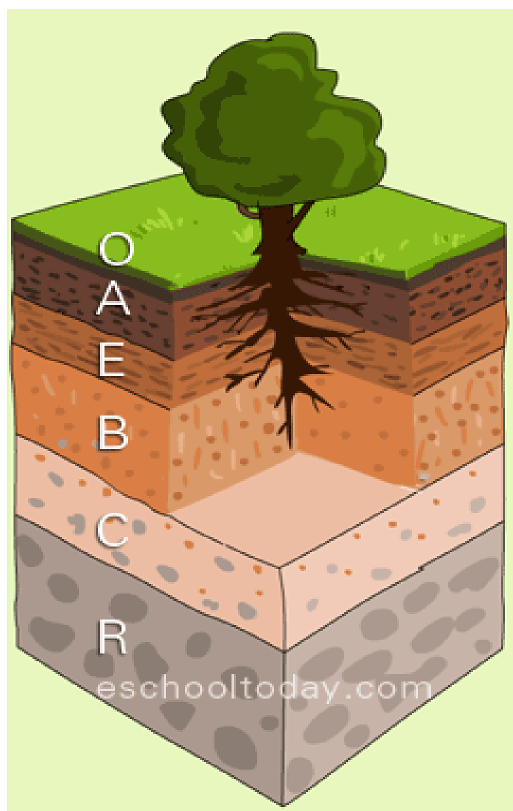
How are they different?

- **The O-Horizon:**

The O horizon is very common in many surfaces with **lots of vegetative cover**. It is the layer made up of organic materials such as dead leaves and surface organisms, twigs and fallen trees. It has about 20% organic matter. It is possible to see various levels of decomposition occurring here (minimal, moderately, highly and completely decomposed organic matter). This horizon is often black or dark brown in color, because of its **organic content**. It is the layer in which the roots of small grass are found.

- **The A-Horizon:**

The A horizon may be seen in the absence of the O horizon, usually known as the **topsoil**. It is the top layer soils for many grasslands and agricultural lands. Typically, they are made of **sand, silt and clay with high amounts of organic matter.** This layer is most vulnerable to **wind and water erosion.** It is also known as the **root zone.**



- **The E-Horizon:**

The E horizon is usually lighter in color, often below the O and A horizons. It is often **rich in nutrients** that are leached from the top A and O horizons. It has lower clay content and is **common in forested lands** or areas with high quality O and A horizons.

- **The B-Horizon:**

The B-horizon has some similarities with the E-horizon. This horizon is formed below the O, A and E horizons and may contain **high concentrations of silicate clay, iron, aluminum and carbonates**. It is also called the **illuviation zone** because of the **accumulation of minerals**. It is the layer in which the roots of big trees end.

- **The C-Horizon:**

The C horizon lacks all the properties of the layers above it. It is mainly made up of **broken bedrock and no organic material**. It has cemented sediment and geologic material. There is little activity here although additions and losses of soluble materials may occur. The C horizon is also known as **saprolite**.

- **The R-Horizon:**

The R horizon is **bedrock**, material, compacted and cemented by the weight of the overlying horizons. It is the unweathered parent material. Rock types found here include **granite, basalt and limestone**.

Factors affecting soil formation

Soils form from the interplay of five main factors namely Parent material, Time, Climate, Relief and Organisms.

- **Parent material:**

This refers to the mineral material or organic material from which the soil is formed. Soils will carry the characteristics of its parent material such as color, texture, structure, mineral composition and so on.

For example, if soils are formed from an area with large rocks (parent rocks) of red sandstone, the soils will also be red in color and have the same feel as its parent material.

- **Time:**

Soils can take many years to form. Younger soils have some characteristics from their parent material, but as they age, the addition of organic matter, exposure to moisture and other environmental factors may change its features. With time, they settle and are buried deeper below the surface, taking time to transform. Eventually, **they may change from one soil type to another.**

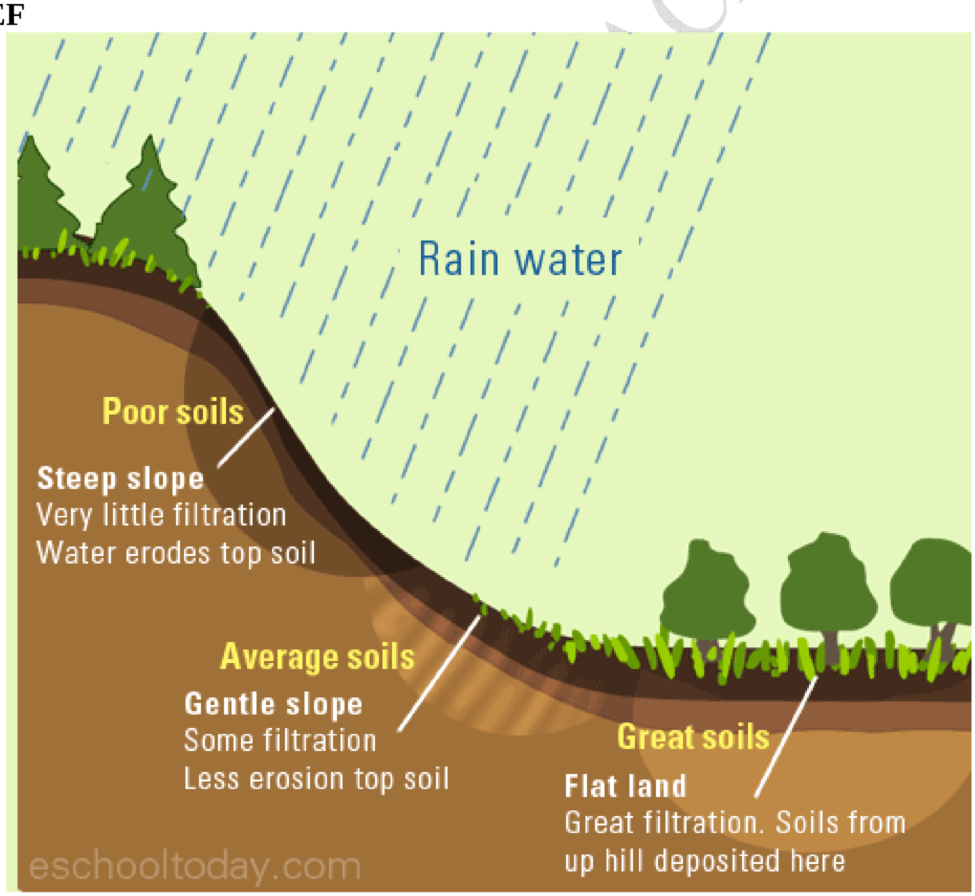
- **Climate:**

This is probably the most important factor that can shape the formation of soils. Two important climatic components, **temperature and precipitation** are key. They determine how quickly weathering will be, and what kind of organic materials may be available on and inside of the soils. **Moisture determines the chemical and biological reactions** that will occur as the soils are formed. A warmer climate with more rainfall means more vegetative cover and more animal action. It also means more runoff, more percolation and more water erosion. They all help to determine the kind of soils in an area.

- **Relief:**

This refers to the **landscape position and the slopes** it has. Steep, long slopes mean water will run down faster and potentially erode the surfaces of slopes. The effect will be poor soils on the slopes, and richer deposits at the foot of the slopes. Also, slopes may be exposed to more direct sunlight, which may dry out soil moisture and render it less fertile. (**As shown in the below diagram**)

RELIEF



- **Organisms:**

The source and richness of organic matter are down to the living things (plants and animals) that live on and in the soils. Plants, in particular, provide lots of vegetative residues that are added to soils. Their roots also hold the soils and protect them from wind and water erosion. They shelter the soils from the sun and other environmental conditions, helping the soils to retain the needed moisture for chemical and biological reactions. Fungi, bacteria, insects, earthworms, and burrowing animals help with soil aeration. Worms help break down organic matter and aid decomposition. Animal droppings, dead insects and animals result in additional decaying organic matter. Microorganisms also help with mineral and nutrient cycling and chemical reactions.

ORIGIN OF THE EARTH'S ATMOSPHERE

Introduction:

Atmosphere refers to the complex system of gases and air that surrounds the Earth. It is due to the presence and circulation of the atmospheric gases that life on Earth is possible. However, the nature of the various atmospheric layers is determined by a number of factors like-insolation, altitude, pressure and humidity. Based on the pressure gradients at different locations the wind system evolves. Another significant factor in the atmospheric forces is the humidity and precipitation.

Composition of the Atmosphere:

Atmosphere **- Envelope of gases that surrounds the Earth. Used by life as a reservoir of chemical compounds used in living systems. Atmosphere has** no outer boundary, just fades into space. **Dense part of atmosphere (97% of mass) lies within 30 km of the Earth (so about same thickness as continental crust).**

- **Chemical Composition**: Nitrogen (N_2)- 78%, Oxygen (O_2)- 21%, Carbon Dioxide (CO_2) - 0.03 %, plus other miscellaneous gases (H_2O for one).

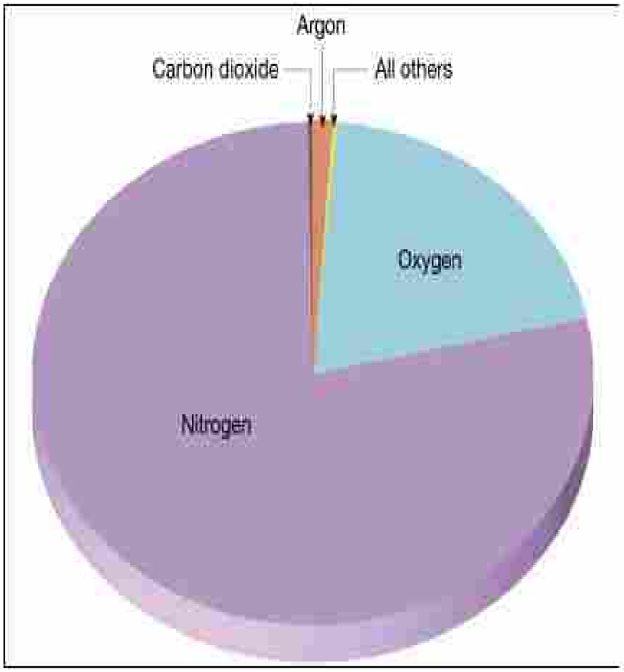


Table 1–2 Principal gases of dry air

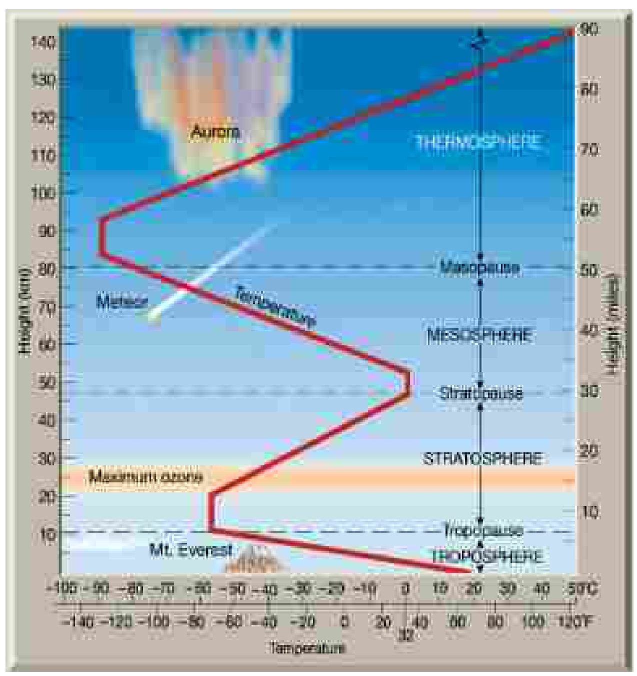
Constituent	Percent by Volume	Concentration in Parts Per Million (PPM)
Nitrogen (N_2)	78.084	780,840.0
Oxygen (O_2)	20.946	209,460.0
Argon (Ar)	0.934	9,340.0
Carbon dioxide (CO_2)	0.036	360.0
Neon (Ne)	0.00182	18.2
Helium (He)	0.000524	5.24
Methane (CH_4)	0.00015	1.5
Krypton (Kr)	0.000114	1.14
Hydrogen (H_2)	0.00005	0.5

Atmospheric Structure:

The Atmosphere can be divided into layers according to **major changes in temperature**. Due to the force of gravity most of the earth's gases, in fact 99% can be found in the bottom 32km.

- **Troposphere:**

The troposphere is the atmospheric layer closest to the planet and contains the largest percentage (around 80%) of the mass of the total atmosphere. **Temperature and water vapor content** in the troposphere decrease rapidly with altitude. Water vapor plays a major role in regulating air temperature because it absorbs solar energy and thermal radiation from the planet's surface. The troposphere contains 99% of the water vapor in the atmosphere. Water vapor concentrations vary with latitude. They are greatest above the tropics, where they may be as high as 3 %, and decrease toward the polar regions.



All weather phenomena occur within the troposphere, although turbulence may extend into the lower portion of the stratosphere. Troposphere means "region of mixing" and is so named because of vigorous convective air currents within the layer.
The upper boundary of the layer, known as the **tropopause**, ranges in height from 5 miles (8 km) near the poles up to 11 miles **(18 km) above the equator**. **Its height also varies with the seasons; highest in the summer and lowest in the winter.**

- **Stratosphere:**

The stratosphere is the second major strata of air in the atmosphere. It extends above the tropopause to an altitude of about **30 miles (50 km)** above the planet's surface. The air temperature in the stratosphere remains relatively constant up to an altitude of 15 miles (25 km). Then it increases gradually to up to the stratopause. Because the air temperature in the stratosphere increases with altitude, it does not cause convection and has a stabilizing effect on atmospheric conditions in the region. Ozone plays the major role in regulating the thermal regime of the stratosphere, as **water vapor content within the layer is very low**. **Temperature increases with ozone concentration**. Solar energy is converted to kinetic energy when ozone molecules absorb ultraviolet radiation, resulting in heating of the stratosphere.

The **ozone layer** is centered at an altitude between 10-15 miles (15-25 km). Approximately 90 % of the ozone in the atmosphere resides in the stratosphere. Ozone concentration in this region is about 10 parts per million by volume (ppmv) as compared to approximately 0.04 ppmv in the troposphere. Ozone absorbs the bulk of solar ultraviolet radiation in wavelengths from 290 nm - 320 nm (UV-B radiation). These wavelengths are harmful to life because they can be absorbed by the nucleic acid in cells. Increased penetration of ultraviolet radiation to the planet's surface would damage plant life and have harmful environmental consequences. Appreciably large amounts of solar ultraviolet radiation would result in a host of biological effects, such as a dramatic increase in cancers.

- **Mesosphere:**

The mesosphere a layer extending from approximately **30 to 50 miles (50 to 85 km)** above the surface is characterized by decreasing temperatures. The coldest temperatures in Earth's atmosphere occur at the top of this layer, the mesopause, especially in the summer near the pole. The mesosphere has sometimes jocularly been referred to as the "**ignorosphere**" because it had been probably the least studied of the atmospheric layers. The stratosphere and mesosphere together are sometimes referred to as the middle atmosphere.

- **Thermosphere:**

The thermosphere is located above the mesosphere. The temperature in the thermosphere generally increases with altitude reaching 600 to 3000 F (600-2000 K) depending on solar activity. This increase in temperature is due to the absorption of intense solar radiation by the limited amount of remaining molecular oxygen. At this extreme altitude gas molecules are widely separated. Above 60 miles (100 km) from Earth's surface the chemical composition of air becomes strongly dependent on altitude and the atmosphere becomes enriched with lighter gases (atomic oxygen, helium and hydrogen).

Also at 60 miles (100 km) altitude, Earth's atmosphere becomes too thin to support aircraft and vehicles need to travel at orbital velocities to stay aloft. This demarcation between aeronautics and astronautics is known as the Karman Line. Above about 100 miles (160 km) altitude the major atmospheric component becomes atomic oxygen. At very high altitudes, the residual gases begin to stratify according to molecular mass, because of gravitational separation.

- **Exosphere:**

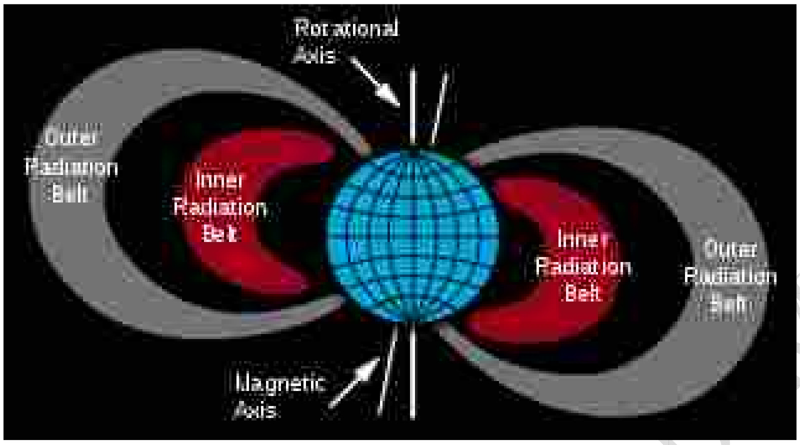
The exosphere is the most distant atmospheric region from Earth's surface. In the exosphere, an upward travelling molecule can escape to space (if it is moving fast enough) or be pulled back to Earth by gravity (if it isn't) with little probability of colliding with another molecule. The altitude of its lower boundary, known as the **thermopause or exobase**, ranges from about **150 to 300 miles (250-500 km)** depending on solar activity. The upper boundary can be defined theoretically by the altitude (about 120,000 miles, half the distance to the Moon) at which the influence of solar radiation pressure on atomic hydrogen velocities exceeds that of the Earth's gravitational pull. The exosphere observable from space as the geocorona is seen to extend to at least 60,000 miles from the surface of the Earth. The exosphere is a transitional zone between Earth's atmosphere and interplanetary space.

Van Allen radiation belts:

A Van Allen radiation belt is a zone of energetic charged particles, most of which originate from the solar wind, that are captured by and held around a planet by that planet's magnetic field. Earth has two such belts and sometimes others may be temporarily created. The discovery of the belts is credited to James Van Allen, and as a result, Earth's belts are known as the Van Allen belts. Earth's two main belts extend from an altitude of about 640 to 58,000 km (400 to 36,040 mi) above the surface in which region radiation levels vary. Most of the particles that form the belts are thought to come **from solar wind** and other particles by cosmic rays. By trapping the solar wind, the magnetic field deflects those energetic particles and protects the atmosphere from destruction.

The belts are located in the inner region of Earth's magnetosphere. The belts trap energetic electrons and protons. Other nuclei, such as alpha particles, are less prevalent. The belts endanger satellites, which must have their sensitive components protected with adequate shielding if they spend significant time near that zone. In 2013, NASA reported that the **Van**

Allen Probes had discovered a transient, third radiation belt, which was observed for four weeks until it was destroyed by a powerful, **interplanetary shock wave from the Sun**.



TEMPERATURE BELTS OF THE EARTH'S SURFACE

Temperature differs from one part of the world to the other. Since Insolation is the basic source of energy for the atmosphere, the distribution of insolation would determine the temperature of the earth. Thus **latitude, altitude, distance from sea, features of the surface, nature of the landscape** are some important factors that affect the distribution of temperature.
Since, the insolation is highest at equator; temperature should be highest at the equator and lowest near the poles, however actually it is not. Highest temperature on earth is recorded at a few degrees north of equator. Altitude is the second major control of temperature of a place. Altitude is the second major control of temperature of a place. The temperature depends upon **albedo** of the surface also.

One major factor affecting the distribution of the temperature of Earth is distribution of Land and Oceans. Since there is more land in Northern Hemisphere and more waters in Southern hemisphere and there is a big difference between the specific heat of land and water; **the loss of heat from the continents is bigger than the oceans**. The continents get heated faster and get cooled faster in comparison to the Oceans. This is the reason that the temperatures of the Oceans are moderate while that of continents is extreme. The moderating effect on temperature of the land due to proximity of the seas is called **Maritime influence**. The increasing effect on temperature of the land at interior of the continents is called Continental Influence.

Three Broad Temperature Zones

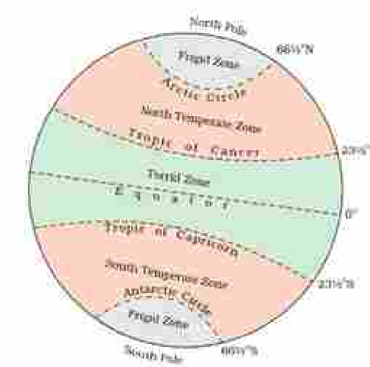
The earth can be generally divided into three broad temperature zones viz. Torrid Zone, Temperate Zone and Frigid zone.

- **Torrid Zone**

Torrid Zone is the tropical region. The temperature remains high. Sun is directly overhead at least once during the year. In the Northern Hemisphere, the overhead Sun moves north from the equator until it reaches 23.5 °North (Tropic of Cancer) for the June solstice after which it moves back south to the equator. The year is consequently divided nearly into four equal parts by the two times at which the sun crosses the equator (Equinoxes) and those two at which it attains greatest declinations (Solstices). The Torrid Zone forms the hottest region of the world with two annual seasons namely a dry and a wet season. This zone includes most of Africa, southern Asia, Indonesia, New Guinea, northern Australia, southern Mexico, Central America and northern South America.

- **Temperate Zones**

Temperate zones are the mid latitudinal areas, where the temperature is moderate. There are two temperate areas viz. North and South. In the two Temperate Zones, consisting of the tepid latitudes, the Sun is never directly overhead, and the climate is mild, generally ranging from warm to cool. The four annual seasons, Spring, Summer, Autumn and Winter occur in these areas. The North Temperate Zone includes Great Britain, Europe, northern Asia, North America and northern Mexico. The South Temperate Zone includes southern Australia, New Zealand, southern South America and South Africa.



- **Frigid Zones**

The two Frigid Zones, or polar regions, experience the midnight sun and the polar night for part of the year – the cliff of the zone experiences one day at the solstice when the Sun doesn't rise or set for 24 hours, while in the centre of the zone (the pole), the day is literally one year long, with six months of daylight and six months of night. **Please note that the Frigid Zones are not the coldest parts of the earth, and are covered with ice and snow.** The coldest temperature on earth has been recorded a few degrees below the 90°N.

➢ INSOLATION AND HEAT BALANCE OF THE EARTH

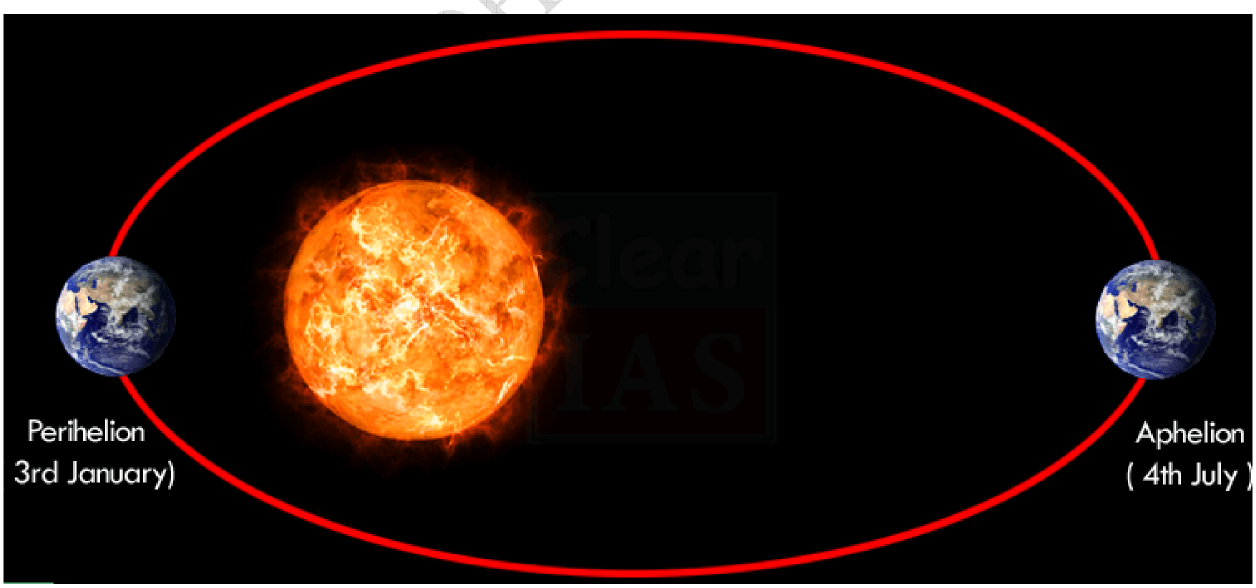
Insolation or Incoming Solar Radiation

As we all know, the sun is the primary source of energy for the earth. The sun radiates its energy in all directions into space in short wavelengths, which is known as solar radiation.
The earth's surface receives only a part of this radiated energy (2 units out of 1,00,00,00,000 units of energy radiated by the sun).

The energy received by the earth's surface in the form of short waves is termed as Incoming Solar Radiation or Insolation. The amount of insolation received on the earth's surface is far less than that is radiated from the sun because of the small size of the earth and its distance from the sun.

Moreover, water vapour, dust particles, ozone and other gases present in the atmosphere absorb a small amount of solar radiation.] The solar radiation received at the top of the atmosphere varies slightly in a year due to the variations in the distance between the earth and the sun.

During the earth's revolution around the sun, the earth is farthest from the sun on **4th July**. This position of the earth is called **aphelion**. On **3rd January**, the earth is nearest to the sun. This position is called **perihelion**.



Due to this variation in the distance between the earth and the sun, the annual insolation received by the earth on 3rd January is slightly more than the amount received on 4th July. However, the effect of this variation is masked by some other factors like the distribution of land and sea and the atmospheric circulation. Hence the variation does not have a greater effect on daily weather changes on the surface of the earth.

Factors influencing Insolation

The amount of insolation received on the earth's surface is not uniform everywhere. It varies according to the place and time. When the tropical regions receive maximum annual insolation, it gradually decreases towards the poles. Insolation is more in summers and less in winters. The major factors which influence the amount of insolation received are:

1. Rotation of the earth on its axis
2. The angle of incidence of the sun's rays
3. Duration of the day
4. Transparency of the atmosphere

1. Rotation of the earth on its axis

The earth rotates on its own axis which makes an angle of 66.5 with the plane of its orbit around the sun. The rotation of the earth on this inclined axis has a greater influence on the amount of insolation received at different latitudes.

2. The angle of incidence of the sun's rays

- Since the earth is a geoid resembling a sphere, the sun's rays strike the surface at different angles at different places. This depends on the latitude of the place.
- The higher the latitude, the less is the angle they make with the surface of the earth.
- The area covered by the vertical rays is always less than the slant rays. If more area is covered, the energy gets distributed and the net energy received per unit area decreases.
- Moreover, the sun's rays with small angle traverse more of the atmosphere than rays striking at a large angle.

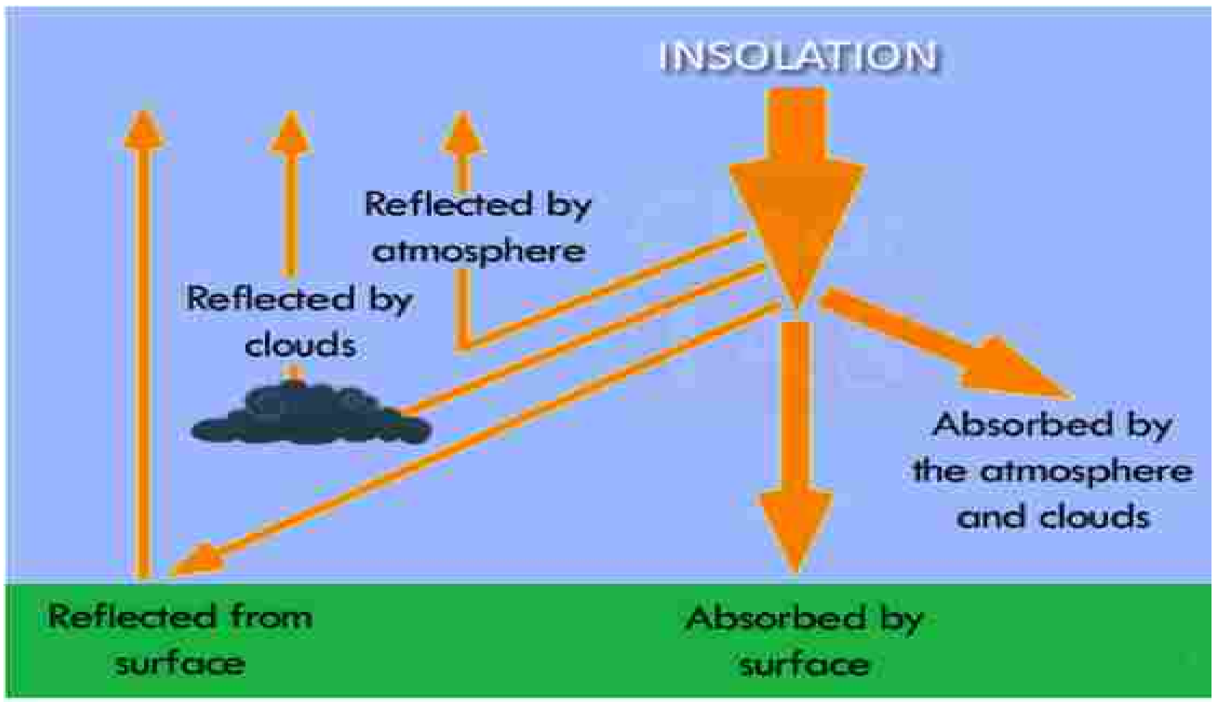
3. Duration of the day

- Duration of the day varies from place to place and season to season. It decides the amount of insolation received on the earth's surface.
- The longer the duration of the day, the greater is the amount of insolation received. Conversely shorter the duration of the day leads to receipt of less insolation.

4. Transparency of the atmosphere

- The transparency of the atmosphere depends upon the cloud cover and its thickness, dust particles, water vapour, etc. They reflect, absorb or transmit insolation.
- Thick cloud hinders the solar radiation to reach the earth's surface. Similarly, water vapour absorbs solar radiation resulting in less amount of insolation reaching the surface.

- When the solar radiation passes through the atmosphere, water vapour, ozone and other gases absorb much of the near infrared radiation (mainly in the troposphere).
- Very small suspended particles in the troposphere scatter visible spectrum both to space and towards the earth's surface. This process adds colour to the sky.
- The red colour of the rising and the setting sun and the blue colour of the sky are the results of scattering of the light within the atmosphere.



Note: Maximum insolation is received over the subtropical desert, where the cloudiness is the least. The equator receives comparatively less insolation than the tropics. Generally, at the same latitude, the insolation is more over the continent than over the oceans. In winter, the middle and higher latitudes receive less radiation than in summer.

Heating and Cooling of the Atmosphere

The sun is the ultimate source of atmospheric heat and energy. There are different ways of heating and cooling of the atmosphere. They are:

1. Terrestrial Radiation
2. Conduction
3. Convection
4. Advection

1. Terrestrial Radiation

Before discussing terrestrial radiation, the following facts about radiation are worth noting.

i) All objects whether hot or cold emit radiant energy continuously.
ii) Hotter objects emit more energy per unit area than colder objects.
iii) The temperature of an object determines the wavelength of radiation. Temperature and wavelength are inversely proportional. Hotter the object, shorter is the length of the wave.

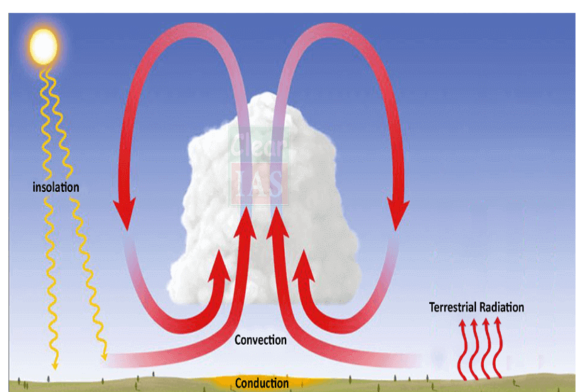
- So, when the earth's surface after being heated up by the insolation (in the form of short waves), it becomes a radiating body.
- The earth's surface starts to radiate energy to the atmosphere in the form of long waves.
- This is what we call as terrestrial radiation. This energy heats up the atmosphere from bottom to top.
- It should be noted that the atmosphere is transparent to short waves and opaque to long waves.
- The long-wave radiation is absorbed by the atmospheric gases particularly by carbon dioxide and other greenhouse gases. Thus, the atmosphere is indirectly heated by the terrestrial radiation.
- The atmosphere, in turn, radiates and transmits heat to space. Finally, the amount of heat received from the sun is returned to space, thereby maintaining a constant temperature at the earth's surface and in the atmosphere.

2. Conduction (transfer of heat by contact)

- Conduction is the process of heat transfer from a warmer object to a cooler object when they come in contact with each other.
- The flow of heat energy continues till the temperature of both the objects become equal or the contact is broken.
- The conduction in the atmosphere occurs at the zone of contact between the atmosphere and the earth's surface.
- Conduction is important in heating the lower layers of the atmosphere.

3. Convection (vertical transfer of heat)

- Transfer of heat by the movement of a mass or substance from one place to another, generally vertical, is called convection.
- The air of the lower layers of the atmosphere gets heated either by the earth's radiation or by conduction. The heating of the air leads to its expansion. Its density decreases and it moves upwards.
- The continuous ascent of heated air creates a vacuum in the lower layers of the atmosphere.



As a consequence, cooler air comes down to fill the vacuum, leading to convection.

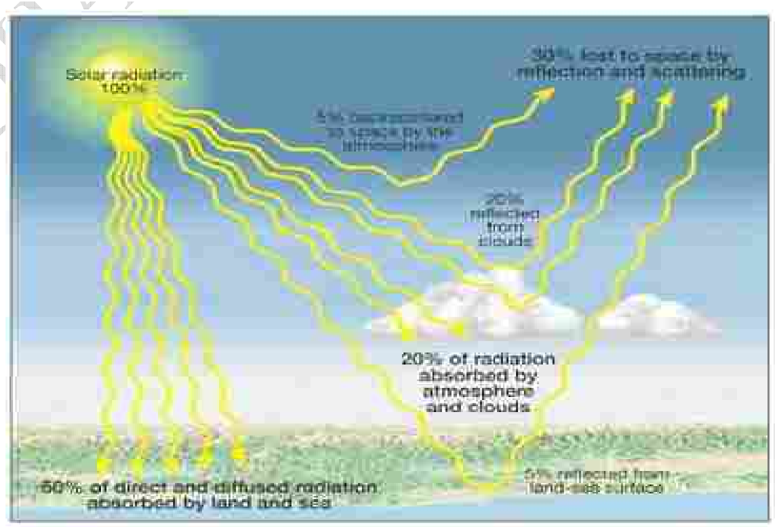
- The cyclic movement associated with the convectional process in the atmosphere transfer heat from the lower layer to the upper layer and heats up the atmosphere.
- The convection transfer of energy is confined only to the troposphere.

4. Advection (horizontal transfer of heat)

- The transfer of heat through horizontal movement of air (wind) is called advection.
- Winds carry the temperature of one place to another. The temperature of a place will rise if it lies in the path of winds coming from warmer regions. The temperature will fall if the place lies in the path of the winds blowing from cold regions.
- Horizontal movement of the air is relatively more important than the vertical movement. In the middle latitudes, most of diurnal (day and night) variations in daily weather are caused by advection alone.
- In tropical regions particularly in northern India during the summer season, local winds called '**Loo'** is the outcome of advection process.

HEAT BUDGET

The earth as a whole does not accumulate or lose heat. It maintains its temperature. This can happen only if the amount of heat received in the form of insolation equals the amount lost by the earth through terrestrial radiation. This balance between the insolation and the terrestrial radiation is termed as the heat budget or heat balance of the earth. This is why the earth neither warms up nor cools down despite the huge transfer of heat that takes place.



While on average, Earth's heat budget is balanced, the interactions that take place as heat and electromagnetic radiation interact with Earth and its many objects, oceans, and atmosphere are complex. Over all they balance out, however, some places are hotter or cooler day in and day out.

Let's consider how heat is absorbed and passed around throughout the many different parts of our planet. Remember that almost all of the heat on Earth was originally created by the Sun. This electromagnetic energy travels towards the Earth at light speed in the form of ultraviolet radiation, visible light, and infrared radiation. When this energy reaches the Earth, immediately 30% of it bounces off, being reflected back out into space. The ability to reflect the light and radiation of the Sun is known as an object's albedo. Because the

Earth reflects 30% of the light that hits it, it is said that the Earth has an albedo of 30. In contrast, our moon has an albedo of 11. This means that if you were standing on the Moon looking up at the Earth, our planet would appear almost 3 times brighter than looking at the Moon from Earth.

Because 30% of the electromagnetic energy from the Sun has been reflected away, only 70% remains to interact with the Earth and warm it up. 20% of the energy from the Sun is absorbed by the atmosphere as a whole heating it up. This leaves 50% of the Sun's energy to heat both the surface of the Earth as well as the oceans, lakes and streams.

Albedo

- Albedo can be simply defined as a measure of how much light that hits a surface is reflected back without being absorbed.
- It is a reflection coefficient and has a value less than one.
- When the solar radiation passes through the atmosphere, some amount of it is reflected, scattered and absorbed.
- The reflected amount of radiation is called as the albedo of the earth.
- The value of albedo will be different for different surfaces.

Surface	Details	Albedo
Soil	Dark and Wet	0.05 –
	Light and Dry	0.40
Sand		0.15 - 0.45
Grass	Long	0.16 –
	Short	0.26
Agricultural Crops		0.18 – 0.25
Tundra		0.18 – 0.25
Forest	Deciduous	0.15 – 0.20
	Coniferous	0.05 – 0.15
Water	Small Zenith Angle	0.03 – 0.10
	Large Zenith Angle	0.10 – 1.00
Snow	Old	0.40 –
	Fresh	0.95
Ice	Sea	0.30 – 0.45
	Glacier	0.20 – 0.40
Clouds	Thick	0.60 – 0.90
	Thin	0.30 – 0.50

Fresh snow > Old Snow > Thick cloud > Thin cloud > Sea ice > Glacier > Dry sand > Dry soil > Grass > Crops > >

- Because of the effect of albedo, highly developed areas such as urban cities can experience higher average temperatures than the surrounding suburban or rural areas, a phenomenon known as the **"Urban Heat Island Effect".**
- The higher average temperature can be attributed to less vegetation, higher population densities, and more infrastructures with dark surfaces (asphalt roads, brick buildings, etc.).

Variation in the net budget at the earth's surface

- Although the earth as a whole maintains a balance between the insolation and the terrestrial radiation, this is not true what we observe at different latitudes.
- As we have discussed earlier, there are variations in the amount of insolation received at different latitudes.
- In the tropical region, the amount of insolation is higher than the amount of terrestrial radiation. Hence it is a region of surplus heat. In the polar region, the heat gain is less than the heat loss. Hence it is a region of deficit heat.
- Thus the insolation creates an imbalance of heat at different latitudes.
- This imbalance is nullified to some extent by winds and ocean currents, which transfer heat from surplus heat regions to deficit heat regions.
- This process of redistribution and balancing of latitudinal heat is commonly known as **Latitudinal Heat Balance.**

PRESSURE BELTS ON EARTH'S SURFACE

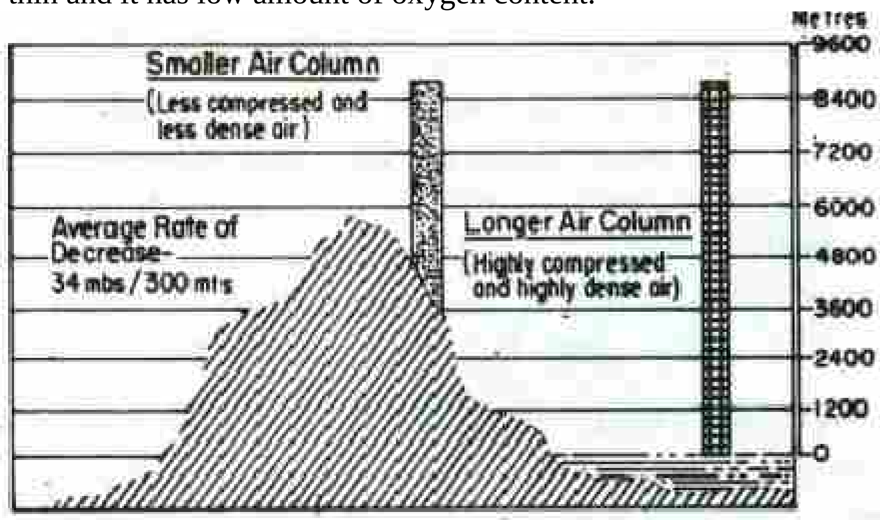
The air, that is a mixture of several gases, exerts pressure through its weight. Air pressure or atmospheric pressure is defined as total weight of a mass of column of air above per unit area at sea level.

Distribution of Air pressure

Distribution of atmospheric pressure on the surface of the earth is not uniform. It varies both vertically and horizontally.

(a) Vertical Distribution

Air is a mixture of various gases. It is highly compressible. As it compresses, its density increases. The higher the density of air, the greater is the air pressure and vice versa. The mass of air above in the column of air compresses the air under it hence its lower layers are more dense than the upper layers; As a result, the lower layers of the atmosphere have higher density, hence, exert more pressure. Conversely, the higher layers are less compressed and, hence, they have low density and low pressure. The columnar distribution of atmospheric pressure is known as vertical distribution of pressure. Air pressure decreases with increase in altitude but it does not always decrease at the same rate. Dense components of atmosphere are found in its lowest parts near the mean sea level. Temperature of the air, amount of water vapour present in the air and gravitational pull of the earth determine the air pressure of a given place and at a given time. Since these factors are variable with change in height, there is a variation in the rate of decrease in air pressure with increase in altitude. The normal rate of decrease in air pressure is 34 millibars per every 300 metres increase in altitude; (see figure 11.1). The effects of low pressure are more clearly experienced by the people living in the hilly areas as compared to those who live in plains. In high mountainous areas rice takes more time to cook because low pressure reduces the boiling point of water. Breathing problem such as faintness and nose bleedings are also faced by many trekkers from outside in such areas because of low pressure conditions in which the air is thin and it has low amount of oxygen content.



Vertical Distribution of Air Pressure

(b) Horizontal Distribution

The distribution of atmospheric pressure over the globe is known as horizontal distribution of pressure. It is shown on maps with the help of isobars. An isobar is a line connecting points that have equal values of pressure. Isobars are analogous to the contour lines on a relief map. The spacing of isobars expresses the rate and direction of change in air pressure. This charge in air pressure is referred to pressure gradient. Pressure gradient is the ratio between pressure difference and the actual horizontal distance between two points. Close spacing of isobars expresses steep pressure gradient while wide spacing indicates gentle pressure gradient (see above fig.) The horizontal distribution of atmospheric pressure is not uniform in the world. It varies from time to time at a given place; it varies from place to place over short distances. The factors responsible for variation in the horizontal distribution of pressure are as follows:

- Air temperature
- The earth's rotation
- Presence of water vapour

(i) Air Temperature:

The earth is not heated uniformly because of unequal distribution of insolation, differential heating and cooling of land and water surfaces. Generally there is an inverse relationship between air temperature and air pressure. The higher the air temperature, the lower is the air pressure. The fundamental rule about gases is that when they are heated, they become less dense and expand in volume and rise. Hence, air pressure is low in equatorial regions and it is higher in polar regions. Along the equator lies a belt of low pressure known as the "equatorial low or doldrums". Low air pressure in equatorial regions is due to the fact that hot air ascends there with gradual decrease in temperatur causing thinness of air on the surface. In polar region, cold air is very dense hence it descends and pressure increases. From this we might expect, a gradual increase in average temperature thords equator. However, actual readings taken on the earth's surface at different places indicate that pressure does not increase latitudinally in a regular fashion from equator to the poles. Instead, there are regions of high pressure in subtropics and regions of low pressure in the subpolar areas

(ii) The Earth's Rotation:

The earth's rotation generates centrifugal force. This results in the deflection of air from its original place, causing decrease of pressure. It is believed that the low pressure belts of the sub polar regions and the high pressure belts of the sub-tropical regions are created as a result of the earth's rotation. The earth's rotation also causes convergence and divergence of moving air. Areas of convergence experience low pressure while those of divergence have high pressure.

(iii) Pressure of Water Vapour:

Air with higher quantity of water vapour has lower pressure and that with lower quantity of water vapour has higher pressure. In winter the continents are relatively cool and tend to develop high pressure centres; in summer they stay warmer than the oceans and tend to be dominated by low pressure, conversely, the oceans are associated with low pressure in winter and high pressure in summer.

Pressure Belts of Earth

On the earth's surface, there are seven pressure belts. They are the Equatorial Low, the two Subtropical highs, the two Subpolar lows, and the two Polar highs. Except the Equatorial low. the others form matching pairs in the Northern and Southern Hemispheres. There is a pattern of alternate high and low pressure belts over the earth. This is due to the spherical shape of the earth—different parts of the earth are heated unequally. The Equatorial region receives great amount of heat throughout the year. Warm air being light, the air at the Equator rises, creating a low pressure. At the poles the cold heavy air causes high pressure to be created/formed. It is also due to the rotation of the earth. In the Subpolar region around latitudes 60° to 65° North and South of the Equator, the rotation of the earth pushes up the bulk of the air towards the Equator, creating a low pressure belt in this region.

(i) Equatorial Low Pressure Belts

This low pressure belt extends from 0 to 5° North and South of Equator. Due to the vertical rays of the sun here, there is intense heating. The air therefore, expands and rises as convection current causing a low pressure to develop here. This low pressure belt is also called as doldrums, because it is a zone of total calm without any breeze.

(ii) Subtropical High Pressure Belts

At about 30°North and South of Equator lies the area where the ascending equatorial air currents descend. This area is thus an area of high pressure. It is also called as the Horse latitude. Winds always blow from high pressure to low pressure. So the winds from subtropical region blow towards Equator as Trade winds and another wind blows towards Sub-Polar Low-Pressure as Westerlies.

(iii) Circum-Polar Low Pressure Belts

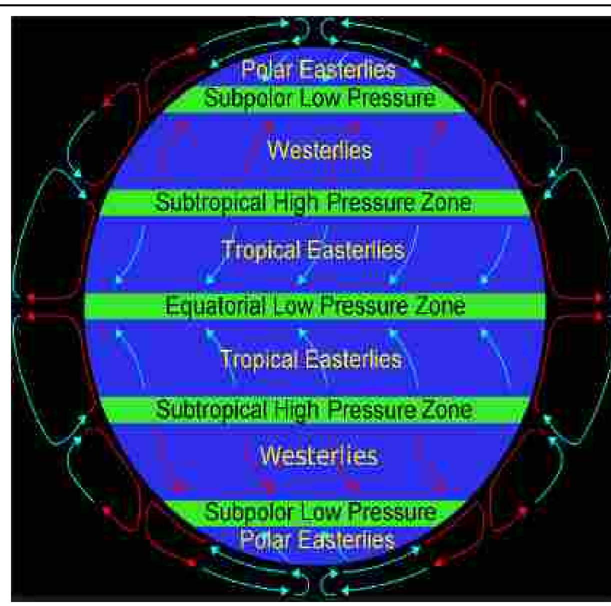
These belts located between 60° and 70° in each hemisphere are known as Circum-Polar Low Pressure Belts. In the Subtropical region the descending air gets divided into two parts. One part blows towards the Equatorial Low Pressure Belt. The other part blows towards the Circum-Polar Low Pressure Belt. This zone is marked by ascent of warm Subtropical air over cold polar air blowing from poles. Due to earth's rotation, the winds surrounding the Polar region blow towards the Equator. Centrifugal forces operating in this region create the low pressure belt appropriately called Circumpolar Low Pressure Belt. This region is marked by violent storms in winter.

(iv) Polar High Pressure Areas

At the North and South Poles, between 70° to 90° North and South, the temperatures are always extremely low. The cold descending air gives rise to high pressures over the Poles. These areas of Polar high pressure are known as the Polar Highs. These regions are characterised by permanent Ice Caps.

Shifting of Pressure Belts

If the earth had not been inclined towards the sun, the pressure belts, as described above, would have been as they are. But it is not so, because the earth is inclined 23 1/2° towards the sun. On account of this inclination, differences in heating of the continents, oceans and pressure conditions in January and July vary greatly.



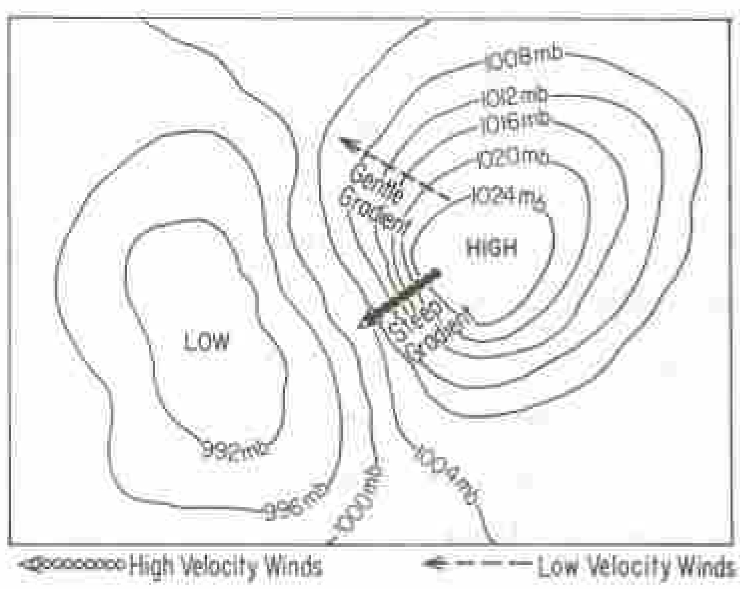
January represents winter season and July, summer season in the Northern Hemisphere. Opposite conditions prevail in the Southern Hemisphere. When the sun is overhead on the Tropic of Cancer (21 June) the pressure belts shift 5° northward and when it shines vertically overhead on Tropic of Capricorn (22 December), they shift 5° southward from their original position.

The shifting of the pressure belts cause seasonal changes in the climate, especially between latitudes 30° and 40° in both hemispheres. In this region the Mediterranean type of climate is experienced because of shifting of permanent belts southwards and northwards with the overhead position of the sun.

During winters Westerlies prevail and cause rain. During summers dry Trade Winds blow offshore and are unable to give rainfall in these regions. When the sun shines vertically over the Equator on 21st March and 23rd September (the Equinoxes), the pressure belts remain balanced in both the hemispheres.

WINDS

We have just studied that air pressure is unevenly distributed. Air attempts to balance the uneven distribution of pressure. Hence, it moves from high pressure areas to low pressure areas. Horizontal movement of air in response to difference in pressure is termed as wind while vertical or nearly vertical moving air is called air current. Both winds and air currents form the system of circulation in the atmosphere.



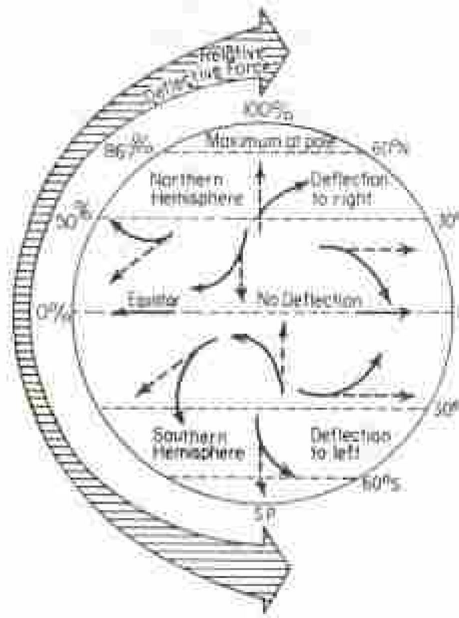
Relationship between Pressure Gradient and Winds

(i) Pressure Gradient and Winds

There is a close relationship between the pressure and the wind speed. The greater the difference in air pressure between the two points, the steeper is the pressure gradient and greater is the speed of the wind. The gentler the pressure gradient slower is the speed of the wind.

(ii) The Coriolis Effect and Wind

Winds do not cross the isobars at right angles as the pressure gradient directs them. They get deflected from their original paths. One of the most potent influences on wind direction is the deflection caused by the earth's rotation on its axis. Demonstrated by Gaspaved de Coriolis in 1844 and known as the Coriolis effect or coriolis force. Coriolis force tend to deflect the winds from there original direction. In northern hemisphere winds are deflected towards their right, and in the southern hemisphere towards their left (see below fig.) This is known as Farrel's law. The Coriolis force is absent along the equator but increases progressively towards the poles.



Deflection of Winds by Coriolis Force

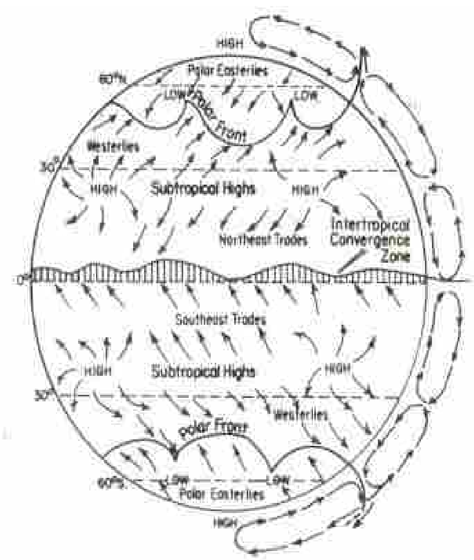
Types of Winds

For ages man has observed that in some areas of the earth the winds blow predominantly from one direction throughout the year; in other areas the wind direction changes with the season and in still others the winds are so variable that no pattern is discernible. Despite these difference, the winds are generalized under three categories.

- planetary winds or permanent winds
- periodic winds and
- local winds

(a) Planetary Winds

Planetary or permanent winds blow from high pressure belts to low pressure belts in the same direction throughout the year. They blow over vast area of continents and oceans. They are easterly and westerlies and polar easterlies.



Planetary Winds

(i) The Easterlies

The winds that blow from sub-tropical high pressure areas towards equatorial low pressure areas called trade or easterly winds: The word trade has been derived from the German word 'trade' which means track. To blow trade means 'to blow steadily and constantly in the same direction'. Because of the Coriolis effect the northern trade winds move away from the subtropical high in north-east direction. In southern hemisphere the trade winds diverge out of the sub-tropical high towards the equatorial low from the southeast direction As the trade winds tend to blow mainly from the east, they are also known as the Tropical easterlies**. (see fig. Planetary Winds)**

In northern hemisphere winds, are deflected towards their right and in the southern hemisphere towards their left. This is known as **Ferrel's law.**

(ii) The Westerlies

The winds that move poleward from the sub-tropical high pressure in the northern hemisphere are detected to the right and thus blow from the south west. These in the southern hemisphere are deflected to the left and blow from the north-west. Thus, these winds are called westerlise **(see fig. Planetary Winds)**

(iii) Polar Easterlies

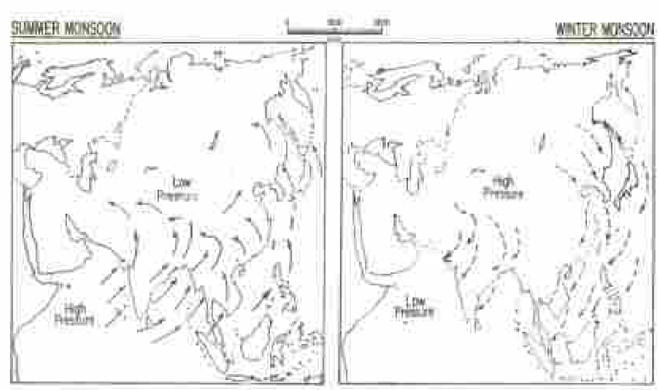
Polar easterlies blow from polar regions towards sub-polar low pressure regions. Their direction in the northern hemisphere is from north-east to southwest and from south-east to north-west in the southern hemisphere.

(b) Periodic Winds

The direction of these winds changes with the change of seasons. Monsoon winds are the most important periodic winds.

Monsoon Winds

The word 'Monsoon' has been derived from the Arabic word '**Mausim'** meaning season. The winds that reverse their direction with the change of seasons are called monsoon winds. During summer the monsoon winds blow from sea towards land and during winter from land towards seas. Traditionally these winds were explained as land and sea breezes on a large scale. But this explanation does not hold good now. Now a days the monsoon is generally accepted as seasonal modification of the general planetary wind system. The Asiatic monsoon is



The Monsoon Winds

the result of interaction of both planetary wind system and regional factors, both at the surface and in the upper troposphere **(see below fig)**

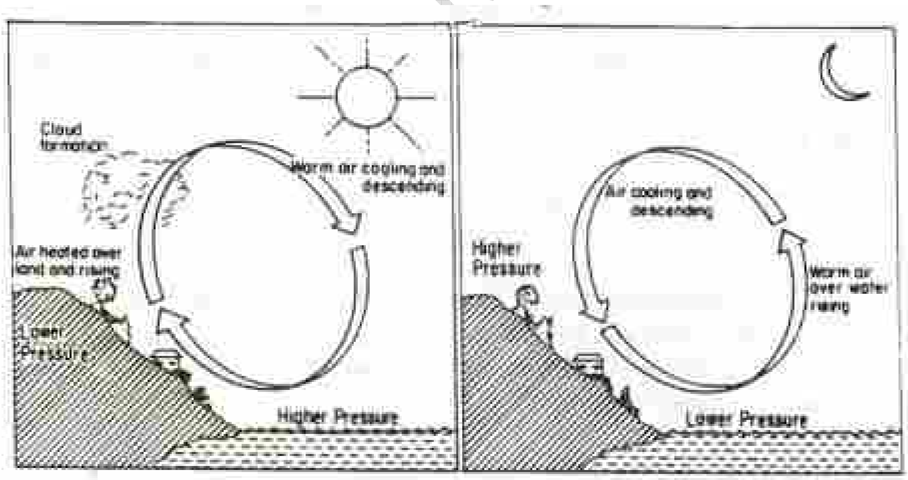
India, Pakistan, Bangladesh, Myanmar(Burma), Sri Lanka, the Arabian Sea, the Bay of Bengal, South-east Asia, North Australia, China and Japan are important regions where monsoon winds are prevalent.

(c) Local Winds

Till now we were discussing the major winds of the earth's surface, which are vital for understanding the climatic regions. But we are all aware that there are winds that affect local weather. Local winds usually affect small areas and are confined to the lower levels of the troposphere. Some of the local winds are given below :

(i) Land and Sea Breezes

Land and sea breezes are prevalent on the narrow strips along the coasts or a lake. It is a diurnal (daily) cycle, in which the differential heating of land and water produces low and high pressures. During the day when landmass gets heated more quickly than the adjoining sea or large lake; air expands and rises. This process produces a local low pressure area on land. Sea breeze then develops, blowing from the water (high pressure) towards the land (low pressure). The sea breeze begins to develop shortly before noon and generally reaches its greatest intensity during mid-day to late afternoon. These cool winds have a significant moderating influence in coastal area.



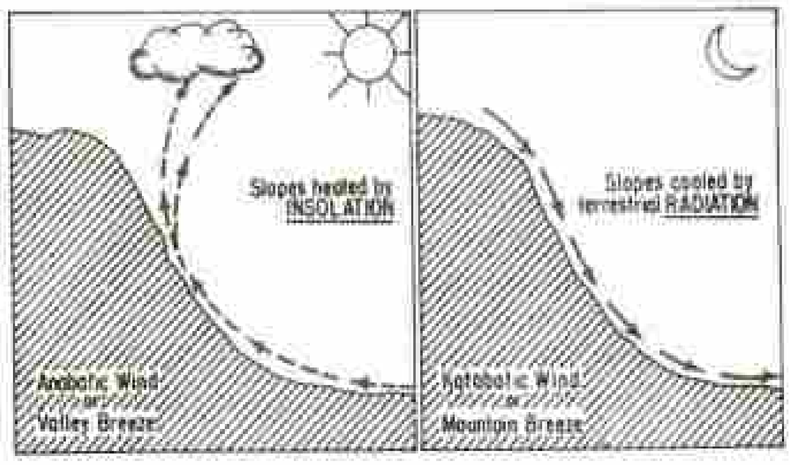
Sea and Land Breezes

At night, the land and the air above it cools more quickly than the nearby water body. As a result, land has high pressure while the sea has comparatively a low pressure area. Gentle wind begins to blow from land (high pressure) towards sea (low pressure). This is known as land breeze **(see above fig.)**

(ii) The Mountain and Valley Breezes

Another combination of local winds that undergoes a daily reversal consists of the mountain and valley breezes. On a warm sunny day the mountain slopes are heated more than the valley floor. Hence, the pressure is low over the slopes while it is comparatively high in the valleys below. As a result gentle wind begins to blow from valley towards slopes and it assumes the name of valley breeze (see below fig.).

After sunset, the rapid radiation takes place on the mountain slopes. Here, high pressure develops more rapidly than on the valley floor. Cold arid heavy air of mountain slopes starts moving down towards the valley floor. This is known as the mountain breeze (see below fig.).



Mountain and Valley Breezes

The valley and mountain breezes are also named as **anabatic** and **katabatic breezes** respectively.

(iii) Hot Winds

Loo, Foehn and Chinook are important hot winds of local category.

(1) Loo

Loo are hot and dry winds, which blow very strongly over the northern plains of India and Pakistan in the months of May and June. Their direction is from west to east and they are usually experienced in the afternoons. Their temperature varies between 45°C to 50°C.

(2) Foehn

Foehn is strong, dusty, dry and warm local wind which develops on the leeward side of the Alps mountain ranges. Regional pressure gradient forces the air to ascend and cross the barrier. Ascending air sometimes causes precipitation on the windward side of the mountains. After crossing the mountain crest, the Foehn winds starts descending on the leeward side or northern slopes of the mountain as warm and dry wind. The temperature of the winds vary from 15°C to 20°C which help in melting snow. Thus making pasture land ready for animal grazing and help the grapes to ripe early.

(3) Chinook

Chinook is the name of hot and dry local wind which moves down the eastern slopes of the Rockies in U.S.A. and Canada. The literal meaning of chinook is 'snow eater' as they help in melting the snow earlier. They keep the grasslands clear of snow. Hence they are very helpful to ranchers.

(iv) Cold Winds

The local cold winds originate in the snow-capped mountains during winter and move down the slopes towards the valleys. They are known by different names in different areas.

(1) Mistral

Mistrals are most common local cold winds. They originate on the Alps and move over France towards the Mediterranean Sea through the Rhone valley. They are very cold, dry and high velocity winds. They bring down temperature below freezing point in areas of their influence. People in these areas protect their orchards and gardens by growing thick hedges and build their houses facing the Mediterranean sea.

TROPICAL AND TEMPERATE CYCLONES

(1) Air Mass

An air mass is an extensive portion of the atmosphere having uniform characteristics of temperature, pressure and moisture which are relatively homogeneous horizontally.

An air mass develops when the air over a vast and relatively uniform land or ocean surface remains stationary for long time to acquire the temperature or moisture from the surface. The major source regions of the air masses are the high latitude polar or low latitude tropical regions having such homogeneous conditions. Air masses, therefore, are of two kinds-polar and tropical air masses. Polar air mass is cold and tropical air mass is warm. When cold air mass and warm air mass blow against each other, the boundary line of convergence separating the two air masses is termed as front. When the warm air mass, moves upward over the cold air mass the front formed in such a situation is called warm front. On the contrary, when the cold air mass advances faster and undercuts the warm air mass and forces the warm air upwards, the front so formed is called cold front. The frontal surface of cold front is steeper than that of a warm front. A prevailing air mass in any region - polar, tropical, maritime or continental largely controls the regions general weather.

(2) Cyclones

Typical cyclones are elliptical arrangement of isobars having low pressure at the centre with a convergence of winds within them. The wind direction in the cyclones is anti clockwise in the northern hemisphere and clockwise in the southern hemisphere. Cyclones are of two types - the temperate or mid latitude cyclones and the tropical or low latitude cyclones **(see above fig.)**

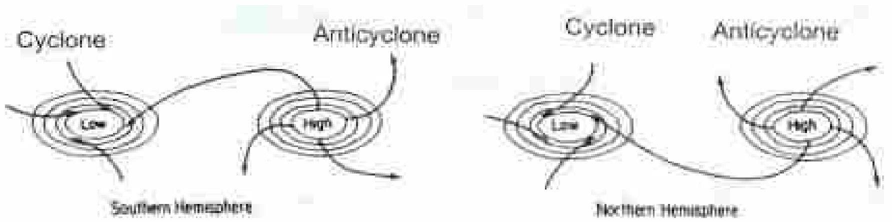
(a) Temperate Cyclones

Temperate cyclones are formed along a front in mid-latitudes between 35° and 65° N and S. They blow from west to east and are more pronounced in winter season.
Atlantic Ocean and North West Europe are major regions of temperate cyclones. They are generally extensive having a thickness of 9 to11 kilometers and with 1040-1920 km short and long diametres respectively. Each such cyclone alternates with a high pressure anticyclone. The weather associated with the cyclone is drizzling rain and of cloudy nature for number of days. The anticyclone weather is sunny, calm and of cold waves.

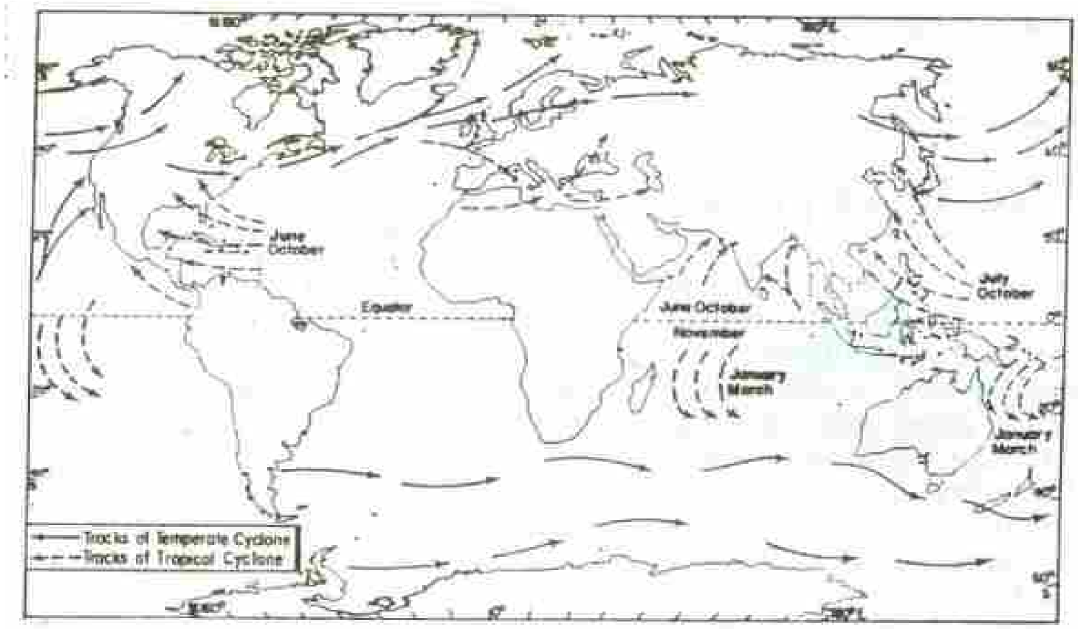
(b) Tropical Cyclones

Tropical cyclones are formed along the zone of confluence of north-east and south-east trade winds. This zone is known as the Inter Tropical Convergence Zone (ITCZ). Cyclones generally occur in Mexico, South-Western and North Pacific Ocean, North Indian Ocean and South Pacific Ocean. These cyclones differ from temperate cyclones in many ways. There are no clear warm and cold fronts as temperature seldom differs in Inter Tropical Convergence Zone. They do not have well-defined pattern of winds and are energised by convectional currents within them.

Generally, these are shallow depressions and the velocity of winds is weak. These are not accompanied by **anticyclones**. The arrangement of isobars is almost circular. These are not extensive and have the diametres of 160-640km. However, a few of them become very violent and cause destruction in the regions of their influence. They are called hurricanes in the Carribean Sea, typhoons in the China, Japan and phillipines, cyclones in the Indian Ocean and willy-willies in Northern Australia **(see below fig.)**



Movement of Wind associated with Cyclones and Anticyclone in Northern and Southern Hemisphere



Tracks of Temperate and Tropical Cyclones

Tropical cyclones often cause destruction on the coasts. You would have heard cyclones striking Indian coasts in summer and autumn months. They cause heavy loss of life and property in these regions. The steeper pressure gradient causing strong high velocity winds and torrential rainfall bursting upon a restricted area combine to create destructive storms. However about 8 to 48 km. area around their centre called the eye of these stormy cyclones remains calm and rainless. If this eye is detected, it is possible for the modern science to stop further development of these strong cyclones and thus protecting us from them.

- An air mass is a large body of air having uniform temperature and moisture contents.
- The boundary line separating two air masses is termed as front.
- Temperate cyclones are prevalent in mid-latitudes while tropicalλ cyclones develop in tropical regions.

Jet streams:

Jet streams are currents of air high above the Earth. They move eastward at altitudes of about 8 to 15 kilometers (5 to 9 miles). They form where large temperature differences exist in the atmosphere.

An air current is a flowing movement of air within a larger body of air. Air currents flow in the atmosphere, the layers of air surrounding the Earth. They form because the sun heats the

Earth unevenly. As the sun beams down on the Earth, it warms some areas, particularly the tropics, more than others, such as the poles. As the Earth is heated, it warms the air just above it. The warmed air expands and becomes lighter than the surrounding air. It rises, creating a warm air current. Cooler, heavier air then pushes in to replace the warm air, forming a cool air current. Jet streams are air currents in the highest part of the atmosphere.

➢ CLOUDS

Clouds are given different names based on their **shape and their height** in the sky. Some clouds are near the ground. Others are almost as high as jet planes fly. Some are puffy like cotton. Others are grey and uniform.

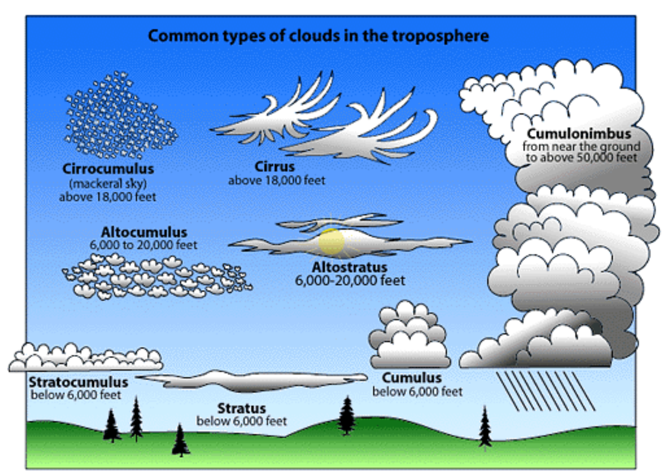
What is a cloud?

- A cloud is an accumulation or grouping of tiny water droplets and ice crystals that are suspended in the earth atmosphere. They are masses that consist of huge density and volume and hence it is visible to naked eyes.
- There are different types of Clouds. They differ each other in size, shape, or colour.
- They play different roles in the climate system like being the bright objects in the visible part of the solar spectrum, they efficiently reflect light to space and thereby helps in the cooling of the planet.
- Clouds are formed when the air becomes saturated or filled, with water vapour. The warm air holds more water vapour than cold air.
- Being made of the moist air and it becomes cloudy when the moist air is slightly cooled, with further cooling the water vapour and ice crystals of these clouds grew bigger and fall to earth as precipitation such as rain, drizzle, snowfall, sleet, or hail.

What are the different types of cloud?

1. Clouds are classified primarily based on – their **shape** and their **altitude.**
Based on **shape**, **clouds** are classified into three. They are:
   1) Cirrus
   2) Cumulus
   3) Stratus

2. Classification of clouds – based on their **altitude (height):**
Based on the height or altitude the clouds are classified into three. They are –



1) High Clouds
2) Middle Clouds
3) Low Clouds

1) High Clouds

- They can reach above 6000 metres or 20,000 feet.
- They are also known as **Cirrus Clouds.**
- They are usually thin and are made up of ice.
- They often indicate fair weather and hence do not produce rain.

Types of High Clouds	Description
Cirrus	They are thin and often wispy cirrus clouds. Typically found at heights greater than 20,000feet (6,000 meters), they are composed of ice crystals that originate from the freezing of supercooled water droplets.
Cirrostratus	They are high, very thin, comprises a uniform layer, and are composed of ice-crystals. It is difficult to detect and is capable of forming halos when the cloud takes the form of thin cirrostratus nebulosus.
Cirrocumulus	They are small rounded puffs shaped clouds that usually appear in long rows high in the sky and are usually white, but sometimes appear grey.

2) Middle Clouds

- They form between 6,500 feet and cirrus level or from 2000 to 6000 metres.
- They are also known as **"Alto"** clouds.
- They frequently indicate an approaching storm.
- They may sometimes produce **Virga**, which is a rain or snow that does not reach the ground.

Types of Middle Clouds	Description
Altostratus	These clouds are in the form of continuous sheet or veil, grey or blue-gray in colour. They are composed of ice crystals and water droplets. In its thinner areas, the sun can still be visible as a round, dim disk. These clouds may often form ahead of storms with continuous rain or snow.
Altocumulus	They are greyish sheet cloud, characterised by globular masses or rolls in layers or patches, the individual elements being larger and darker than those of cirrocumulus and smaller than those of stratocumulus.

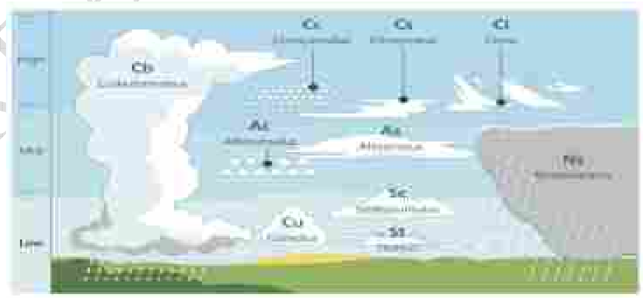
3) Low Clouds

- They lie below 6,500 feet, which means from the surface to 2,000 meters.
- Low clouds are also known as **Stratus Clouds.**
- They may appear dense, dark, and rainy (or snowy) and can also be cottony white clumps interspersed with blue sky.

Types of Low Clouds	Description
Strato Cumulus	Usually arranged in a large dark, rounded or globular masses, usually in groups, lines, or waves.
Stratus	Usually looks like a huge grey blanket that hangs low in the sky that resembles fog, comprises uniform layer and appear dull, if these clouds are warm it means rain and if it is cold it snows.
Nimbostratus	They are known as 'Rain Clouds' and they are dark, thick and accompanied by light to moderately falling precipitation.

4) Great Vertical Extent Clouds

- They are most dramatic types of clouds.
- Great Vertical Extent Clouds are also known as the **Storm Clouds**.
- They rise to dramatic heights, and sometimes well above the level of transcontinental jetliner flights.



Types of Great Vertical Extent Clouds	Description
Cumulus	They are convection clouds, puffy, that sometimes look like pieces of floating cotton. The base of each cloud is often flat and may be only 1000 meters (3300 feet) above the ground. The top of the cloud has rounded towers.
Cumulonimbus	They are dense towering vertical cloud, it's top acquiring an 'Anvil Shape', associated with thunderstorms and atmospheric instability, forming from water vapour carried by powerful upward air currents.

Why clouds appear white in colour?

- The clouds usually appear white because the tiny water droplets and ice crystals inside them are tightly packed, and they reflect most of the sunlight that falls on these masses (scattering).
- The tiny cloud particles equally scatter all colours of light, which make the viewer to perceive all wavelengths of sunlight mixed together as white light.

Why do clouds darken at the time of rain?

- The clouds appear dark or grey in colour at the time of rain is due to their particulate density.
- The water vapour will bind together into raindrops, leaving larger spaces between these drops of water and hence less amount of light is reflected, lending a darker appearance of the rain clouds.

➢ PRECIPITATION

Precipitation has been defined as water in liquid or solid forms falling to the earth. Rain, snow, hail and sleet are the common forms of precipitation. Fog dew, frost are, however, been excluded from precipitation.

Precipitation involves the process of **evaporation, condensation, saturation** and **precipitation**. The process of condensation involves a change from water vapour to liquid, while the process of precipitation the falling out of water as rain, hail or sleet.
Droplets produced by the condensation process are very small in size, averaging less than 10 micrometers in diameter (compare with the human hair which is about 75 micrometers in diameter).

Forms of Precipitation

All forms of precipitation are collectively termed hydrometeors. The major types of precipitation are rain, drizzle, snow, sleet, and hail. A brief account of each one of them has been given as under.

- **Rain**

Rain is precipitation of water in liquid state. The liquid water particle, either in the form of drops or more than 0.5 mm diameter or in the form of smaller widely scattered drops. Whenever the rain drops fall from high altitude clouds, some of them evaporate while passing through a layer of dry air.

- **Drizzle**

When the drops of falling precipitation are very small and of uniform size, and seem to float in the air, It is called as drizzle. Drizzle is fairly uniform precipitation composed exclusively of uniform water drops. They are formed in very low stratus type clouds with high water content. The relative humidity in the inter layers of air between the cloud base and the ground is often nearly 100 per cent, so that the small drops never evaporate in their journey.

- **Snow**

It is precipitation of white and opaque grains of snow. In other words, snow is precipitation of solid water. Generally, in the winter season, when temperatures are below freezing in the whole atmosphere, the ice crystals falling from the alto stratus clouds do not melt and reach the ground as snow.

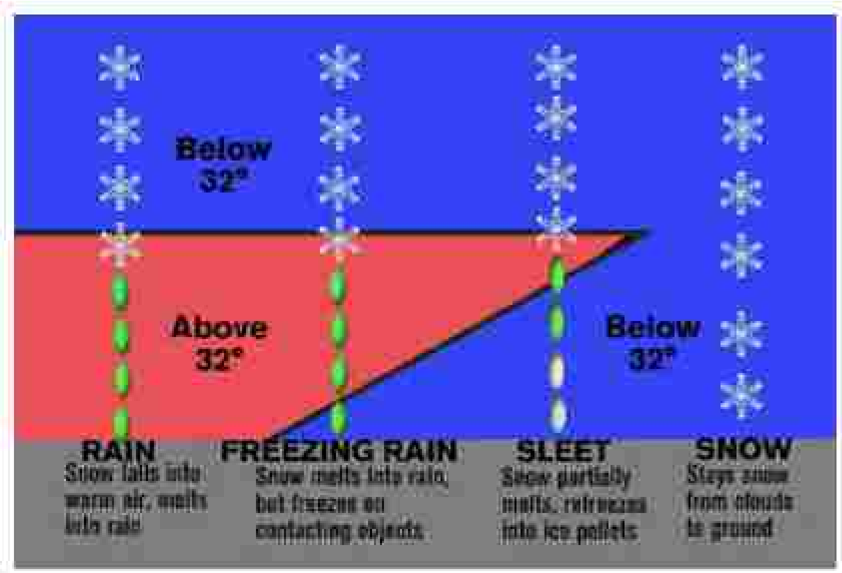
- **Sleet**

Sleet is a type of precipitation in the form of mixture of rain and snow. It is a frozen rain, which forms when rain, while falling to the earth, passes through a layer of cold air and freezes. Sometimes, sleet may grow into hailstorms when violent vertical currents are produced in the atmosphere.

- **Hail**

A type of precipitation which falls in the form of small pellets of ice (hailstones) with a diameter between 5 to 50 mm and sometimes more. Hailstones are generally of pea size or even smaller, but in rare cases they attain the size of a baseball. Hail is the most destructive form of precipitation produced in violent thunder storms or cumulonimbus clouds. The structure of a hail resembles to that of an onion.

Hailstorms seldom occur in the tropics and in the higher latitudes. Oceans are also almost free from them. In both the hemispheres, area lying between 30° to 60° north and south latitudes, have the maximum number of these storms.

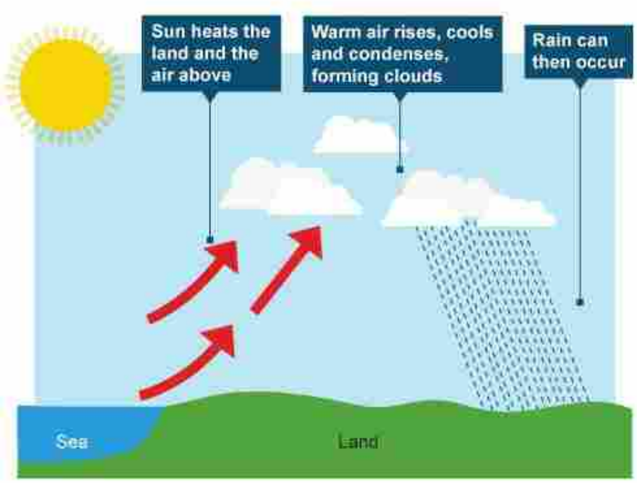


Types of Rainfall (Precipitation)

On the basis of origin, rainfall may be classified into three main types – **the convectional, orographic or relief and the cyclonic or frontal.**

Conventional Rainfall

The, air on being heated, becomes light and rises up in convection currents. As it rises, it expands and loses heat and consequently, condensation takes place and cumulous clouds are formed. This process releases **latent heat of condensation** which further heats the air and forces the air to go further up.



Convectional precipitation is heavy but of **short duration, highly localised** and is associated with minimum amount of cloudiness. It occurs mainly during **summer** and is common over **equatorial doldrums** in the Congo basin, the Amazon basin and the islands of south-east Asia.

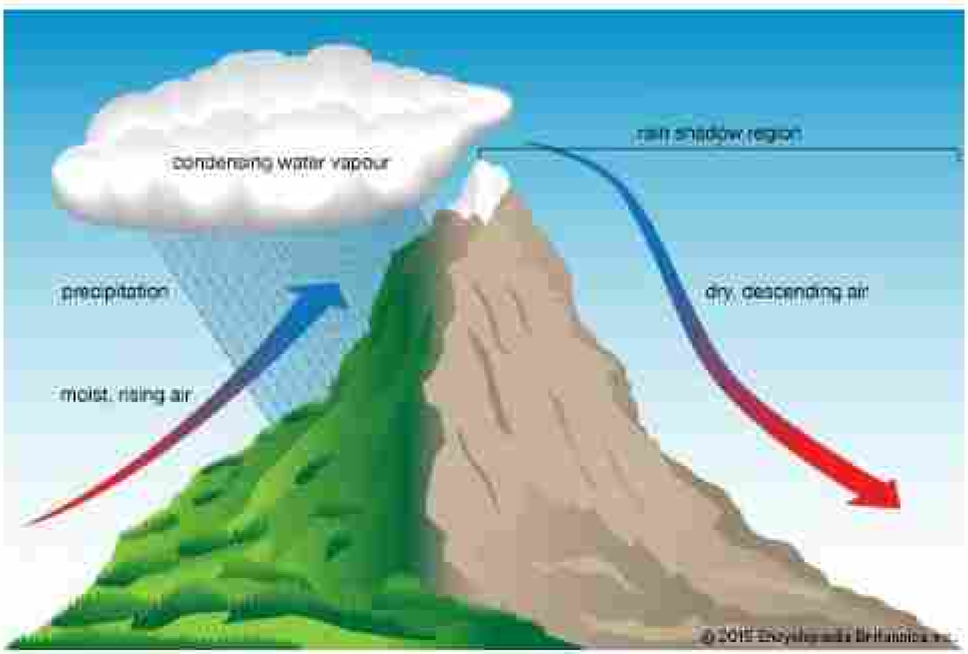
Adiabatic Lapse Rate – Latent Heat of Condensation

Orographic Rainfall

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. This type of precipitation occurs when warm, humid air strikes an orographic barrier (a mountain range) head on. Because of the initial momentum, the air is forced to rise. As the moisture laden air gains height, condensation sets in, and soon saturation is reached. The surplus moisture falls down as orographic precipitation along the windward slopes.

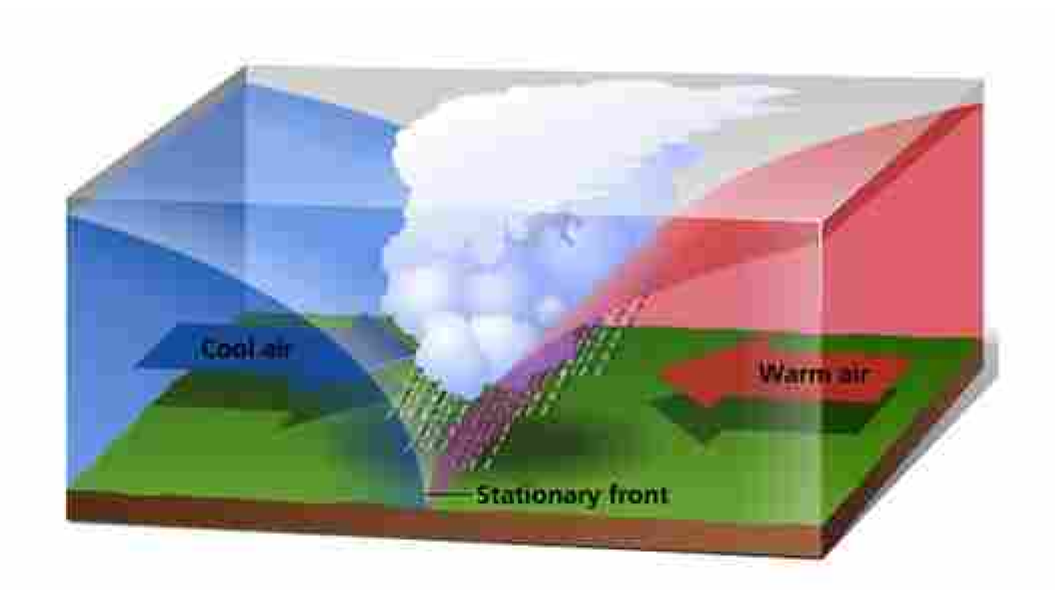
The chief characteristic of this sort of rain is that the **windward slopes** receive greater rainfall. After giving rain on the windward side, when these winds reach the other slope, they descend, and their temperature rises. Then their capacity to take in moisture increases and hence, these **leeward 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.
The Wind Descending on the Leeward Side is heated adiabatically and is called **Katabatic Wind.**



Frontal Precipitation

When two air masses with different temperatures meet, turbulent conditions are produced. Along the front convection occurs and causes precipitation (we studied this in Fronts). For instance, in north-west Europe, cold continental air and warm oceanic air converge to produce heavy rainfall in adjacent areas.

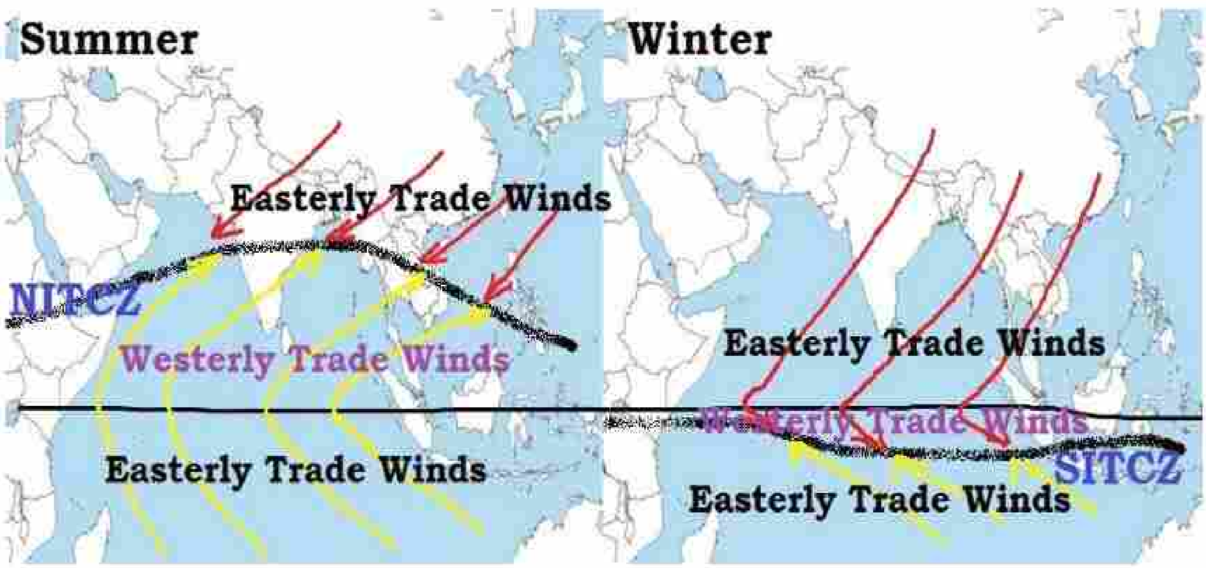


Cyclonic Rain

Cyclonic Rainfall is **convectional rainfall on a large scale**. The precipitation in a tropical cyclone is of convectional type while that in a temperate cyclone is because of frontal activity.

Monsoonal Rainfall

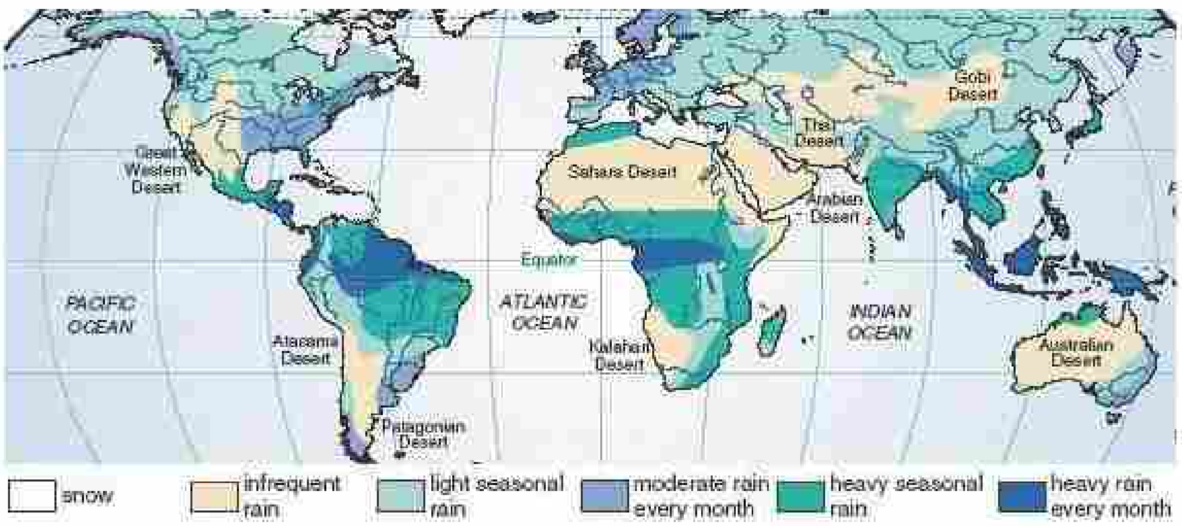
This type of precipitation is characterized by **seasonal reversal of winds** which carry oceanic moisture (especially the south-west monsoon) with them and cause extensive rainfall in south and southeast Asia. (More while studying Indian Monsoons).



World Distribution of Rainfall

- Different places on the earth's surface receive different amounts of rainfall in a year and that too in different seasons. In general, as we proceed from the equator towards the poles, rainfall goes on decreasing steadily.
- The coastal areas of the world receive greater amounts of rainfall than the interior of the continents. The rainfall is more over the oceans than on the landmasses of the world because of being great sources of water.
- Between the latitudes 35° and 40° N and S of the equator, the rain is heavier on the eastern coasts and goes on decreasing towards the west. But, between 45° and 65° N and S of equator, due to the **westerlies**, the rainfall is first received on the western margins of the continents and it goes on decreasing towards the east.
- Wherever mountains run parallel to the coast, the rain is greater on the coastal plain, on the windward side and it decreases towards the leeward side.
- On the basis of the total amount of annual precipitation, major precipitation regimes of the world are identified as follows.
- The equatorial belt, the windward slopes of the mountains along the western coasts in the cool temperate zone and the coastal areas of the monsoon land receive heavy rainfall of over 200 cm per annum.
- Interior continental areas receive moderate rainfall varying from 100 – 200 cm per annum. The coastal areas of the continents receive moderate amount of rainfall.

- The central parts of the tropical land and the eastern and interior parts of the temperate lands receive rainfall varying between 50 – 100 cm per annum.
- Areas lying in the **rain shadow zone** of the interior of the continents and high latitudes receive very low rainfall – less than 50 cm per annum.
- Seasonal distribution of rainfall provides an important aspect to judge its effectiveness. In some regions rainfall is distributed evenly throughout the year such as in the equatorial belt and in the western parts of cool temperate regions.



➢ CLIMATE AND DIFFERENT WORLD CLIMATES

Introduction

Climate holds an important place in our own life. Our life and various economic activities (agriculture, industries, commerce, etc.) are affected by climate. Climate has also an important place in physical geography. Climate is a measure of the average pattern of variation in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other meteorological variables in a given region over long periods of time. Any independent study of each of these elements does not present any comprehensive view of climate. On the basis of these elements, there could be thousands of types of climates in the world.

Elements of climate

There are various environmental elements which have significant influence on the climate of a region. Among them, temperature, pressure, precipitation and winds are the most important because of their far reaching global influence. These elements are affected in different manner by the following climatic factors: latitude, altitude, continentality, ocean currents, insolation, prevailing winds, slope and aspect, natural vegetation and soil.

Factors affecting climate Latitude:

Due to the earth's inclination, the mid-day sun is almost overhead within the tropics but the sun's rays reach the earth at an angle outside the tropics. Thus, temperature diminishes from equatorial regions to the poles.

Altitude:

Earth’s atmosphere is mainly heated through conduction from the surface, so places near the surface are warmer than those higher up. Thus temperature decreases with increasing height above sea level. This rate of decrease in temperature with altitude (lapse rate) is never constant, varying from place to place and from season to season. However, for all practical purposes, it may be reckoned that a fall of 6.5°C occurs with an ascent of 1000 meters or 1o C per 165 meters.

Continentality (Distance from sea):

Land surfaces have higher specific heat capacity of heat as compared to water bodies i.e. it takes less energy to raise the temperature of a given volume of land by 1o C as compared to same volume of water body. This accounts for temperature extremes in the continental interiors as compared to maritime areas.

Oceans Currents:

Marine areas are influenced by the warm or cold ocean currents. Ocean currents like the Gulf Stream or the North Atlantic Drift warm the coastal districts of Western Europe keeping their ports ice-free. Ports located in the same latitude but washed by cold currents, such as the cold Labrador Current off north-east Canada, are frozen for several months. Cold currents also lower the summer temperature, particularly when they are carried landwards by on-shore winds.

Local winds:

If winds are warm i.e. they have been blown from a hot area, they will raise temperatures. If winds have been blown from cold areas, they will lower temperatures. Local winds like Fohn, Chinook, Sirocco and Mistral also produce marked changes in temperature.

Relief and Topography:

Climate can be affected by mountains. Mountains receive more rainfall than low lying areas because as air is forced over the higher ground it cools, causing moist air to condense and fall out as rainfall. The higher the place is above sea level the colder it will be. This happens because as altitude increases, air becomes thinner and is less able to absorb and retain heat.

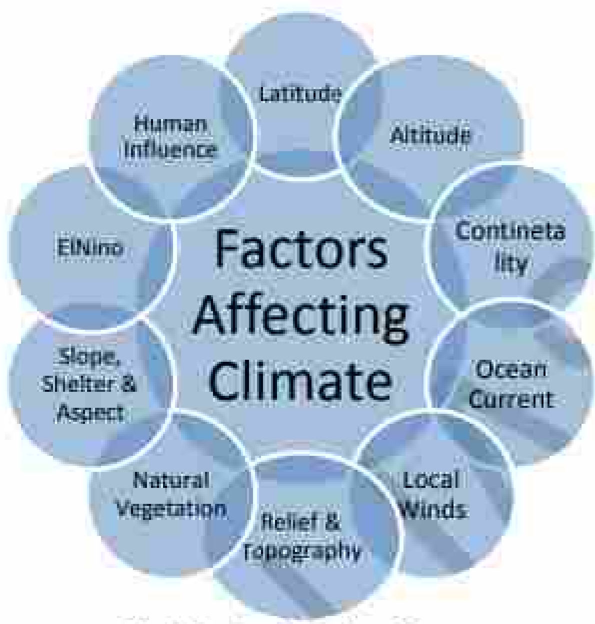


Fig 1: Factors Affecting Climate

Natural Vegetation and Soil:

Natural vegetation affects the temperature of the region significantly. Often areas with dense forest cover like areas in thick foliage of Amazon jungles receive less insolation and are, often, cooler than the areas in open space. Light soils reflect more heat than darker soils which are better absorbers. Such soil differences may give rise to slight variations in the temperature of the region. As a whole, dry soils like sands are very sensitive to temperature changes, whereas wet soils, like clay, retain much moisture and warm up or cool down more slowly.

Slope, Shelter and Aspect:

A steep slope experiences much rapid change in temperature as compared to a gentle slope. Mountain ranges that have an east-west alignment like the Alps show a higher temperature on the south-facing 'sunny slope' than the north facing 'sheltered slope'. The greater insolation of the southern slope is better suited for vine cultivation and has a more flourishing vegetative cover. Consequently, there are more settlements and it is better utilised than the **'shady slope'**.

El Niño Effect:

El Niño, which affects wind and rainfall patterns, has been blamed for droughts and floods in countries around the Pacific Rim. **El Niño refers to the irregular warming of surface water in the Pacific.** The warmer water pumps energy and moisture into the atmosphere, altering global wind and rainfall patterns. The phenomenon has caused tornadoes in Florida, smog in Indonesia, and forest fires in Brazil. El Niño is Spanish for 'the Boy Child' because it comes about the time of the celebration of the birth of the Christ Child. **The cold counterpart to**

El Niño is known as La Niña, Spanish for 'the girl child', and it also brings with it weather extremes.

Human Influence:

The factors above affect the climate naturally. However, we cannot forget the influence of humans on our climate. Early on in human history our effect on the climate would have been quite small. However, as populations increased and trees were cut down in large numbers, so our influence on the climate increased. The number of trees being cut down has also increased, reducing the amount of carbon dioxide that is taken up by forests.

Classification of climate

If we were to compare the climates of different places on the basis of climatic elements, we would come across many such places which would have similarity between one and more of these elements. On the basis of these very regional similarities and differences of climatic elements, attempts have been made to classify climate for easy understanding, description and analysis.

Three broad approaches have been adopted for classifying climate. They are empirical, genetic and applied. Empirical classification is based on observed data, particularly on temperature and precipitation. Genetic classification attempts to organise climates according to their causes. Applied classification is for specific purpose.

Koeppen Classification: The most widely used classification of climate is the climate classification scheme developed by German climatologist and plant geographer V. Koeppen. in 1918. The annual as well as monthly averages of temperature and precipitation formed the basis of Koeppen classification of climate.

He also based his classification on the distribution of weather conditions. This classification is both empirical and genetic type. Koeppen in his classification laid great emphasis that all the characteristics of climate can well be expressed through the distribution of natural vegetation that's why he tried to associate his climate types with vegetation zones of the world.

He made use of annual averages of temperature and precipitation in fixing the climate regions of the world. He presented five main climate types. Each of these climate types was represented by capital English alphabets of A, B, C, D and E. He used the letter 'H' for highland type of climates. While keeping temperature and precipitation variations in view these five climate types were further subdivided as shown in the above following table.

Sr. No.	Chief Climatic Groups	Climatic Types
A	Tropical Climate (Average temperature of the coldest month is 18° C or higher)	1. Tropical rain forest type climate 2. Savannah type climate 3. Monsoon type climate
B	Dry Climate (Potential evaporation exceeds precipitation)	4. Desert climate 5. Steppe (Semi-desert) climate
C	Temperate Climate (The average temperature of the coldest month is higher than minus 3°C but below 18°C)	6. Mediterranean climate 7. China type climate 8. West European type climate
D	Continental Climate (The average temperature of the coldest month is minus 3° C or below)	9. Taiga climate 10. Eastern coastal cold climate 11. Continental climate
E	Polar Climate (Average temperature for all months is below 10° C)	12. Tundra climate 13. Snow-capped region type climate
H	Highland Climate (Cold due to elevation)	

Thornthwaite Classification:

Thornthwaite was an American climatologist. He presented his first climate classification in 1931. In 1931, his classification looked similar to Koeppen. Like Koeppen, Thornthwaite also thought that vegetation is the indicator of climate type. Two basic features of this classification are (i) Precipitation Effectiveness, (ii) Temperature Efficiency. On the basis of these two indicators, Thornthwaite divided the world into five humidity regions. Each region had its own special type of vegetation as shown in the table below:

Sr. No.	Humidity Region	Special type of Vegetation
A	Very Humid	Rain Forest
B	Humid	Forest
C	Semi Humid	Grassland
D	Semi Dry	Steppe
E	Dry	Desert

On the basis of distribution of seasonal rainfall the above types of humidity regions were further divided into following subdivisions:

Y = Heavy rainfall in all seasons

s = Scarcity of rainfall in summer season

w = Scarcity of rainfall in winter season

d = Scarcity of rainfall in all seasons

After linking precipitation effectiveness and seasonal distribution of rainfall to temperature anomalies, the climates could be of 120 different types.

Global Climate Classification

The global climatic conditions can be studied under the following twelve classifications.

Climatic Zone	Latitude (Approximate)	Climatic Type	Rainfall Regime (with approx. total)	Natural Vegetation
Equatorial Zone	0^0-10^0N and S	1. Hot. wet equatorial	Rainfall all year round : 80 inches	Equatorial rain forests
Hot Zone	10^0-30^0N and S	2. a) Tropical Monsoon b) Tropical Marine	Heavy summer rain: 80 inches Much summer rain: 70 inches	Monsoon forests
		3. Sudan Type	Rain mainly in summer: 30 inches	Savanna (tropical grassland)
		4. Desert: a) Saharan type b) Mid-latitude type	Little rain: 5 inches	Desert vegetation and scrub
Warm Temperate Zone	30-^{0}40^{0}N & S	5. Western Margin (Mediterranean type)	Winter rain: 35 inches	Mediterranean forests and shrub
		6. Central Continental (Steppe type)	Light summer rain: 20 inches	Steppe or temperate grassland
		7. Eastern Margin: a) China type b) Gulf type c) Natal type	Heavier summer rain : 20 inches	Warm, wet forests and bamboo

Cool Temperate Zone	45^0-65^0N & S	8. Western Margin (British type)	More rain in autumn & winter: 30 inches	Deciduous forests
		9. Central Continental (Siberian type)	Light summer rain: 25 inches	Evergreen coniferous forests
		10. Eastern Margin (Laurentian type)	Moderate summer rain : 40 inches	Mixed forests (coniferous and deciduous)
Cold Zone	65^0-90^0 N & S	11. Arctic or Polar	Very light summer rain : 10 inches	Tundra, mosses, lichens
Alpine Zone		12. Mountain climate	Heavy rainfall (variable)	Alpine pastures, conifers, fern, snow

The Hot, Wet Equatorial Climate

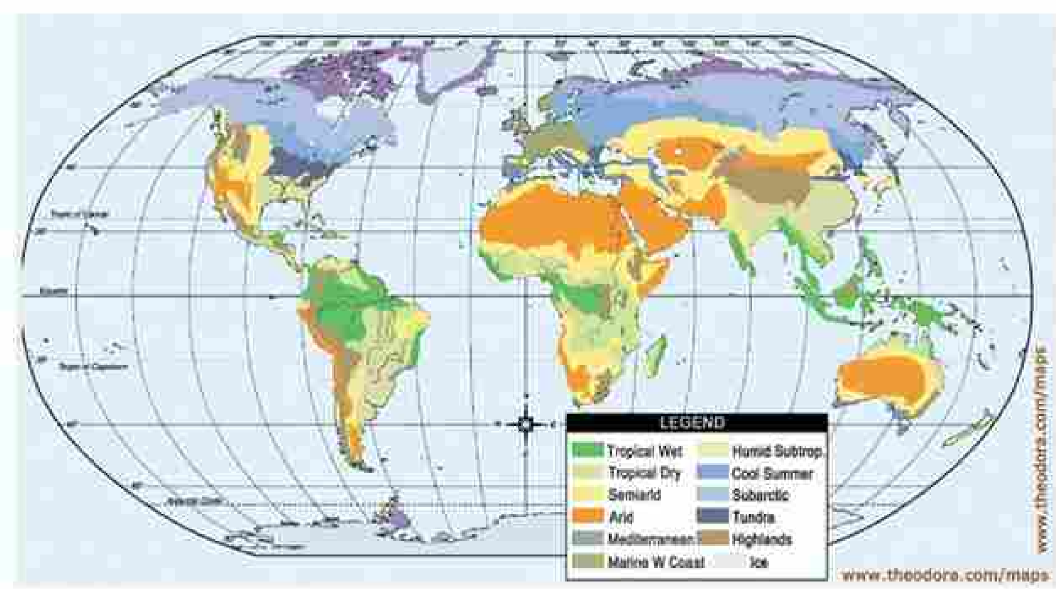
Distribution

The equatorial, hot, wet climate is found between 5o and 10 o north and south of the equator. Its greatest extent is found in the lowlands of the Amazon, the Congo, Malaysia and the East Indies. Further away from the equator, the influence of the on-shore Trade Winds, gives rise to a modified type of equatorial climate with monsoonal influences

Climatic Zones of the World

Introduction

The world has several climatic zones. These are summarized on the map below.



1. Tropical Moist Climates (Af)

- *Average temperature: 18 °C (°F)*
- *Annual Precipitation: 262 cm. (103 in.)*
- *Latitude Range: 10° S to 25 ° N*
- *Global Position: Amazon Basin; Congo Basin of equatorial Africa; East Indies, from Sumatra to New Guinea.*

- This climate is located upto 50 to 100 latitudes on both the hemispheres.
- The zone is subjected to seasonal shifting due to northward and southward movement of Sun.
- The tropical climate is characterized by two major properties – uniformly high temperature throughout the year and uniformly adequate rainfall throughout the year by convectional rainfall. The total annual rainfall is often more than 250 cm.
- Humidity is between 77 and 88%.
- The equatorial climate is found in – The Amazon Basin in South America, Congo Basin in Africa, Guinea coast in Africa, Java, Sumatra, Malaysia etc.
- The climates on eastern sides of continents are influenced by maritime tropical air masses. These air masses flow out from the moist western sides of oceanic high-pressure cells, and bring lots of summer rainfall. The summers are warm and very humid. It also rains a lot in the winter.
- This region accounts for the largest number of plant species due to high temperature and high rainfall.
- This climatic region is characterized by broad leaf evergreen dense forests comprising mahogany, rosewood, bamboos, sandal etc.

2. Wet-Dry Tropical Climates (Aw) savanna

- *Temperature Range: 16 °C*
- *Annual Precipitation: 0.25 cm. (0.1 in.). All months less than 0.25 cm. (0.1 in.)*
- *Latitude Range: 15 ° to 25 ° N and S*
- *Global Range: West Africa, southern Africa, South America and the north coast of Australia*

- This type of climate is located between 50 – 200 latitudes on either side of the equator.
- This climatic type is bounded by tropical rainforest climate towards the equator and by dry climate towards the poles.
- The Savanna type is found in the southern continents and all the regions are to the south of the Tropic of Cancer.
- These are

a) South America: Cuba, Jamaica and the islands in the Pacific.
b) Africa: The Sudan, large parts of the newly formed Republics – Senegal, Guinea, Mali, Niger, Chad and also in Ghana, Togo, Kenya, Zimbabwe, Tanzania, Angola and Uganda.
c) Australia: The northern region and Queensland.

- The Savanna climate is characterized by distinct wet and dry seasons, mean high temperature throughout the year and high insolation.
- There is sunshine for 13 to 14 hours and humidity is low, the air is hot, dry and dusty.
- The average monthly temperature during the dry season ranges between 22°C and 37°C.
- Coastal regions on the windward side of the mountains get heavier rain. Rainfall decreases as one goes either towards north (in the Northern Hemisphere) or towards south (in the Southern Hemisphere).
- The Savanna vegetation marks the transition from the dense equatorial forests, where the rainy season lasts practically throughout the year, and the semi-desert and deserts where the dry season lasts practically throughout the year.
- The seasonal rain allows only grass to grow. These are therefore the natural grasslands of the world. Rainfall is not sufficient to support tall trees but grass grows well and one variety known as the elephant grass grows up to four and a half metres.
- Trees occur more as one goes towards the Equator.

3. Hot Desert Climate

- *Temperature Range: 16° C*
- *Annual Precipitation: 0.25 cm (0.1 in). All months less than 0.25 cm (0.1 in).*
- *Latitude Range: 15° - 25° N and S.*
- *Global Range: southwestern United States and northern Mexico; Argentina; North Africa; South Africa; central part of Australia.*

- This type of climate is located between the latitudinal belt of 150 – 300 in both the hemispheres.
- The arid deserts lie close to the Tropic of Cancer and Tropic of Capricorn in the western margins of continents.
- The climatic zone lies in – The Sahara, the Arabia, the Thar, Mohave and Sonoran (South Western U.S.A.), Kalahari and Namib (South Western Africa), Simpson, Gibson, Great Sandy (Australia)
- The climate is dominated by the subsidence of air masses and marked stability of the sub-tropical anticyclones and hence nearly rainless. The highest temperatures in the world are recorded here (Azazia 58.7°C). The greatest daily ranges of temperature of (15°C) are seen here.
- These areas receive the lowest annual rainfall (12 to 15 cm). Cold currents also influence the climate on the western margins of continents. The aridity is intensified because of these currents which chill the air and further stabilize it.
- The vegetation found here is cactus, thorny plants, shrubs, herbs.

4. Steppe Climate

- *Temperature Range: 24° C (43° F).*
- *Annual Precipitation: less than 10 cm (4 in) in the driest regions to 50 cm (20 in) in the moister steppes.*
- *Latitude Range: 35° - 55° N.*
- *Global Range: Western North America (Great Basin, Columbia Plateau, Great Plains); Eurasian interior, from steppes of eastern Europe to the Gobi Desert and North China.*

- This type of climatic zone is found between 40° and 55° North and South. They lie far away from the influence of the sea, in the heart of continents.
- The areas are – Prairies (North America), Pampas (South America), Velds (South Africa), Downs (Australia) and Steppes (Russia)
- The temperature in summer varies from 18°C to 24°C and in winter from – 4°C to 2°C. The range of temperature is large. Rainfalls in spring and early summer and vary between 23 cm. and 65 cm. It is of convectional type but very light.
- This dry climate exists in the interior regions of the North American and Eurasian continents. Moist ocean air masses are blocked by mountain ranges to the west and south. These mountain ranges also trap polar air in winter, making winters very cold. Summers are warm to hot.
- Short grass grows everywhere. Trees appear only on the slopes of mountains.

5. Monsoon Climate

- *Temperature Range: 27.05 °C*
- *Latitude Range: 10° and 25° and North and South of the equator.*
- *Global Range: The countries are along the coastal regions of southwest India, Sri Lanka, Bangladesh, Myanmar, South western Africa, French Guiana, and northeast and southeastern Brazil.*

- Monsoon climate is generally related to those areas which register complete seasonal reversal of wind direction and are associated with tropical deciduous forests. The region lies between 10°N to 30°N and 10°S to 30°S latitude.
- Climatic zone areas are – Eastern Brazil (S. America), Central American countries, Natal coast (South Africa), India, Pakistan and Bangladesh, South East Asia including Burma, Thailand, Vietnam and the Philippines etc., Parts of East Africa including Malagasy, North Australia.
- The annual average temperature is about 26°C and the annual range is about 3°C. The maximum temperatures occur in May before the summer rainfall maximum in June and July. The annual rainfall amounts to about 300 cm.

- The characteristic feature of this type of climate is a reversal in the wind direction with the change of season.
- During the summer season, the wind is on shore, bring large amount of moisture to the land surface. Rainfall is both orographic and cyclonic in nature.
- In winter season the wind is off shore and hence is cool and dry. But some parts like Madras coast get rain during this season because winds are on shore there.

6. Mediterranean Climate:

- *Temperature Range: 7 °C (12 °F)*
- *Annual Precipitation: 42 cm (17 in).*
- *Latitude Range: 30° - 50° N and S*
- *Global Position: central and southern California; coastal zones bordering the Mediterranean Sea; coastal Western Australia and South Australia; Chilean coast; Cape Town region of South Africa.*

- This type of climate has developed between 300 – 400 latitudes in both the hemispheres.
- This is a wet-winter, dry-summer climate. Extremely dry summers are caused by the sinking air of the subtropical highs and may last for up to five months.
- This climatic region includes European, Asiatic and African lands bordering the Mediterranean Sea.
- This climate owes its origin to the seasonal shifting of wind and pressure belts due to northward and southward migration of the sun.
- In winter they are under the influence of westerlies which are moisture laden thus brings rainfall in winters whereas they come under the influence of subtropical high pressure belt in summers thus associated with anti cyclonic conditions.
- Plants have adapted to the extreme difference in rainfall and temperature between winter and summer seasons. Sclerophyll plants range in formations from forests, to woodland, and scrub. Eucalyptus forests cover most of the chaparral biome in Australia.
- Fires occur frequently in Mediterranean climate zones.

7. Taiga Climate

- *Temperature Range: lows; -25 °C (-14 °F), highs; 16 °C (60 °F).*
- *Average Annual Precipitation: 31 cm (12 in).*
- *Latitude Range: 50° – 70° N and S.*
- *Global Position: central and western Alaska; Canada, from the Yukon Territory to Labrador; Eurasia, from northern Europe across all of Siberia to the Pacific Ocean.*

- This climate type has been named after the coniferous forest cover of the same name found in the region. the region extends from 50-55 degrees to 60-70 degrees latitudes in northern hemisphere.
- It stretches as an almost continuous belt across southern Canada, northern Europe and Russia. The Tundra region lies on the north and the Temperate Grasslands on the south.
- The areas are – Southern Alaska, Southern Canada, parts of Norway, Sweden, Finland, Northern Russia, Northern Siberia, Sakhalin Island.
- Winters are very cold and severe from 6 to 7 months with temperatures below freezing. In this region lies Verkhoyansk the "cold pole" colder than the Arctic region.
- Summers are short lasting for 3 or 4 months but the days are long; at 60°N the sun shines for over 18 hours.
- Rainfall varies from 25 to 100cm. There is more rainfall near the coast. Most of the rain comes from cyclonic weather. It falls throughout the year but maximum in summer in frequent showers. In winter it takes the form of snow, which may remain, on the ground from 5 to 7 months.
- The vegetation associated with this climate type is the soft-wood coniferous forests.

8. Tundra Climate

· *Temperature Range: -22 °C to 6 °C (-10 °F to 41 °F).*

· *Average Annual Precipitation: 20 cm (8 in).*

· *Latitude Range: 60° – 75° N.*

· *Global Position: arctic zone of North America; Hudson Bay region; Greenland coast; northern Siberia bordering the Arctic Ocean.*

- The tundra climate is found along arctic coastal areas. Polar and arctic air masses dominate the tundra climate.
- The winter season is long and severe. A short, mild season exists, but not a true summer season. Moderating ocean winds keep the temperatures from being as severe as interior regions.

➢ MOVEMENTS OF OCEAN WATERS

Movements of ocean water: The classification

You all know that the ocean water is never still. There are different types of movements of ocean water under the influence of different physical characteristics like temperature, salinity, density, etc. Movements of ocean water are also affected by external forces like the sun, moon and the winds.

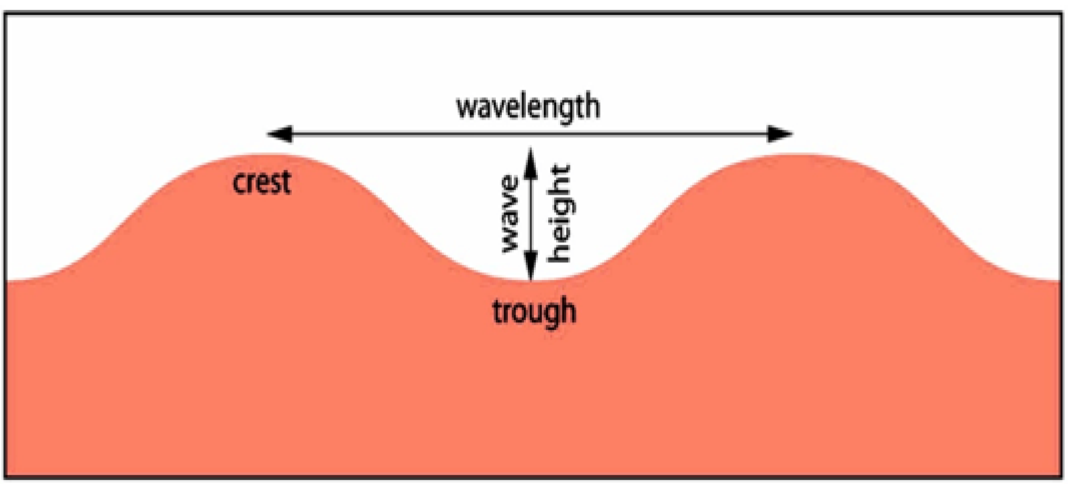
The major movements of the ocean waters can be classified into three. They are:

1) Waves
2) Tides
3) Ocean Currents

Waves and the ocean currents are horizontal movements of ocean waters while the tide is a kind of vertical movement of the ocean water.

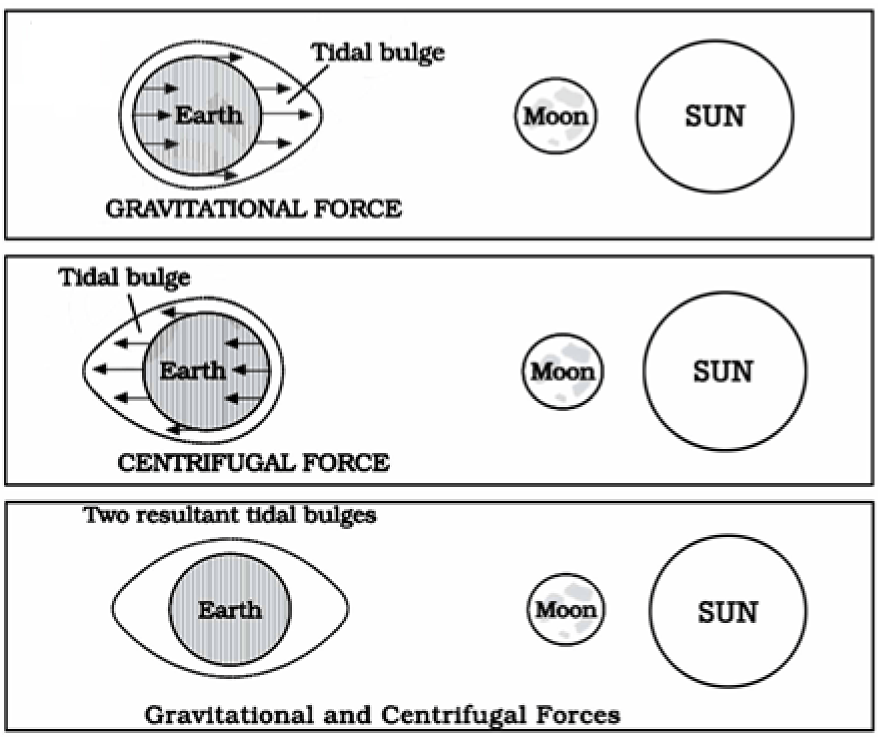
Waves

- Waves are nothing but the **oscillatory movements** that result in the rise and fall of water surface.
- Waves are a kind of horizontal movements of the ocean water.
- They are actually the energy, not the water as such, which moves across the ocean surface.
- This energy for the waves is provided by the **wind**.
- In a wave, the movement of each water particle is in a circular manner.
- A wave has two major parts: the raised part is called as the **crest** while the low-point is called as the **trough**.



Tides

- Tide are the **periodical rise and fall of the sea levels,** once or twice a day, caused by the combined effects of the gravitational forces exerted by the sun, the moon and the rotation of the earth.
- They are a vertical movement of waters and are different from movements of ocean water caused by meteorological effects like the winds and atmospheric pressure changes.
- Note: The water movements which are caused by the meteorological effects like the said above are called as **surges** and they are not regular like tides.
- The moon's gravitational pull to a great extent is the major cause of the occurrence of tides (the moon's gravitational attraction is more effective on the earth than that of the sun).
- Sun's gravitational pull and the centrifugal force due to the rotation of earth are the other forces which act along with the moon's gravitational pull.



- The highest tides in the world occur in the Bay of Fundi in Canada.
- When the tide is channeled between islands or into bays and estuaries, they are termed as Tidal Currents.
- The regular interval between two high or two low tides is 12 hours 25 minutes.

FLOW TIDE AND EBB TIDE

- A **flow tide or a flood tide** is a **rising tide or incoming tide** which results in a high tide.
- It is thus the time period between a low tide and a high tide (i.e., the rising time).
- **Ebb Tide** is the **receding or outgoing tide**. It is the period between high tide and low tide during which water flows away from the shore.

Types of Tides

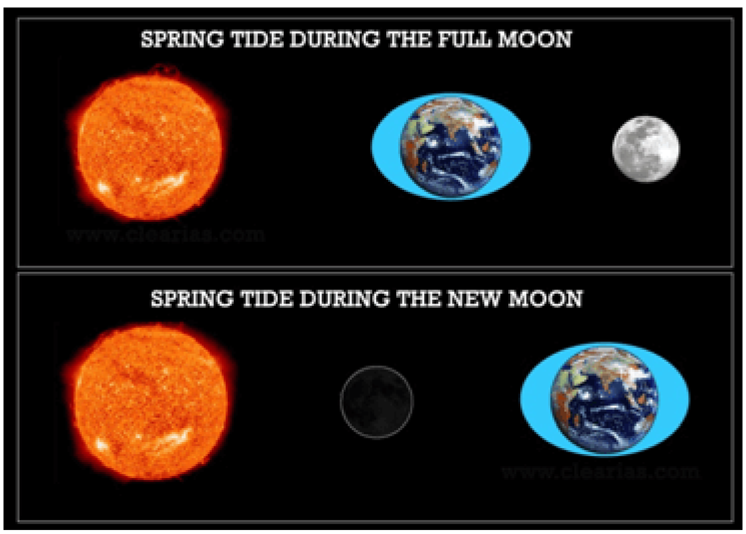
A. TIDES BASED ON THE FREQUENCY

- **Semi-diurnal Tide:** They are the most common tidal pattern, featuring two high tides and two low tides each day.
- **Diurnal Tides:** Only one high tide and one low tide each day.
- **Mixed Tide:** Tides having variations in heights are known as mixed tides. They generally occur along the west coast of North America.

B. TIDES BASED ON THE SUN, THE MOON, AND THE EARTH'S POSITIONS

1. Spring Tides:

When the sun, the moon, and the earth are in a straight line, the height of the tide will be higher than normal. These are called as a spring tides. They occur twice in a month-one on the full moon (Poornima) and the other on the new moon (Amavasya).



2. Neap Tides:

Normally after seven days of a spring tide, the sun and the moon become at a right angle to each other with respect to the earth. Thus, the gravitational forces of the sun and the moon tend to counteract one another. The tides during this period will be lower than the normal which are called as the neap tides. They also occur twice in a month- during the first quarter moon and the last quarter moon.

Magnitude of Tides

Perigee:

When the moon's orbit is closest to the earth, it is called as perigee. During this period, unusually high and low tide occur.

Apogee:

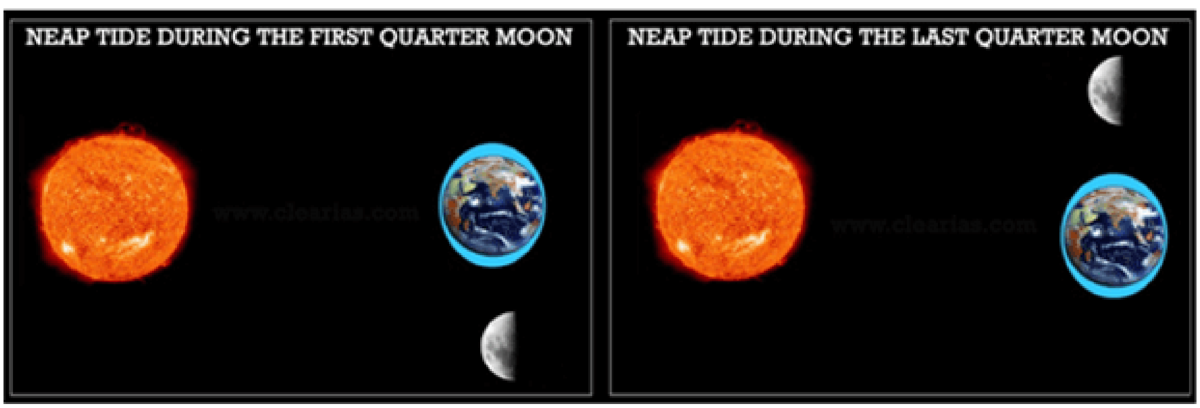
When the moon's orbit is farthest from the earth, it is called as apogee. Tidal ranges will be much less than the average during this period.

Perihelion:

It is the position where the earth is closest to the sun (around January 3rd). Unusual high and low tides occur during this time.

Aphelion:

It is the position where the earth is farthest from the sun (around July 4th). Tidal ranges are much less than the average during this period.

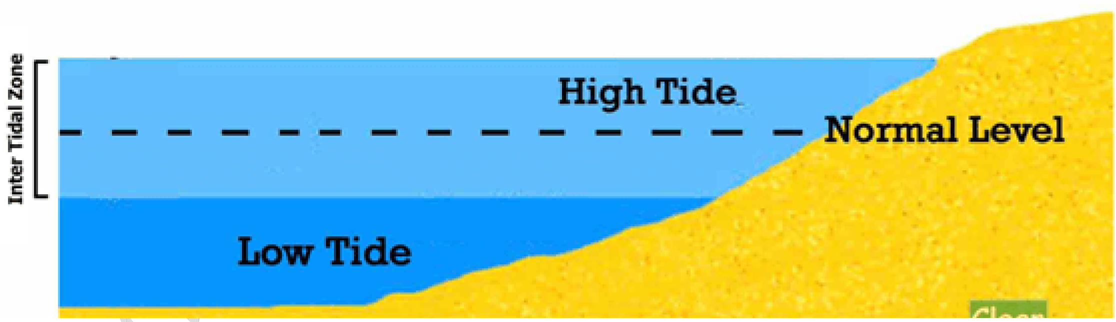


TIDAL BORE

When the leading edge of the incoming tide forms a wave/ waves of water that travel up a river or a narrow bay against the direction of the river or bay's current, it is called as a tidal bore. The Indian rivers like the Ganges, Brahmaputra, Indus, etc exhibits tidal bores.

INTER-TIDAL ZONE

The intertidal zone, also known as the foreshore and seashore and sometimes referred to as the littoral zone, is the area that is above water at low tide and under water at high tide (i.e., the area between the tide-marks).



EFFECTS OF TIDES

- Tides act as a link between the port and the open sea. Some of the major ports of the world, such as London port on the river Thames and Kolkata port on river Hugli are located on the rivers away from the sea coast.
- The tidal current clear away the river sediments and slows down the growth of delta.
- It increases the depth of water which helps ships to move safely to the ports.
- It also acts as a source for producing electricity.

Ocean Currents

- The ocean currents are the horizontal flow of a mass of water in a fairly defined direction over great distances.
- They are just like a river flowing in an ocean.
- Ocean currents can be formed by the winds, density differences in ocean waters due to differences in temperature and salinity, gravity and events such as earthquakes.
- The direction of movement of an ocean current is mainly influenced by the rotation of the earth **(due to Coriolis force, most ocean currents in northern hemisphere move in clockwise manner and ocean currents in southern hemisphere move in an anti-clockwise manner).**

GYRE, DRIFT, AND STREAM

- Any large system of rotating ocean current, particularly those involved with large wind movements is called as a **Gyre**. They are caused by the Coriolis force.
- When the ocean water moves forward under the influence of prevailing wind, it is called as **Drift** (The term 'drift' is also used to refer the speed of an ocean current which is measured in knots). E.g. North Atlantic Drift.
- When a large mass of the ocean water moves in a definite path just like a large river on the continent, it is called as a **Stream**. They will have greater speed than drifts. E.g. Gulf Stream.

OCEAN CURRENTS

Ocean currents are like river flow in oceans. They represent a regular volume of water in a definite path and direction. Ocean currents are influenced by two types of forces namely : (i) primary forces that initiate the movement of water; (ii) secondary forces that influence the currents to flow.

The primary forces that influence the currents are:

- heating by solar energy;
- wind;
- gravity;
- coriolis force.

Heating by solar energy causes the water to expand. That is why, near the equator the ocean water is about 8 cm higher in level than in the middle latitudes. This causes a very slight gradient and water tends to flow down the slope. Wind blowing on the surface of the ocean pushes the water to move. Friction between the wind and the water surface affects the movement of the water body in its course. Gravity tends to pull the water down to pile and create gradient variation. The Coriolis force intervenes and causes the water to move to the right in the northern hemisphere and to the left in the southern hemisphere. These large accumulations of water and the flow around them are called Gyres. These produce large circular currents in all the ocean basins.

Differences in water density affect vertical mobility of ocean currents. Water with high salinity is denser than water with low salinity and in the same way cold water is denser than warm water. Denser water tends to sink, while relatively lighter water tends to rise. Cold-water ocean currents occur when the cold water at the poles sinks and slowly moves towards the equator. Warm-water currents travel out from the equator along the surface, flowing towards the poles to replace the sinking cold water.

Types of Ocean Currents

The ocean currents may be classified based on their depth as surface currents and deep water currents:

- surface currents constitute about 10 per cent of all the water in the ocean, these waters are the upper 400 m of the ocean;
- deep water currents make up the other 90 per cent of the ocean water. These waters move around the ocean basins due to variations in the density and gravity. Deep waters sink into the deep ocean basins at high latitudes, where the temperatures are cold enough to cause the density to increase.

Ocean currents can also be classified based on temperature : as cold currents and warm currents:

- cold currents bring cold water into warm water areas. These currents are usually 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;
- warm currents bring warm water into cold water areas and are usually observed on the east coast of continents in the low and middle latitudes (true in both hemispheres). In the northern hemisphere they are found on the west coasts of continents in high latitudes.

Major Ocean Currents

Major ocean currents are greatly influenced by the stresses exerted by the prevailing winds and coriolis force. The oceanic circulation pattern roughly corresponds to the earth's atmospheric circulation pattern. The air circulation over the oceans in the middle latitudes is mainly anticyclonic (more pronounced in the southern hemisphere than in the northern hemisphere). The oceanic circulation pattern also corresponds with the same. At higher latitudes, where the wind flow is mostly cyclonic, the oceanic circulation follows this pattern. In regions of pronounced monsoonal flow, the monsoon winds influence the current movements. Due to the coriolis force, the warm currents from low latitudes tend to move to the right in the northern hemisphere and to their left in the southern hemisphere. The oceanic circulation transports heat from one latitude belt to another in a manner similar to the heat transported by the general circulation of the atmosphere. The cold waters of the Arctic and Antarctic circles move towards warmer water in tropical and equatorial regions, while the warm waters of the lower latitudes move polewards. The major currents in the different oceans are shown in below Figure.

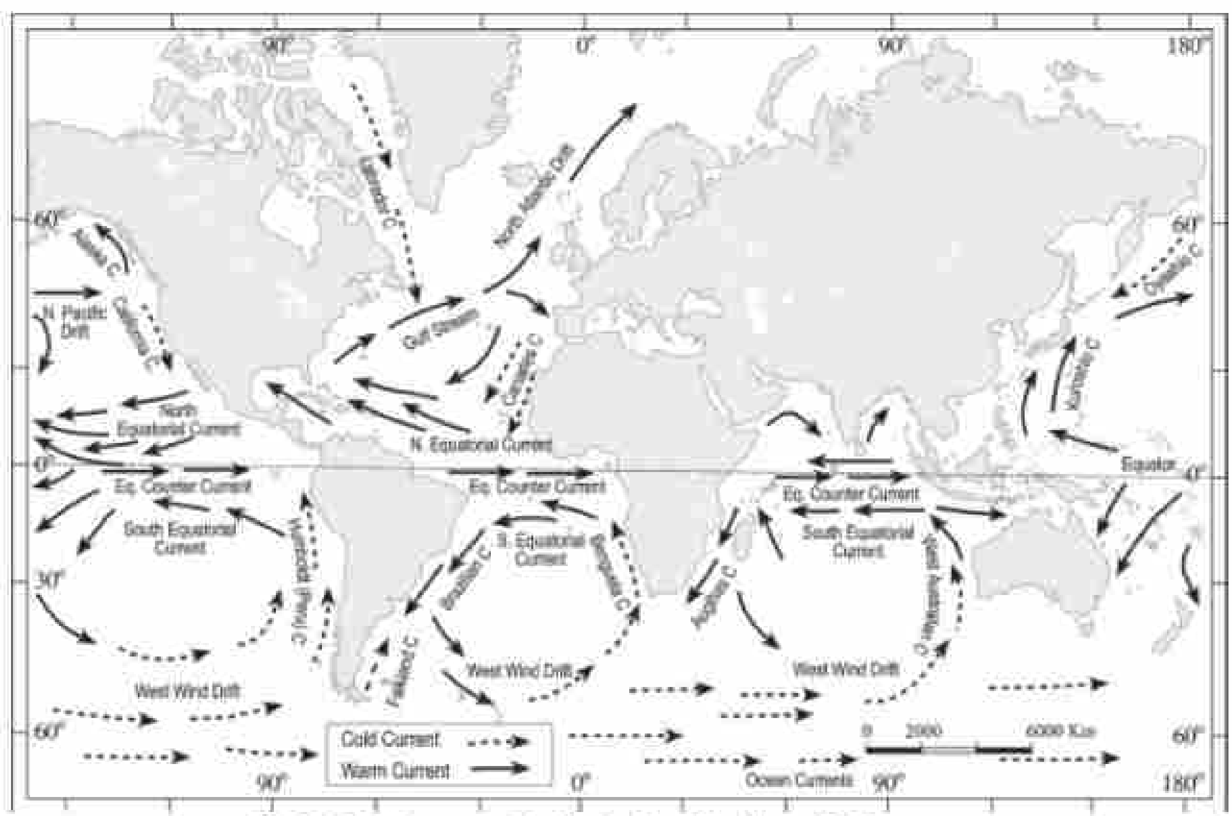


Fig. 14.3 : Major currents in the Pacific, Atlantic and Indian oceans

Effects of Ocean Currents

Ocean currents have a number of direct and indirect influences on human activities. West coasts of the continents in tropical and subtropical latitudes (except close to the equator) are bordered by cool waters. Their average temperatures are relatively low with a narrow diurnal and annual ranges. There is fog, but generally the areas are arid. West coasts of the continents in the middle and higher latitudes are bordered by warm waters which cause a distinct marine climate. They are characterised by cool summers and relatively mild winters with a narrow annual range of temperatures. Warm currents flow parallel to the east coasts of the continents in tropical and subtropical latitudes. This results in warm and rainy climates. These areas lie in the western margins of the subtropical anti-cyclones. The mixing of warm and cold currents help to replenish the oxygen and favour the growth of planktons, the primary food for fish population. The best fishing grounds of the world exist mainly in these mixing zones.

Characteristics of Ocean Currents

Currents are referred to by their “drift”. Usually, the currents are strongest near the surface and may attain speeds over five knots. At depths, currents are generally slow with speeds less than 0.5 knots. We refer to the speed of a current as its “drift.” Drift is measured in terms of knots. The strength of a current refers to the speed of the current. A fast current is considered strong. A current is usually strongest at the surface and decreases in strength (speed) with depth. Most currents have speeds less than or equal to 5 knots.

INDIAN GEOGRAPHY

➢ INDIA

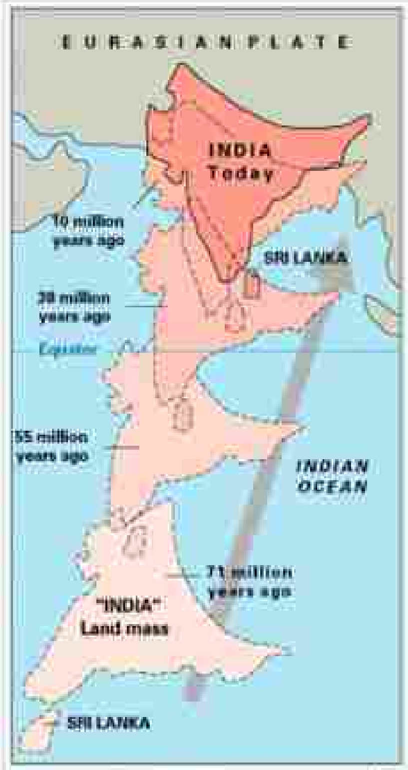
India is the seventh largest country in the world in terms of area. It lies on the Indian Plate, which is the northern portion of the Indo-Australian Plate. The Indian subcontinent is surrounded by three different water bodies and is easily recognisable on the world map.

The mainland of India extends from Kashmir in the north to Kanniyakumari in the south and Arunachal Pradesh in the east to Gujarat in the west. India's territorial limit further extends towards the sea upto 12 nautical miles (about 21.9 km) from the coast.

The country covers an area of about 3.28 million sq. km. The mainland of India extends between 8°4' and 37°6' N latitude and 68°7' and 97°25' E longitude. The Tropic of Cancer 23°30' N divides India into almost two halves. The total length of the coastline is 7,517 kilo meters. The Indian peninsula tapers southwards resulting in the division of the Indian Ocean into two water bodies - the Bay of Bengal and the Arabian Sea. In India, there is a great diversity of landforms such as lofty mountains, deep valleys, extensive plains, Plateau and coastal ghats, the desert and a number of islands.

GEOLOGICAL DEVELOPMENT

India is situated entirely on the Indian Plate, a major tectonic plate that was formed when it split off from the ancient continent Gondwanaland (ancient landmass, consisting of the southern part of the supercontinent of Pangea). The Indo-Australian plate is subdivided into the Indian and Australian plates. About 90 million years ago, during the late Cretaceous Period, the Indian Plate began moving north at about 15 cm/year (6 in/yr).



The Indian Plate

About 50 to 55 million years ago, in the Eocene Epoch of the Cenozoic Era, the plate collided with Asia after covering a distance of 2,000 to 3,000 km (1,243 to 1,864 mi), having moved faster than any other known plate. In 2007, German geologists determined that the Indian Plate was able to move so quickly because it is only half as thick as the other plates which formerly constituted Gondwanaland.

The collision with the Eurasian Plate along the modern border between India and Nepal formed the orogenic belt that created the Tibetan Plateauand the Himalayas. As of 2009, the Indian Plate is moving northeast at 5 cm/yr (2 in/yr), while the Eurasian Plate is moving north at only 2 cm/yr (0.8 in/yr). India is thus referred to as the "fastest continent". This is causing the Eurasian Plate to deform, and the Indian Plate to compress at a rate of 4 cm/yr (1.6 in/yr).

SIZE

The size of India has endowed her with great physical diversity. Thus, you may appreciate the presence of lofty mountains in the north; large rivers such as Ganga, Brahmaputra, Mahanadi, Krishna, Godavari and Kaveri; green forested hills in northeast and south India; and the vast sandy expanse of Marusthali.

You may further appreciate that bounded by the Himalayas in the north, Hindukush and Sulaiman ranges in the northwest, Purvachal hills in the north-east and by the large expanse of the Indian Ocean in the south, it forms a great geographic entity known as the Indian subcontinent. It includes the countries — Pakistan, Nepal, Bhutan, Bangladesh and India.
The Himalayas, together with other ranges, have acted as a formidable physical barrier in the past. Except for a few mountain passes such as the Khyber, the Bolan, the Shipkila, the Nathula, the Bomdila, etc. it was difficult to cross it. It has contributed towards the evolving of a unique regional identity of the Indian subcontinent.

Thus India, as a country, is a physically diverse land providing occurrence of varied resources.

INDIA AND ITS NEIGHBOURS

By seeing above map, you will notice that India is located in the south-central part of the continent of Asia, bordering the Indian Ocean and its two arms extending in the form of Bay of Bengal and the Arabian Sea. This maritime location of Peninsular India has provided links to its neighbouring regions through the sea and air routes. Prepare a list of India's neighbouring countries by consulting the map. Sri Lanka and Maldives are the two island countries located in the Indian Ocean, which are our neighbours. Sri Lanka is separated from India by the Gulf of Mannar and Palk Strait.

Its borders with Pakistan and Bangladesh were delineated according to the Radcliffe Line, which was created in 1947 during Partition of India. Its western border with Pakistan extends up to 3,323 km (2,065 mi), dividing the Punjab region and running along the boundaries of the Thar Desert and the Rann of Kutch. This border runs along the Indian states of Jammu & Kashmir, Rajasthan, Gujarat, and Punjab. Both nations delineated a Line of Control (LoC) to serve as the informal boundary between the Indian and Pakistan-administered areas of Jammu and Kashmir. India shares a 106 km (66 mi) border with Afghanistan in northwestern Kashmir, which the Indian government officially regards as occupied by Pakistan.

India's border with Bangladesh runs 4,096.70 km (2,545.57 mi). West Bengal, Assam, Meghalaya, Tripura and Mizoram are the States which share the border with Bangladesh. Before 2015, there were 92 enclaves of Bangladesh on Indian soil and 106 enclaves of India were on Bangladeshi soil. These enclaves were eventually exchanged in order to simplify the border. After the exchange, India lost roughly 40 km² (10,000 acres) to Bangladesh.

The Line of Actual Control (LAC) is the effective border between India and the People's Republic of China. It traverses 4,057 km along the Indian states of Jammu and Kashmir, Uttarakhand, Himachal Pradesh, Sikkim and Arunachal Pradesh.

The border with Burma (Myanmar) extends up to 1,643 km (1,021 mi) along the southern borders of India's northeastern states viz. Arunachal Pradesh, Nagaland, Manipur and Mizoram. Located amidst the Himalayan range, India's border with Bhutan runs 699 km (434 mi). Sikkim, West Bengal, Assam and Arunachal Pradesh are the States, which share the border with Bhutan.

The border with Nepal runs 1,751 km (1,088 mi) along the foothills of the Himalayas in northern India. Uttarakhand, Uttar Pradesh, Bihar, West Bengal and Sikkim are the States, which share the border with Nepal. The Siliguri Corridor, narrowed sharply by the borders of Bhutan, Nepal and Bangladesh, connects peninsular India with the northeastern states.

PHYSICAL DIVISIONS OF INDIA

India can be divided into six physiographic regions. They are:

1) The Himalayas (young fold mountains),
2) Indo-Gangetic Plain (monotonous topography – featureless topography),
3) The Peninsular Plateau (one of the most stable landmasses; one of the oldest plateaus of the world),
4) Coastal Plains (Sediments due to fluvial action).
5) The Indian Islands [Coral Islands == coral reef built up on atolls – Lakshadweep. Tectonic == Andaman and Nicobar Islands – Interaction between Indian Plate and Eurasian plate]
6) Indian Desert

Himalayas

- Includes the Himalayas, Purvanchal and their extensions Arakan Yoma (Myanmar) and Andaman and Nicobar Islands (but we will consider these as islands only).
- It is the youngest and **highly unstable** landmass of India. [Continent – Continent Convergence]
- Tectonic movements are very common.

Indo-Gangetic Plain

- Between Peninsular and Himalayan region.
- Most youthful, monotonous [lack of change or variety] region prone to tectonic forces.

Peninsular Plateau

- Includes the entire south India, central India, Aravalis, Rajmahal hills, Meghalaya plateau, Kuchchh-Kathiawar region (Gujarat) etc.
- It is the oldest and the most **stable landmass of India.**

Coastal Plains

- Eastern Coastal Plains and Western Coastal Plains.
- Formed due to consolidation of sediments brought by rivers (fluvial deposits).
- Highly **stable** just like peninsular plateau.

Indian Islands

- Two major groups – Lakshadweep and, Andaman and Nicobar islands.
- Lakshadweep [Hotspot] are group of atolls occupied by coral reefs. No significant volcanism or tectonic activity in recent past. Highly vulnerable to sea-level rise.

- Andaman and Nicobar islands – Continuation of Arakan Yoma. Has active volcanoes and is tectonically active.

Indian Desert

- The Thar Desert is by some calculations the world's seventh largest desert, by some others the tenth. It forms a significant portion of western India.

HIMALAYAN RANGES

Series of several **parallel or converging ranges**. The ranges are separated by deep valleys creating a highly **dissected topography** [(of a plateau or upland) divided by a number of deep valleys].

The **southern slopes have steep gradients** and northern slopes have comparatively gentler slopes. [Scaling Mount Everest is less hectic from the northern side. But China puts restrictions so climbers take the steeper southern slopes from Nepal]

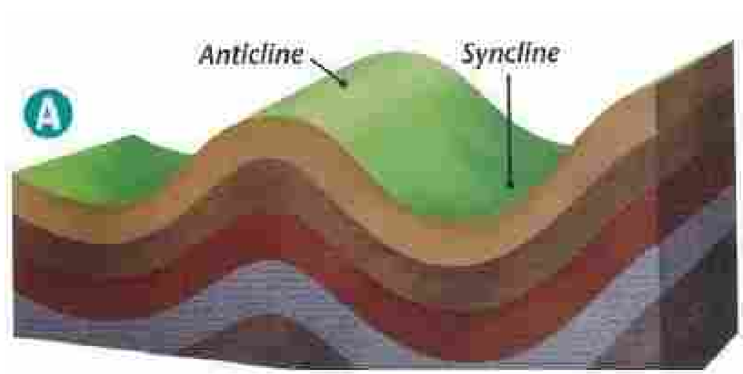
Most of the Himalayan ranges fall in India, Nepal and Bhutan. The northern slopes are partly situated in Tibet (trans-Himalayas) while the western extremity lies in Pakistan, Afghanistan and Central Asia.
Himalayas between Tibet and Ganga Plain is a succession of three parallel ranges.

Division of the Himalayas

1) **Shiwaliks or outer Himalayas**
2) **Lesser or Middle Himalayas**
3) **The Greater Himalayas**
4) **The Trans-Himalayas – Tibetan Himalayas.**
5) **The Eastern Hills – Purvanchal: A chain of hills in North-East India.**

Shiwalik Range

- Also known as **Outer Himalayas**. Located in between the Great Plains and Lesser Himalayas.
- The altitude varies from 600 to 1500 metres. Runs for a distance of 2,400 km from the Potwar Plateau to the Brahmaputra valley.
- The southern slopes are steep while the northern slopes are gentle.



- The width of the Shiwaliks varies from 50 km in Himachal Pradesh to less than 15 km in Arunachal Pradesh. They are almost unbroken chain of low hills except for a gap of 80-90 km which is occupied by the valley of the Tista River and Raidak River.
- Shiwalik ranges from North-East India up to Nepal are covered with thick forests but the forest cover decreases towards west from Nepal (The quantum of rainfall decreases from east to west in Shiwaliks and Ganga Plains).
- The southern slopes of Shiwalik range in Punjab and Himachal Pradesh are almost devoid of forest cover. These slopes are highly dissected by seasonal streams called Chos.
- Valleys are part of synclines and hills are part of anticlines or antisynclines.

Formation

- Shiwaliks were formed last of all the ranges (2-20 million years ago).
- The Shiwaliks are consolidated sands, gravels and conglomerate deposits [Alluvial fans] which were brought by the rivers flowing from the higher ranges.
- These deposits were folded and hardened due to compression offered by the northward movement of Indian plate.

The Shiwaliks are known by different names in different areas

Region	Name of Shiwaliks
Jammu Region	Jammu Hills
Dafla, Miri, Abor and Mishmi Hills	Arunachal Pradesh
The Dhang Range, Dundwa Range	Uttarakhand
Churia Ghat Hills	Nepal

Formation of Duns (Duras)

- Shiwalik Hills were formed by the accumulation of conglomerates (sand, stone, silt, gravel, debris etc.).
- These conglomerates, in the initial stages of deposition, obstructed the courses of the rivers draining from the higher reaches of the Himalayas and formed temporary lakes**.**
- With passage of time, these temporary lakes accumulated more and more conglomerates. The conglomerates were well settled at the bottom of the lakes.
- When the rivers were able to cut their courses through the lakes filled with conglomerate deposits, the lakes were drained away leaving behind plains called ‘duns’ or ‘doons’ in the west and ‘duars’ in the east.
- Dehra Dun in Uttarakhand is the best example [75 km long and 15-20 km wide]
- Kotah, Patli Kothri, Chumbi, Kyarda, Chaukhamba, Udhampur and Kotli are other important duns.

Middle or the Lesser Himalaya

In between the Shiwaliks in the south and the Greater Himalayas in the north. Runs almost parallel to both the ranges. It is also called the **Himachal or Lower Himalaya**.

Lower Himalayan ranges are 60-80 km wide and about 2400 km in length. Elevations vary from 3,500 to 4,500 m above sea level. Many peaks are more than 5,050 m above sea level and are snow covered throughout the year.

Lower Himalayas have steep, bare southern slopes [steep slopes prevent soil formation] and gentler, forest covered northern slopes.

- In Uttarakhand, the Middle Himalayas are marked by the Mussoorie and the Nag Tibba ranges.
- The Mahabharat Lekh, in southern Nepal is a continuation of the Mussoorie Range
- East of the Kosi River, the Sapt Kosi, Sikkim, Bhutan, Miri, Abor and Mishmi hills represent the lower Himalayas.

The Middle Himalayan ranges are friendlier to human contact.

Majority of the Himalayan hill resorts like Shimla, Mussoorie, Ranikhet, Nainital, Almora and Darjeeling, etc. are located here.

Important ranges of Lesser Himalayas	Region
The Pir Panjal Range	Jammu and Kashmir (They are to the south of Kashmir Valley)
The Dhaola Dhar Range	Himachal Pradesh
The Mussoorie Range and The Nag Tiba Range	Uttarakhand
Mahabharat Lekh	Nepal

The Pir Panjal range

- The Pir Panjal range in Kashmir is the longest and the most important range.
- It extends from the Jhelum river to the upper Beas river for over 300 km.
- It rises to 5,000 metres and contains mostly volcanic rocks.

Passes in Pir Panjal

- Pir Panjal Pass (3,480 m), the Bidil (4,270 m), Golabghar Pass (3,812 m) and Banihal Pass (2,835 m).
- The **Banihal** Pass is used by the Jammu-Srinagar highway and Jammu-Baramula railway.
- The Kishanganga, the Jhelum and the Chenab cut through the range.

- Southeast of the Ravi, the Pir Panjal continues as Dhaola Dhar range, passing through Dalhousie, Dharmshala, and Shimla.

Important Valleys

- Between the Pir Panjal and the Zaskar Range of the main Himalayas, lies the valley of Kashmir. (average elevation is 1,585 m above mean sea level)
- The synclinal basin of the valley is floored with alluvial, lacustrine [lake deposits], fluvial [river action] and glacial deposits. {Fluvial Landforms, Glacial Landforms}
- Jehlum River meanders through these deposits and cuts a deep gorge in Pir Panjal through which it drains. (Kashmir is like a basin with very few outlets)
- In Himachal Pradesh there is Kangra Valley. It is a strike valley and extends from the foot of the Dhaola Dhar Range to the south of Beas.
- On the other hand, the Kulu Valley in the upper course of the Ravi is transverse valley.

The Greater Himalayas

Also known as **Inner Himalaya, Central Himalaya or Himadri.** Average elevation of 6,100 m above sea level and an average width of about 25 km. It is mainly formed of the central crystallines (granites and gneisses) overlain by metamorphosed sediments [limestone]. {Rock System}

The folds in this range are asymmetrical with steep south slope and gentle north slope giving 'hog back (a long, steep hill or mountain ridge)' topography. This mountain arc convexes to the south just like the other two. Terminates abruptly at the syntaxial bends. One in the Nanga Parbat in north-west and the other in the Namcha Barwa in the north-east.

This mountain range boasts of the tallest peaks of the world, most of which remain under perpetual snow.

Regional name of Mount Everest	Region
Sagarmatha (The Goddess of the Sky)	Nepal
Chomlungma (Mother of the World)	China (Tibet)

Mount Everest was first located by George Everest, the then Surveyor General of India in 1841 and in 1852 it was established as the highest peak of the world by the Great Trigonometrical Survey of India.

Passes in the Greater Himalayas

The passes because they are generally higher than 4,570 m above sea level and are snowbound for most of the year

State	Passes of Greater Himalayas
Jammu and Kashmir	Burzil Pass Zoji La [La means pass]
Himachal Pradesh	Bara Lacha La Shipki La [The Hindustan-Tibet Road connecting Shimla with Gartok in Western Tibet]
Uttarakhand	Thaga La Niti Pass Lipu Lekh
Sikkim	Nathu La Jelep La [important trade route connecting Kalimpong (near Darjeeling) with Lhasa in Tibet, passes through Jelep La (4,386 m)]

The Trans Himalayas

- The Himalayan ranges immediately north of the Great Himalayan range. Also called the Tibetan Himalaya because most of it lies in Tibet.
- The Zaskar, the Ladakh, the Kailas and the Karakoram are the main ranges. It stretches for a distance of about 1,000 km in east-west direction. Average elevation is 3000 m above mean sea level. The average width of this region is 40 km at the extremities and about 225 km in the central part.
- The **Nanga Parbat (8126 m)** is an important range which is in The Zaskar Range. North of the Zaskar Range and running parallel to it is the Ladakh Range. Only a few peaks of this range attain heights of over 6000 metres.
- The Kailas Range (Gangdise in Chinese) in western Tibet is an offshoot of the Ladakh Range. The highest peak is Mount Kailas (6714 m). River Indus originates from the northern slopes of the Kailas range.
- The northern most range of the Trans-Himalayan Ranges in India is the Great Karakoram Range also known as the Krishnagiri range.
- Karakoram Range extends eastwards from the Pamir for about 800 km. It is a range with lofty peaks [elevation 5,500 m and above]. It is the abode of some of the greatest glaciers of the world outside the polar regions.
- Some of the peaks are more than 8,000 metre above sea level. K2 (8,611 m)[Godwin Austen or Qogir] is the second highest peak in the world and the highest peak in the Indian Union.
- The Ladakh Plateau lies to the north-east of the Karakoram Range. It has been dissected into a number of plains and mountains [Soda Plains, Aksai Chin, Lingzi Tang, Depsang Plains and Chang Chenmo]

Purvanchal or Eastern Hills

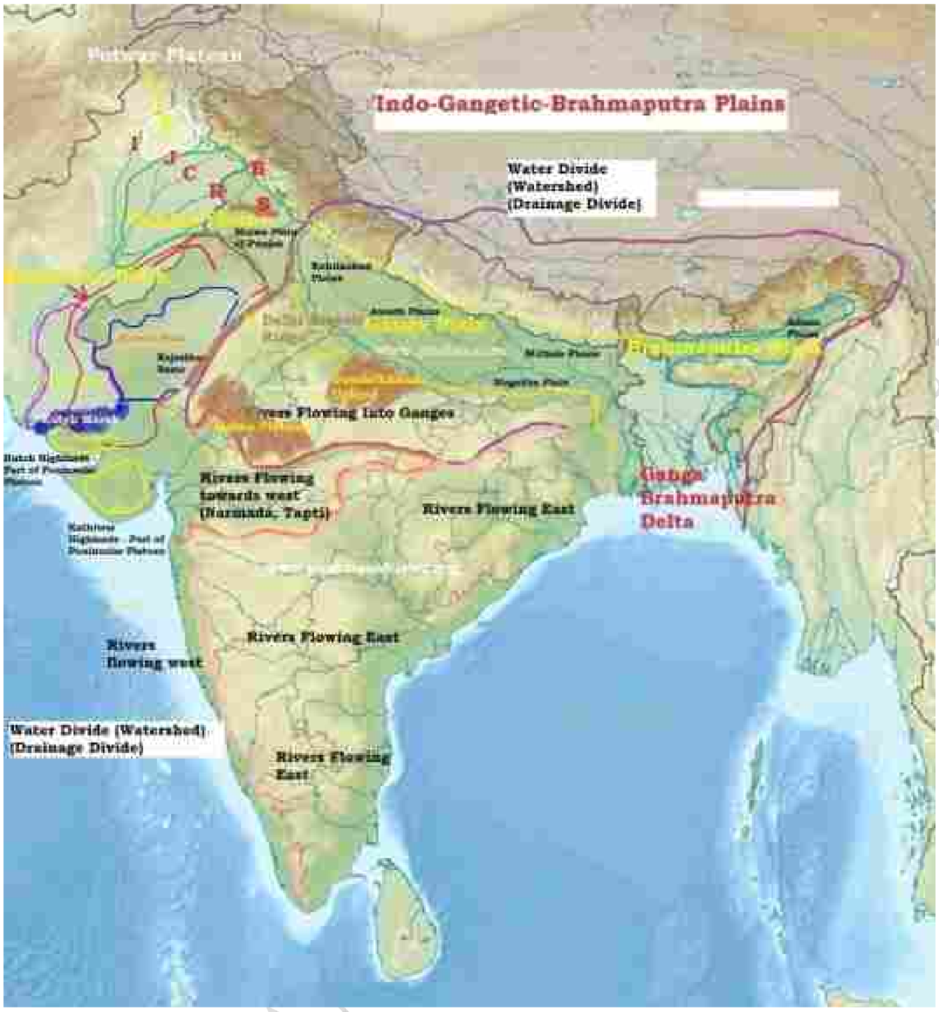
- Eastern Hills or The Purvanchal are the southward extension of Himalayas running along the north-eastern edge of India.
- At the Dihang gorge, the Himalayas take a sudden southward bend and form a series of comparatively low hills which are collectively called as the Purvanchal.
- Purvanchal hills are convex to the west.
- They run along the India-Myanmar Border extending from Arunachal Pradesh in the north to Mizoram in the south.

- **Patkai Bum** hills are made up of strong sandstone; elevation varying from 2,000 m to 3,000 m; merges into Naga Hills where **Saramati (3,826 m)** is the highest peak. Patkai Bum and Naga Hills form the watershed between India and Myanmar.
- South of Naga Hills are the Manipur hills which are generally less than 2,500 metres in elevation. The Barail range separates Naga Hills from Manipur Hills.
- Further south the Barail Range swings to west into Jaintia, Khasi and Garo hills which are an eastward continuation of the Indian peninsular block. They are separated from the main block by Ganga and Brahmaputra rivers.
- South of the Manipur Hills are the Mizo Hills (previously known as the Lushai hills) which have an elevation of less than 1,500 metres. The highest point is the Blue Mountain (2,157 m) in the south.

Syntaxial Bends of the Himalayas

- Himalayas extend in the east-west direction from the Indus gorge in the west to the Brahmaputra gorge in the east.
- Himalayan ranges take sharp southward bends at these gorges. These bends are called syntaxial bends of the Himalayas.
- The western syntaxial bend occurs near the **Nanga Parbat** where the Indus river has cut a deep gorge.
- The eastern syntaxial bend occurs near the **Namche Barwa.**

INDO-GANGETIC PLAIN



Formation of Indo – Gangetic – Brahmaputra trough

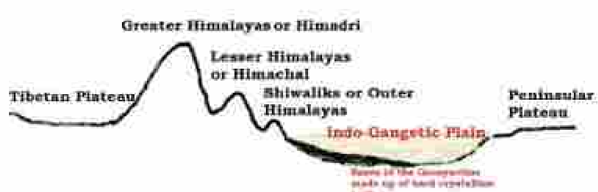
- The rivers which were previously flowing into Tethys sea (Before Indian Plate collided with Eurasian Plate – continental drift, plate tectonics) deposited huge amount of sediments in the Tethys Geosyncline. [Geosyncline – a huge depression]
- Himalayas are formed out of these sediments which were uplifted, folded and compressed due to northern movement of Indian Plate.
- Northern movement of Indian Plate also created a trough to the south of Himalayas.

Depositional Activity

- During the initial stages of upliftment of sediments, the already existing rivers changed their course several times and they were rejuvenated each time (perpetual youth stage of rivers {Fluvial Landforms}).
- The rejuvenation is associated with intense headward and vertical downcutting of the soft strata overlying the harder rock stratum.
- Headward erosion and vertical erosion of the river valley in the initial stages, lateral erosion in later stages contributed huge amount of conglomerates (detritus)(rock debris, silt, clay etc.) which were carried downslope.
- [Head ward erosion == Erosion at the origin of a stream channel, which causes the origin to move back away from the direction of the stream flow, and so causes the stream channel to lengthen]
- These conglomerates were deposited in the depression (Indo-Gangetic Trough or Indo-Gangetic syncline) (the base of the geosyncline is a hard crystalline rock) between peninsular India and the convergent boundary (the region of present day Himalayas).

New rivers and more alluvium

- The raising of Himalayas and subsequent formation of glaciers gave rise to many new rivers. These rivers along with glacial erosion {Glacial Landforms}, supplied more alluvium which intensified the filling of the depression.
- With the accumulation of more and more sediments (conglomerates), the Tethys sea started receding.
- With passage of the time, the depression was completely filled with alluvium, gravel, rock debris (conglomerates) and the Tethys completely disappeared leaving behind a monotonous aggradational plain.
- [Monotonous == featureless topography; aggradational plain == plain formed due to depositional activity. Indo-Gangetic plain is a monotonous aggradational plain formed due to fluvial depositions].
- Upper peninsular rivers have also contributed to the formation of plains, but to a very small extent.
- During the recent times (since few million years), depositional work of three major river systems viz., the Indus, the Ganga and the Brahmaputra have become predominant.
- Hence this arcuate (curved) plain is also known **as Indo-Gangetic-Brahmaputra Plain**.



Features of Indo – Gangetic – Brahmaputra Plain

Features of Indo – Gangetic – Brahmaputra Plain

- Indo-Gangetic-Brahmaputra Plain is the largest alluvial tract of the world.
- It stretches for about 3,200 km from the mouth of the Indus to the mouth of the Ganga. Indian sector of the plain accounts for 2,400 km.
- The northern boundary is well marked by the Shiwaliks and the southern boundary is a wavy irregular line along the northern edge of the Peninsular India.
- The western border is marked by Sulaiman and Kirthar ranges. On the eastern side, the plains are bordered by Purvanchal hills.
- The width of the plain varies from region to region. It is widest in the west where it stretches for about 500 km. Its width decreases in the east.
- The thickness of the alluvium deposits also vary from place to place. The maximum depth of the alluvium up to the basement rocks is about 6,100 m (not uniform and varies greatly from place to place).
- The cones or alluvial fans of Kosi in the north and those of Son in the south exhibit greater alluvial thickness while the intra-cone areas have relatively shallower deposits.
- Extreme horizontality of this monotonous plain is its chief characteristic.
- Its average elevation is about 200 m above mean sea level, highest elevation being 291 m above mean sea level near Ambala (This elevation forms the drainage divide or watershed between Indus system and Ganga system).
- Its average gradient from Saharanpur to Kolkata is only 20 cm per km and it decreases to 15 cm per km from Varanasi to the Ganga delta.

Geomorphological features of Indo – Gangetic – Brahmaputra Plain

A. The Bhabar

- It is a narrow, porous, northern most stretch of Indo-Gangetic plain.
- It is about 8-16 km wide running in east-west direction along the foothills (alluvial fans) of the Shiwaliks.
- They show a remarkable continuity from the Indus to the Tista.
- Rivers descending from the Himalayas deposit their load along the foothills in the form of alluvial fans.
- These alluvial fans have merged together to build up the bhabar belt.
- The porosity of bhabar is the most unique feature.
- The porosity is due to deposition of huge number of pebbles and rock debris across the alluvial fans.
- The streams disappear once they reach the bhabar region because of this porosity.
- Therefore, the area is marked by dry river courses except in the rainy season.
- The Bhabar belt is comparatively narrow in the east and extensive in the western and north-western hilly region.

The area is not suitable for agriculture and only big trees with large roots thrive in this belt.

B. The Terai

- Terai is an ill-drained, damp (marshy) and thickly forested narrow tract to the south of Bhabar running parallel to it.
- The Terai is about15-30 km wide.
- The underground streams of the Bhabar belt re-emerge in this belt.

This thickly forested region provides shelter to a variety of wild life. [Jim Corbett National Park in Uttarakhand and Kaziranga National Park in Assam lie in terai region]

- The Terai is more marked in the eastern part than in the west because the eastern parts receive comparatively higher amount of rainfall.
- Most of the Terai land, especially in Punjab, Uttar Pradesh and Uttarakhand, has been turned into agricultural land which gives good crops of sugarcane, rice and wheat.

The Bhangar

- The Bhangar is the older alluvium along the river beds forming terraces higher than the flood plain.
- The terraces are often impregnated with calcareous concretions known as 'KANKAR'.
- 'The Barind plains' in the deltaic region of Bengal and the **'bhur formations'** in the middle Ganga and Yamuna doab are regional variations of Bhangar.

[Bhur denotes an elevated piece of land situated along the banks of the Ganga river especially in the upper Ganga-Yamuna Doab. This has been formed due to accumulation of wind-blown sands during the hot dry months of the year]

- Bhangar contains fossils of animals like rhinoceros, hippopotamus, elephants, etc.

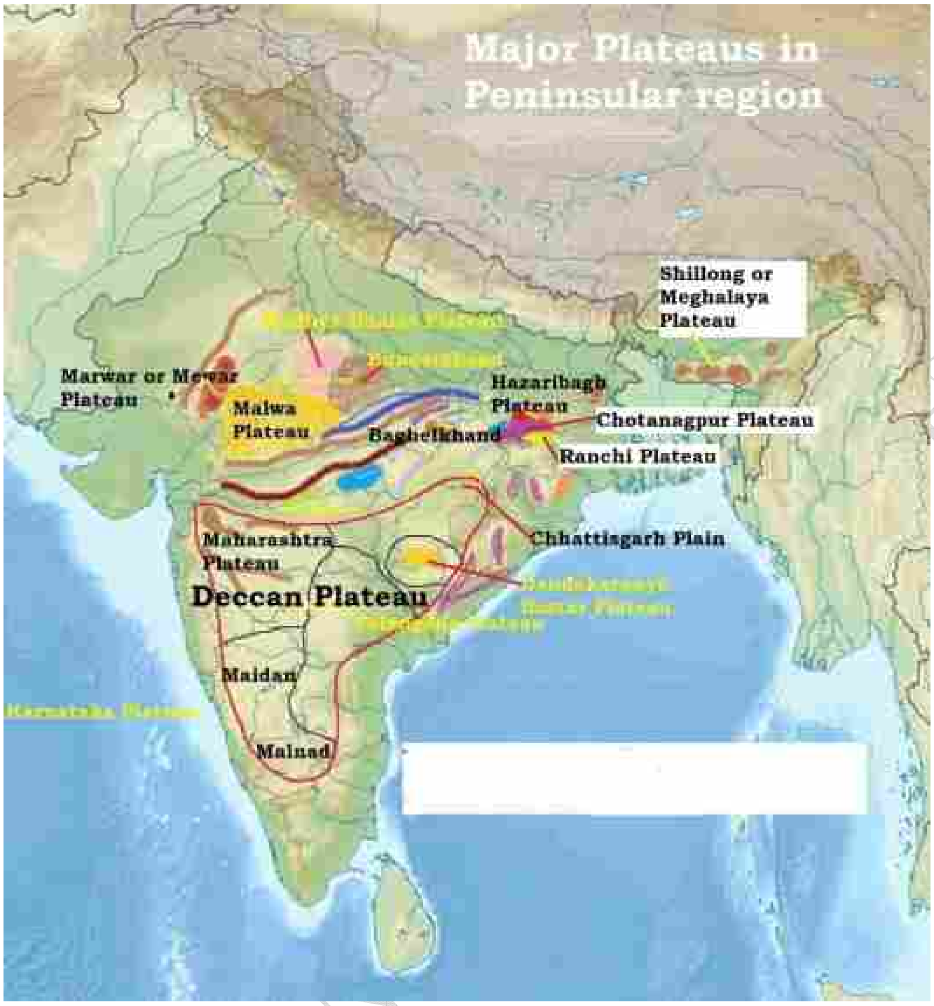
The Khadar

- The Khadar is composed of newer alluvium and forms the flood plains along the river banks.
- A new layer of alluvium is deposited by river flood almost every year.
- This makes them the most fertile soils of Ganges.

Reh or Kollar

- Reh or Kollar comprises saline efflorescences of drier areas in Haryana.
- Reh areas have spread in recent times with increase in irrigation (capillary action brings salts to the surface).

THE PENINSULAR PLATEAU



Features of the Peninsular Plateau

- Roughly triangular in shape with its base coinciding with the southern edge of the great plain of North India. Apex of the triangular plateau is at Kanniyakumari.
- It covers a total area of about 16 lakh sq km (India as a whole is 32 lakh sq km).
- The average height of the plateau is 600-900 m above sea level (varies from region to region).
- Most of the peninsular rivers flow west to east indicating it's general slope.
- Narmada-Tapti are the exceptions which flow from east to west in a rift (rift is caused by divergent boundary (Go back to Interaction of plates).
- The Peninsular Plateau is a one of the oldest landforms of earth.
- It is a highly stable block composed mostly of the Archaean gneisses and schists {Rock System}.

- It has been a stable shield which has gone through little structural changes since its formation.
- Since few hundred million years, Peninsular block has been a land area and has never been submerged beneath the sea except in a few places.
- Peninsular Plateau is an aggregation of several smaller plateaus, hill ranges interspersed with river basins and valleys.

Minor Plateaus in the Peninsular Plateau

Marwar Plateau or Mewar Plateau

- It is the plateau of eastern Rajasthan. [Marwar plain is to the west of Aravalis whereas Marwar plateau is to the east].
- The average elevation is 250-500 m above sea level and it slopes down eastwards.
- It is made up of sandstone, shales and limestones of the Vindhayan period.
- The Banas river, along with its tributaries [Berach river, Khari rivers] originate in the Aravali Range and flow towards northwest into Chambal river. The erosional activity of these rives make the plateau top appear like a rolling plain.

[Rolling Plain: ‘Rolling plains’ are not completely flat: there are slight rises and fall in the land form. Ex: Prairies of USA]

Central Highland

- Also called **the Madhya Bharat Pathar or Madhya Bharat Plateau**.
- It is to the east of the Marwar or Mewar Upland.
- Most of plateau comprises the basin of the **Chambal river** which flows in a **rift valley.**
- The Kali Sindh, flowing from Rana Prataph Sagar, The Banas flowing through Mewar plateau and The Parwanand the Parbati flowing from Madhya Pradesh are its main tributaries.
- It is a rolling plateau with rounded hills composed of sandstone. Thick forests grow here.
- To the north are the ravines or badlands of the Chambal river [They are typical to Chambal river basin]{ Arid landforms}.

Bundelkhand Upland

- Yamuna river to the north, Madhya Bharat Pathar to the west, Vindhyan Scarplands to the east and south-east and Malwa Plateau to the south.
- It is the old dissected (divided by a number of deep valleys) upland of the ‘Bundelkhand gneiss’ comprising of **granite** and **gneiss**.
- Spreads over five districts of Uttar Pradesh and four districts of Madhya Pradesh.
- Average elevation of 300-600 m above sea level, this area slopes down from the Vindhyan Scarp toward the Yamuna River.
- The area is marked by a chain of hillocks (small hill) made of granite and sandstone.
- The erosional work of the rivers flowing here have converted it into an undulating (wave like surface) area and rendered it unfit for cultivation.

- The region is characterized by senile (characteristic of or caused by old age) topography.
- Streams like **Betwa**, **Dhasan** and **Ken** flow through the plateau.

Malwa Plateau

- The Malwa Plateau roughly forms a triangle based on the Vindhyan Hills, bounded by the Aravali Range in the west and Madhya Bharat Pathar to the north and Bundelkhand to the east.
- This plateau has two systems of drainage; one towards the Arabian sea (The Narmada, the Tapi and the Mahi), and the other towards the Bay of Bengal (Chambal and Betwa, joining the Yamuna).
- In the north it is drained by the Chambal and many of its right bank tributaries like the Kali, the Sindh and the Parbati. It also includes the upper courses of the Sindh, the Ken and the Betwa.
- It is composed of extensive lava flow and is covered with black soils.
- The general slope is towards the north [decreases from 600 m in the south to less than 500 m in the north]
- This is a rolling plateau dissected by rivers. In the north, the plateau is marked by the Chambal ravines.

Baghelkhand

- North of **the Maikal Range** is the Baghelkhand.
- Made of limestones and sandstones on the west and granite in the east.
- It is bounded by the Son river on the north.
- The central part of the plateau acts as a water divide between the **Son** drainage system in the north and the Mahanadi river system in the south.
- The region is uneven with general elevation varying from 150 m to 1,200 m.
- The Bhanrer and Kaimur are located close to the trough-axis.
- The general horizontality of the strata shows that this area has not undergone any major disturbance.

Chotanagpur Plateau

- Chotanagpur plateau represents the north-eastern projection of the Indian Peninsula.
- Mostly in Jharkhand, northern part of Chhatisgarh and Purulia district of West Bengal.
- The Son river flows in the north-west of the plateau and joins the Ganga.
- The average elevation of the plateau is 700 m above sea level.
- This plateau is composed mainly of **Gondwana rocks.**
- The plateau is drained by numerous rivers and streams in different directions and presents a radial drainage pattern. {Drainage Pattern}
- Rivers like the **Damodar**, the **Subarnrekaha**, the **North Koel**, the **South Koel** and the **Barkar** have developed extensive drainage basins.
- The Damodar river flows through the middle of this region in a rift valley from west to east. Here are found the Gondwana coal fields which provide bulk of coal in India.

- North of the Damodar river is the Hazaribagh plateau with an average elevation of 600 m above mean sea level. This plateau has isolated hills. It looks like a peneplain due to large scale erosion.
- The Ranchi Plateau to the south of the Damodar Valley rises to about 600 m above mean sea level. Most of the surface is rolling where the city of Ranchi (661 m) is located.
- At places it is interruped by monadnocks (an isolated hill or ridge of erosion-resistant rock rising above a peneplain. Ex: Ayers Rock in Australia) and conical hills.
- The Rajmahal Hills forming the north eastern edge of the Chotanagpur Plateau are mostly made of basalt and are covered by lava flows {Basaltic Lava}.
- They run in north-south direction and rise to average elevation of 400 m (highest mount is 567 m). These hills have been dissected into separate plateaus.

Meghalaya Plateau

- The peninsular plateau extends further east beyond the Rajmahal hills to from **Meghalaya or the Shillong plateau**.
- Garo-Rajmahal Gap separates this plateau from the main block.
- This gap was formed by down-faulting (normal fault: a block of earth slides downwards). It was later filled by sediments deposited by the Ganga and Brahmaputa.
- The plateau is formed by Archaean quartzites, shales and schists.
- The plateau slopes down to Brahmaputra valley in the north and the Surma and Meghna valleys in the south.
- Its western boundary more or less coincides with the Bangladesh border.
- The western, central and the eastern parts of the plateau are known as the **Garo Hills** (900 m), the Khasi-Jaintia Hills (1,500 m) and the Mikir Hills (700 m).
- **Shillong (1,961 m)** is the highest point of the plateau.

Deccan Plateau

- It covers an area of about five lakh sq km.
- It is triangular in shape and is bounded by the Satpura and the Vindhya in the north-west, the Mahadev and the Maikal in the north, the Western Ghats in the west and the **Eastern** Ghats in the east.
- Its average elevation is 600 m.
- It rises to 1000 m in the south but dips to 500 m in the north.
- Its general slope is from west to east which is indicated by the flow of its major rivers.
- Rivers have further subdivided this plateau into a number of smaller plateaus.

Maharashtra Plateau

- The Maharashtra Plateau lies in Maharashtra.
- It forms the northern part of the Deccan Plateau.
- Much of the region is underlain by basaltic rocks of lava origin [Most of the Deccan Traps lies in this region].
- The area looks like a rolling plain due to weathering.

- The horizontal lava sheets have led to the formation of typical Deccan Trap topography [step like].
- The broad and shallow valleys of the Godavari, the Bhima and the Krishna are flanked [bordered on the opposite sides] by flat-topped steep sided hills and ridges.
- The entire area is covered by black cotton soil known as regur.

Karnataka Plateau

- The Karnataka Plateau is also known as **the Mysore plateau**.
- Lies to the south of the Maharashtra plateau.
- The area looks like a rolling plateau with an average elevation of 600-900 m.
- It is highly dissected by numerous rivers rising from the Western Ghats.
- The general trend of the hills is either parallel to the Western Ghats or across it.
- The highest peak (1913 m) is at Mulangiri in Baba Budan Hills in Chikmaglur district.
- The plateau is divided into two parts called **Malnad** and **Maidan**.
- The Malnad in Kannada means hill country. It is dissected into deep valleys covered with dense forests.
- The Maidan on the other hand is formed of rolling plain with low granite hills.
- The plateau tapers between the Western Ghats and the Eastern Ghats in the south and merges with the Niligiri hills there.

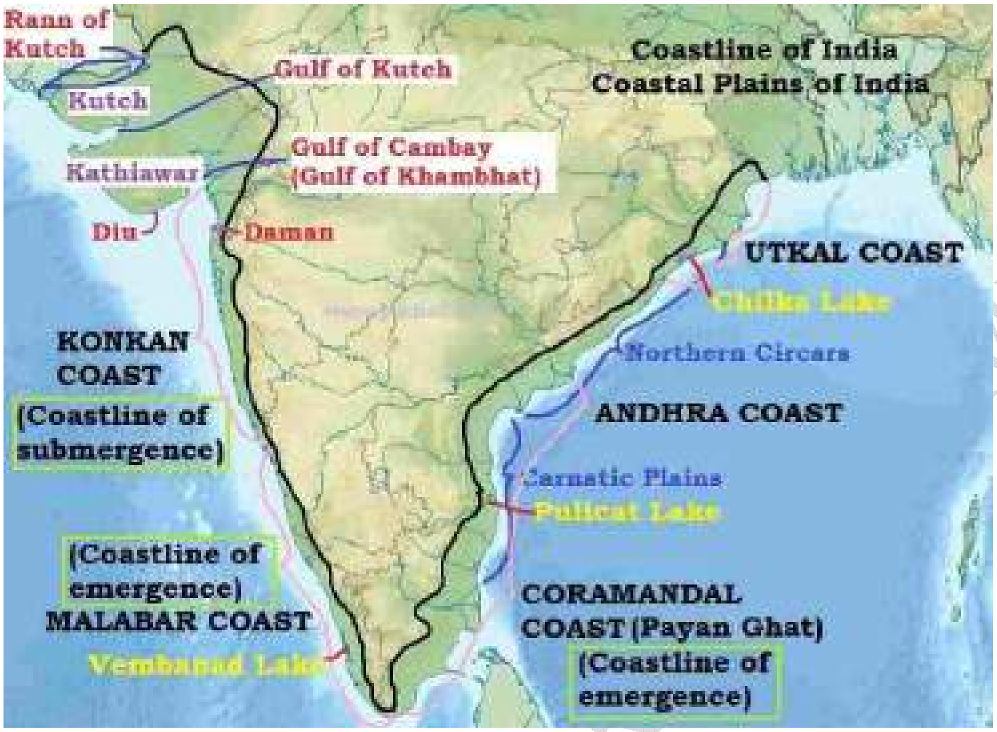
Telangana plateau

- The Telangana plateau consists of Archaean gneisses.
- It's average elevation is 500-600 m.
- The southern part is higher than its northern counterpart.
- The region is drained by three river systems, the Godavari, the Krishna and the Penneru.
- The entire plateau is divided into Ghats and the Peneplains (a vast featureless, undulating plain which the last stage of deposition process).

Chhattisgarh Plain

- The Chhattisgarh plain is the only plain worth the name in the Peninsular plateau.
- It is a saucer shaped depression drained by the upper Mahanadi.
- The whole basin lies between the **Maikala Range** and **the Odisha hills.**
- The region was once ruled by Haithaivanshi Rajputs from whose thirty six forts (Chhattisgarh) it derives its name.
- The basin is laid with nearly horizontal beds of limestone and shales.
- The general elevation of the plain ranges from 250 m in the east to 330 m in the west.

THE COASTAL PLAINS



India has a coastline of 7516.6 Km [6100 km of mainland coastline + coastline of 1197 Indian islands] touching 13 States and Union Territories (UTs). The straight and regular coastline of India is the result of faulting of the Gondwanaland during the Cretaceous period. {Continental Drift}. As such the coast of India does not offer many sites for good natural harbours.
[Indented coastlines of Europe provide good natural harbours whereas African and Indian coastlines are not indented].

The Bay of Bengal and the Arabian Sea came into being during the Cretaceous or early Tertiary period after the disintegration of Gondwanaland.

East Coast of India

- Lies between the Eastern Ghats and the Bay of Bengal.
- It extends from the Ganga delta to Kanniyakumari.
- It is marked by deltas of rivers like the Mahanadi, the Godavari, the Krishna and the Cauvery.
- Chilka lake and the Pulicat lake (lagoon) are the important geographical features of east coast.

Regional Names of The East Coast of India

- In Orissa (Odisha) it is known as Utkal coast.
- From the southern limit of the Utkal plain, stretch the Andhra coast.
- In the south of the Andhra plain is the Tamil Nadu coast.
- The Tamil Nadu coast and parts of Andhra coast together are known as Coramandal Coast or Payan Ghat [False Divi Point in AP (Krishna River Delta) in the north to Kanyakumari in the south.].

West Coast of India

- The west coast strip extends from the Gulf of Cambay (Gulf of Khambhat) in the north to Cape Comorin (Kanniyakumari).
- Starting from north to south, it is divided into
  - ✓ the Konkan coast,
  - ✓ the Karnataka coast and
  - ✓ the Kerala cost.
- It is made up of alluvium brought down by the short streams originating from the Western Ghats.
- It is dotted with a large number of coves (a very small bay), creeks (a narrow, sheltered waterway such as an inlet in a shoreline or channel in a marsh) and a few estuaries. {Marine Landforms}
- The estuaries, of the Narmada and the Tapi are the major ones.
- The Kerala coast (Malabar Coast) has some lakes, lagoons and backwaters, the largest being the Vembanad Lake.

Regional Names of The West Coast of India

- Konkan coast == Maharashtra coast and Goa coast;
- Malabar Coast == Kerala and Karnataka coast.

Coastlines

- Coastline of Emergence
- Coastline of Submergence

Coastlines of Emergence and Submergence

- Coastline of emergence is formed either by an uplift of the land or by the lowering of the sea level. Coastline of submergence is an exact opposite case.
- Bars, spits, lagoons, salt marshes, beaches, sea cliffs and arches are the typical features of emergence. {Marine Landforms}
- The east coast of India, especially its south-eastern part (Tamil Nadu coast), appears to be a coast of emergence.
- The west coast of India, on the other hand, is both emergent and submergent.
- The northern portion of the coast is submerged as a result of faulting and the southern portion, that is the Kerala coast, is an example of an emergent coast.

Coramandal coast (Tamil Nadu) ==> Coastline of emergence
Malabar coast (Kerala Coast) ==> Coastline of emergence
Konkan coast (Maharashtra and Goa Coast) ==> Coastline of submergence.

Western Coastal Plains of India

- Rann of Kachchh in the north to Kanniyakumari in the South.
- These are narrow plains with an average width of about 65 km.

Kutch and Kathiawar region

- Kutch and Kathiawar, though an extension of Peninsular plateau (because Kathiawar is made of the Deccan Lava and there are tertiary rocks in the Kutch area), they are still treated as integral part of the Western Coastal Plains as they are now levelled down.
- The Kutch Peninsula was an island surrounded by seas and lagoons. These seas and lagoons were later filled by sediment brought by the Indus River which used to flow through this area. Lack of rains in recent times has turned it into arid and semi-arid landscape.
- Salt-soaked plain to the north of Kutch is the Great Rann. Its southern continuation, known as the Little Rann lies on the coast and south-east of Kachchh.
- The Kathiawar Peninsula lies to the south of the Kachchh. The central part is a highland of Mandav Hills from which small streams radiate in all directions (Radial Drainage). Mt. Girnar (1,117 m) is the highest point and is of volcanic origin.
- The Gir Range is located in the southern part of the Kathiawar peninsula. It is covered with dense forests and is famous as home of the Gir lion.

Gujarat Plain

- The Gujarat Plain lies east of Kachchh and Kathiawar and slopes towards the west and south west.
- Formed by the rivers Narmada, Tapi, Mahi and Sabarmati, the plain includes the southern part of Gujarat and the coastal areas of the Gulf of Khambhat.
- The eastern part of this plain is fertile enough to support agriculture, but the greater part near the coast is covered by windblown loess (heaps of sand).

Konkan Plain

- The Konkan Plain south of the Gujarat plain extends from Daman to Goa (50 to 80 km wide).
- It has some features of marine erosion including cliffs, shoals, reefs and islands in the Arabian Sea.
- The Thane creek around Mumbai is an important embayment (a recess in a coastline forming a bay) which provides an excellent natural harbour.

Karnataka Coastal Plain

- Goa to Mangalore.
- It is a narrow plain with an average width of 30-50 km, the maximum being 70 km near Mangalore.
- At some places the streams originating in the Western Ghats descend along steep slopes and make waterfalls.
- The Sharavati while descending over such a steep slope makes an impressive waterfall known as Gersoppa (Jog) Falls which is 271 m high. [Angel falls (979 m) in Venezuela is the highest waterfall on earth. Tugela Falls (948 m) in Drakensberg mountains in South Africa is the second highest.]
- Marine topography is quite marked on the coast.

Kerala Plain

- The Kerala Plain also known as the Malabar Plain.
- Between Mangalore and Kanniyakumari.
- This is much wider than the Karnataka plain. It is a low lying plain.
- The existence of lakes, lagoons, backwaters, spits, etc. is a significant characteristic of the Kerala coast.
- The backwaters, locally known as kayals are the shallow lagoons or inlets of the sea, lying parallel to the coastline.
- The largest among these is the Vembanad Lake which is about 75 km long and 5-10 km wide and gives rise to a 55 km long spit {Marine Landforms}.

Eastern Coastal Plains of India

- Extending from the Subarnarekha river along the West Bengal-Odisha border to Kanniyakumari.
- A major part of the plains is formed as a result of the alluvial fillings of the littoral zone (relating to or on the shore of the sea or a lake) by the rivers Mahanadi, Godavari, Krishna and Cauvery comprising some of the largest deltas.
- In contrast to the West Coastal Plains, these are extensive plains with an average width of 120 km.
- This plain is known as the Northern Circars between the Mahanadi and the Krishna rivers and Carnatic between the Krishna and the Cauvery rivers.

Utkal Plain

- The Utkal Plain comprises coastal areas of Odisha.
- It includes the Mahanadi delta.
- The most prominent physiographic feature of this plain is the Chilka Lake.
- It is the biggest lake in the country and its area varies between 780 sq km in winter to 1,144 sq km in the monsoon months.
- South of Chilka Lake, low hills dot the plain.

Andhra Plain

- South of the Utkal Plain and extends upto Pulicat Lake**.** This lake has been barred by a long sand spit known as Sriharikota Island (ISRO launch facility).
- The most significant feature of this plain is the delta formation by the rivers Godavari and Krishna.
- The two deltas have merged with each other and formed a single physiographic unit.
- The combined delta has advanced by about 35 km towards the sea during the recent years. This is clear from the present location of the Kolleru Lake which was once a lagoon at the shore but now lies far inland {Coastline of Emergence}.
- This part of the plain has a straight coast and badly lacks good harbours with the exception of Vishakhapatnamand Machilipatnam**.**

Tamil Nadu Plain

- The Tamil Nadu Plain stretches for 675 km from Pulicat lake to Kanniyakumari along the coast of Tamil Nadu. Its average width is 100 km.
- The most important feature of this plain is the Cauvery delta where the plain is 130 km wide.
- The fertile soil and large scale irrigation facilities have made the Cauvery delta the granary of South India.

Significance of the Coastal Plains

- Large parts of the coastal plains of India are covered by fertile soils on which different crops are grown. Rice is the main crop of these areas.
- Coconut trees grow all along the coast.
- The entire length of the coast is dotted with big and small ports which help in carrying out trade.
- The sedimentary rocks of these plains are said to contain large deposits of mineral oil (KG Basin).
- The sands of Kerala coast have large quantity of MONAZITE which is used for nuclear power.
- Fishing is an important occupation of the people living in the coastal areas.
- Low lying areas of Gujarat are famous for producing salt.
- Kerala backwaters are important tourist destinations.
- Goa provides good beaches. This is also an important tourist destination.

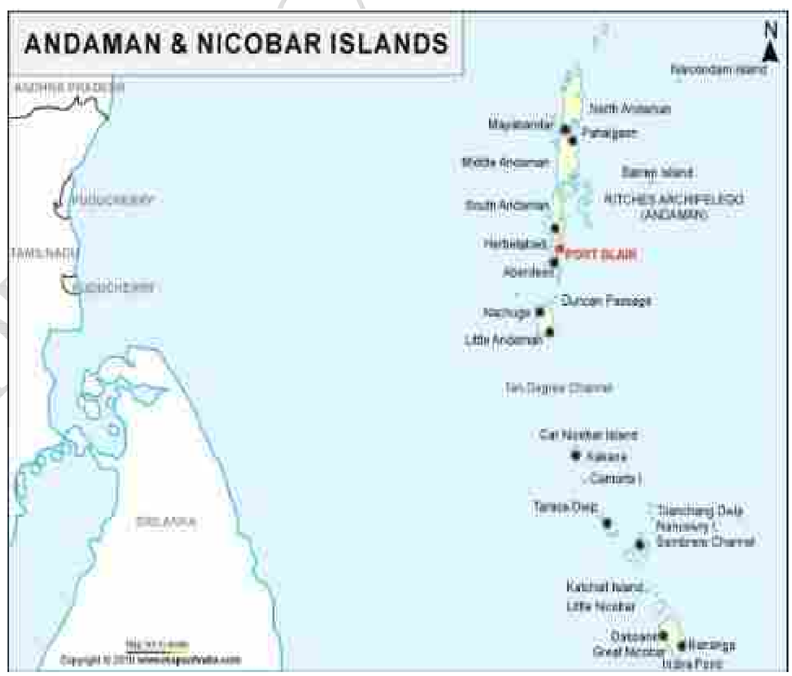
THE INDIAN ISLANDS

The major islands groups of India are Andaman and Nicobar Archipelago (A chain of islands similar in origin) in Bay of Bengal and Lakshadweep islands in Arabian Sea.
Andaman and Nicobar Islands were formed due to collision between Indian Plate and Burma Minor Plate [part of Eurasian Plate][Similar to formation of Himalayas]. Andaman and Nicobar Islands are southward extension of Arakan Yoma range [Myanmar][Arakan Yoma in itself is an extension of Purvanchal Hills].

Lakshadweep Islands are coral islands. These islands are a part Reunion Hotspot volcanism.

Other than these two groups there are islands in Indo-Gangetic Delta [they are more a part of delta than islands] and between India and Sri Lanka [Remnants of Adams Bridge; formed due to submergence].

Andaman and Nicobar Islands



This archipelago is composed of 265 big and small islands [203 Andaman islands + 62 Nicobar Islands]. The Andaman and Nicobar islands extend from 6° 45′ N to 13° 45′ N and from 92° 10′ E to 94° 15′ E for a distance of about 590 km.
The Andaman islands are divided into three main islands i.e. North, Middle and South. Duncan passage separates Little Andaman from South Andaman. The Great Andaman group of islands in the north is separated by the Ten Degree Channel from the Nicobar group in the south [Prelims 2014].
Port Blair, the capital of Andaman Nicobar Islands lies in the South Andaman. Among the Nicobar islands, the Great Nicobar is the largest. It is the southernmost island and is very close to Sumatra island of Indonesia. The Car Nicobar is the northernmost. Most of these islands are made of tertiary sandstone, limestone and shale resting on basic and ultrabasic volcanoes [Similar to Himalayas].

THE BARREN AND NARCONDAM ISLANDS, north of Port Blair, are volcanic islands [these are the only active volcanoes in India][There are no active volcanoes in main land India].

Some of the islands are fringed with coral reefs. Many of them are covered with thick forests. Most of the islands are mountainous.
Saddle peak (737 m) in North Andaman is the highest peak.

Lakshadweep Islands

- In the Arabian Sea, there are three types of islands.
  - (a) **Amindivi Islands** (consisting of six main islands of Amini, Keltan, Chetlat, Kadmat, Bitra and Perumul Par). [don't have to remember all these names]
  - (b) **Laccadive Islands** (consisting of five major islands of Androth, Kalpeni, **Kavaratti**, Pitti and Suheli Par) and
  - (c) **Minicoy Island**.
- At present these islands are collectively known as Lakshadweep.
- The Lakshadweep Islands are a group of 25 small islands.
- They are widely scattered about 200-500 km south-west of the Kerala coast.
- Amendivi Islands are the northern most while the Minicoy Island is the southernmost.
- All are tiny islands of coral origin {Atoll} and are surrounded by fringing reefs.
- The largest and the most advanced is **the Minicoy Island** with an area of 4.53 sq km.
- Most of the islands have low elevation and do not rise more than five metre above sea level (Extremely Vulnerable to sea level change).
- Their topography is flat and relief features such as hills, streams, valleys, etc. are absent.

INDIAN DESERT

The Thar Desert is by some calculations the world's seventh largest desert, by some others the tenth. It forms a significant portion of western India and covers an area of 200,000 to 238,700 km^2 (77,200 to 92,200 sq mi). The desert continues into Pakistan as the Cholistan Desert. Most of the Thar Desert is situated in Rajasthan, covering 61% of its geographic area.

- About 10 percent of this region consists of sand dunes, and the remaining 90 percent consist of craggy rock forms, compacted salt-lake bottoms, and interdunal and fixed dune areas.
- Annual temperatures can range from 0 °C (32 °F) in the winter to over 50 °C (122 °F) during the summer. Most of the rainfall received in this region is associated with the short July–September southwest monsoon that brings 100 to 500 mm (3.9 to 19.7 in) of precipitation.
- Water is scarce and occurs at great depths, ranging from 30 to 120 metres (98 to 394 ft) below the ground level. Rainfall is precarious and erratic, ranging from below 120 mm (4.7 in) in the extreme west to 375 mm (14.8 in) eastward.
- The only river in this region is **Luni**. The soils of the arid region are generally sandy to sandy-loam in texture. The consistency and depth vary as per the topographical features. The low-lying loams are heavier may have a hard pan of **clay, calcium carbonate or gypsum.**

New Moore Island

It is a small uninhabited offshore sandbar landform {Marine Landforms} in the Bay of Bengal, off the coast of the Ganges-Brahmaputra Delta region.
It emerged in the Bay of Bengal in the aftermath of the **Bhola cyclone in 1970**. It keeps on emerging and disappearing.
Although the island was uninhabited and there were no permanent settlements or stations located on it, both **India and Bangladesh claimed sovereignty over it because of speculation over the existence of oil and natural gas in the region**.
The issue of sovereignty was also a part of the larger dispute over the **Radcliffe Award** methodology of settling the maritime boundary between the two nations.

In western India, the Kutch region in Gujarat and Koyna in Maharashtra are classified as a Zone IV region (high risk) for earthquakes. The Kutch city of Bhuj was the epicentre of the 2001 Gujarat earthquake, which claimed the lives of more than 1,337 people and injured 166,836 while destroying or damaging near a million homes.

➢ DRAINAGE OF INDIA

The flow of water through well-defined channels is known as drainage and the network of such channels is known as **drainage system**.

The drainage pattern of an area is the result of the geological time period, nature, and structure of rocks, topography, slope, etc. About 77% of the drainage area consisting of the Ganga, the Brahmaputra, the Mahanadi, the Krishna, etc. is oriented towards the Bay of Bengal. On the other hand, 23% comprising the Indus, the Narmada, the Tapi, the Mahi, and the Periyar systems discharge their waters in the Arabian Sea.

- A river drain is a specific area, which is known as the **catchment area** of that river.
- An area drained by a river and its tributaries is known as a **drainage basin**.
- The boundary line separating one drainage basin from the other is called as the **watershed area**.

Drainage Pattern

Following are the major drainage patterns −

- Dendritic
- Radial
- Centripetal
- Trellis

A drainage pattern which looks like tree branches with lots of twigs is known as Dendritic drainage pattern.
For example, the rivers of northern plain.

Radial drainage patterns form when rivers originate from a hill and flow in all directions.
For example, the rivers originating from the Amarkantak.

Centripetal drainage pattern is formed when rivers discharge their waters from all directions into a lake or a depression.
For example, Loktak lake in Manipur.

Trellis drainage pattern is formed when the primary tributaries of main rivers flow parallel to each other and secondary tributaries join them at right angles.

For example, rivers in the upper part of the Himalayan region.

DRAINAGE SYSTEM IN INDIA

The drainage system of India, that is, the rivers, is divided into two major groups:

- the Himalayan rivers
- the Peninsular rivers

On the basis of the size of the watershed, the drainage basins of India are grouped into three categories:

(i) **Major river basins** with more than 20,000 sq. km of catchment area. It includes 14 drainage basins such as the Ganga, the Brahmaputra, the Krishna, the Tapi, the Narmada, the Mahi, the Pennar, the Sabarmati, the Barak, etc.
(ii) **Medium river basins** with catchment area between 2,000-20,000 sq. km incorporating 44 river basins such as the Kalindi, the Periyar, the Meghna, etc.
(iii) **Minor river basins** with catchment area of less than 2,000 sq. km include fairly good number of rivers flowing in the area of low rainfall.

THE HIMALAYAN RIVERS

The three main Himalayan rivers are the Indus**,** the Ganga and the Brahmaputra. These rivers are long and are joined by many tributaries. A river along with its tributaries forms a river system**.** Let's study of each river and its tributaries.

Indus River System:

The Indus originates in the northern slopes of the Kailash range in Tibet near Lake Manasarovar. It enters Indian territory in Jammu and Kashmir.
It has a large number of tributaries in both India and Pakistan and has a total length of about 2897 km from the source to the point near Karachi where it falls into the Arabian Sea. The main tributaries of the Indus in India are Jhelum, Chenab, Ravi, Beas and Sutlej.

Jhelum
The Jhelum originates in the south-eastern part of Kashmir, in a spring at Verinag.

Chenab
The Chenab originates from the confluence of two rivers, the Chandra and the Bhaga, which themselves originate from either side of the Bara Lacha Pass in Lahul. It is also known as the Chandrabhaga in Himachal Pradesh.

Ravi
The Ravi originates near the Rotang pass in the Kangra Himalayas and follows a north-westerly course

Beas
The Beas originates in Beas Kund, lying near the Rohtang pass It joins the Sutlej river near Harika, after being joined by a few tributaries. The total length of the river is 615 km.

Sutlej
The Sutlej originates from the Rakas Lake, which is connected to the Manasarovar lake by a stream, in Tibet.

The Ganga River System
'Bhagirathi' which is the headwaters of the Ganga is fed by the **Gangotri Glacier**. It is joined by the Alaknanda at Devaprayag in Uttarakhand. The Ganga emerges at Haridwar from

the mountains on to the plane. Many major rivers join the Ganga which includes the **Yamuna**, the Ghaghara, the Gandak and the Kosi. the river Yamuna emerges from the Yamunotri Glacier in the Himalayas. It meets the Ganga at Allahabad at the right bank.

Tributaries of Ganga:

- **Yamuna (1375 km)** is its most important tributary (on right bank). It rises at the Yamunotri glacier in Uttarakhand. It runs parallel to Ganga for 800km and joins it at Allahabad. Important tributaries of Yamuna are: a) Chambal (1050 km) which rises from Vindhyas hill near Indore (M.P), Betwa (480 km).
- Ghaghra (1080 km), Originated from Tibetan Plateau near Lake Mansarovar.
- Son (780 km),which rises from Amarkantak Plateau(M.P)
- Gandak (425 km),Originates from **Nhubine Himal Glacier** in the Mustang region of Nepal
- Kosi (730 km),Kosi is infamous as ‘Sorrow of Bihar. This river is also called as “Saptkoshi”. Originated from hills of Nepal and Tibet.
- Gomti (805 km), originated from Gomat Taal near Pillibhit(U.P), India.
- Damodar (541 km). Damodar gets the name ‘Sorrow of Bengal’ as these cause floods in these regions.Originated from Chota Nagpur Plateau (Jharkhand).

Brahmaputra River System:

- The Brahmaputra originates in the Mansarovar lake, also the source of the Indus and the Satluj.
- It is slightly longer than the Indus, but most of its course lies outside India.
- In Tibet, the river is known as the Tsangpo. There, it receives less volume of water and has less silt.
- The shifting of the channels of the river is also very common. The fury of the river during rains is very high. It is known for creating havoc in Assam and Bangladesh. At the same time, quite a few big pockets suffer from drought.
- It has a total length of 2900 km
- Important Tributaries: Subansiri, Kameng, Dhansiri, Manas, Teesta.

- In Bangladesh, Brahmaputra is known by the name of Jamuna while Ganga gets the name Padma. Their combined stream is known as Meghna .

List of comparison between Himalayan and the Peninsular River of India

Characteristics	Himalayan Rivers	Peninsular Rivers
Place of origin	Himalayan mountains (covered with glaciers).	Pre-Cambrian Peninsular plateau and central highland.
Nature of flow	Perennial; receive water from glacier and rainfall.	Seasonal; dependent on monsoon rainfall.
Drainage Pattern	Antecedent (Older than Himalaya). For example- Indus, Brahmaputra etc. Non-antecedent (Younger than Himalaya) For example- Ganga, Yamuna, Jhelum etc.	Most of the rivers of peninsular India super imposed, rejuvenated resulting in trellis, radial, and rectangular patterns.
Nature of river	Long course, flowing through the rugged mountains experiencing head ward erosion and river capturing; In plains, meandering and shifting off course.	Smaller, fixed course with well adjusted valleys.
Catchment area	Big catchment area	Smaller catchment area
Age of the river	Young and youthful, active and deepening in the valleys	Old rivers with graded profile, and have almost reached their base levels.

THE PENINSULAR RIVERS

The Western Ghats, which runs from north to south close to the western coast, forms the main water divide in Peninsular India. The major rivers of the Peninsula which flow into the Bay of Bengal include the Mahanadi, the Godavari, the Krishna and the Kaveri. The Narmada and the Tapi are the only long rivers which flow west and make estuaries.

Evolution of Peninsular Drainage System

Three major geological events in the distant past have shaped the present drainage systems of Peninsular India:

• Subsidence of the western flank of the Peninsula leading to its submergence below the sea during the early tertiary period. Generally, it has disturbed the symmetrical plan of the river on either side of the original watershed.

• Upheaval of the Himalayas when the northern flank of the peninsular block was subjected to subsidence and the consequent trough faulting. The Narmada and The Tapi flow in trough faults and fill the original cracks with their detritus materials. Hence, there is a lack of alluvial and deltaic deposits in these rivers.

• Slight tilting of the peninsular block from northwest to the south-eastern direction gave orientation to the entire drainage system towards the Bay of Bengal during the same period.

The Tapi Basin

The Tapi rises in the Satpura ranges, in the Betul district of Madhya Pradesh. Its basin covers parts of Madhya Pradesh, Gujarat and Maharashtra. the main west rivers flowing west are Sabarmati, Mahi, Bharathpuzha and Periyar.

The Narmada Basin

The Narmada river rises in the Amarkaantak hills in Madhya Pradesh. It flows towards the west in a rift valley. On its way to the sea, it forms many picturesque locations like the 'Marble rocks' and the 'Dhuadhar falls'.The tributaries of the Narmada are very short. This basin covers parts of Madhya Pradesh and Gujarat.

The Godavari Basin

It is the largest peninsular river system due to this it is also called the Dakshin Ganga. It rises in the Nasik district of Maharashtra and discharges its water into the Bay of Bengal. Its tributaries run through the states of Maharashtra, Madhya Pradesh, Chhattisgarh, Orissa and Andhra Pradesh. The Penganga, the Indravati, the Pranhita, and the Manjra are its principal tributaries. The Godavari is subjected to heavy floods in its lower reaches to the south of Polavaram, where it forms a picturesque gorge. It is navigable only in the deltaic stretch. The river after Rajamundri splits into several branches forming a large delta.

The Mahanadi Basin

The Mahanadi rises in the highlands of Chhattisgarh. It reaches the Bay of Bengal after flowing through Odisha. The length of the Mahanadi river is 860 km. It covers parts of Maharashtra, Chhatisgarh**,** Jharkhand and Odisha.

The Krishna Basin

The Krishna river rises from a spring near Mahabaleshwar and flows for 1400 km. It reaches the Bay of Bengal. The tributaries of Krishna river are the Tungabhadra, the Koyana, the Ghatprabha, the Musi and the Bhima. Its drainage system covers parts of Maharashtra, Karnataka and Andhra Pradesh**.**

The Kaveri Basin

The Kaveri rises in the Brahmagri range of the Western Ghats and reaches the Bay of Bengal in the south of Cuddalore, in Tamil Nadu. The total length of the Kaveri river is 760 km. The main tributaries of Kaveri river are Amravati, Bhavani, Hemavati and Kabini. It covers parts of Karnataka, Kerala and Tamil Nadu.

The Narmada Basin

It originates on the western flank of the Amarkantak plateau at a height of about 1,057 m. flowing in a rift valley between the Satpura in the south and the Vindhyan range in the north; it forms a picturesque gorge in marble rocks and Dhuandhar waterfall near Jabalpur. After flowing a distance of about 1,312 km, it meets the Arabian sea south of Bharuch, forming a broad 27 km long estuary. Its catchment area is about 98,796 sq. km. The Sardar Sarovar Project has been constructed on this river.

The Luni Basin

It is the largest river system of Rajasthan, west of Aravali. It originates near Pushkar in two branches, i.e. the Saraswati and the Sabarmati, which join with each other at Govindgarh. From here, the river comes out of Aravali and is known as Luni. It flows towards the west till Telwara and then takes a southwest direction to join the Rann of Kuchchh. The entire river system is ephemeral.

List of the east and west flowing rivers of India with their characteristics

East Flowing Rivers	West Flowing Rivers
Have large catchment areas and form deltas not estuary	Form estuaries and not deltas
Flows towards Bay of Bengal	Flows towards Arabian Sea
77 per cent of the drainage area of the country is flows towards the Bay of Bengal	23 per cent of the drainage area of the country is flows towards the Arabian sea
The Ganga, the Brahmaputra, theMahanadi, the Godavari, the Krishna, theCauvery, the Penneru, the Penneiyar, the Vaigai, and the Subarnarekha.	The Indus, the Narmada, the Tapi, the Sabarmati, the Mahi, the Ghagghar,the Luni,theSaravati, the Pumba, thePeriyar, the Bharatpuja and the large number of swift flowing western coast rivers descending from the Sahyadris.

LAKES OF INDIA

Chilika Lake

- It is present in the state of Odisha
- It is the largest brackish water lagoon in the Asian continent
- Contains major islands such as Somolo, Nalabana, Kalijal, Honeymoon, etc
- It was designated as a Ramsar site in 1981 to provide more protection
- It attracts migrating birds in winters

Dal Lake

- It is present in Srinagar, Jammu & Kashmir
- It has the largest tulip garden in Asia
- The lake houses three islands
- It is known for its floating garden

Jaisamand Lake

- It is present in Rajasthan
- It happens to be the second largest artificial lake in Asia
- It is also known by the name ‘Dhebar’
- It contains 7 islands. One of the islands is inhabited by the tribe of Bhil Minas.
- It was created in the seventeenth century as a freshwater lake

Kanwar Lake

- Present in Bihar
- One of the largest freshwater oxbow lake in the Asian continent
- The lake has been shrinking at an alarmingly high rate
- This lake is one of the silent bird sanctuaries in the country

Kolleru Lake

- It is present in Andhra Pradesh
- It is the largest shallow freshwater lake in the whole of Asia
- It is situated between Godaveri and Krishna deltas
- It is designated under the Ramsar Convention

Lonar Lake

- It is a saline soda lake formed in the basalt rock
- It is present in Buldhana district, Maharashtra

Nal Sarovar Lake

- It is present in Gujarat
- It houses the largest Indian bird sanctuary

Pulicat Lake

- It is present in Andhra Pradesh
- It is the second largest brackish water lake or lagoon in the country
- Sriharikota island isolates this lake from the Bay of Bengal

Roop Kund Lake

- It is present in Uttarakhand
- Also known as Mystery Lake or Skeletons Lake because of the presence of hundreds of skeletons found at the lake's edge
- There are places considered for Hindus in the vicinity of the lake

Sambhar Lake

- It is present in Rajasthan
- India's largest inland salt lake
- It has a bowl shape
- The lake gets its water from an endorheic basin
- It is the source of most of the salt production of the state of Rajasthan

Vembanad Kayal

- It is present in Kerala
- It is the longest lake in India
- It is the largest lake of Kerala

Wular Lake

- It is present in Jammu and Kashmir
- It was formed because of tectonic activity and fed by the river Jhelum
- The lake is one of the 26 Indian wetlands selected as a Ramsar site

Role of Rivers in Economy

Rivers are of great importance to humans. We use them for irrigation, navigation, hydropower generation, etc. A country like India, where agriculture is an important occupation, rivers are of significant importance. Thus, the drainage system of India is a basic natural resource of water.

River Pollution

Humans have been modifying everything according to their needs since ages. All the growing needs and demand for water has affected the quality of water in rivers. More and more water is being removed from the rivers reducing its volume. on the other hand, a lot of sewage and waste material is added to water in rivers which affects the quality of water.
We should realize the importance of rivers and the drainage system of India and take actions to conserve water in rivers. Therefore, it is crucial for us to preserve the drainage system of India.

➢ SOILS OF INDIA

Soil can be simply defined as a mixture of small rock particles/debris and organic materials/ humus which develop on the earth surface and support growth of plants.

CLASSIFICATION OF SOIL

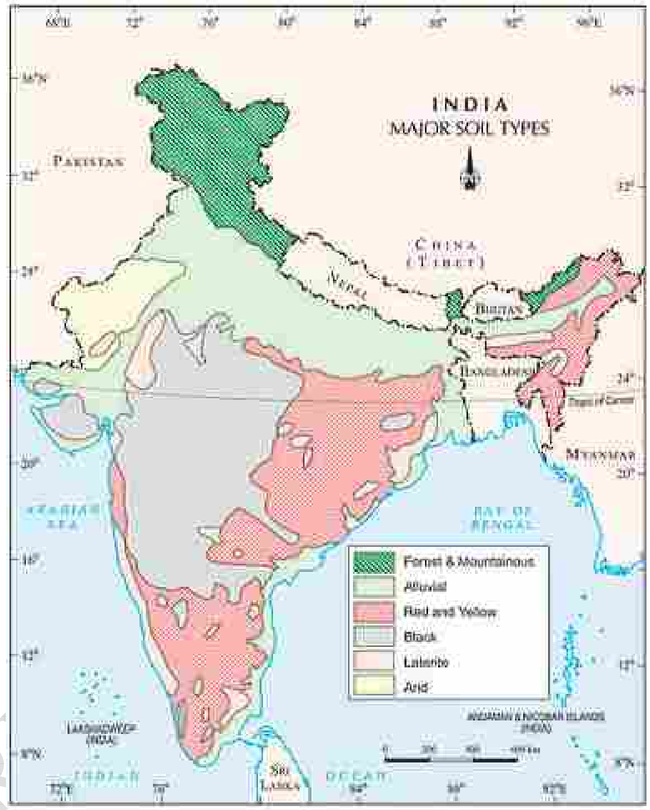
The first scientific classification of soil was done by Voelekar and Leather. According to them, Indian soils were classified into four categories.

(a) Alluvial
(b) Regur (black)
(c) Red soil
(d) Lateritic soil

The All India soil and land use survey organization attempted a classification on the basis of texture, color, structure, pH value, porosity etc in 1957. After that recently, the Indian council of agricultural research, on the basis of texture, structure, color, pH value, porosity etc.

Alluvial soil

The alluvial soil occurs mainly in the Satluj- Ganga- Brahmaputra Plains. They are also found in the valleys of the Narmada, Tapi and in the Eastern and Western coastal plains. These soils are mainly derived from the debris brown from the Himalayas. This soil is well drained and poorly drained with an immature profile in undulating areas. This soil has potash deficiency. The color of soil varies from light grey to ash. This soil is suited for Rice, maize, wheat, sugarcane, oilseeds etc.
This soil is divided into



- **Khadar soil:** the khaddar soils are enriched with fresh silts. They are low lying, frequently inundated by floods during the rainy season. It occupies the flood plains of rivers. The khaddar tracts called as kankar are rich in concentration.
- **The Bhangar:** This soil lies above the flood level. It is well- drained but because of the calcium carbonate nodules. The texture of soil varies from the loamy soil to clayey soil.

Red soil

This soil developed on Archean granite occupies the second largest area of the country. They are mainly found in the Peninsula from Tamil Nadu in the south to Bundelkhand in the north and Raj Mahal in the east to Kathiawad in the west. This soil is also known as omnibus group. The presence of ferric oxides makes the color of soil red. The top layer of the soil is read and horizon below is yellowish. Generally, these soils are deficient in phosphate, lime, magnesia, humus and nitrogen. This soil is good for the cultivation of wheat, cotton, pulses, tobacco, millets, orchards, potato, and oilseeds.

Black or Regur soils

Black soil is also known cotton soil and internationally it is known as 'Tropical Chernozems'. This is the third largest group in India. This soil is formed from rocks of cretaceous lava. This stretch over the parts of Gujarat, Maharashtra, Western parts of Madhya Pradesh, North- Western Andhra Pradesh, Karnataka, Tamil Nadu, Rajasthan, Chhattisgarh, Jharkhand up to Raj Mahal hills. The soil is rich in iron, lime, calcium, potash, magnesium and aluminum. It has high water retaining capacity and good for the cotton cultivation, Tobacco, citrus fruits, castor, and linseed.

Desert soil

This soil is deposited by wind action and mainly found in the arid and semi-arid areas like Rajasthan, West of the Aravallis, Northern Gujarat, Saurashtra, Kachchh, Western parts of Haryana and southern part of Punjab. They are sandy with low organic matter. It has low soluble salts and moisture with very low retaining capacity. If irrigated these soil give a high agricultural return. These suitable less water requiring crops like Bajra, pulses, fodder, and guar.

Laterite Soil

These soft, when they are wet and 'hard and cloddy' on drying. These are found mainly in the hills of the Western Ghats, Raj Mahal hills, Eastern Ghats, Satpura, Vindhya, Odisha, Chhattisgarh, Jharkhand, West Bengal, North Cachar hills, and the Garo hills. These are poor in organic matter, nitrogen, potassium, lime and potash. These iron and aluminum rich soils are suitable for the cultivation of rice, ragi, sugarcane and cashew nuts.

Mountain soils

These soils have less developed soil profile and mainly found in the valleys and hill slopes of Himalayas. These soils are immature and dark brown in color. This soil has very low humus and it is acidic in nature. The orchards, fodder, legumes are grown in this soil.

Red and Black soils

These are developed over the granite, gneiss and quartzite of Precambrian and Archean era. This soil performs well if irrigated. Generally, this soil has very less productivity.

Grey and brown soils

These soils are found in Rajasthan and Gujarat. It is formed by the weathering of granite, quartzite, and gneiss. These loose, friable soils contain iron- oxide (haematite and limonite)

Submontane soil

These are formed by the deposition of eroded material from Shiwaliks and the lesser Himalayas. These are found in the Tarai region of the submontane stretching from Jammu and Kashmir to Assam. The soil supports a luxuriant growth of forest and more prone to soil erosion.

Snow fields

This soil found under the snow and glaciers at the highest peak of greater Himalayas, Karakoram, Ladakh, and Zaskar. This soil is immature in nature and unsuitable for crops.

Karewa soil

Karewa soils are the lacustrine deposits in the Kashmir valleys and Bhadarwah valley. The fine silt, clay, and boulder gravels are the composition of Karewa soil. They are characterized with the fossils. These soils are mainly devoted to the cultivation of saffron, almonds, apple, walnut etc.

Peaty and marshy soils

This soil originates from the areas where adequate drainage is not possible. It is rich in organic matter and has high salinity. They are deficient in potash and phosphate. These mainly found in Sunderbans delta, Kottayam, and Alappuzha districts of Kerala, Rann of Kachchh, deltas of Mahanadi etc.

Saline and alkaline soils

Theses also called as Reh, Usar, Kallar, Rakar, Thur and Chopan. These are mainly found in Rajasthan, Haryana, Punjab, Uttar Pradesh, Bihar and Maharashtra. Sodium chloride and sodium sulphate are present in this soil. It is suitable for leguminous crops.

Types of Soils	States where found	Rich in	Lacks in	Crops grown
Alluvial	Mainly found in the plains of Gujarat, Punjab, Haryana, UP, Bihar, Jharkhand etc.	Potash and Lime	Nitrogen and Phosphorous	Large variety of rabi and kharif crops such as wheat, rice, sugarcane, cotton, jute etc.
Black (Regur soil)	Deccan plateau-Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh,Tamil Nadu, Valleys of Krishna and Godavari.	Lime, Iron, Magnesia and Alumina, Potash	Phosphorous, Nitrogen and organic matter	Cotton, sugarcane, jowar, tobacco, wheat, rice etc.
Red	Eastern and southern part of the deccan plateau, Orissa, Chattisgarh and southern parts of the middle Ganga plain.	Iron and Potash	Nitrogen, Phosphorous and humus.	Wheat, rice, cotton, sugarcane and pulses
Laterite	Karnataka, Kerala, Tamilnadu, Madhya	Iron oxide and potash	Organic matter,	Cashewnuts, tea, coffee, rubber

	Pradesh, Assam and Orissa hills.		Nitrogen, Phosphate and Calcium	
Arid and Desert	Western Rajastan, north Gujarat and southern Punjab	Soluble salts, phosphate	Humus, Nitrogen	Only drought resistant and salt tolerant crops such as barley, rape, cotton, millets maize and pulses
Saline and Alkaline	Western Gujarat, deltas of eastern coast, Sunderban areas of West Bengal, Punjab and Haryana	Sodium, Potassium, Magnesium	Nitrogen and Calcium	Unfit for agriculture

➢ VEGETATION AND FORESTS OF INDIA

- **Climate, soil and topography** are the major factors that influence Natural Vegetation of a place.
- The main climatic factors are **rainfall and temperature**. The amount of annual rainfall has a great bearing on the type of vegetation.

Annual Rainfall	Type of Vegetation
200 cm or more	Evergreen Rain Forests
100 to 200 cm	Monsoon Deciduous Forests
50 to 100 cm	Drier Deciduous or Tropical Savanna
25 to 50 cm	Dry Thorny Scrub (Semi-arid)
Below 25 cm	Desert (Arid)

- Temperature is the major factor in Himalayas and other hilly regions with an elevation of more than 900 metres.
- As the temperature falls with altitude in the Himalayan region the vegetal cover changes with altitude from tropical to sub-tropical, temperate and finally alpine.
- Soil is an equally determining factor in few regions. Mangrove forests, swamp forests are some of the examples where soil is the major factor.
- Topography is responsible for certain minor types e.g. alpine flora, tidal forests, etc.

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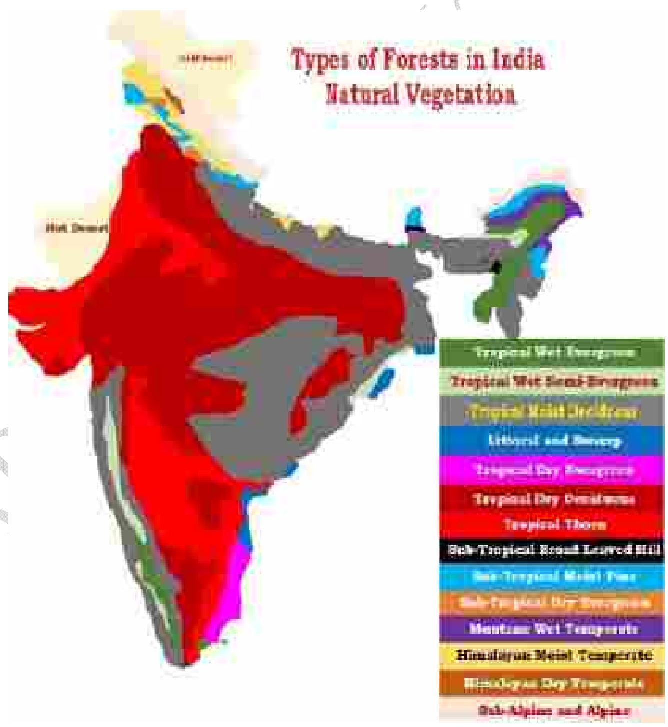
Classification of Natural Vegetation of India

- Classification of Natural Vegetation of India is primarily based on spatial and annual variations in rainfall. Temperature, soil and topography are also considered.
- India's vegetation can be divided into 5 main types and 16 sub-types as given below.

A. Moist Tropical Forests

- Tropical Wet Evergreen
- Tropical Semi-Evergreen
- Tropical Moist Deciduous
- Littoral and Swamp



B. Dry Tropical Forests

- Tropical Dry Evergreen
- Tropical Dry Deciduous
- Tropical Thorn

C. Montane Sub-tropical Forests

- Sub-tropical broad leaved hill
- Sub-tropical moist hill (pine)
- Sub-tropical dry evergreen

D. Montane Temperate Forests

- Montane Wet Temperate
- Himalayan Moist Temperate
- Himalayan Dry Temperate

E. Alpine Forests

- Sub-Alpine
- Moist Alpine scrub
- Dry Alpine scrub

Forest Type in India	% of Total Area
Tropical Moist Deciduous	37
Tropical Dry Deciduous	28
Tropical Wet Evergreen	8
Sub-Tropical Moist Hill	6
Tropical Semi-Evergreen	4
Rest below 4 %	

Moist Tropical Forests

Tropical Wet Evergreen Forests or Rain Forests

Climatic Conditions

- Annual rainfall exceeds 250 cm
- The annual temperature is about 25°-27°C
- The average annual humidity exceeds 77 per cent and
- The dry season is distinctly short.

Characteristics

- Evergreen: Due to high heat and high humidity, the trees of these forests do not shed their leaves together.
- Mesosphytic: Plants adopted to neither too dry nor too wet type climate.
- Lofty: The trees often reach 45 – 60 metres in height.
- Thick Canopy: From the air, the tropical rain forest appears like a thick canopy of foliage, broken only where it is crossed by large rivers or cleared for cultivation.
- All plants struggle upwards (most ephiphytes) for sunlight resulting in a peculiar layer arrangement. The entire morphology looks like a green carpet when viewed from above.
- Less undergrowth: The sun light cannot reach the ground due to thick canopy. The undergrowth is formed mainly of bamboos, ferns, climbers, orchids, etc.

What are mesophytes?

- Unlike **hydrophytic plants**, such as water lily or pondweed, that grow in saturated soil or water, or **xerophytic plants**, such as cactus, that grow in extremely dry soil, mesophytes are ordinary plants that **exist between the two extremes.**
- Mesophytic environments are marked by average to hot temperatures and soil that is **neither too dry nor too wet.**

Distribution

- Western side of the Western Ghats (500 to 1370 metres above sea level).
- Some regions in the Purvanchal hills.
- In the Andaman and Nicobar Islands.

Timber

- Hardwood: The timber of these forests is fine-grained, hard and durable.
- It has high commercial value but it is highly challenging to exploit due to dense undergrowth, absence of pure stands and lack of transport facilities.
- The important species of these forests are mahogany, mesua, white cedar, jamun, canes, bamboo etc.

Tropical Semi-Evergreen Forests

- They are transitional forests between tropic
- They are comparatively drier areas compared to tropical wet evergreen forests.

Climatic Conditions

- Annual rainfall is 200-250 cm
- Mean annual temperature varies from 24°C to 27°C
- The relative humidity is about 75 per cent
- The dry season is not short like in tropical evergreen forests.

Distribution

- Western coast
- Assam
- Lower slopes of the Eastern Himalayas
- Odisha and
- Andamans.

Characteristics

- The semi-evergreen forests are less dense.
- They are more gregarious [living in flocks or colonies – more pure stands] than the wet evergreen forests.
- These forests are characterized by many species.
- Trees usually have buttressed trunks with abundant epiphytes.
- The important species are laurel, rosewood, mesua, thorny bamboo – Western Ghats, white cedar, Indian chestnut, champa, mango, etc. – Himalayan region.

Timber

- Hardwood: Similar to that in tropical evergreen forests except that these forests are less dense with more pure stands (timber industry here is better than in evergreen forests).

Tropical Moist Deciduous Forests

Climatic Conditions

- Annual rainfall 100 to 200 cm.
- Mean annual temperature of about 27°C
- The average annual relative humidity of 60 to 75 per cent.
- Spring (between winter and summer) and summer are dry.

Characteristics

- The trees drop their leaves during the spring and early summer when sufficient moisture is not available.
- The general appearance is bare in extreme summers (April-May).
- Tropical moist deciduous forests present irregular top storey [25 to 60 m].
- Heavily buttressed trees and fairly complete undergrowth.
- These forests occupy a much larger area than the evergreen forests but large tracts under these forests have been cleared for cultivation.

Distribution

- Belt running along the Western Ghats surrounding the belt of evergreen forests.
- A strip along the Shiwalik range including terai and bhabar from 77° E to 88° E.
- Manipur and Mizoram.
- Hills of eastern Madhya Pradesh and Chhattisgarh.
- Chota Nagpur Plateau.
- Most of Odisha.
- Parts of West Bengal and
- Andaman and Nicobar islands.

Timber

- These provide valuable timer like Teak.
- The main species found in these forests are teak, sal, laurel, rosewood, amla, jamun, bamboo, etc.
- It is comparatively easy to exploit these forests due to their high degree of gregariousness (more pure stands).

Littoral and Swamp Forests

- They can survive and grow both in fresh as well as brackish water (The mixture of seawater and fresh water in estuaries is called brackish water and its salinity can range from 0.5 to 35 ppt).
- Occur in and around the deltas, estuaries and creeks prone to tidal influences (delta or tidal forests).
- Littoral (relating to or on the shore of the sea or a lake) forests occur at several places along the coast.
- Swamp forests are confined to the deltas of the Ganga, the Mahanadi, the Godavari, the Krishna and the Cauvery.
- Dense mangroves occur all along the coastline in sheltered estuaries, tidal creeks, backwaters, salt marshes and mudflats. It provides useful fuel wood.
- The most pronounced and the densest is the Sunderban in the Ganga delta where the predominant species is Sundri (Heriteera).

Timber

- It provides hard and durable timber which is used for construction, building purposes and making boats.
- The important species found in these forests are Sundri, agar, rhizophora, screw pines, canes and palms, etc.

Dry Tropical Forests

Tropical Dry Evergreen Forests

Distribution

- Along the coasts of Tamil Nadu.

Climatic Conditions

- Annual rainfall of 100 cm [mostly from the north-east monsoon winds in October – December].
- Mean annual temperature is about 28°C.
- The mean humidity is about 75 per cent.
- The growth of evergreen forests in areas of such low rainfall is a bit strange.

Characteristics

- Short statured trees, up to 12 m high, with complete canopy.
- Bamboos and grasses not conspicuous.
- The important species are jamun, tamarind, neem, etc.
- Most of the land under these forests has been cleared for agriculture or casuarina plantations.

Tropical Dry Deciduous Forests

Climatic Conditions

- Annual rainfall is 100-150 cm.

Characteristics

- These are similar to moist deciduous forests and shed their leaves in dry season.
- The major difference is that they can grow in areas of comparatively less rainfall.
- They represent a transitional type – moist deciduous on the wetter side and thorn forests on the drier side.
- They have closed but uneven canopy.
- The forests are composed of a mixture of a few species of deciduous trees rising up to a height of 20 metres.
- Undergrowth: Enough light reaches the ground to permit the growth of grass and climbers.

Distribution

- They occur in an irregular wide strip running from the foot of the Himalayas to Kanniyakumari except in Rajasthan, Western Ghats and West Bengal.
- The important species are teak, axlewood, rosewood, common bamboo, **red sanders**, laurel, satinwood, etc.
- Large tracts of this forest have been cleared for agricultural purposes.
- These forests have suffer from over grazing, fire, etc.

Tropical Thorn Forests

Climatic Conditions

- Annual rainfall less than 75 cm.
- Humidity is less than 50 per cent.
- Mean temperature is 25°-30°C.

Characteristics

- The trees are low (6 to 10 metres maximum) and widely scattered.
- Acacias and Euphorbias are very prominent.
- The Indian wild date is common. Some grasses also grow in the rainy season.

Distribution

- Rajasthan, south-western Punjab, western Haryana, Kachchh and neighbouring parts of Saurashtra.
- Here they degenerate into desert type in the Thar desert.
- Such forests also grow on the leeside of the Western Ghats covering large areas of Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu.
- The important species are neem, babul, cactii, etc.

Montane Sub-Tropical Forests

Sub-tropical Broad-leaved Hill Forests

Climatic conditions

- Mean annual rainfall is 75 cm to 125 cm.
- Average annual temperature is 18°-21°C.
- Humidity is 80 per cent.

Distribution

- Eastern Himalayas to the east of 88°E longitude at altitudes varying from 1000 to 2000 m.

Characteristics

- Forests of evergreen species.
- Commonly found species are evergreen oaks, chestnuts, ash, beech, sals and pines.
- Climbers and epiphytes [a plant that grows non-parasitically on a tree or other plant] are common.
- These forests are not so distinct in the southern parts of the country. They occur only in the Nilgiri and Palni hills at 1070-1525 metres above sea level.
- It is a "stunted rain-forest" and is not so luxuriant as the true tropical evergreen.
- The higher parts of the Western Ghats such as Mahabaleshwar, the summits of the Satpura and the Maikal Range, highlands of Bastar and Mt. Abu in the Aravali Range carry sub-types of these forests.

Sub-tropical Moist Pine Forests

Distribution

- Western Himalayas between 73°E and 88°E longitudes at elevations between 1000 to 2000 metres above sea level.
- Some hilly regions of Arunachal Pradesh, Manipur, Naga Hills and Khasi Hills.

Timber

- **Chir or Chil** is the most dominant tree which forms pure stands.
- It provides **valuable timber** for furniture, boxes and buildings.
- It is also used for producing resin and turpentine.

Sub-tropical Dry Evergreen Forests

Distribution

- Found in the Bhabar, the Shiwaliks and the western Himalayas up to about 1000 metres above sea level.

Climatic Conditions

- Annual rainfall is 50-100 cm (15 to 25 cm in December-March).
- The summers are sufficiently hot and winters are very cold.

Characteristics

- Low scrub forest with small evergreen stunted trees and shrubs.
- Olive, acacia modesta and pistacia are the most predominant species.

Montane Temperate Forests

Montane Wet Temperate Forests

Climatic Conditions

- Grows at a height of 1800 to 3000 m above sea level
- Mean annual rainfall is 150 cm to 300 cm
- Mean annual temperature is about 11°C to 14°C and the
- Average relative humidity is over 80 per cent.

Distribution

- Higher hills of Tamil Nadu and Kerala, in the Eastern Himalayan region.

Characteristics

- These are closed evergreen forests. Trunks have large girth.
- Branches are clothed with mosses, ferns and other epiphytes.
- The trees rarely achieve a height of more than 6 metres.
- Deodar, Chilauni, Indian chestnut, birch, plum, machilus, cinnamomum, litsea, magnolia, blue pine, oak, hemlock, etc. are important species.

Himalayan Moist Temperate Forests

Climatic Conditions

- Annual rainfall varies from 150 cm to 250 cm

Distribution

- Occurs in the temperate zone of the Himalayas between 1500 and 3300 metres.
- Cover the entire length of this mountain range in Kashmir, Himachal Pradesh, Uttarakhand, Darjeeling and Sikkim.

Characteristics

- Mainly composed of coniferous species.
- Species occur in mostly pure strands.
- Trees are 30 to 50 m high.
- Pines, cedars, silver firs, spruce, etc. are most important trees.
- They form high but fairly open forest with shrubby undergrowth including oaks, rhododendrons and some bamboos.

Timber

- It provides fine wood which is of much use for construction, timber and railway sleepers.

Himalayan Dry Temperate Forests

Climatic Conditions

- Precipitation is below 100 cm and is mostly in the form of snow.

Characteristics

- Coniferous forests with xerophytic shrubs in which deodar, oak, ash, olive, etc are the main trees.

Distribution

- Such forests are found in the inner dry ranges of the Himalayas where south-west monsoon is very feeble.
- Such areas are in Ladakh, Lahul, Chamba, Kinnaur, Garhwal and Sikkim.

Alpine Forests

- Altitudes ranging between 2,900 to 3,500.
- These forests can be divided into: (1) sub-alpine; (2) moist alpine scrub and (3) dry alpine scrub.
- The sub-alpine forests occur lower alpine scrub and grasslands.
- It is a mixture of coniferous and broad-leaved trees in which the coniferous trees attain a height of about 30 m while the broad leaved trees reach only 10 m.
- Fir, spruce, rhododendron, etc. are important species.
- The moist alpine scrub is a low evergreen dense growth of rhododendron, birch etc. which occurs from 3,000 metres and extends upto snowline.
- The dry alpine scrub is the uppermost limit of scrub xerophytic, dwarf shrubs, over 3,500 metres above sea level and found in dry zone. Juniper, honeysuckle, artemesia etc. are important species.

CLIMATE OF INDIA

Climate is an important element of the physical environment of mankind. It is the aggregate of atmospheric conditions involving heat, moisture and air movement. In a developing country like India climatic characteristics have a dominant role in affecting the economic pattern, way of life, mode of living, food preferences, costumes and even the behavioural responses of the people. In India despite a lot of scientific and technological developments our dependence on monsoon rainfall for carrying out successful agricultural activities, has not been minimized. The climate of India belongs to the 'tropical monsoon type' indicating the impact of its location in tropical belt and the monsoon winds. Although a sizeable part of the country lying north of the Tropic of Cancer falls in the northern temperate zone but the shutting effects of the Himalayas and the existence of the Indian Ocean in the south have played significant role in giving India a distinctive climatic characteristics.

Climatic Seasons of India

Winter:	December to February
Summer:	March to May
Monsoon or Rainy Season:	June to September
Retreating Monsoon:	October and November

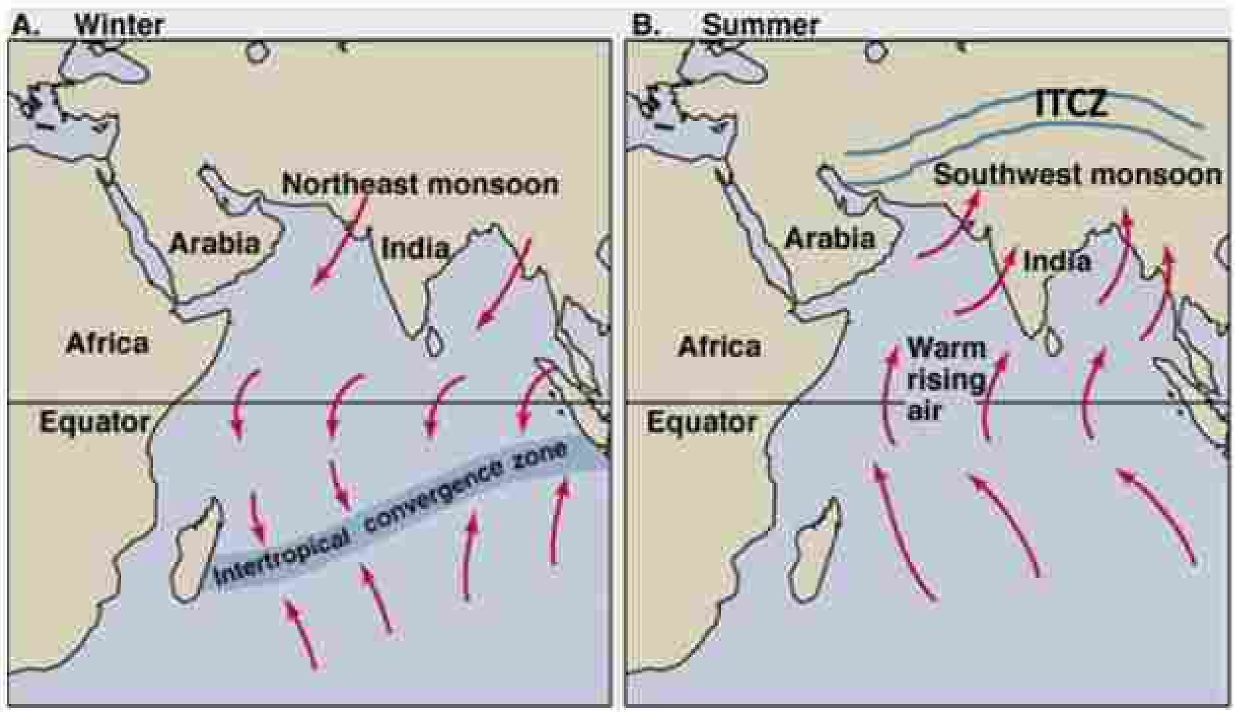
The South west monsoon controls the agriculture of India, which is the main occupation of the people. When the monsoons fail, there is drought, and the crops also fail. When the monsoon is heavy, there are floods causing destruction to life and property.

MAJOR FACTORS AFFECTING INDIAN CLIMATE

- Northward shifting of the Westerly Jet (north of Himalayas)
- Northward shifting of the ITCZ.
- S-E trade winds from S. hemisphere cross the equator and turn right due to coriolis force
- Latitudinal Extent
- Southern Seas
- Northern Mountains
- El – Nino
- La – Nina
- Westerlies in Northern part of India from Mediterranean (in winters)
- Easterlies due to Heating of Tibetian Plateau
- Jet streams

INDIAN MONSOON FEATURES

- Unique weather phenomenon
- Seasonal reversal of winds
- Sudden Onset (Sudden rain start)
- Gradual Advance
- Gradual retreat
- Variation – regional and temporal
-



Monsoon is seasonal changes in atmospheric circulation and precipitation associated with the asymmetric heating of land and sea. The southwest monsoon brings rains towards the end of summer as the high pressure built in the Indian Ocean pushes the wind masses towards the low pressure formed on land.

Temperature Gradient – It's the temperature variation between the sea and the landmass.

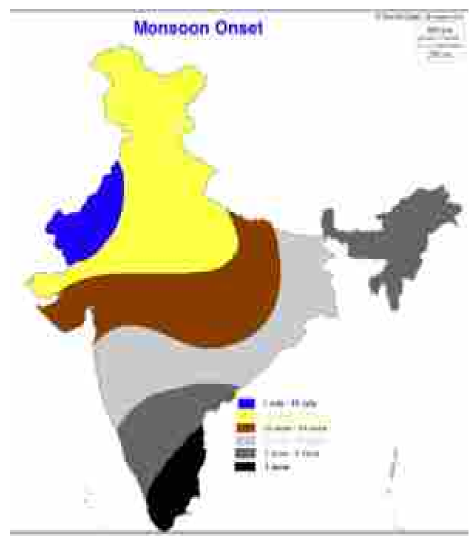
SUMMER MONSOON IN INDIA (SW MONSOON)

Originates due to Northward shift of ITCZ – SE trade winds cross equator – Deflect & enter into India as SW Monsoon. Easterly Jet Stream / SE Monsoon / BOB Monsoon – Due to differential heating of Tibetian plateau & Himalayan region with respect to BOB.

The southwest monsoon arrives in two branches: the Bay of Bengal branch and the Arabian Sea branch. The Bay of Bengal branch, which initially tracks the Coromandal Coast northeast from Cape Comorin to Orissa, swerves to the northwest towards the Indo-Gangetic Plains. The Arabian Sea branch extends toward a low-pressure area over the Thar Desert and is roughly three times stronger than the Bay of Bengal branch. The Arabian Sea branch moves northeast towards the Himalayas.

Initiation of Summer Monsoon- onset of the monsoon

The southwest monsoon typically breaks over Indian Territory by around 25 May, when it lashes the Andaman and Nicobar Islands in the Bay of Bengal. It strikes the Indian mainland around 1 June near the Malabar Coast of Kerala. By 9 June, it reaches Mumbai; it appears over Delhi by 29 June. By the first week of July, the entire country experiences monsoon rain. On average, South India receives more rainfall than North India. However, Northeast India receives the most precipitation.



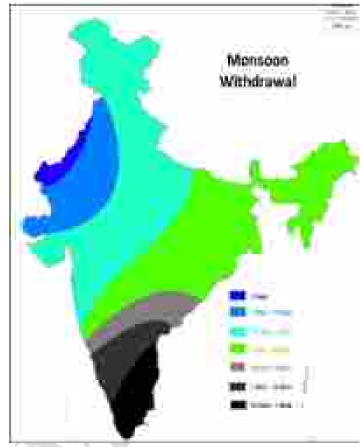
Arabian Sea Branch

It strikes Western Ghats and move parallel to Aravallis & Strike Himalayas. Rainfall at Western Ghats & Coastal Regions and Northern Plains. It strikes at Western Ghats; and gives rainfall to the western most regions. While rain shadow interiors, the Deccan plateau receive very less rainfall.

Bay of Bengal Branch

Moves parallel with the Eastern Ghats and produce very less rainfall until it strikes at NE. It bifurcates at Meghalaya hills & move parallel to Himalaya. One branch provides rainfall to NE India region and another moves westward providing rainfall to northern plains. It will going westward Rainfall Decreases. Rainfall at Northern East plains and Northern Plains.

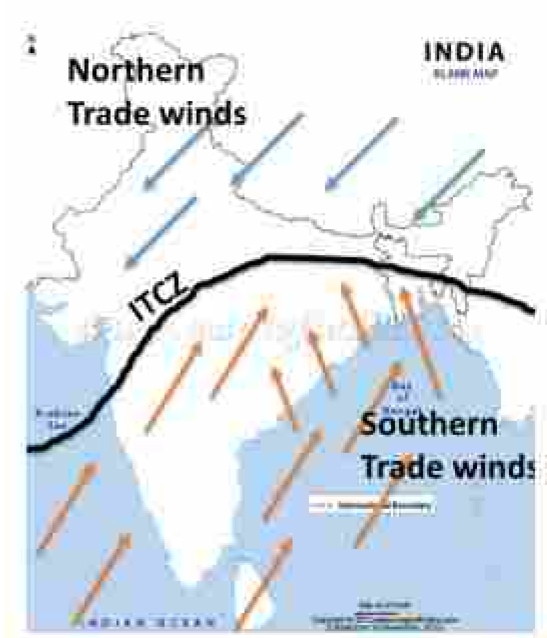
Withdrawal of Summer Monsoon



- Monsoon clouds begin retreating from North India by the end of August; it withdraws from Mumbai by 5 October
- As India further cools during September, the southwest monsoon weakens. By the end of November, it leaves the country

Retreating or NE Monsoon

- Around September, with the sun fast retreating south, the northern land mass of the Indian subcontinent cool off rapidly
- With this, air pressure begins to build over northern India, but the Indian Ocean and its surrounding atmosphere still holds its heat
- surrounding atmosphere still holds its heat Indo-Gangetic Plain towards the vast spans of the Indian Ocean south of the Deccan peninsula
- This is known as the Northeast Monsoon or Retreating Monsoon

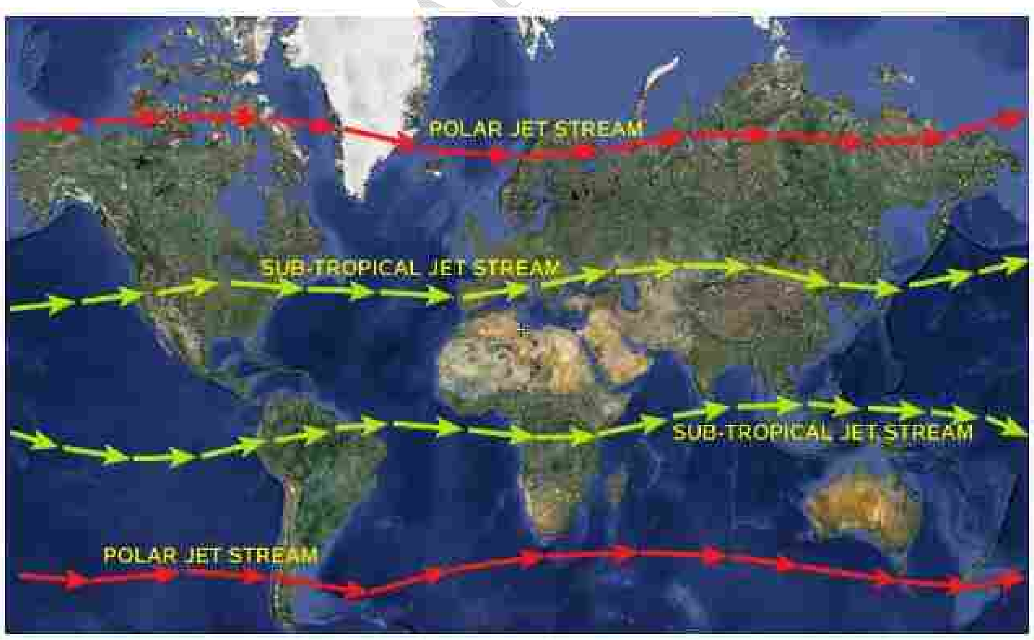


Winter Rainfall in South India

- While travelling towards the Indian Ocean, the dry cold wind picks up some moisture from the Bay of Bengal and pours it over peninsular India and parts of Sri Lanka
- Cities like Madras, which get less rain from the Southwest Monsoon, receive rain from this Monsoon.
- About 50% to 60% of the rain received by the state of Tamil Nadu is from the Northeast Monsoon.
- In Southern Asia, the northeastern monsoons take place from December to early March when the surface high-pressure system is strongest

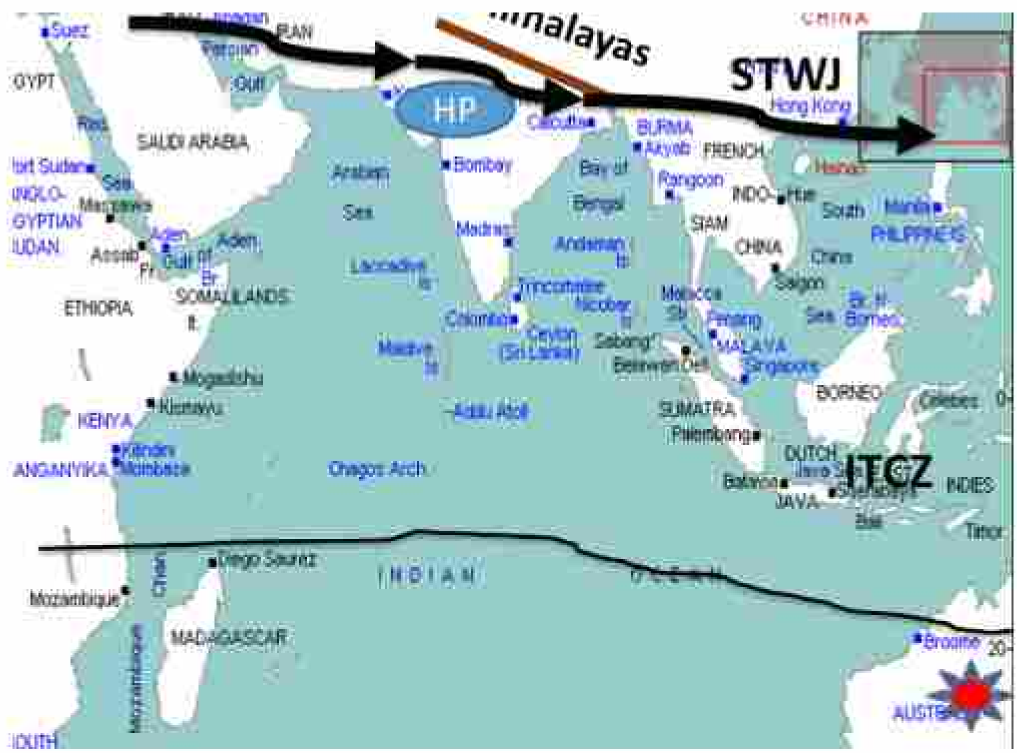
Jet Streams

- Jet streams are currents of air high above the Earth
- They at altitudes of about 8 to 15 kilometers, located near tropopause
- The major jet streams on Earth are westerly winds (flowing west to east)
- Flow at very high speeds → 120 kmph in winters and 50 kmph in summers
- Jet streams are caused by a combination of a planet's rotation on its axis and atmospheric heating
- Jet streams form near boundaries of adjacent air masses with significant differences in temperature, such as the polar region and the warmer air towards the equator
- All year round westerlies flow over north India south of Himalayas but in summers with shift of the sun they flow north of Himalayas & replaced by easterlies



Sub-tropical jet stream

- They prevail over the lower latitudes of westerlies.
- It is produced by the rotation of earth and its spherical shape.
- The air over equator has the highest velocity (Coriolis effect)
- As it rises and moves towards north, it has a higher velocity than the air at lower altitude prevailing at same latitude
- So it begins to flow from west to east around 30º latitude



Sub-Tropical Westerly Jet

- Winter – entirely south of Himalayas – over north India
- Major cause of western disturbance
- STWJ maintain the High pressure over north India
- Hence no Monsoon in winters
- During summers it flows to the north of Himalayas
- Hence low pressure over north India & monsoon

Note → Tropical Easterly Jet Stream which is associated closely with the burst of monsoon. It is also a major reason why there are no cyclones during Monsoon because the presence of an Easterly jet over the Indian landmass in the upper troposphere prevents vertical circulation of air, which is a pre-condition for formation of cyclones.

- It is more variable and is produced by a temperature difference
- In summers its position shifts towards poles and in winters towards equator

Tropical Cyclones in India

- Increase in sea surface temperature of Bay of Bengal and Arabian Sea in Late summer
- Hence Possibility of Tropical cyclone
- Retreating SW monsoon branch drag them towards Eastern coast
- Tropical cyclones move from east to West
- They are secondary circulations and maintain the larger direction of the planetary winds (i.e. Trade winds which blow from East to West).
- So, any cyclones to form in Arabian sea is less likely to affect India
- But the Delta region of eastern coast is frequently struck by cyclone

Tropical cyclone

- A tropical cyclone is a storm system characterized by a large low-pressure center
- Marked by numerous thunderstorms that produce strong winds and heavy rain
- Winds spiral at high speed 120 kmph about a calm eye
- Develop over sea where surface temperature is above 27 degree Celsius
- Acquire energy from the latent heat of condensation of water vapour
- Form between 8-20 degree north and south of equator and never between 0-8 degrees north and south of equator because of weak coriolis force
- Quickly dissipate over land as their moisture supply is cut off
- Cause heavy rains with thunderstorms but rain is short lived
- Most violent and destructible type of storms

Western Disturbances

- Western Disturbances are the Temperate cyclones or extra-tropical storm originating in the Mediterranean
- Brings sudden winter rain and snow to the northwestern parts of the Indian subcontinent
- This is a non-monsoonal precipitation pattern driven by the Westerlies
- The moisture in these storms usually originates over the Mediterranean Sea and the Atlantic Ocean
- They travel from place to place due to difference in pressure. There is high pressure in northwestern Indian subcontinent favouring its travel
- During winters, low pressure system originates over the Mediterranean Sea & western Asia and moves into India, along with westerly flow.
- Western Disturbances are important to the development of the Rabi crop in the northern subcontinent, esp. wheat
- They shower rain over Pakistan, India and Nepal

- Extra-tropical storms are a global, rather than a localized, phenomena with moisture usually carried in the upper atmosphere (unlike tropical storms where it is carried in the lower atmosphere)

Winter Rainfall occurs due to

- North East Monsoon
- Western Disturbances
- Tropical Cyclones

Factors Responsible for Regional Variability of Rainfall over India

- Windward regions (ex. Western Ghats) get more rainfall than interiors
- Regions obstructing monsoonal branches like that perpendicular to Arabian Sea branch get rainfall ex. Himalayan foothill states
- Aravallis parallel to Arabian Sea branch remains dry
- South eastern region parallel to Bay of Bengal branch remains dry
- Regions near to the sea get more rainfall as winds bear more moisture
- Regions of the confluence of the 2 major branches also receive more rainfall

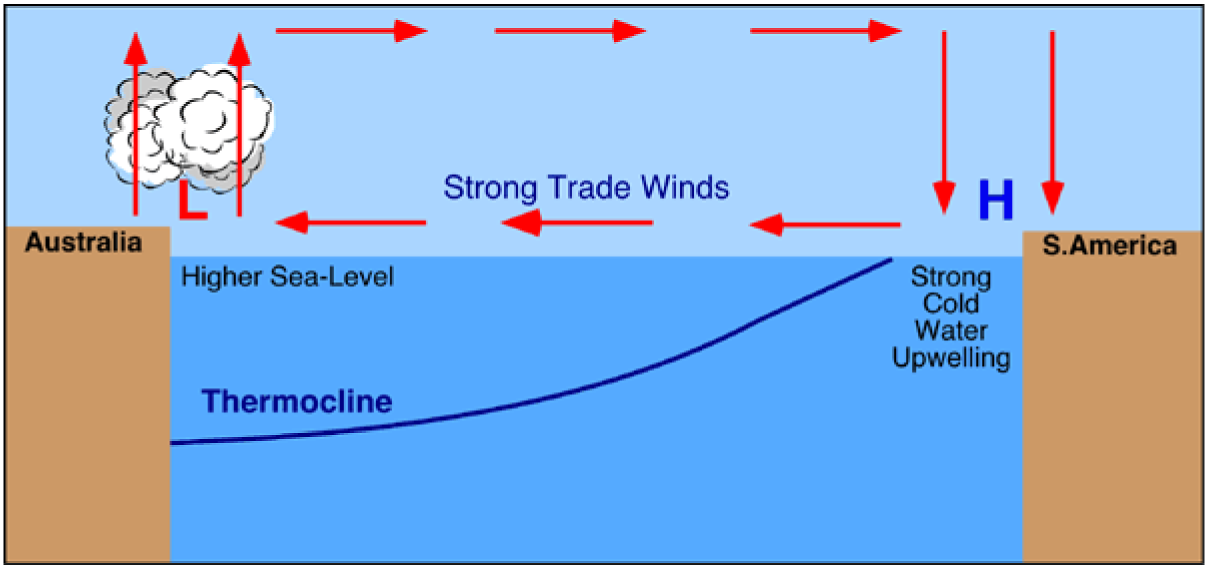
Southern Oscillations

- A curious see-saw pattern of meteorological changes has been observed b/w Indian Ocean & Pacific ocean
- Whenever pressure is higher over Indian Ocean, low pressure prevails over Pacific Ocean & vice versa
- Scales used for this pattern is SOI (Southern Oscillation Index) → (Tahiti – Darwin) Pressure

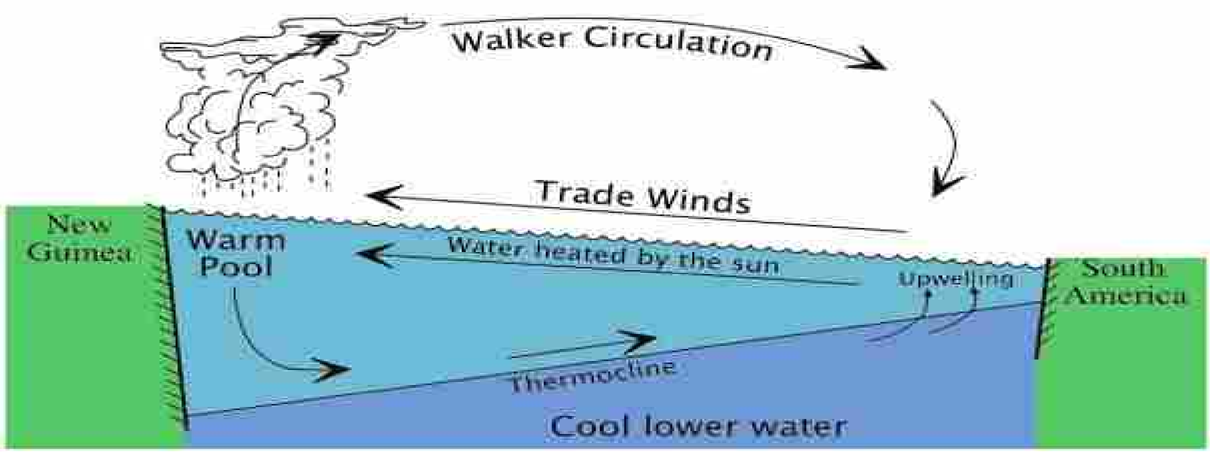
Tahiti = Pacific Ocean, Darwin = Indian Ocean

- When SOI > 0 → Good monsoon in India → La Nina Condition
- When SOI < 0 → Bad monsoon in India → Al Nino Condition

Normal Year – Walker cell Condition at south Pacific

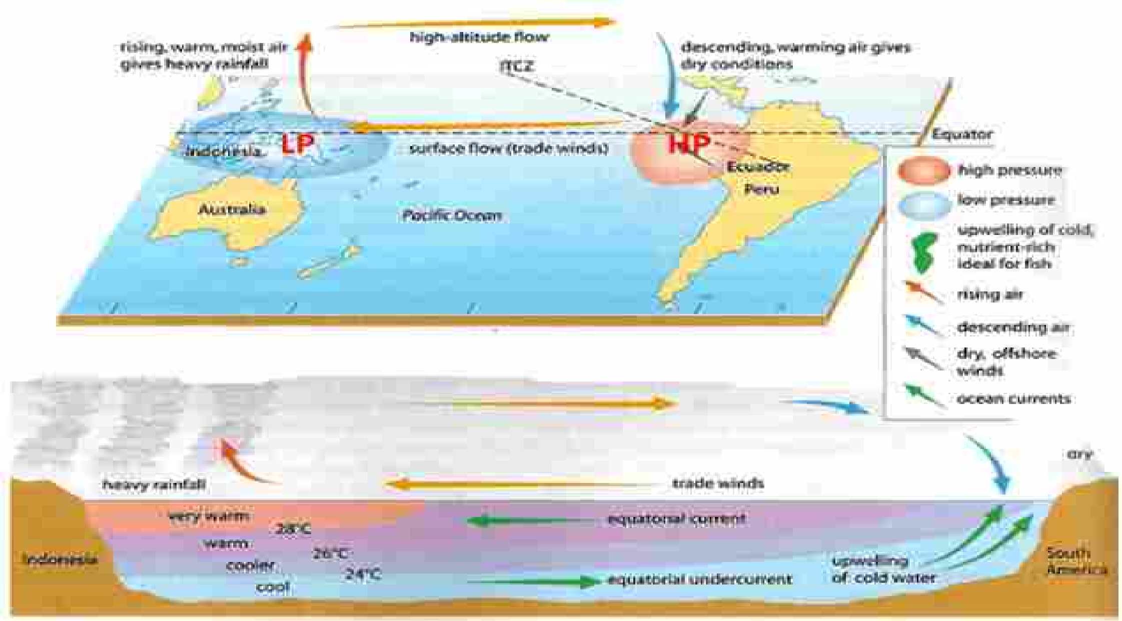


- LP – Northern Australia and HP – South America (Peru)
- South equatorial current pile up water at northern Australia – increase SST – called West Pacific Pool
- It brings rainfall in Northern Australia
- The diverging air above Australia move towards Peruvian coast
- They descend at Peruvian coast = HP – desiccating effect to Atacama desert
- Completes the Walker cell



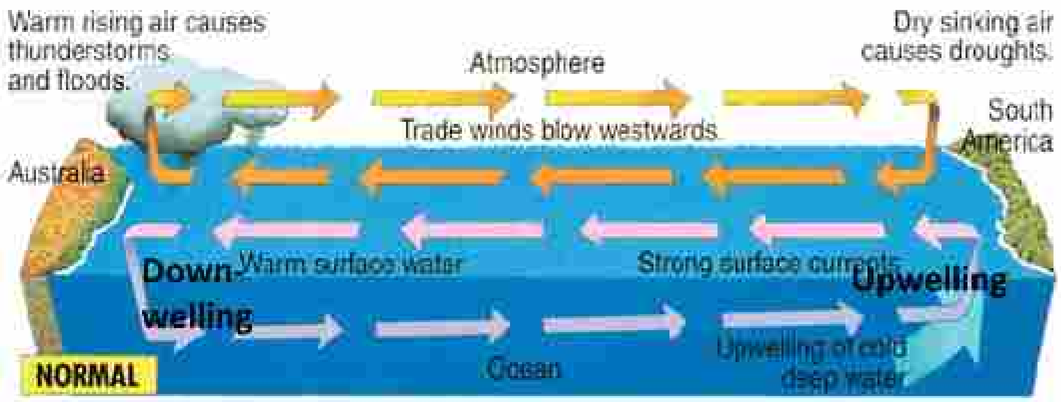
Normal Conditions

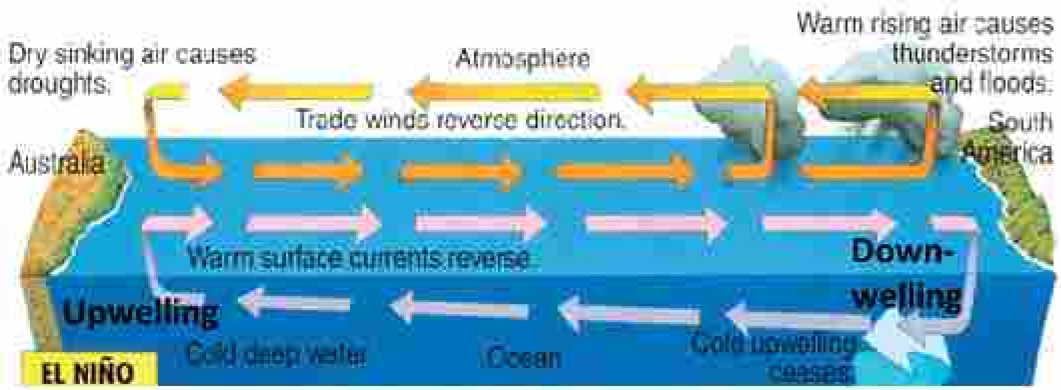
- As south equatorial current take water from east to west
- It led water from bottom to come up and take the space
- Up-welling at the Peruvian coast = rich fishing ground



El Nino

- Direction of walker cell reverses
- South equatorial current weakens (reason unknown) & strong counter current activates
- Weak piling up of water at Northern Australia
- Weakening of west Pacific Pool
- Ocean water move towards Peruvian coast
- Create LP system over there and rainfall at Atacama Desert
- The rising and diverging wind above Peru descends over Australia = HP condition – drought in Northern Australia
- The reversal in wind direction alters submarine cycle as well
- Down-welling at Peruvian coast →loss in fishing business



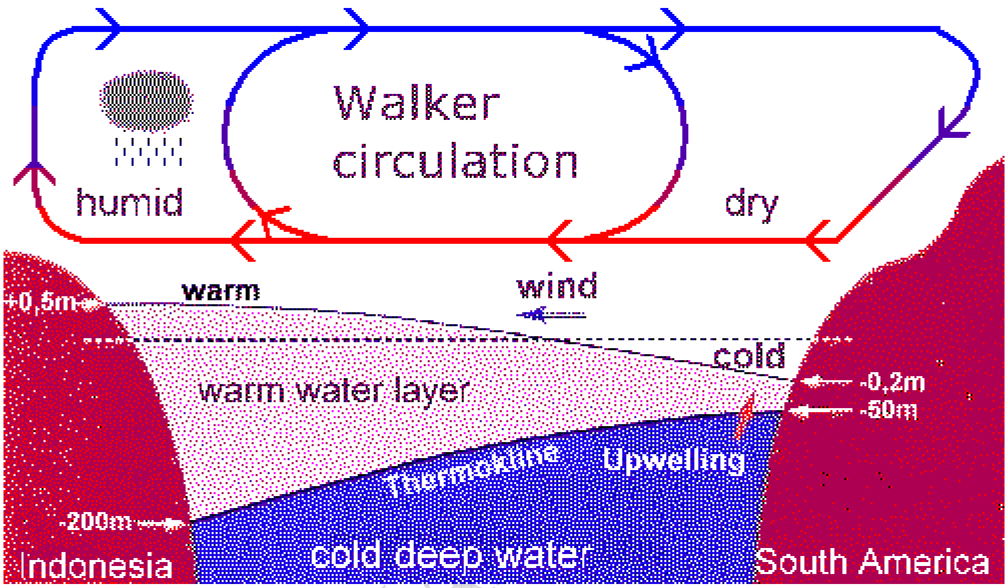


- It is a warm current which appears off the coast of Peru in December (3 – 36* S of Equator), also known as child Christ as it appears around Christmas
- It is temporary replacement of cold Peruvian / Humbolt current which normally flows against the coast & appears once in 3 – 7 years
- Responsible for widespread flood & droughts in various tropical regions of the world
- Warming of tropical pacific water affects the global pattern of pressure & wind system, including monsoon winds in Indian Ocean
- High pressure of Indian Ocean & low pressure at said area of Pacific Ocean shifts some of the monsoon winds to Pacific Ocean side which results in scarcity of rainfall in India
- Bring drought condition in Indonesia as well – forest fire

La Nina (The Girl in Spanish)

- After El Nino when weather conditions return to normal, trade winds become strong
- Hence they cause abnormal accumulation of cold water in central & eastern pacific region
- This creates a high pressure region in Pacific Ocean as compared to Indian Ocean

- Heavy rainfall – flood condition in Northern Australia – good monsoon in India
- Very good fishing business at Peruvian coast – price crash
- Drought in Atacama
- La Nina brings heavy monsoon showers in India due to N – E monsoon along with monsoon laiden pacific winds from tropical Pacific Ocean although it marks an active hurricane season at Peru



Some basic Terms Related to Pre Monsoon

Mango Showers	• The pre-monsoon showers in the Indian states of Karnataka and Kerala that help in the ripening of mangoes • Also known as April rains or Summer showers, they are a result of thunderstorms over the Bay of Bengal • These summer rains normally come in the second half of the month of April. • The showers prevent the mangoes from dropping prematurely from trees and are crucial for the mango cultivators of South India
Cherry Blossom	• In Karnataka and associated region the local thunderstorms are called as cherry blossoms • Caused due to the meeting of humid sea winds and hot dry local wind • Pre monsoon Showers which occur in the month of April & May • These showers help in the ripening of coffee plants

Kal Baishakhi	• Pre monsoon Showers • Known as Kal Baisakhi at Bengal & Assam
Norwesters	• The shallow cyclonic disturbances that travel to India from Mediterranean sea and Persian gulf • Cause rainfall in the East India viz. Assam, West Bengal, & Orissa during winter season

➢ AGRICULTRE IN INDIA

Agriculture plays a vital role in India's economy. Over 58 per cent of the rural households depend on agriculture as their principal means of livelihood. Agriculture, along with fisheries and forestry, is one of the largest contributors to the Gross Domestic Product (GDP).

As per estimates by the Central Statistics Office (CSO), the share of agriculture and allied sectors (including agriculture, livestock, forestry and fishery) was 15.35 per cent of the Gross Value Added (GVA) during 2015-16 at 2011-12 prices.

The Department of Agriculture and Cooperation under the Ministry of Agriculture is responsible for the development of the agriculture sector in India. It manages several other bodies, such as the National Dairy Development Board (NDDB), to develop other allied agricultural sectors.

Facts:

India is the largest producer, consumer and exporter of spices and spice products.

- India's fruit production has grown faster than vegetables, making it the second largest fruit producer in the world.
- India's horticulture output, comprising fruits, vegetables and spices, is estimated to be 283.4 million tonnes (MT) in 2015-16 after the third advanced estimate.
- Agricultural export constitutes 10 per cent of the country's exports and is the fourth-largest exported principal commodity.
- India is an agricultural economy where approximately 49% of the people depend on agriculture.
- Net sown area still accounts for about 47% of the total cultivable area of India.
- Accounts for about 35% of our national income.
- Share in GDP – around 14 %.
- Provides food for the people and fodder for the animals.

- Main source of raw materials to the agro-based industries viz. sugar, textile, edible oil, etc.
- Predominance of food crop? 2/3rd of total cropped area.
- 1st rank in Milk (17% of world production), Mango, banana, coconut, cashew, papaya, peas, cassava and pomegranate.
- Largest producer and exporter of spices, Millets, Pulses, Dry Bean, Ginger.
- Overall, second largest producer of vegetable, fruits and fishes.
- Have three main cropping seasons viz. **Kharif, Rabi** & **Zaid**.

Three main cropping seasons:

Kharif Crops:
• Also known as Monsoon/Summer Crops
• Requires plenty of water
• Require long hot weather for growth
• Sown - May – July, Harvest → Sep – Oct
• Major Crops - Paddy, Sugarcane, Maize, Jowar, Bajra, Cotton, Pulses, Groundnut, Soybean, Sunflower, Tea, Coffee, Rubber, Sesame, Gaur etc.
Rabi Crops:
• Also Known as Winter Season Crops
• Requires less water
• Require cold weather for growth
• Sown - Oct – Nov, Harvest → Feb – April
• Major Crops - Wheat, Gram, Potato, Peas, Oil seeds (Rapeseed, linseed), Mustard etc.
Zaid Crops:
• Sown between Rabi & Kharif crops i.e. from March to June
• Requires warm dry weather for growth & longer day length for flowering
• Major Crops - Seasonal fruits & vegetables (Musk melon, Water melon, Cucumber, China Paddy, Gourds, Fodder crops)

BRANCHES OF AGRICULTURE:

- **Vermiculture:** Agriculture of Earth worm
- **Tissue culture:** Production of a new plant from plant cells
- **Apiculture:** Study of honey bee
- **Horticulture:** Study of fruits and vegetables
- **Pomology:** Study of fruits
- **Sericulture:** Rearing of silk worm
- **Moriculture:** Production of mulberry
- **Vity culture:** Production of grapes

	AGRICULTURAL TERMINOLOGIES
Agriculture	Science of cultivating soil, raising crops and rearing livestock including fishing and forests
Agricultural Land	Net Cropped area + Fallow Land -- Cultivated Area
Net Cropped Area	• Total area sown in country • Also known as net sown area • Area sown more than once in a year counted only once
Fallow Land	• Land left out of cultivation for a definite period of time to restore its fertility
Gross Sown Area	• Also known as Gross Cropped Area • Sum total of -- Area sown more than once in agricultural year + Net sown area
Cropping intensity	• No. of crops raised on field during an agricultural year • (Total Crop Area / Net sown area) * 100 -- ~132 % for India
Agricultural Efficiency	• Ratio of Output to input • Input includes manpower, seeds, fertilizers, pesticides etc.
Yield / Area	• Intensive agriculture • Heavy manpower & inputs deployed -- India, Japan
Yield / Person	• Extensive agriculture • Very large land holdings & very less manpower -- USA, Russia, Canada
Cropping Pattern	• Refers to proportion of area under different crops at a given point of time • Broadly, cropping pattern in India shows greater production of food grains than non-food grains
Food Crops	• Food Grains • Cereals & Millets + Pulses • Fruits & Vegetables

Non Food Crops	• Oil seeds • Fiber crops • Forage crops
Commercial Agriculture	• Farmer grows the crop with the aim of selling it in the market i.e. for monetary purpose • Also known as cash crops • Ex: Cotton, Sugarcane, Tobacco, Tea etc.
Plantation Agriculture	• A large-scale farming of one crop resembling the factory production • Processing and marketing the final products • Ex: Coffee, Rubber, Coconut, Spices etc.
Fiber Crops	• Cash crops which yield fibers • Used for making textiles or packaging materials • Examples include Jute & Cotton
Fodder Crops	• Harvested when green • Used as cattle fodder eg. Barseem • Some fodder crops can also be matured as food grains eg. Jowar

Mixed Cropping	• Also known as Multiple cropping • When two or more than two crops are grown simultaneously on the same field • Increases crop yield & Fertility of soil
Mixed Farming	• Cultivation of crops + Rearing of animals • Fodder crops -- An important component of mixed farming along with other crops
Dry land Farming	• Adopted in scanty rainfall areas viz. < 75 cm /year • Draught resistance crops are grown as they require less irrigation • Farming of arid & semi-arid regions • Also known as Rain fed Farming • Rainwater is only source of moisture for crops • Minimal use of chemicals, Pesticides, fertilizers etc. • Contributes 40% of the food production • Provide support to nearly 45% of the population
Wet Land farming	• Practiced in high rainfall and irrigated areas
Terrace Farming	• Farming on steps cut on mountainous region • Mainly for prevention of soil erosion • Also provides easy irrigation

Extensive Agriculture	• Farmers tries to get the greater output by bringing more and more new land areas under cultivation • Agriculture at large farm with extensive use of machinery • Yield / Area is low but Yield / Labour is high • Crops are grown solely for the purpose of commercial activities
Intensive Agriculture	• Land holding is small which is intensively used by means of labour provided by family members • Hence, Yield / Area is high but Yield / Labour is low
Subsistence Agriculture	• Farming in which the main production is consumed by the farmer's household • For Livelihood, Small land area & Great no. of labours
Shifting Agriculture	• Farmers clear the forestland and use it for growing crops. • The crops are grown for 2 to 3 years. • When the fertility of the soil decreases, the farmer shifts to a new land

	• Also known as Slash & Burn agriculture • Practised in East India, Central Africa, America
Horticulture	• Intensive cultivation of vegetables, fruits and flowers
Dairy Farming	• Animals are reared for milk & main emphasis is on cattle breeding & vetenary services • Rearing of Milch animals is an important aspect of Dairy farming
Mediterranean Agriculture	• Practised in Mediterranean lands surrounding Mediterranean Sea • Highly specialized commercial agriculture, done mainly for citrus fruits • Famous for Viticulture i.e. grape cultivation for wines
Market Gardening / Horticulture	• Cultivation of high valued day to day market crops like fruits, flowers & vegetation • Grown on small farms which are well connected with urban markets by cheap n efficient means of transportation • Netherland >> Famous for flowers, especially Tulips • Farmers specialised in vegetables only mainly practice Truck farming with overnight market transportation
Cooperative Farming	• Farmers voluntarily pool their resources together like land, machinery etc. to form a co-operative society. • Cooperative societies help farmers to procure more inputs, sell farm products at best prices & procure essentials in quantity at cheaper rates • For Ex. Denmark, Netherland
Collective Farming	• State owned agriculture esp. in socialist countries like Russia • Farmers pool their resources together to achieve yearly targets set by gov. to sell their produce at fixed rates. • Excess of produce is distributed among members or are sold in the market • Members are also paid according to the nature of work allotted to them.

INFRASTRUCTURE FACTORS RELATED TO AGRICULTURE

A. Seed:

Seed is a fertilized matured ovule together covered with seed coat.

Importance of seed

(a) Seed bridge between the two generations of plant life.
(b) Seed is the medium which transferring character from one generation to next generation.
(c) Seed is the vital and most important input for crop production.
(d) Seed as food, feed, medicinal, industries or ornamental value.

- **Hybrid seeds** are obtained by cross pollination of different varieties of related plants.
- **Genetically Modified seeds**, are the ones in which the genetic material (DNA) has been altered in such a way as to get the required quality.

B. Fertilizers:

- Fertilizers are chemical compounds applied to promote plant and fruit growth.
- Organic fertilizers are fertilizers derived from animal matter, human excreta or vegetable matter. (e.g. compost, manure). Naturally occurring organic fertilizers include animal wastes from meat processing, peat, manure, slurry, and guano.
- Inorganic fertilizers contain simple inorganic chemicals. Some of the common nutrients present in fertilizers are nitrogen, phosphorus and potassium (NKP). They also contain secondary plant nutrients such as calcium, sulphur and magnesium.

Bio-fertilizers Pros:

- Increases crop yield by 20-30%
- Provide protection against drought and some soil-borne diseases
- Replaces chemical nitrogen & phosphorus by 25%
- Stimulates plant growth
- Cost-effective
- Environment friendly
- To some extent, helps to cleanse the plant from precipitated chemical fertilizers

Bio-fertilizers Cons:

- Effects are slower compared to chemical fertilizer
- Difficulty to store as sensitive to temp. and humidity changes
- Much lower nutrient density – requires large amounts to get enough for most crops
- Sometimes, are hard to locate/purchase in faraway rural areas.

C. Irrigation

- Irrigation is an artificial application of water to the soil. It is usually used to assist in growing crops in dry areas and during periods of inadequate rainfall.
- Additionally, irrigation also has a few other uses in crop production, which include protecting plants against frost, suppressing weed growing in rice fields and helping in preventing soil consolidation.
- There are large reserves of underground water in the alluvial plains of north India. Digging and constructing wells and tube-wells is easy and cost of their construction is also comparatively less. Therefore irrigation by wells and tube-wells here is popular
- An irrigation canal is a waterway, often man-made or enhanced, built for the purpose of carrying water from a source such as a lake, river, or stream, to soil used for farming or landscaping.
- A tank consists of water storage which has been developed by constructing a small bund of earth or stones built across a stream. The water impounded by the bund is used for irrigation or other purposes.
- Localized irrigation is a system where water is distributed under low pressure through a piped network, in a pre-determined pattern, and applied as a small discharge to each plant or adjacent to it. Drip irrigation, spray or micro-sprinkler irrigation and bubbler irrigation belong to this category of irrigation methods.

D. HYV (High Yielding Variety) Seeds? Green Revolution by Norman Borlaug

Positives:

- To achieve self-sufficiency in food
- Shorter Life cycles
- Increased productivity
- Benefited Wheat & Rice
- Benefitted Punjab, Haryana, UP, TN, Andhra Pradesh & Maharashtra

Negatives:

- Input cost increased
- More water & fertilizer required
- Chemical poisoning of soil
- Salinity & Alkalinity increased which makes soil impermeable
- Depletion of ground water
- Loss of fertility of soil
- Limited to selective states only
- Limited to selected crops only

E. Green Manure

- A type of cover crop grown primarily to add nutrients and organic matter to the soil.
- A green manure crop is grown for a specific period of time, and then ploughed under and incorporated into the soil while it is still green or shortly after flowering.
- Provides subsidy on purchase of seeds & on cost for production of seeds for green manure plants.
- Leguminous types — Have Nitrogen fixing ability for ex. Cowpeas, Soybeans.
- Non- Leguminous types — For weed suppression & addition of biomass to the soil for eg. Sudan grass, Millets, Sorghum & Buckwheat.

Advantage:

- Helps in soil improvement & soil protection
- Provides forage for pollinating insects
- Deep rooting properties? Increase aeration of soil+ Efficient at suppressing weeds
- Fix nitrogen in soil, thus Less chemical fertilizers are required
- Provides habitat for predatory beneficial insects which kill and eat harmful insects thus less pesticides are required

Disadvantage:

- Leguminous plants require good amount of irrigation
- The "time" factor — one cannot plant the primary marketable crop during green manuring phase.

F. Genetically Modified Food

- Modified form of agricultural plants to enhance desired traits such as increased resistance to herbicides or improved nutritional content
- Using the latest molecular biology techniques & genetic engineering, plants are undertaken breeding to get the desired results
- Last decade, genetically modified (GM) crops were introduced esp. for Cotton & Brinjal in India but as of now only GM Bt. Cotton production is allowed.

Advantages of GM Foods

- Pest resistance
- Herbicide resistance
- Disease resistance
- Draught tolerance
- Salinity tolerance
- Increased nutrition

- Better flavour and colour
- Early maturing
- All year availability
- Easy to store

Disadvantages of GM Foods

- Reduced effectiveness to pesticides
- Unknown effects on human health
- Gene transfer to non-target species
- Playing with nature and its mechanisms
- Monopoly of MNCs in GM seeds
- High input cost — Requires high dose of fertilizers

INDIAN CROPS Famous Indian Crops	
Rice	• 20 - 27* C of average Temperature • 150 cm of average Rainfall • Require Warm & Humid climate • Clayely or alluvial moisture retentive soil • Labour intensive crop
Wheat	• 15 - 20* C of average Temperature • 75 cm of average Rainfall • Require moderate cool climate • Clayely or well drained fertile soil • Machine intensive crop
Maize	• 18 - 27* C of average Temperature • 75 cm of average Rainfall • Atleast 140 frost free days • Require Warm climate • Alternate Rainy & Sunny Season is best for this crop
Sugarcane	• Belongs to Bamboo family • Indigenous to India • Long duration crop - 10 - 15 months • 20 - 27* C of average Temperature • 75 - 150 cm of average Rainfall • No from with moderately warm climate • Soil exhausting crop - Requires heavy dose of fertilizers • Special Feature - Ratooning

Millets	• 20 - 30* C of average Temperature • 40 - 60 cm of average Rainfall • Requires warm & dry climate • Can be grown on medium to low fertility soil • Best is sandy loamy soil with good drainage • Bigger millets are called Sorghums • For example Jowar - Great Millet
Cotton	• 20 - 30* C of average Temperature • 50 - 100 cm of average Rainfall • Requires approx. 210 frost free days • Requires mineral rich black lava soil (Regur) • Soil exhausting crop - Requires heavy dose of fertilizers

Jute	• Obtained from the bark of the plant • 25 - 35* C of average Temperature • 120 - 150 cm of average Rainfall • Requires Hot & Humid climate • Soil exhausting crop -- Requires heavy dose of fertilizers • Requires rich delta or alluvial soil • Famous Jute substitutes -- Mesta, Kenaf
Tobacco	• More than 18* C of average Temperature • 50 cm of average Rainfall • Requires 120 - 180 frost free days • Sandy soil with good drainage
Tea	• 20 - 30* C of average Temperature • 150 - 250 cm of average Rainfall • Requires heavy rainfall but no stagnant water • Hence grown on hill slopes
Coffee	• 15 - 25* C of average Temperature • 150 - 250 cm of average Rainfall • Shade loving crop -- Grown in shades of banana or rubber • Requires heavy rainfall but no stagnant water • Hence grown on hill slopes

Cocoa	• 25* C of average Temperature • 125 cm of average Rainfall • Requires protection from direct sunrays • Hence grown in shades
Barley	• Same climatic conditions as wheat • Can be grown in areas of poor soil with less rainfall • Mainly used as fodder
Rubber	• Obtained from the latex of plants (Heavea Brasitiensis) • 20 - 30* C of average Temperature • 250 cm of average Rainfall • Grown on hill slopes to prevent water logging

LIST OF AGRICULTURAL REVOLUTIONS IN INDIA

Green Revolution	Food grain Production
White Revolution	Milk Production
Black Revolution	Petroleum production
Blue Revolution	Fish production
Golden Fiber Revolution	Jute Production
Grey Revolution	Fertilizer production
Pink Revolution	Onion production/Pharmaceutical (India)/Prawn production
Red Revolution	Meat & Tomato production
Round Revolution	Potato production
Silver Fiber Revolution	Cotton production
Silver Revolution	Egg/Poultry production
Yellow Revolution	Oil Seeds production
Evergreen Revolution	Overall development of Agriculture

NITI Aayog has identified **three key areas for reform** and is now persuading states to undertake the reforms. The areas identified for immediate reforms are:

- **Agricultural market reforms**
- **Land lease reforms**
- **Reforms related to forestry on private land – felling and transit of trees.**

Three crucial reforms pertaining to marketing in agriculture have been recommended by NITI Aayog.

First is the immediate need to amend existing regulations in order to liberalize markets. Farmer to should be given the freedom to decide to whom, where and how he wants to sell his produce. Seven indicators have been developed by NITI in this regard.
The reforms also suggest special treatment of fruits and vegetables from other farm produce as they are perishable and produced in small quantities. Importantly, the recommended reforms place importance on IT in marketing for the creation of a 'national market' for agriculture, so that farmers across the country may benefit from interconnected markets, through the use of appropriate technology. This important reform has so far eluded the country due to strong lobbies of middlemen and the reluctance of political class to take favourable steps.

NITI Aayog has launched an index to rank States and UTs that is based on implementation of seven provisions proposed under model APMC Act, joining eNAM initiative, special treatment to fruits and vegetables for marketing and level of taxes in mandis.
These indicators reveal ease of doing agribusiness as well as opportunities for farmers to benefit from modern trade and commerce and have wider option for sale of her/his produce. These indicators also represent competitiveness, efficiency and transparency in agri markets.

The second area of reforms included in the index is relaxation in restrictions related to lease in and lease out agricultural land and change in law to recognise tenant and safeguard land owners liberalisation.

The third area included in the index represent freedom given to farmers for felling and transit of trees grown on private land.

LIVESTOCK RESOURCES

Livestock is a natural capital that can act as a living bank with offspring as interest, and an insurance against income shocks in times of crop failure and natural calamities. Moreover, it provides nutrient-rich food products such as milk, meat, egg, draught power, dung as organic manure and domestic fuel, hides and skin, and is a regular source of cash income for rural households. In the recent decade, demand for various livestock based products has increased significantly due to increase in per-capita income, urbanization, changing taste and preference and increased awareness about food nutrition. Livestock sector is also considered as a potential sector for export earnings.

LIVESTOCK RESOURCES:

- First in the total buffalo population in the world.
- Second in the population of cattle and goats
- Third in the population of sheep (72 millions)
- Fifth in the population of ducks and chicken
- Tenth in camel population in the world.

Livestock Population – Growth Trends

	2007 (Millions)	2012 (Millions)	% Change
Cattle	199.07	190.90	-4.10
Buffaloes	105.34	108.70	3.19
Goats	140.53	135.17	-3.82
Sheep	71.55	65.06	-9.07
Camel	0.517	0.400	-22.63
Pigs	11.13	10.29	-7.54
Dogs#	19.08	11.67	-38.85
Horses & Ponies	0.612	0.625	2.12

- Excluding Stray Dogs

Source: 19th Livestock Census Report by DAHD, Govt.of India Report released in June 2014

FISHERIES SECTOR

Fisheries are an important sector. India ranks world number two in fish production and also the second highest aquaculture country in the world. After Independence, fish production has been increased from 7.5 lakh tonnes in 1950-51 to 100.70 lakh tonnes during 2014-15, while the export earnings of 33,441 crore in 2014-15 (US$ 5.51 billion), equaled about 18% of the export earnings from the agriculture sector. Our overall fish production has crossed 10 million tons with a growth rate of over 5 % and today we are ahead of all countries except China. The export earnings of Rs. 33,441 crore in 2014-15 (US$ 5.51 billion), equaled about 18% of the export earnings from the agriculture sector.

Coming to Aquaculture, India is the second largest producer (42. 10 lakh tonnes) of fish from aquaculture which contributes about 6.3 per cent to global aquaculture production. Fisheries supports livelihood of almost 1.5 million peoples in our country. India is one of the leading producers of fish in the world, occupying the second position globally in terms of production. The contribution of Indian fish to the food basket of the world has been substantial.

Potential of Fisheries in India:

- India has over 8000 Km. of coastal line and nearly 2 million Sq Km of EEZ and half a million Sq Km. of Continental Shelf.
- From these marine resources, India has an estimated fisheries potential of 4.11 million tons.
- Similarly, 3.0 million hectares of reservoirs, 2.5 million hectares of ponds and tanks, 1.25 million hectares of brackish water area
- Cold water resources of hilly states and all other inland fishery resources offer a production potential of about 15 million tons.
- Against this potential, the production from inland sector was 6.58 million tonnes during 2014-15.

The marine fish production in the country during the last four years has been reported as 33.20 lakh tonnes in 2012-13; 34.39 lakh tonnes in 2013-14; 36.55 lakh tonnes (Provisional) in 2014-15 and 35.83 lakh tonnes (Provisional) in 2015-16 respectively, against the potential yield of 44.12 lakh tonnes estimated for the Indian Exclusive Economic Zone (EEZ). The variations in fish production may be attributed to several reasons such as high fishing pressure, changes in fishing gear dimensions, over capacity, pollution, environmental factors, climate change etc. Deep-sea fishing vessels (DSFVs) in the Exclusive Economic Zone are only allowed to carry out resource-specific fishing beyond 12 nautical miles from the territorial limits. Apprehensions of local fishing community, if any, regarding poor fish yield in territorial waters due to operation of these DSFVs are largely unsubstantiated, as the areas of operation as well as targeted resources are different in case of DSFVs and the local traditional fishing communities.

Terms related to fishery sector

- **Aquaculture:** It is the farming of freshwater and saltwater organisms including molluscs, crustaceans and aquatic plants.
- **Commercial fishery:** An umbrella term covering fisheries resources and the whole process of catching and marketing fish, molluscs and crustaceans. It includes the fishermen and their boats, and all activities and resources involved in harvesting, processing, and selling.
- **Mariculture** is a specialized branch of aquaculture involving the cultivation of marine organisms for food and other products in the open ocean, an enclosed section of the ocean, or in tanks, ponds or raceways which are filled with seawater.
- **Fish farming or pisciculture** involves raising fish commercially in tanks or enclosures, usually for food.
- **Ghost Fishing:** The accidental capture of aquatic organisms by fi shing gear (usually gillnets, or traps, pots, etc.) that has been lost or discarded into the sea and which continues to entangle or trap aquatic animals.
- **Sustainable Fishing:** Fishing activities that do not cause or lead to undesirable changes in the biological and economic productivity, biological diversity, or ecosystem structure and functioning from one human generation to the next.

➢ IRRIGATION IN INDIA

Irrigation refers to the supplying water to the dry land as a supplementation of rain water. It is mainly aimed for cultivation. There are various types of systems of irrigation practices in India (will discuss in future).

Why irrigation needed for India?

- There is a great necessity of irrigation in Indian Agriculture.
- India has a great diversity and variety of climate and weather conditions.
- These conditions range from extreme heat to extreme cold and from extreme dryness to excessive rainfall.
- Due to some reasons irrigation is needed in Indian agriculture

(a) Uncertainty of monsoon rainfall both in time and place
(b) Irregularity in distribution of rainfall throughout the year
(c) Excessive rainfall causing flood
(d) Drought is an annual event in some areas
(e) India is a land of Summer crops. But there is no rainfall in winter months
(f) Some soils need more water
(g) Introduction of HYV (High Yielding Varieties) seeds and multiple cropping need water throughout the year.

Types of Irrigation in India

Only 48.3% of land is irrigated throughout the country
Irrigation in India is mainly classified into

(a) Well Irrigation
(b) Tank Irrigation
(c) Canal Irrigation

WELL IRRIGATION

- **Areas:** Rajasthan, Gujarat, Maharashtra, Madhya Pradesh
- There are various types of wells (Shallow Wells, Deep Wells, Tube Wells, Artesian Wells)
- **Shallow Wells:** From the shallow wells water is not always available as the level of water goes down during the dry months.
- **Deep Wells:** more suitable for the purpose of irrigation as water from them is available throughout the year
- **Tube Wells:** a deep tube well worked by electricity, can irrigate a much larger area (about 4000 hectares) than a surface well

TANK IRRIGATION

Areas: Tamil Nadu, Andhra Pradesh, Karnataka, Telangana (mainly in Southern India)
Reservoirs are made by constructing dames
Tanks are constructed for storing water
From all these tanks, water is carried to the field the rough canals
The same type can be seen especially in most of the temples in Tamil Nadu. Chola architecture had a great knowledge in this type. They built the tanks in the temple. That time it was meant for rain water harvesting scheme (recently The Hindu carried an article regarding this) and also for irrigation purpose. Now most of the tanks are destroyed and living in a 'civilised society'

CANAL IRRIGATION

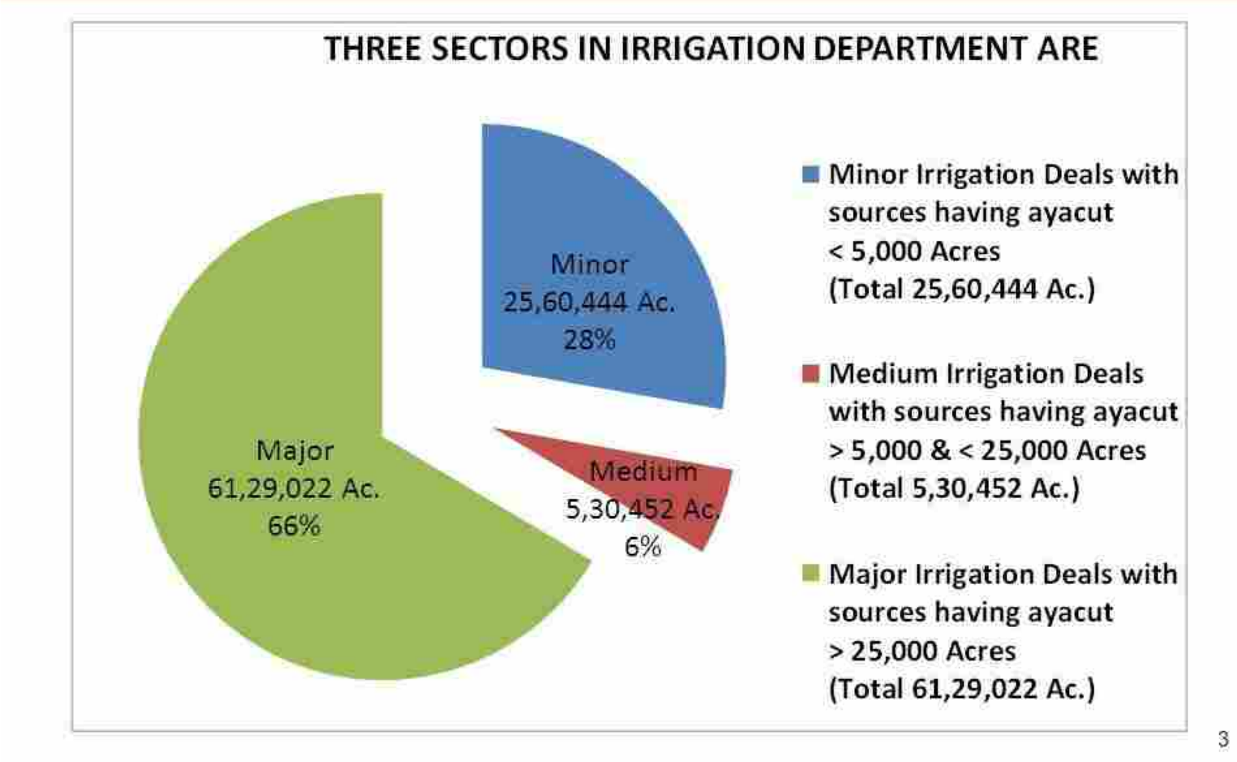
Areas: Punjab, Haryana, Uttar Pradesh, West Bengal, Odisha, Bihar
42% of total irrigated land in India is by canal irrigation
In many places during the rainy season, there is flood in the rivers. The flood water is carried to the field through canals.
They supply water only when there is flood in the rivers, and therefore, are of no use during the dry season when water is required most Perennial Canal Irrigation
In order to supply water throughout the year, reservoirs are constructed for storing water
From these reservoirs, water can be supplied to the fields whenever there is demand for it

Irrigation project classifications

Irrigation projects in India are classified into three categories: Major, medium and Minor irrigation

Drip Irrigation

- Also known as **Trickle Irrigation or micro Irrigation**
- An irrigation method that saves water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters.
- It is done through narrow tubes that deliver water directly to the base of the plant.
- Modern drip irrigation began its development in Germany in 1860
- The usage of plastic to hold and distribute water in drip irrigation was later developed in Australia by Hannis Thill



Sprinkler Irrigation

- Also known as overhead Irrigation
- Water is piped to one or more central locations within the field and distributed by overhead high-pressure sprinklers

Surface Irrigation

- Water moves over and across the land by simple gravity flow in order to wet it and to infiltrate into the soil
- Also called as **Flood Irrigation**

Pradhan Mantri Krishi Seenchayi Yojana

- Introduce by Prime Minister, (Aug 19, 2014) in Haryana
- To meet the irrigation needs of all farmers across the country
- Rs. 1000 crore allocated for implementing this scheme
- This scheme was announced by Union Finance minister, in Lok Sabha in his maiden Budget Speech

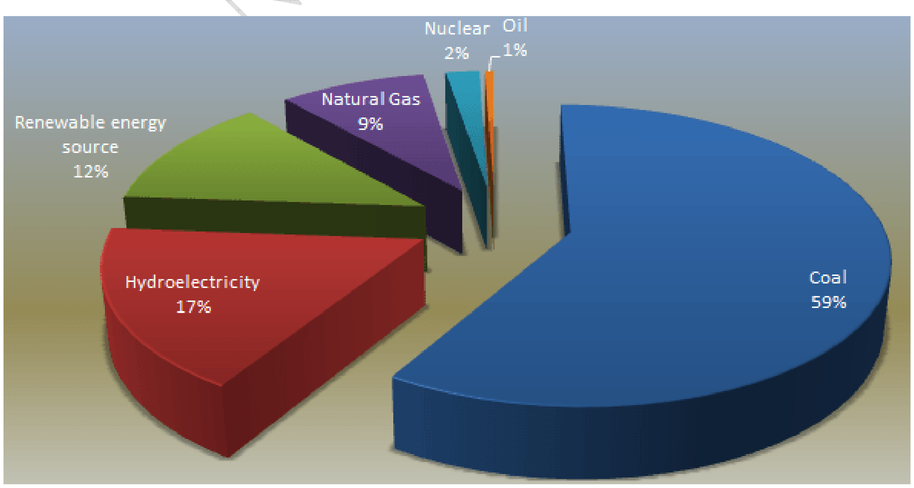
PMKSY to be implemented across India

- Farmers in various villages across India are taking benefit from the Prime Minister's Krishi Sinchayee Yojana (PMKSY).
- The Central government has chosen the districts to implement this programme to take water to the last field in the areas.
- Under the PMSKY, existing schemes of water management have been brought under one head to efficiently use water.

➢ ENERGY RESOURCES OF INDIA

India is 4th largest consumer of energy after USA, China, and Russia, but it is not endowed with abundant energy resources. It must, therefore, meet its development needs by using all available domestic resources of coal, uranium, oil, hydro, and other renewable resources. Meeting energy needs of achieving 8% economic growth, while also meeting energy requirements of the population at affordable prices, therefore, presents a major challenge. It calls for a sustained effort at increasing energy efficiency, while increasing domestic production as much as possible.

Conventional resources of Energy	The resources which are widely used and constitute the major source of energy Examples → Coal, Oil, Natural gas, Wood etc. Limited, Non-renewable, Costly, Cause Pollution & Exhaustible
Non-conventional resources	Solar Energy, Wind Energy, Tidal Energy, Geothermal Energy, OTEC (Ocean thermal energy conversion) etc. Renewable, Cheap, Pollution free & Inexhaustible
Renewable sources of Energy	Solar Energy, Wind Energy, Tidal Energy, Fish, Trees etc.
Non – Renewable sources of Energy	Fossils (Coal, Gas), Minerals, Nuclear Power etc.
Biotic resources	Which have life >> Forests, Crops, Animals, Coal & Mineral oil
Abiotic resources	Land, Water, Minerals



Ashok Chawla Committee on Natural Resources

- Creation of national database of natural resources
- Allocation of natural resources, if possible, through e-auction
- Measures for benefit of stakeholders in mineral rich areas

Need for conserving Conventional Energy Resources

- Are limited in supply and cannot be renewed easily.
- Due to population explosion, modernization and industrialization the demand for energy resources is increasing day by day
- To control energy crisis there is need to conserve conventional energy resources.
- There is also an eminent need to explore alternative sources of energy

Energy Crisis

- A situation in which resources are less than the demand
- In the past few decades due to high demand, there is shortage of energy resources, which has created energy crisis
- Major causes for Energy Crisis:

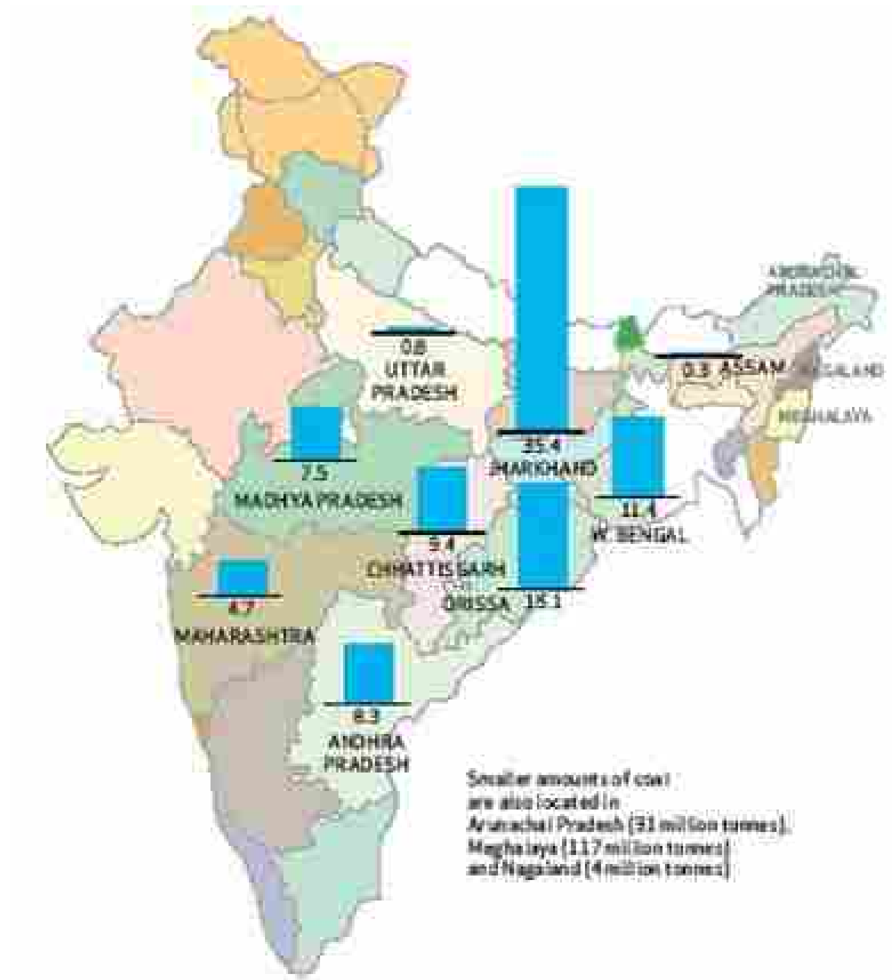
(a) Rapid Industrialization
(b) Over Population
(c) Transfer losses
(d) Rise in oil prices
(e) Problems in Middle east
(f) Wastage of energy resources

COAL

- Quality of coal is determined by its carbon content
- Major problems of Indian Coal -

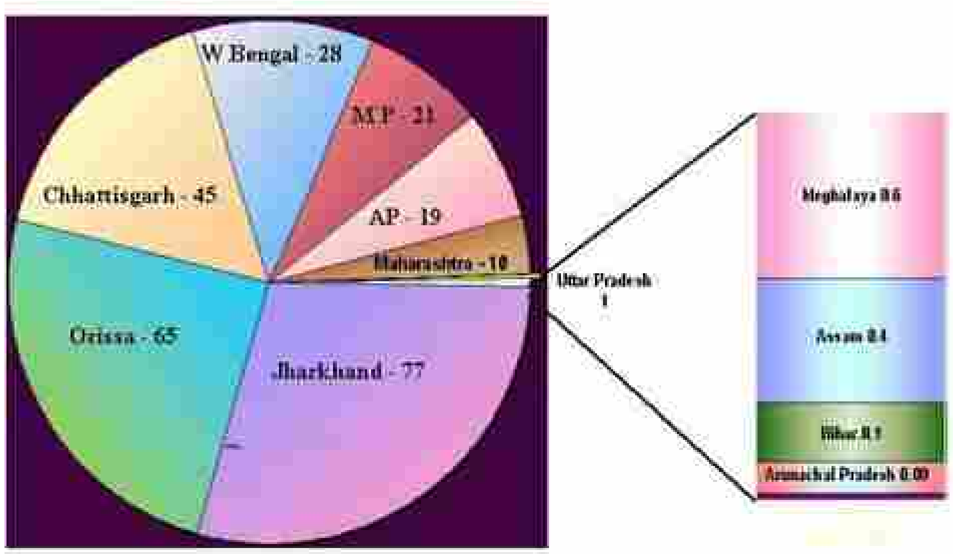
(a) Low Carbon content
(b) High Ash content
(c) Low Calorific Value

- Major coal producing areas in India → Jharkhand > Odisha > Chhattisgarh > West Bengal
- Chhota Nagpur Region → Hub of 90 % of Indian minerals (esp.in Coal & Iron → Ruhr of India)



Major types of Coals

Anthracite ▪ Best quality coal ▪ Approx. 90 % carbon content ▪ Found at J & K only in India ▪ Very little smoke & ash content ▪ Burns without flames	**Bituminous** ▪ 70 – 90 % carbon content ▪ Most common in India ▪ Used in making coke
Lignite ▪ 40 – 70 % carbon content ▪ Known as brown coal	**Peat** ▪ 1st transformation of wood into coal ▪ ~ 40 % carbon content



Coke

- Formed by destructive distillation of coal.
- Heating of coal in the absence of oxygen to burn of volatile gases
- High in carbon content

Petroleum / Mineral oil

- Found in sedimentary rocks of marine origin
- Formed by decomposition of tiny marine creatures, plants & vegetation under mud, silt & sand
- Over the years, it underwent chemical changes to form crude oil & natural gas under the action of heat & pressure
- 20 % of India's crude oil & gas demand is produced domestically & 80 % is imported
- Jamnagar Refineries of Reliance industries is world largest refinery complex

Natural Gas

- Mainly contains methane & found in association with mineral oil (75 % lies in Bombay high & Bassein oil fields)
- Largest share of NG is as follows –

(a) 40 % → Production of chemical fertilizers
(b) 30 % → Power generation
(c) 10 % → LPG (Cooking Gas)
(d) Conventional sources → Shale gas, Coal bed methane, Methane Hydrates, Tight sandstones

Bio-Fuels

Fuel derived from Non fossil plants

- In India, mainly centers around cultivation & processing of Jatropha plant seeds, used in production of Bio – Diesel
- Encouraged only on wasteland / government / forest land
- Not allowed on fertile land

To produce ethanol from sugarcane (Bio-ethanol)

National Bio-fuel Policy

Targets minimum 20 % biofuel blending (both bio-diesel and bio-ethanol) across the country by 2017

Electricity in India → Thermal > Hydro > Wind > Nuclear

Thermal Energy

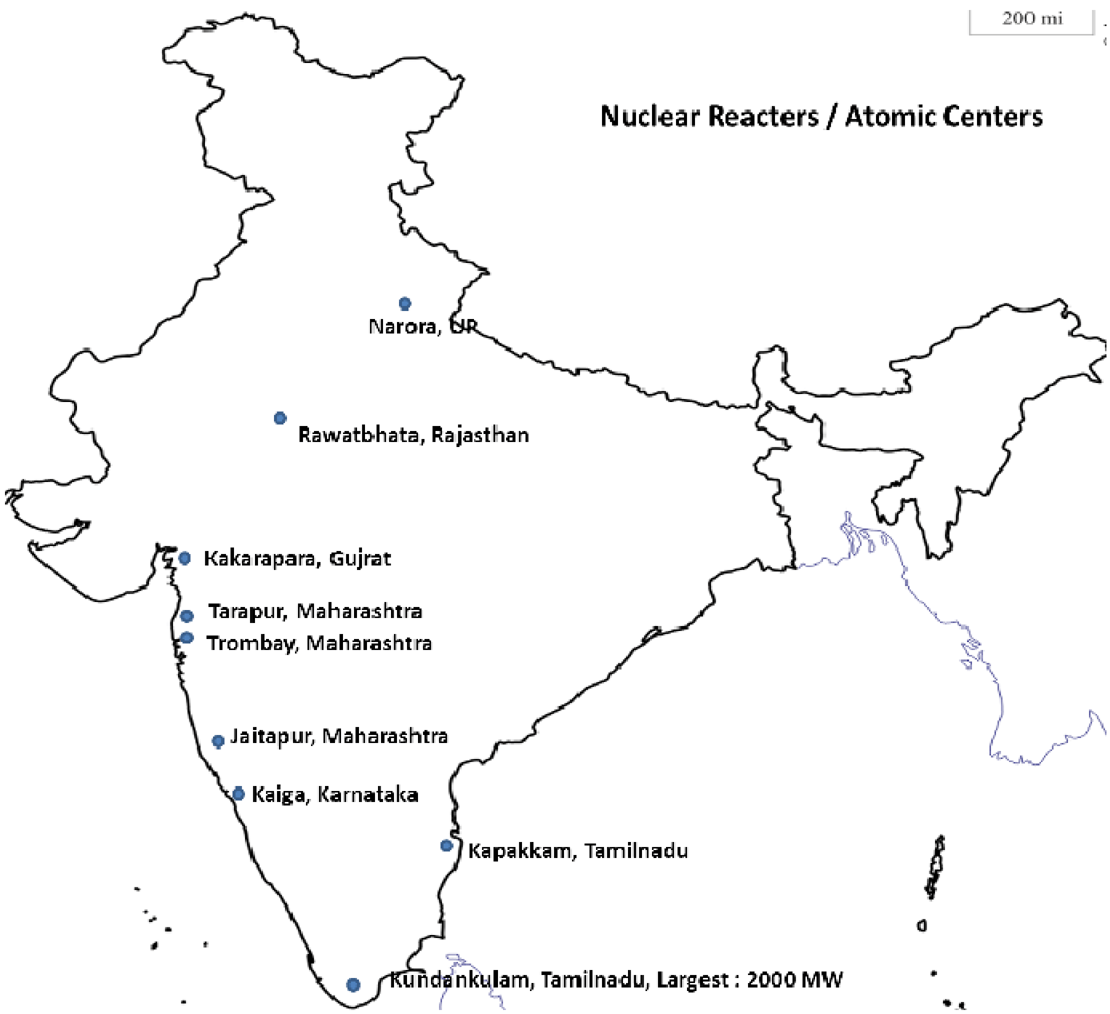
- 67 % of total energy production
- Generated by using fossil fuels (Coal, Petroleum, Natural gas)
- No Geological conditions required
- Limited reserves, Rising demands (cost) & non – ecofriendly
- Largest Producer → **Maharashtra**
- To boost Thermal power production gov. has promoted Ultra Mega Power Projects (4000 MW & above)

Hydroelectricity

- 18 % of total energy production
- Eco-friendly, Clean & Renewable
- Small hydel power projects < 25 MW
- Are counted under New renewable energy sources
- Largest Producer → **Andhra Pradesh**
- Central electricity authority (CEC) has estimated Hydel power potential of 84000 MW at 60 % load factor from 39000 MW at present

Nuclear Energy

- 26 % of total energy production
- Energy obtained from atomic minerals viz. Uranium, Thorium, zircon, beryllium
- Provide colossal energy through a small quantity of substance
- Thorium → Found as monazite sand in lakes & sea beds
- Thorium → AP > TN > Kerala > Orissa constitutes 30 % of world reserves
- Largest Producer → **Tamil Nadu**
- Very economical; does not produce green-house gases that pollute atmosphere



Wind Energy

- Non-conventional Renewable source of energy
- 5th largest installed wind power capacity in the world
- Largest Producer → **Tamil Nadu**
- High cost as compared to the efficiency of power generated
- Nagercoil (TN) and Jaisalmer (Rajasthan) are well known for effective use of wind energy in the country

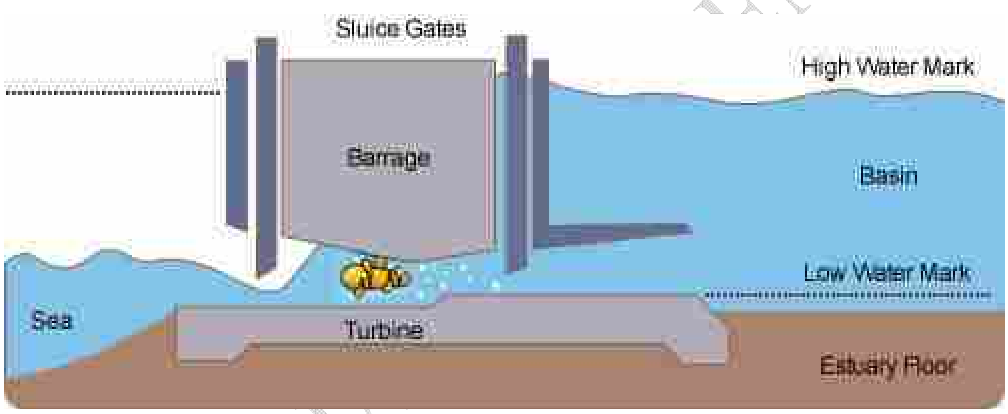
Solar Energy

- Non-conventional Renewable source of energy
- Thermal + Photovoltaic → Sunlight to energy
- High cost as compared to the efficiency of power generated
- India plans to add 20000 MW of solar energy by 2022 under Jawahar Nehru National Solar Mission

- The largest solar plant of India is located at Madhavpur, near Bhuj, where solar energy is used to sterilise milk cans.

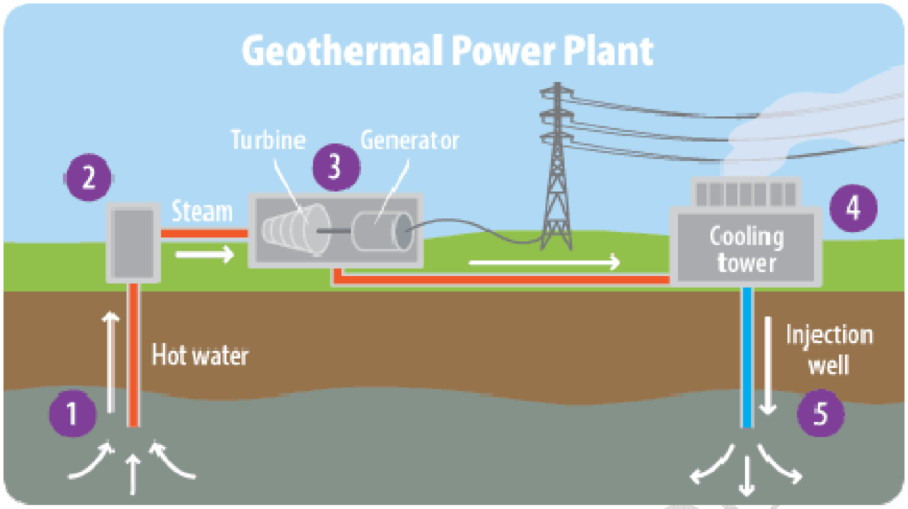
Tidal Energy

- Non-conventional Renewable source of energy
- Oceanic tides can be used to generate electricity.
- Floodgate dams are built across inlets
- During high tide water flows into the inlet and gets trapped when the gate is closed.
- After the tide falls outside the flood gate, the water retained by the floodgate flows back to the sea via a pipe that carries it through a power-generating turbine.
- In India, the Gulf of Kutch, provides ideal conditions for utilising tidal energy.
- Experimental plant (150 kw) at Vizinjam (Thiruvananthapuram) & 900 mw at Kutch



Geo Thermal Energy

- Refers to the heat and electricity produced by using the heat from the interior of the Earth
- Exists because, the Earth grows progressively hotter with increasing depth
- Groundwater in such areas absorbs heat from the rocks and becomes hot.
- It is so hot that when it rises to the earth's surface, it turns into steam.
- This steam is used to drive turbines and generate electricity.
- Two experimental projects have been set up in India to harness geothermal energy
- Parvati valley near Manikarn in Himachal Pradesh and Puga Valley, Ladakh



Bio Gas

- Energy produced from organic waste such as farm waste, shrubs, animal and human waste
- Converted into energy by direct combustion or by conversion of such wastages into alcohol, methane, or other storage fuels
- Provides pollution-free energy
- Cheaper than most of the common fuels
- The residue can be used as manure
- Has higher thermal efficiency in comparison to kerosene, cow dung, coal and charcoal

The following plant species are known to be good sources for the biodiesel

(a) **Jatropha curcas (Jatropha)**
(b) **Pongamia pinnata (Karanj)**
(c) **Azadirachta indica (Neem)**
(d) **Madhuca indica (Mahua)Advantages of Bio Diesel**

OTEC

- Ocean thermal energy conversion
- Uses the difference between cooler deep and warmer shallow surface ocean waters to run a heat engine
- Ocean Thermal Energy Conversion is a technology that converts solar radiation to electric power.
- OTEC systems use the ocean's natural thermal gradient, consequently the temperature difference between the warm surface water and the cold deep water below 600 meters by about 20o C, an OTEC system can produce a significant amount of power. The oceans are thus a vast renewable resource, with the potential to help us produce billions of watts of electric power.
- OTEC has a potential installed capacity of 180,000 MW in India.

➢ TRANSPORT GEOGRAPHY OF INDIA

An efficient transport system is a pre-requisite for sustained economic development. It is not only the key infrastructural input for the growth process but also plays a significant role in promoting national integration, which is particularly important in a large country like India. The transport system also plays an important role of promoting the development of the backward regions and integrating them with the mainstream economy by opening them to trade and investment. India has a well-developed transport network comprising rail, road, coastal shipping, air transport, etc.

ROAD TRANSPORT → 100 % FDI

National Highways

- Responsibility of National highway authority of India (NHAI)
- Constitutes 2 % of all roads & carry 40 % of total road traffic
- Funded by cess on petrol & high speed diesel (From central road fund in Public accounts of India)
- UP → Highest length of National Highways

NH7	Varanasi – Cape – comrin (Kanyakumari)
NH6	Surat – Kolkata
NH5	Jharkhand – Chennai
NH2	Delhi – Kolkata
NH8	Delhi – Mumbai
NH4	Mumbai – Chennai
NH3	Agra – Mumbai

International Border Highways

- Connects Indian borders with neighboring countries
- Responsibility lies with Border road organization (BRO)
- Financed by World Bank

NH1	INDO – PAK BORDER (DELHI, HARYANA, PUNJAB)
NH22	INDO – CHINA BORDER (HARYANA, PUNJAB, HIMACHAL PRADESH)
NH35	INDO – BANGLADESH BORDER (WB)
NH39	INDO – BHUTAN BORDER (ASSAM, NAGALAND, MANIPUR)
NH28A	INDO – NEPAL BORDER (BIHAR)

Famous Highway Projects

- **Golden Quadrilateral** → 6 lane highway project connecting Delhi – Mumbai – Kolkata – Chennai
- **North – South Corridor** → Linking Srinagar – Kanyakumari
- **East – West Corridor** → Linking Silchar (Assam) – Porbandar
- Mumbai – Pune expressway (1st expressway of country) is not under NHAI as it was built by state government

State Highways

- Connects state capitals with district centres & are constructed by **state governments**
- Union from Central road fund (CRF) provides grants & financial assistance to states, if required
- Maharashtra has the largest length of state highways

District Highways

- District centers to other important places of districts like business centers, industrial centers etc.
- Zila Parishad constructs & maintains these roads (Constitutes 1/3rd of total Indian roads)
- Maharashtra has the largest length of District highways

Village Roads

- Connects villages with neighboring towns & cities
- Responsibility of village roads lies with Gram Panchayat
- Central gov. has launched Pradhan Mantri Gram Sadak Yojana (PMGSY) in 2000 as 100 % centrally sponsored scheme to provide rural connectivity to unconnected rural areas with population of 500 persons or more (250 persons in case of Hilly, Tribal & Desert areas)

Project Bharatmala

- A road built along India’s vast west-to east land border, approx. 5300km, from Gujarat to Mizoram
- Linking it to a road network in coastal states, from Maharashtra to Bengal
- This is a road network that will, as it were, garland the territory of India
- The Bharat Mala plan has a strong strategic component
- It’s India’s attempted answer to improve reach and connectivity in border areas, right across a large part of which lies China’s impressive road infrastructure

Rashtriya Rajmarg Zila Sanjoyokta Pariyojna – Roads will be developed to connect 100 district HQs across the country

Setubharatam – Govt to build 210 rails over bridges in the next two years and about 400-500 bridges would be built as standalone projects.

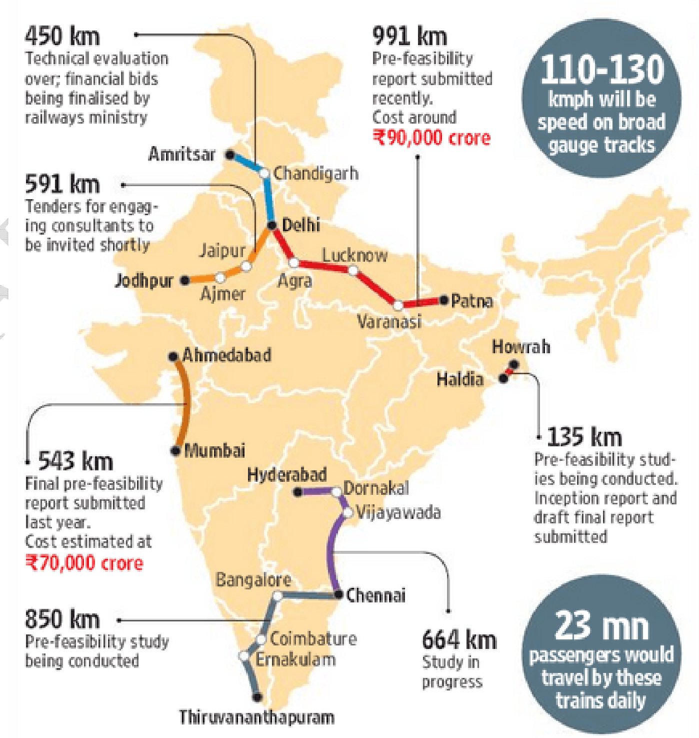
INDIAN RAILWAYS

- Mainly found in 3 gauges
- Broad Gauge = 1.675 m **(70.72 %)**
- Meter Gauge = 1 m **(92 %)**
- Narrow Gauge = .61 & .62 m **(5.36 %)**

Central Railways	Mumbai Central
Northern Railways	Baroda house, New Delhi
Eastern Railways	Kolkata
Western Railways	Mumbai Church Gate
Southern Railways	Chennai Central
North Central Railway	Allahabad
East Central Railway	Hajipur
West Central Railway	Jabalpur
South Central Railway	Secunderabad

Metro Rails (Functioning)

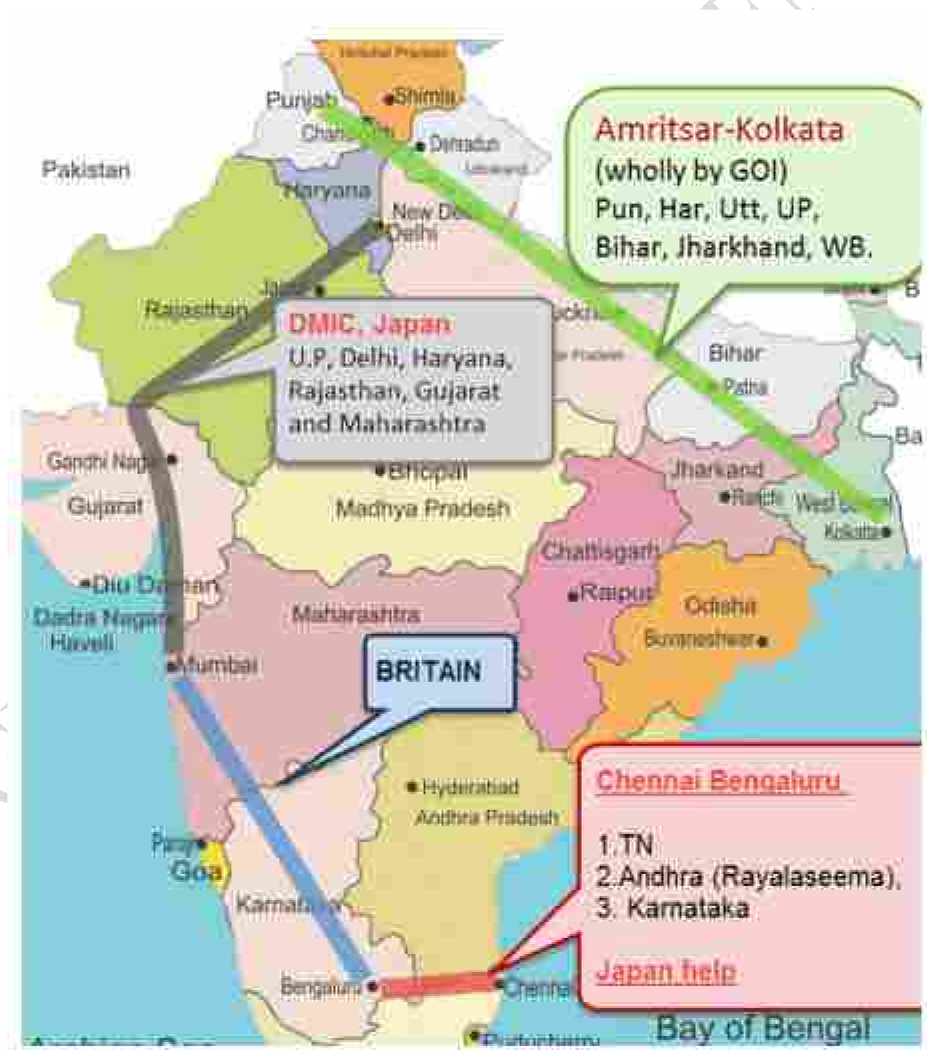
- Kolkata (First mass rapid transit system in India)
- Delhi
- Bangalore (Wifi Enabled)
- Mumbai (Public Private Partnership)
- Jaipur
- Chennai
- Gurgaon (India's first fully privately financed metro + India's first fully privately financed metro stations)



Duronto Express → Fastest Train in India (Called Restless in Bengali)

Diamond Quadrilateral → High speed rails project connecting Delhi – Mumbai – Kolkata – Chennai

Dedicated Freight Corridor Projects		
Amritsar-Kolakata	Punjab, Haryana, Uttar Pradesh, Uttarakhand, Bihar, Jharkhand & WB	Wholly by GOI, funded by WB
Mumbai Bengaluru	MH, Karnataka	Britain
Chennai-Bengaluru	Karnataka, TN, Andhra (Rayalaseema region)	JICA (Japan International cooperation Agency)
Delhi Mumbai (launched & Biggest)	UP, Delhi, Haryana, Rajasthan, Gujarat and Maharashtra	



INDIAN PORTS

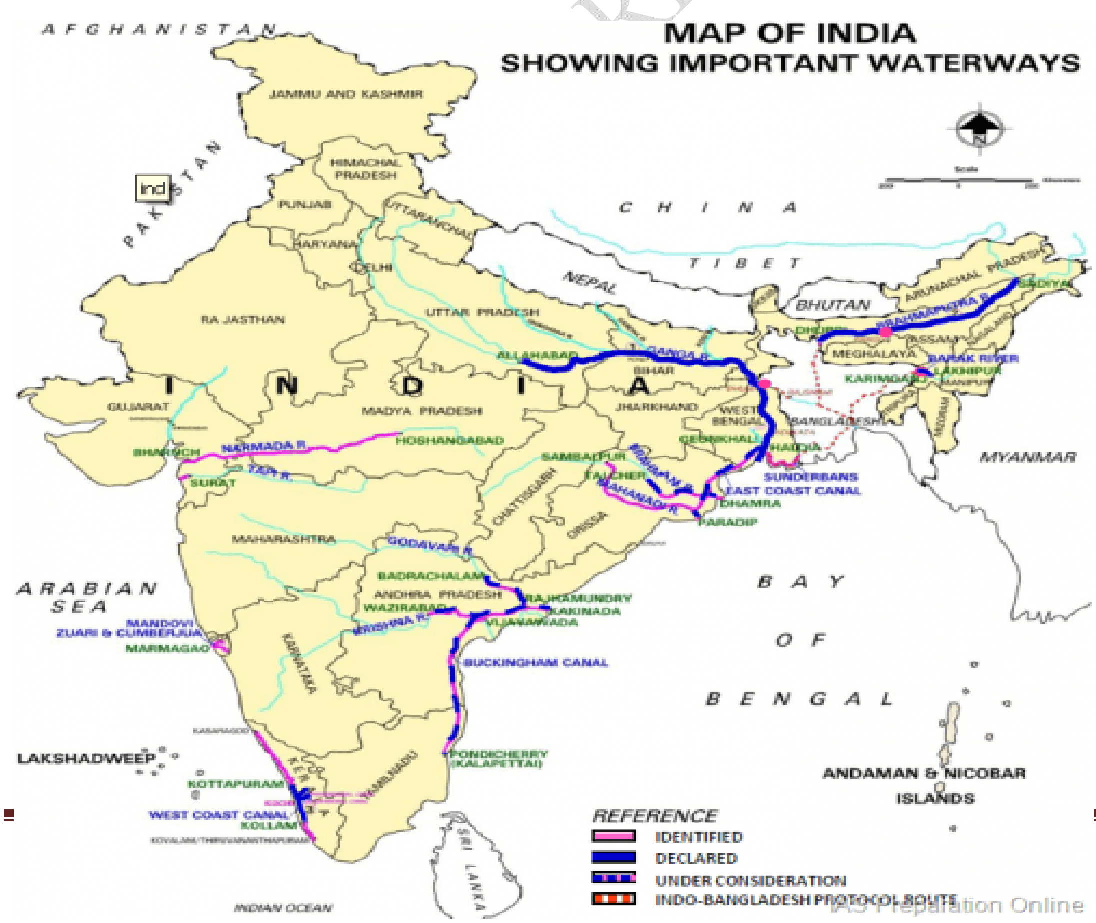
Mumbai	Natural harbor & biggest port of India (Gateway of India)Handles approx. 1/5th of India's foreign trade
Nava Seva	Jawalar Lal Port (Highly Mechanized Port) , Mumbai
Chennai	Oldest artificial harbor on east coast & 2nd largest port in terms of volume of traffic
Ennore	1st corporate port (To release pressure on Chennai port)
Tuticorin (TN)	On Eastern coast of India
Kandla	Tidal Port (To release pressure on Mumbai port, developed after partition of India), Gujrat
Kochi	A natural harbor
Vishakhapatnam	Deepest artificial harbor on east coast
Kolkata	Riverine Port (Handles goods coming from SE Asian countries Australia & New Zealand)
Haldia	Developed on river Hooghly to relieve pressure on Kolkata port
Paradip	Located on Orissa coast
Mormugao	In Goa (5th in total traffic handled)
New Mangalore	On New Mangalore

- **Ennore –** 1st corporate port (To release pressure on Chennai port)
- **Indian Ports -** 95 % by volume & 70 % by value – India's international trade
- In monsoon, all western ports except Mumbai, Cochin & Kandila are closed (12 Major & 1 Minor Port)

(a) Maritime transport is to be administered by both the Central and the State governments.
(b) While the central government's shipping ministry administers the major ports, the minor and intermediate ports are administered by the relevant state gov. of coastal states.
(c) All major ports, except one Ennore Port are government administered. It is the first port in India which is a public company.

Major Inland Waterways by Inland waterways authority of India (IWAI)

Inland Waterway 1	Allahabad-Haldia stretch of Ganga-Bhagirathi-Hooghly river system
Inland Waterway 2	Sadiya-Dhubri stretch of the Brahmaputra River (Assam)
Inland Waterway 3	Kottapuram-Kollam stretch of the West Coast Canal, Champakara Canal and Udyogmandal Canal (Kerala)
Inland Waterway 4	Kakinada-Pondicherry along Godavari and Krishna River system
Inland Waterway 5	Talcher – Paradip (Odisha)
Inland Waterway 6	Lakhipur to Bhanga on the River Barak (Assam – Proposed)



- Central Government has jurisdiction over both the National Highways and the National Waterways
- The States' Governments have NO jurisdiction over the National Waterways.
- Indian Waterways à 1 % of total transport
- Length wise → 1 > 4 > 2 > 5 > 3
- Inland waterways – 14500 km
- Indian coastline – Approx. 7500 km

River Interlinking Program India

The National Water Development Agency has already identified 14 links under the Himalayan Component and 16 under the one for Peninsular Rivers with priority to top 5 projects viz.

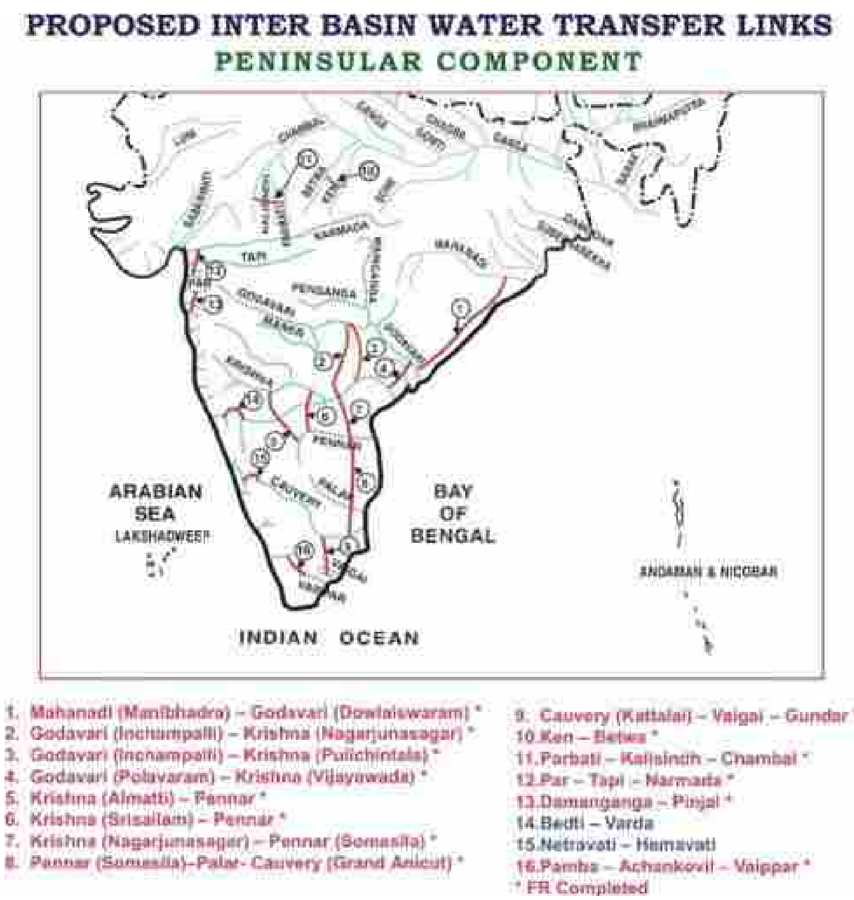
- Ken-Betwa
- Parbati-Kalisindh -Chambal
- Damanganga-Pinjal
- Par-Tapi-Narmada
- Godavari (Polavaram)-Krishna (Vijayawada)

The Himalayan Interlinking Rivers – 14

Objectives of River Interlinking Project

- To diminish water scarcity in western and peninsular India
- To help in irrigation and storage as a large part of Indian agriculture is rainfall dependent
- To mitigate droughts and floods
- To reduce diversity between the water surplus and water scarce parts of India
- Will create employment
- Will help in socio – economic development of people

The Peninsular Interlinking Rivers – 16



Opposition of River Interlinking Project

- Huge capital requirement
- Project may take 50 years to complete
- Can cause seismic hazards in Himalaya
- Execution is difficult as 21/30 links are dependent on other links
- Displacement of tribal and poor

- Interstate water disputes (political)
- Loss of forest and biodiversity
- International Conflicts with Nepal, Bangladesh

Project Sagarmala

- Project Sagarmala aims to improve India's maritime infrastructure by modernizing existing major and minor ports of India and setting up new ports
- Prime objectives of Project Sagarmala

(a) to promote port-led direct and indirect development

(b) to provide infrastructure to transport goods to and from ports quickly, efficiently and cost-effectively

- The Sagarmala initiative will address challenges by focusing on three pillars of development, namely

(a) Supporting and enabling Port-led Development through appropriate policy and institutional interventions and providing for an institutional framework for ensuring inter-agency and ministries/departments/states' collaboration for integrated development

(b) Port Infrastructure Enhancement, including modernization and setting up of new ports

(c) Efficient Evacuation to and from hinterland

- Under Project Sagarmala Shipping ministry has formed new Committee to setup two major ports

1) Sagar, West Bengal
2) Dugarajapatnam, Simandhra

- An illustrative list of the kind of development projects that could be undertaken in Sagarmala initiative are -

1) Port-led industrialization
2) Port based urbanization
3) Port based and coastal tourism and recreational activities
4) Short-sea shipping coastal shipping and Inland Waterways Transportation
5) Ship building, ship repair and ship recycling
6) Logistics parks, warehousing, maritime zones/services
7) Integration with hinterland hubs
8) Offshore storage, drilling platforms
9) Specialization of ports in certain economic activities such as energy, containers, chemicals, coal, agro products, etc.
10) Offshore Renewable Energy Projects with base ports for installations

Indian Airways

Nationalized in 1953 – Indian Airlines
Managed by Airport Authority of India (AAI)

GREEN INVESTMENT	BROWN INVESTMENT
Fresh Investment i.e. to build up airport from scratch	Renovation of old Airports
Bangalore & Hyderabad Airports	Delhi & Mumbai Airports

MINERAL RESOURCES OF INDIA

Minerals generally occur in the Earth's crust in the form of ore. It is mined, extracted, processed and utilised for the economic benefits of the society. India has significant reserves of minerals but their distribution is highly uneven.

Mineral Belts of India

Mineral Belt	States covered	Minerals found
Chottanagpur belt	Jharkhand, Bihar, Odisha, Chhattisgarh, WestBengal	Coal, Mica, Manganese, Chromite, Ilmenite, Bauxite, Iron, Copper, Dolomite, china clay, Limestone
Midland belt	Chhattisgarh, Madhya Pradesh, Andhra Pradesh, Maharashtra	Manganese, Bauxite, Mica, Copper, Graphite, Limestone, Lignite and Marble
Southern belt	Andhra Pradesh, Karnataka, Tamil nadu	Gold, Iron ore, Chromite, Manganese, Lignite, Mica, Bauxite, Gypsum, Asbestos, Dolomite, Ilmenite, Limestone
Western belt	Rajasthan, Gujarath, Maharashtra	Copper, Lead, Zinc, Uranium, Mica, Manganese, Asbestos, precious stones, mineral oil and natural gas
South western belt	Goa, Karnataka, Kerala	Iron ore, Ilmenite, Zircon, Monazite, Garnet, Bauxite, Mica, Limestone
Himalayan belt	Jammu and Kashmir, Uttarakhand, Assam	Copper, Lead, Zinc, Bismuth, Bauxite, Antimony, Nickel, Cobalt, Tungsten, precious stones, gold, silver, gypsum, limestone, dolomite
Indian ocean belt	Continental shelf region of Arabian sea and Bay of Bengal	Mineral oil, natural gas

METALLIC MINERALS

Iron

India stands first in iron ore reserves in Asia. Iron ore is mainly distributed in the peninsular India.

Varieties of Iron Ore:

- Magnetite: The best quality iron ore containing 72% of pure Iron.
- Hematite: Contains 60-70% of pure Iron
- Limonite: Contains 40-60% of pure Iron
- Siderite: Contains less than 40% of pure Iron

Iron Ore Mines in India

State	Mines	Type of Iron	Production
Karnataka	Chikmangalur(Bababudan Hills, Kudremukh), Bellary(Sandur)	Haematite, Magnetite	25%
Odisha	Cuttack, Keonjhar, Sundargarh (Baonaigarh), Koraput, Mayurbhanj(Badampahar)	Haematite	22%
Chhattisgarh	Bastar(Bailadila), Durg(Dalli-Rjhara)	Haematite	20%
Goa	North Goa	Magnetite, Haematite	16%
Jharkhand	Bonai Ragne, Singhbhum, Naomandi, Daltenganj, Hazaribagh, Ranchi, Gurumahisani	Magnetite, Haematite	14%

Manganese

- It is used for smelting of Iron and also for making alloys containing Manganese.
- India has second largest manganese reserves after Zimbabwe.
- India is the fifth largest producer of Manganese in the world.
- Manganese reserves in India are found in Odisha (44%), Karnataka (22%), Madhya Pradesh (13%), and Maharashtra (8%) among others.
- As of 2011-12, Maharashtra is the leading producer of Manganese followed by Madhya Pradesh, Odisha and Andhra Pradesh.

Copper

- It is widely utilised by electrical industry for manufacturing wires and other electrical equipments. It is also added with gold to impart strength.
- Major share of Copper production comes from Madhya Pradesh(58%), Rajasthan(32%) and Jharkhand(11%).
- Major copper mining centres are at Singhbhum (Jharkhand), Malanjkhand(MP), Khetri-Singhana and Alwar(Rajasthan),Kho- Dariba and Delwara-Kirovli.

Bauxite

- It is the ore of Aluminium.
- Major producers of Bauxite are Kalahandi and Koraput belt of Odisha (36%), Gujarath (20%), Maharashtra (13%) and Jharkhand (13%).
- NALCO, BALCO and HINDALCO are major companies engaged in mining of Bauxite in the country.

Gold

- India's share in the world gold production is less than one percent.
- Karnataka is the leading producer of gold accounting for 99% of total production and the rest comes from Jharkhand.
- Major gold fields in India: Kolar (Karnataka), Hutti (Karnataka), Ramgiri (Andhra Pradesh).

Other metallic minerals

- Diamond is found in Panna belt of Madhya Pradesh, Raichur-Gulbarga districts of Karnataka.
- Silver is produced from Zawar mines of Udaipur district of Rajasthan.
- More than 99% of Zinc production comes from Zawar area of Udaipur district of Rajasthan.
- Galena, the ore of lead, is produced from Rajasthan (94%)
- Odisha has the largest reserve of Nickel.

NON METALLIC MINERALS

India produces a large number of non-metallic minerals although only a few of them have assumed as much industrial and economic importance than that of metallic minerals. Non metallic minerals are used in a large variety of industries; the major industries being cement, fertilizers, electricals, etc.

Mica

- Mica's insulating properties have made it a valuable mineral in electrical and electronics industry.
- It can withstand high voltage and has low power loss factor.
- India contributes about 60 per cent of world's total production.
- Andhra Pradesh is the largest mica producing state of India.

Limestone

- Limestone is used for a large variety of purposes. Of the total consumption, 75 per cent is used in cement industry, 16 per cent in iron and steel industry and 4 per cent in the chemical industries. Rest of the limestone is used in paper, sugar, fertilizers, glass, rubber and ferromanganese industries.
- Over three-fourths of the total limestone production in India is from six states , Madhya Pradesh, Rajasthan, Andhra Pradesh, Gujarat, Chhattisgarh and Tamil Nadu.

Asbestos

- The name 'Asbestos' denotes two different minerals, namely, Ampibole and Chrysotile.
- Chrysotile accounts for 80% of asbestos of commercial use.
- Andhra Pradesh is the largest producer of Asbestos in India.

Dolomite

- Limestone with more than 10% Magnesium is called Dolomite.
- True Dolomite has about 45% Magnesium.
- Dolomite is used in Iron and Steel industry (more than 90%), followed by Fertilizer (4%), Glass (2%) and steel (1%).
- Chhattisgarh is the leading producer of Dolomite (28%), followed by Andhra Pradesh (23%), Odisha (13%) and remaining 36% by other states.

Gypsum

- Gypsum is mainly used in making Ammonia sulphate fertilizer and in cement industry.
- Bulk of production of Gypsum comes from Rajasthan (99%) and the remaining 1% from Jammu and Kashmir and Gujarat.

ATOMIC MINERALS

Uranium

- Uranium deposits occur in Jaduguda of Singbhum and Hazaribagh districts of Jharkhand, Gaya district of Bihar and Saharanpur district of Uttar Pradesh.
- India accounts for only 2% of world Uranium production.

Thorium

- It is found in the Monazite sands of Placer deposits of coastal regions.
- Although Monazite sands are found in east and west coast, the largest concentration is on the Kerala coast.
- Thorium is also extracted from Thorianite.
- Kerala, Jharkhand, Bihar, Tamil nadu and Rajasthan are the major producers of Thorium.

Beryllium

- Beryllium oxide is used as moderator in nuclear reactors.
- India has sufficient reserves of Beryllium.

Lithium and Zirconium

- Lithium is a light metal which is distributed in the states of Jharkhand, Madhya Pradesh and Rajasthan.
- Zirconium is found in Kerala coasts and in alluvial deposits of Ranchi and Hazaribagh of Jharkhand.

National Mineral Policy, 2008

The main objectives of the policy includes,

- Use of state-of-the-art technology for exploration.
- Zero-waste mining.
- Transparency in allocation of concessions.
- Independent Mining Administrative Tribunal.
- Auction of Ore bodies prospected at public response.
- A framework for sustainable development to take care of bio-diversity issues.

INDIAN INDUSTRIES

On the basis of size, capital investment, and labor force employed, industries are classified as large, medium, small scale, and cottage industries. On the basis of ownership, industries come under public sector, private sector, joint, and cooperative sector.

Industries of strategic and national importance are usually in the public sector.
Industries are also classified on the basis of the use of their products such as basic goods industries, capital goods industries, intermediate goods industries, and consumer goods industries.

On the basis of raw materials used by the industries − industries are categorized as agriculture-based industries, forest-based industries, mineral-based industries, and industrially processed raw material-based industries.

Location of industries is influenced by several factors like access to raw materials, power, market, capital, transport, and labor, etc.

Establishment of iron and steel industry in Bhilai (Chhattisgarh) and Rourkela (Odisha) were based on decision to develop backward tribal areas of the country.

Iron and Steel Industry

- The major raw materials for the iron and steel industries are iron ore, coking coal, limestone, dolomite, manganese, and fire clay.
- Major iron and steel industries in India are –

(a) The Tata Iron and Steel plant (TISCO);
(b) The Indian Iron and Steel Company (IISCO);
(c) Visvesvaraiya Iron and Steel Works Ltd. (VISL);
(d) Rourkela Steel Plant;
(e) Bhilai Steel Plant;
(f) Durgapur Steel Plant; and
(g) Bokaro Steel Plant.

- Some other major iron and steel industries are −
  (a) Vizag Steel Plant, in Vishakhapatnam in Andhra Pradesh is the first port based plant which started operating in 1992.
  (b) The Vijaynagar Steel Plant at Hosapete in Karnataka was developed by using indigenous technology.
  (c) The Salem Steel Plant in Tamil Nadu was commissioned in 1982.

- The **Rourkela Steel plant** was set up in the year 1959 in the Sundargarh district of Odisha in collaboration with Germany.
- The **Bhilai Steel Plant** was established in 1959 with Russian collaboration in Durg District of Chhattisgarh.
- **Durgapur Steel Plant** was established in 1962 in West Bengal, in collaboration with the government of the United Kingdom
- **Bokaro steel plant** was set up in 1964 at Bokaro with Russian collaboration.

Cotton Industry

- India was famous worldwide for the production of *muslin*, a very fine variety of cotton cloth, calicos, chintz, and other different varieties of fine cotton cloth.
- In **1854**, the first modern cotton mill was established in Mumbai.
- At present, the major centers of the cotton textile industry are Ahmedabad, Bhiwandi, Solapur, Kolhapur, Nagpur, Indore, and Ujjain.
- Tamil Nadu has the largest number of mills; however, most of them produce yarn rather than cloth.
- Davangere, Hubballi, Ballari, Mysuru, and Bengaluru are important cotton growing regions in Karnataka.

Sugar Industry

- With more than one-third of the total production, Maharashtra has emerged as a leading sugar producer in the country.
- Uttar Pradesh is the second largest producer of sugar.

Petrochemical Industry

- Many items are derived from crude petroleum, which provide raw materials for many new industries; hence, these are collectively known as petrochemical industries.
- Petrochemical industries are categorized as polymers, synthetic fibers, elastomers, and surfactant intermediate industries.
- Mumbai is the hub of petrochemical industries.
- Three organizations, which are working in the petrochemical sector under the administrative control of the **Department of Chemicals** and **Petrochemicals** are −
  (a) The Indian Petrochemical Corporation Limited (IPCL);
  (b) The Petrofils Cooperative Limited (PCL);
  (c) The Central Institute of Plastic Engineering and Technology (CIPET).
  (d) The **National Organic Chemicals Industries Limited**(NOCIL), established as private sector in 1961.

Information Technology

Source: NCERT Book (India People & Economy: Class XII)

- The Information Technology (IT) revolution opened up new possibilities of economic and social transformation.
- The IT software and services industry account for almost 2% of India's GDP.

Industrial Policy

- The new **Industrial Policy** was implemented in **1991**.
- The new industrial policy has three main dimensions − liberalization, privatization, and globalization.
- Within this new industrial policy, measures initiated are − abolition of industrial licensing; free entry to foreign technology; foreign investment policy; access to capital market; open trade; abolition of phased manufacturing program; and liberalized industrial location program.
- Globalization means integrating the economy of the country with the world economy.

Industrial Regions

India has **eight** major industrial regions namely (as shown on the map given below) −

- Mumbai-Pune Region,
- Hugli Region,
- Bengaluru-Tamil Nadu Region,
- Gujarat Region,
- Chhotanagpur Region,
- Vishakhapatnam-Guntur Region,
- Gurgaon-Delhi-Meerut Region, and
- Kollam-Thiruvananthapuram Region.

CENSUS 2011

Census operations started in India long back during the period of the Maurya dynasty. It was systematized during the years 1865 to 1872, though it has been conducted uninterruptedly from the year 1881 being a trustworthy resource of information.

The Indian Census is the most credible source of information on Demography (Population characteristics), Economic Activity, Literacy and Education, Housing & Household Amenities, Urbanisation, Fertility and Mortality, Scheduled Castes and Scheduled Tribes, Language, Religion, Migration, Disability and many other socio-cultural and demographic data since 1872. Census 2011 is the 15th National Census of the Country. This is the only source of primary data in the village, town and ward level, it provides valuable information for planning and formulation policies for Central and the State Governments and is widely used by National and International Agencies, scholars, business people, industrialists, and many more.

SOURCES

Population –

- India's total population stands at 1.21 billion, which is 17.7 per cent more than the last decade, and growth of females was higher than that of males.
- There was an increase of 90.97 million males and increase of 90.99 million females. The growth rate of females was 18.3 per cent which is higher than males — 17.1 per cent. India's population grew by 17.7 per cent during 2001-11, against 21.5 per cent in the previous decade.
- Among the major states, highest decadal growth in population has been recorded in Bihar (25.4 per cent) while 14 states and Union Territories have recorded population growth above 20 per cent.

Top Populous of the Country		
1	Uttar Pradesh	19,98,12,341
2	Maharashtra	11,23,74,333
3	Bihar	10,40,99,452
4	West Bengal	9,12,76,115
5	Andhra Pradesh	8,45,80,777
Least Populous of the Country		
1	Lakshadweep	64,473
2	Daman and Diu	2,43,247
3	Dadra and Nagar Haveli	3,43,709
4	Andaman and Nicobar Islands	3,80,581
5	Sikkim	6,10,577

Highest Populous UT	Delhi
Least Populous UT	Lakshadweep
Highest Populous state	Uttar Pradesh
Least populous state	Sikkim
Highest urban Population in india (state& UT)	Maharashtra – 4,11,00,980
Lowest urban Population in india (state& UT)	Lakshadweep – 26,967
Highest Rular Population in india (state& UT)	Uttar Pradesh – 13,16,58,339
Lowest Rular Population in india (state& UT)	Lakshadweep – 33,683

Rural and urban population –

- Altogether, 833.5 million persons live in rural area as per Census 2011, which was more than two-third of the total population, while 377.1 million persons live in urban areas. Urban proportion has gone up from 17.3 per cent in 1951 to 31.2 per cent in 2011. Empowered Action Group (EAG) states have lower urban proportion (21.1 per cent) in comparison to non-EAG states (39.7 per cent).
- Highest proportion of urban population is in NCT Delhi (97.5 per cent). Top five states in share of urban population are Goa (62.2 per cent), Mizoram (52.1 per cent), Tamil Nadu (48.4 per cent), Kerala (47.7 per cent) and Maharashtra (45.2 per cent).

Literacy –

- Literacy rate in India in 2011 has increased by 8 per cent to 73 per cent in comparison to 64.8 per cent in 2001.
- While male literacy rate stands at 80.9 per cent – which is 5.6 per cent more than the previous census, the female literacy rate stands at 64.6 per cent — an increase of 10.9 per cent than 2001.
- The highest increase took place in Dadra and Nagar Haveli by 18.6 points (from 57.6 per cent to 76.2 per cent), Bihar by 14.8 points (from 47.0 per cent to 61.8 per cent), Tripura by 14.0 points (from 73.2 per cent to 87.2 per cent)
- Improvement in female literacy is higher than males in all states and UTs, except Mizoram (where it is same in both males and females) during 2001-11.
- The gap between literacy rate in urban and rural areas is steadily declining in every census. Gender gap in literacy rate is steadily declining in every census. In Census 2011, the gap stands at 16.3 points.
- Top five states and UTs, where literacy rate is the highest, are Kerala (94 per cent), Lakshadweep (91.8 per cent), Mizoram (91.3 per cent), Goa (88.7 per cent) and Tripura (87.2).
- The bottom five states and UTs are Bihar (61.8 per cent), Arunachal Pradesh (65.4 per cent), Rajasthan (66.1 per cent), Jharkhand (66.4 per cent) and Andhra Pradesh (67 per cent).

Literacy Rate in India

Total Person Literacy Rate	74%
Males	82.14%
Females	65.46%
Highest Literacy Rate in State	Kerala (94%)
Lowest Literacy Rate in State	Bihar (63.8%)
Hightest Literacy Rate in UT	Lakshadweep (91%)
Lowest Literacy Rate in UT	Dadra and Nagar Haveli (76.24%)

Density –

- The density of population in the country has also increased from 325 in 2001 to 382 in 2011 in per sq km. Among the major states, Bihar occupies the first position with a density of 1106, surpassing West Bengal which occupied the first position during 2001.
- Delhi (11,320) turns out to be the most densely inhabited followed by Chandigarh (9,258), among all states and UT's, both in 2001 and 2011 Census. The minimum population density works out in Arunachal Pradesh (17) for both 2001 and 2011 Census.

Sex ratio –

- The sex ratio of population in the country in 2011 stands at 940 female against 1000 males, which is 10 per cent more than the last census when the number female per thousand male stood at 933. Haryana has the dubious distinction of having the worst male-female ratio among all states while Kerala fares the best.
- The number of females per 1000 males in Haryana in 2011 stands at 879 followed by Jammu and Kashmir (889 female) and Punjab (895 females).
- The other two worst-performing states in terms of skewed sex ration are Uttar Pradesh (912 females) and Bihar (918 females).
- Five top performing states in terms of sex ratio were Kerala (1,084 females), Tamil Nadu (996), Andhra Pradesh (993), Chhattisgarh (991), Odisha (979).

Sex Ratio (Females per 1000 Males)

Sex ratio in India	943
Highest sex ratio in state	Kerala (1084)
Lowest sex ratio in state	Haryana (879)
Highest sex ratio in UT	Pondicherry (1037)
Lowest sex ratio in UT	Daman and Diu (618)
Child (0-6 years) sex ratio	914
Highest child (0-6) sex ratio in state	Mizoram (971)
Lowest child (0-6) sex ratio in state	Haryana (830)

Child population –

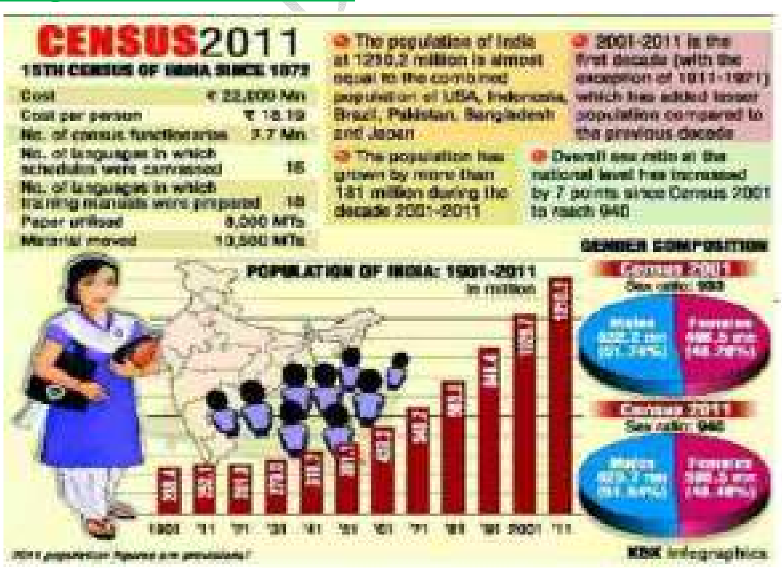
- Child population in the age of 0 to 6 years has seen an increase of 0.4 per cent to 164.5 million in 2011 from 163.8 million in 2001.
- The child population (0-6) is almost stationary. In 17 states and UTs, the child population has declined in 2011 compared to 2001.

- With the declaration of sex ratio in the age group 0-6, the Census authorities tried to bring out the recent changes in the society in its attitude and outlook towards the girl child. It was also an indicator of the likely future trends of sex ratio in the population.
- There has been a decline of 8 per cent in the sex ratio of 0-6 age group. In 2011, the child sex ratio (0-6) stands at 919 female against 1000 male in comparison to 927 females in 2001.
- Male child (0-6) population has increased whereas female child population has decreased during 2001-11. Eight states, Jammu and Kashmir, Rajasthan, Uttar Pradesh, Bihar, Jharkhand, Arunachal Pradesh, Mizoram, and Meghalaya have proportion of child population more than 15 per cent.
- The worst performing states in regard to sex ration in the age group of 0 to 6 years are Haryana (834 females), Punjab (846), Jammu and Kashmir (862), Rajasthan (888) and Gujarat (890).
- The best performing states are Chhattisgarh (969), Kerala (964), Assam (962), West Bengal (956) Jharkhand (948) and Karnataka (948).

Religious demographics –

The religious data on India Census 2011 was released by the Government of India on 25 August 2015. Hindus are 79.8% (966.3 million), while Muslims are 14.23% (172.2 million) in India. For the first time, a "No religion" category was added in the 2011 census. 2.87 million Were classified as people belonging to "No Religion" in India in the 2011 census. – 0.24% of India's population of 1.21 billion. Given below is the decade-by-decade religious composition of India till the 2011 census. There are six religions in India that have been awarded "National Minority" status – Muslims, Christians, Sikhs, Jains, Buddhists and Parsis.

Key findings of 2011 census

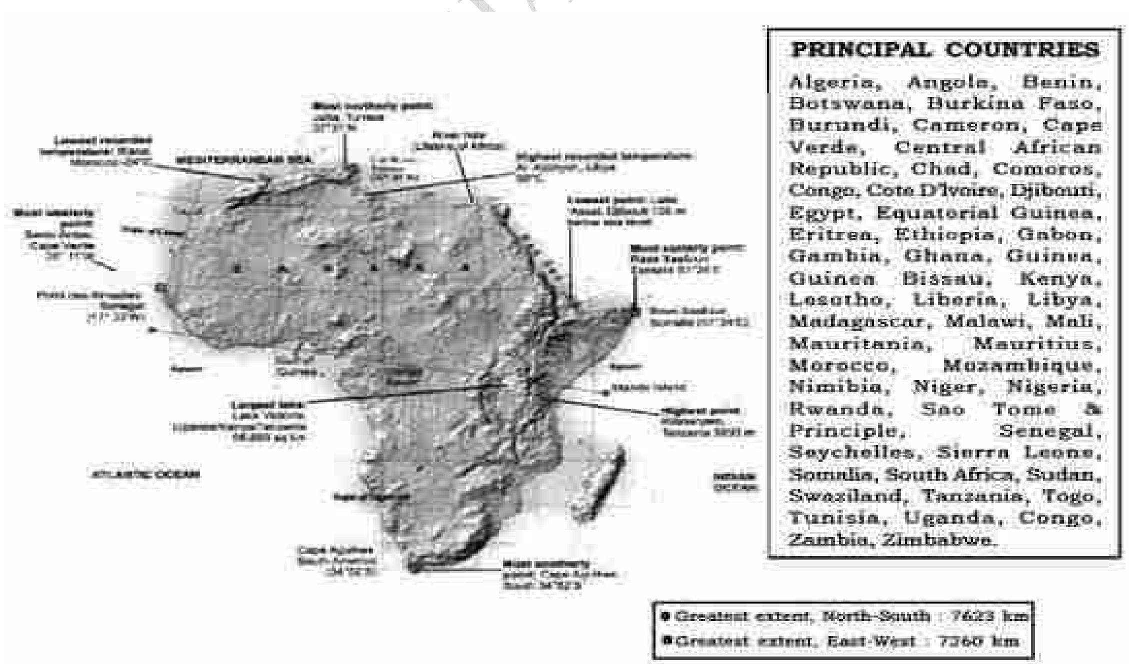


WORLD GEOGRAPHY

AFRICA – PHYSICAL GEOGRAPHY AND MINERAL RESOURCES

- **Area:** 3,03,35,000 sq. km (20.4% of total area Madagascar and other islands of Africa)
- **Population:** 778.5 million
- **Latitude:** 37031'N to 34052'S
- **Longitude**: 25011'W to 51024'E
- **Size:** Second largest continent after Asia and nine times the size of India.
- **Situation:** Situated to the south of Europe and south west of Asia. It is bound by the Mediterranean Sea in the north, the Atlantic Ocean in the west and southwest, the Indian Ocean in the east and the Red Sea in the northeast. Africa belongs to all the four hemispheres and bulk of the continent lies in tropics. It is joined to Asia by the narrow Isthmus of Suez and separated from Eurasia at three different points (Strait of Gibraltar, Suez Canal and Strait of Bab-el-Mandeb). The only continent which is crossed by Tropic of Cancer, Equator and Tropic of Capricorn

Africa is called as the "Dark Continent' because the greater part of its vast interior remained little known to the outside world until the last century.



Important Seas / Ocean Channels around Africa:

Name	Location	African Countries Along the Sea
Mediterranean Sea It separates Africa from Europe. Region around are known for its distinct climate.	North of Africa	Morocco, Algeria, Tunisia, Libya, Egypt.
Red Sea It separates Africa from Asia.	North East of Africa	Egypt, Sudan, Eritrea and Djibouti.
Indian Ocean	East of Africa	Somalia, Kenya, Tanzania, Mozambiquei and South Africa
Atlantic ocean	West of Africa	Morocco, Western Sahara, Mauritania, Senegal, Gambia, Guinea Bissau, Guinea, Sierra Leone, and Liberia, Ivory Coast, Ghana, Togo, Benin, Nigeria, Camernoon, Equatorial Guniea, Gabon, Congo, Zaire, Angola, Namibia, South Africa.
Mozambique Channel	East of Mozambique	Mozambique (West) and Madagascar (East).

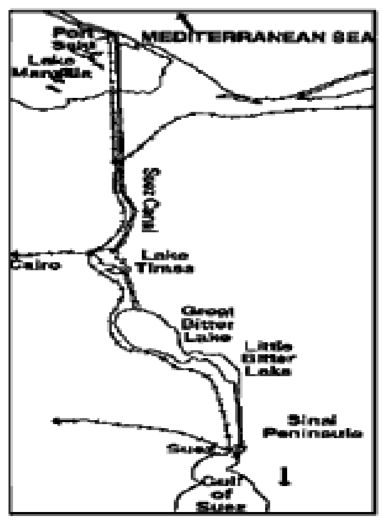
Important Gulfs and Bays

Name	Location
Gulf of Guinea	South of Ivory coast, Ghana, Togo, Benin, Nigeria, Cameroon and Equatorial Guinea in the Atlantic Ocean.
Walvis Bay	West of Namibia, Atlantic Ocean
Maputo Bay	South East of Mozambique, Indian Ocean.

GNANADHARE ACADEMY
#2 Sharada Arcade,Nagarbhavi Main Road Prashanth Nagar, Vijaynagar
North Bangalore-560079, Mob:9513804777/9513809777

Important Straits

Name	Separates	Connects
Strait of Gibraltar	Europe from Africa	Mediterranean Sea with Atlantic Ocean.
Strait of Bab-el-Mandeb	Djibouti (Africa) from Yemen (Asia)	Red Sea with Gulf of Aden.
Coasts of Africa	Countries	
Grain Coast	Sierra Leone and Liberia	
Ivory Coast	Ivory Coast	
Gold Coast	Ghana	
Slave Coast	Togo, Benin and Nigeria.	



RIFT VALLEY OF AFRICA

- It stretches northwards through Zambia, Malawi (L. Nayasa), Tanzania (L. Tanganyika), Kenya and Ethiopia and extends along the Red sea to Israel and Jordan for about 5,000 km. Most of the lakes fill parts of rift valleys and therefore are long, narrow and deep.

SUEZ CANAL

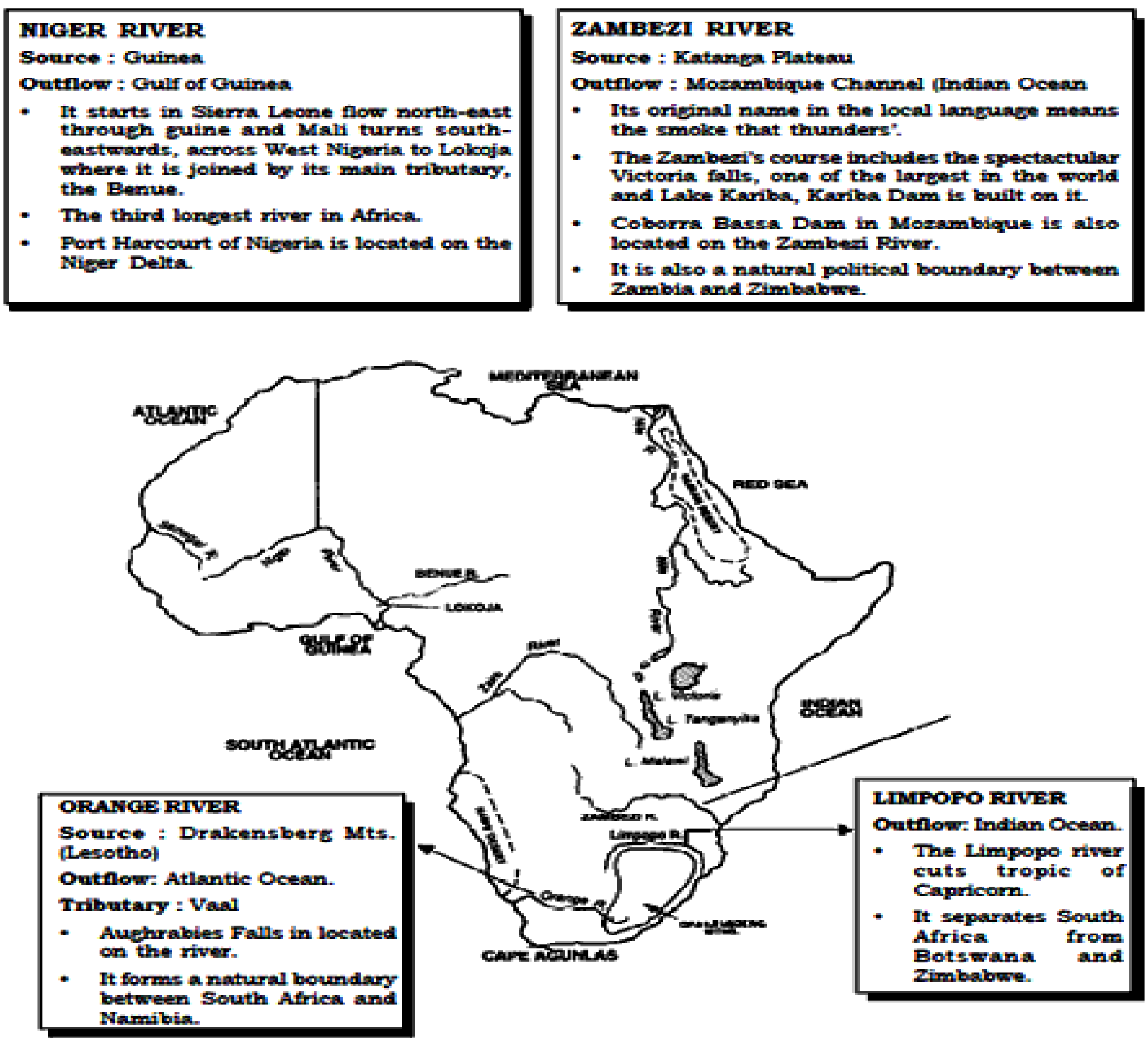
- Connects the Mediterranean Sea with the Gulf of Suez and Red Sea across the low Isthmus of Suez.
- Total length of canal is 172 Km (107 miles.)
- Sea ports of Port Said on the Mediterranean and Suez on the Gulf of Suez are situated at the opposites ends of the canal.

Important Lakes

Name	Information
Lakes from South to North	
LakeKariba	Southernmost lake which is located on the Zambezi River in Zambia. One of the biggest man-made lake where commercial fishing is done. Largest producer of hydroelectricity in Africa.
Lake Nayasa (Lake Malawi)	Rift valley lake, which lies along the Malawi, Mozambique, and Tanzania. Third largest lake in Africa.
Lake Mweru	A small lake which lies along the border of Democratic Republic of Congo (Zaire) and Zambia.
Lake Tanganyika	Rift valley lake which lies along the Tanzania, Zaire and Zambia. World's second deepest lake (1435 m) after Ozero, Baikal and also the second largest lake of Africa. It lies 2500 m above sea level.
Lake Edward	Located between Uganda and Democratic Republic of Congo.
Lake Victoria **Area: 68,880 sq. km.** **Max. depth : 80 m.**	Largest lake of Africa which is located between Uganda, Keyna and Tanzania. Source of White Nile River. It does not lie in the rift valley. A large lake through which equator pass. World's third largest lake after Caspian Sea and Lake Superior. It contains numerous islands coral reefs.
Lake Turkana (Lak Rudolf)	Rift valley lake of Kenya
Lake Tana	Lake situated in the Ethiopian highlands. Source of Blue Nile River.
Lake Nasser	Lake lies on the River Nile. Man-made lake, which is located between Egypt and sudan.
Lake Chad	Largest lake (shallow fresh water lake) of Sahara in chad.

	Actually an example of deflation hollow which is formed due to wind erosion. A lake of inland drainage where the Chari River drains.
Lake Volta	One of the largest man-made lakes on the River Volta in Ghana
Lake Assal	Located in Djibouti. The lowest point in Africa.

Important Rivers



Nile

Source : Blue Nile : Lake Tana (Ethiopian Highlands)

White Nile : Lake Victoria

Outflow : Arcuate

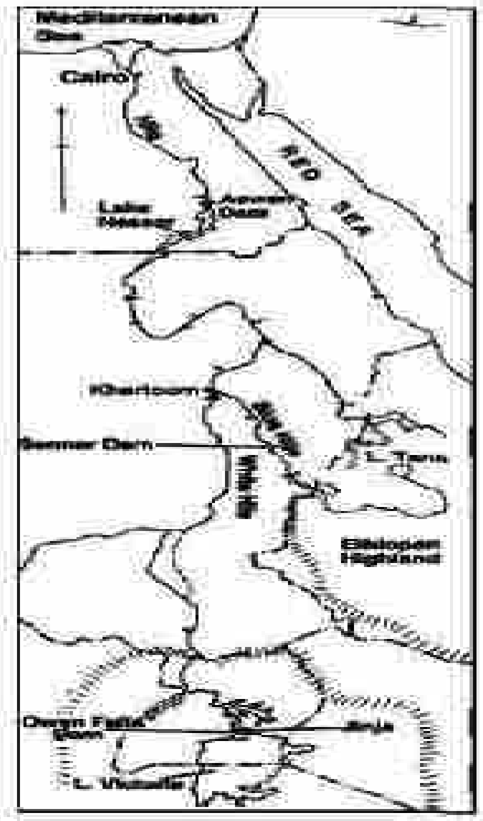
- The White and Blue Nile meet at Khartoum (Sudan) to form the Nile.
- Longest river in the world, life blood of Egypt.

Dams

(1) Owen Dam near the Owen falls, on the White Nile, where it leaves Lake Victoria.
(2) Sennar Dam on the Blue Nile in Sudan.
(3) Aswan Dam on the Nile in Egypt— Controls the flow of the greate river.

Zaire Or Congo

- Confluence of Lualaba and Luapula River.
- Joins the Atlantic Ocean near the port of Matadi.
- Carriers the largest amount of water among all the rivers of Africa.
- Navigable only in part because it has numerous waterfalls and rapids (small waterfalls).
- It cuts equator twice.
- The Kasai and the Oubangi are the main tributaries of Zaire.
- Half the world's supply of industrial diamonds comes from the alluvial deposits of the Kasai river.
- Stanley Fall and Living Stone Fall are on the Zaire River.
- Inga Dam is located on the Zaire River.
- Cities located : Brazzaville, Kinshasa, Matadi and Boma.
- Country's only outlet to the ocean.



Important Mountains and Plateaus:

Name	Information
Atlas Mountains **Divided into five separate running to each other-** **High (Haut) Atlas Mts** **Anti-Atlas** **Middle Atlas** **Sahara Atlas** **Maritime Atlas**	Highest peak- Jbel Toubkal (4165m) located in High Atlas Mountains. Dominates in the rugged country of Morocco These mountains sweep across the centre from north east to south-west and rising 2,750 m in the Middle Atlas to over 4,000 m in the High Atlas and to the south the Anti- Atlas (the uplifted edge of the Saharan platform) reaches 2,000 m. An example of Fold Mountain.

Ethiopian Highlands **Highest peak:** Ras Dashan (4,620 m) is the Africa's third highest peak.	High plateau of volcanic origin. The high plateau is split by the Great Rift valley along a north east-southwest line. Source of the Blue Nite River.
Mt. Kenya (5,200 m)	Africa's second highest peak, volcanic in origin.
Mt. Elgon (4,210 m)	Mighly peak of Kenya, lies on the Uganda border.
Mt. Kilimanjaro (5,895 m)	Also known as Mount Kibo. It stands alone, not apart of mountain range. Africa's highest peak located in Tanzania. An example of extinct volcanoes. Coffee is grown on the slopes of Kilimanjaro. Just 322 km from the equator, mountain peaks covered with perpetual snow throughout the year.
Drakensberg Scarpland	High escarpment in Southeast Africa caused by lava flow. An example of continental plateau, formed due to epeirogenesis (continental building) movement. From the escarpment rim, the land slopes inwards down to the Kalahari desert in the north.
Mount Rouwenzori (5,109 m)	Situated near the Lake Mobutu or Lake Albert in Zaire. Known as the 'The Mountains of the Moon'.
Mount Cameroon (4,070 m)	Only active volcanic mountain of Africa, dominates the coastline of Cameroon. Known for iron ore deposits. Wettest place in Africa along slopes of Mt. Cameroon.
Tibesti Massif (3,400 m)	Desert Mountains which is situated in the south east of Sahara in Northern Chad.
Ahaggar Massif	Desert mountains of Algeria.
Bomi and Nibas hills	The main hills of Liberia, known for Iron ore deposits.
Katanga Plateau	One of the largest copper and diamond producing region of Zaire.
Jos Plateau	The northern half of Nigeria consists of undulating Jos Plateau which rises to over 1,500 m in the centre.

	Tin is the main mineral of this region.
Mount Sinai	Desert mountain of Egypt
Sahara desert	Lies between 150 top 300 N latitudes. The largest stretch of desert, which is 5150 km from east to west and at least 1610 km in area. Erg: Sandy desert of Sahara (9.1 sq. km) is undulating plain of sand, produced by wind deposition. Hamada: Rocky desert of Sahara is bare rock surface formed by deflation. Cities located in the desert fringe are Zinder (Niger), Timbuktu (Mali), Kano (Nigeria), and Kumasi (Ghana).
Libyan desert	Vast arid land of north-east of Africa in Libya. Serir: Stony desert of Libya is covered with boulders, angular pebbles and gravels which have been produced by high diurnal temperature range.
Arabian desert	Arid region of North-East Egypt.
Nubian desert	It is an extension of Sahara which occupies a third of the Sudan’s territory in the north.
Namib desert	A narrow, dune-covered desert belt, runs 1,600 km along the entire Atlantic Sea board of Namibia.
Kalahari desert	Semi desert region of Botswana lies to the east of Namib desert. Home of one of the Africa’s oldest races, the Kalahari Bushmen.

AFRICA’S NATURAL RESOURCES

Africa is a key territory on the global map. Rich in oil and natural resources, the continent holds a strategic position.

Rich in oil and natural resources, Africa is the world's fastest-growing region for foreign direct investment. It has approximately 30 percent of the earth's remaining mineral resources.
It's home to more than 40 different nations and around 2,000 languages. Sub-Saharan Africa has six of the world's 10 fastest-growing economies. North Africa has vast oil and natural gas deposits, the Sahara holds the most strategic nuclear ore, and resources such as coltan, gold, and copper, among many others, are abundant on the continent.

The region is full of promise and untapped riches - from oil and minerals and land to vast amounts of people capital - yet, it has struggled since colonial times to truly realise its potential.

Oil and gas

Africa is home to five of the world's top oil-producing countries, with an estimated 57 percent of Africa's export earnings from hydrocarbons.

- Algeria, Angola, Cameroon, Chad, Republic of Congo, Egypt, Eritrea, Gabon, Ghana, Kenya, Libya, Nigeria, South Sudan, Sudan, Tunisia, and Mozambique are all rich in oil and gas.
- Proven oil reserves have grown by almost 150 percent, increasing from 53.4 billion barrels since 1980, to 130.3 billion barrels by the end of 2012.
- The region is home to five of the top 30 oil-producing countries in the world, and nearly $2tn of investments is expected by 2036.

Other resources

Besides oil and gas, Africa is rich in precious minerals, forests and:

- **Diamonds:** Angola, Botswana, Central African Republic, Democratic Republic of Congo.
- **Gold:** Benin, Burkina Faso, Djibouti, Mali, South Africa, Tanzania.
- **Nickel and Uranium:** Burundi.
- **Pozzolana:** Cape Verde.
- **Fish:** Comoros, Guinea-Bissau, Mauritius, Sao Tome and Principe, Senegal, Seychelles.
- **Timber:** Liberia.
- **Titanium:** Gambia.
- **Graphite:** Madagascar.
- **Tobacco:** Malawi.
- **Iron Ore:** Mauritania.
- **Phosphates:** Western Sahara, Morocco.
- **Aluminum and Gas:** Guinea, Mozambique.
- **Cooper:** Uganda, Zambia.

Major coal deposits exist in southern Africa, North Africa, Zaire, and Nigeria. And North Africa is awash in petroleum reserves, particularly in Libya, Algeria, Egypt, and Tunisia. Nigeria is the biggest petroleum producer in West Africa, but Cameroon, Gabon, and the Congo also contain oil reserves. There are also petroleum reserves in southern Africa, chiefly in Angola.
In South Africa **uranium** is to be found side-by-side with gold, thus decreasing costs of production. Uranium deposits are also found in Niger, Gabon, Zaire, and Namibia. South Africa alone contains half the world's gold reserves.

GNANADHARE ACADEMY
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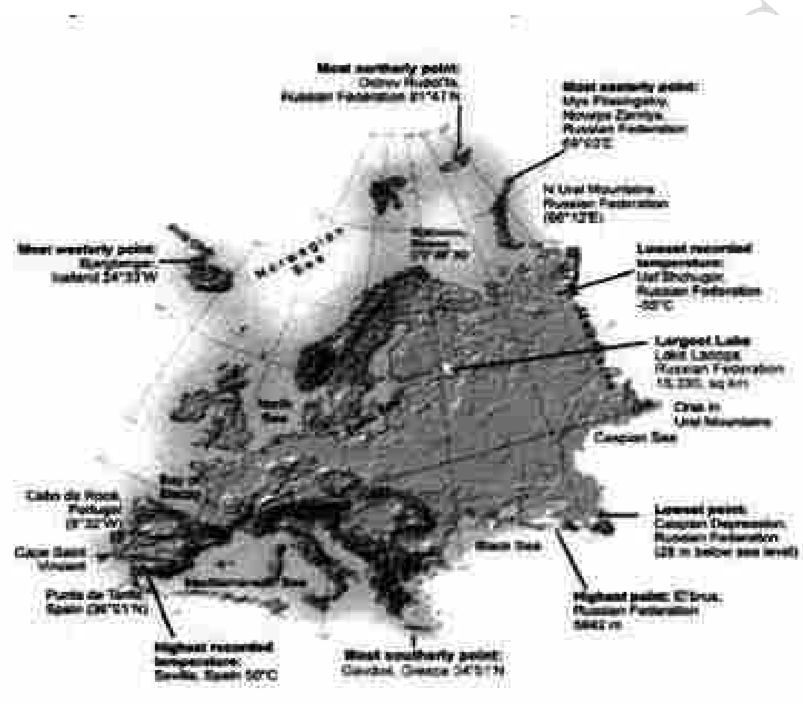
North Bangalore-560079, Mob:9513804777/9513809777

EUROPE – PHYSICAL GEOGRAPHY AND MINERAL RESOURCES

- **Area:** 1,04,98,000 sq. km.
- **Population**: 60 corers
- **Latitude:** 34051'N to 81047'N
- **Longitude:** 24033'W to 69003'E
- **Size:** Second smallest continent in the world in area, after America.
- **Situation:** Europe is situated between Ural Mountains in the east and the Atlantic Ocean in the west, in the west of Asia, and north of Africa. To the north of Europe lies Arctic Ocean, to the south lies the Mediterranean Sea, the Black Sea and the Caucasus Mountains and to the East Ural Mountains and the Caspian Sea.

Europe and Asia as one common landmass, is known as **'Eurasia'**.



PRINCIPAL COUNTRIES

Albania, Andorra, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Moldova, Monaco, Netherlands, Norway, Poland, Portugal, Romania, Russia, San Marino, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom, Vatican City State, Yogoslavia.

Countries of Scandinavia

Iceland, Denmark, Norway, Sweden, Finland are collectively known as Scandinavia.

- Greatest extent, North-South : 4300 km
- Greatest extent, East-West : 5600 km

EUROPE : PHYSICAL

NAME	SEPARATES	PART OF SEA OR OCEAN
Gulf of Riga	Estonia and Latvia	Baltic Sea
Gulf of Finland	Finland and Estonia	Baltic Sea.
Gulf of Bothnia	Sweden and Finland	Baltic Sea.
English Channel	Britain and Spain	Atlantic Ocean
Bay Biscay	France and Spain	Atlantic Ocean
Gulf of Lions	Lies to the south of France	Mediterranean Sea.

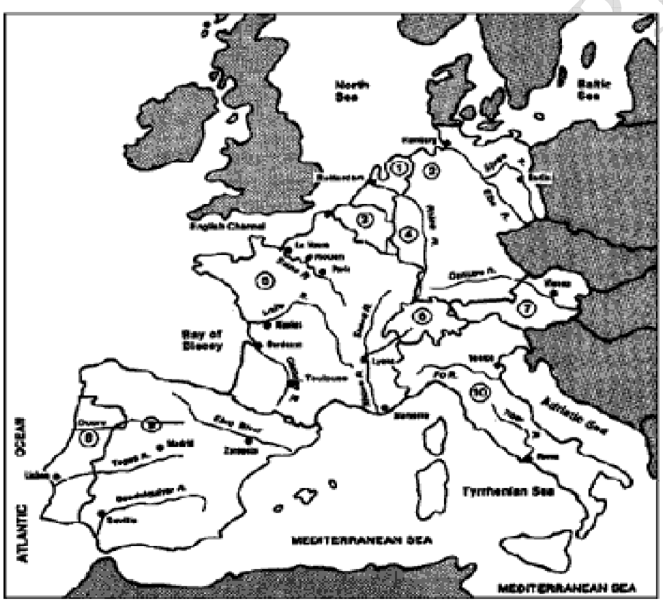
Important Seas

NAME	LOCATION, (PART OF OCEAN)	RIVERS DRAINING INTO THEM
Mediterranean Sea	Separates Europe from Africa, Strait of Gibralter connects it to the Atlantic Ocean.	Tiber (Italy) Rhone (France) Ebro (Spain)
White Sea	North of Russia, Arctic Ocean	Mezen, N. Divina, and Onega
Baltic Sea North Sea Wide continental shelves of North Sea, called as Dogger Bank is one of the most productive regions for fishing in the world. North sea is connected to the Baltic Sea through Kiel Canal.	Atlantic Ocean East of the United Kingdom, Atlantic Ocean	Vistula and Oder Elbe and Weser (Germany) and Rhine (Netherland)
Irish Sea	Lies between Great Britain and Ireland, Atlantic Ocean.	
Adriatic Sea	North east of Italy, Mediterranean Sea	Po (Italy.)
Ionian Sea	Lies between Greece and Italy, Mediterranean Sea.	
Black Sea	Separates Europe from Asia	Dnepr, Dnster, Danube
Sea of Azov	South east of Ukraine, North of Black Sea	Don.
Sea of Marmara	South west of Black Sea	Connects Black Sea and Aegean Sea
Aegean Sea	Lies between Greece and Anatolia Peninsula (Turkey), Mediterranean Sea.	

Important Straits

NAME	SEPARATES	CONNECTS
Strait of Gibralter (Known as 'Key to the Mediterranean').	Europe and Africa	Mediterranean Sea with Atlantic Ocean.
Strait of Bonifacio	Sardina islands. (Italy) and Corsica (France)	Tyrhenian Sea with Mediterranean Sea.
Strait of Messina	Sicily and Peninsular Italy	Tyrhenian Sea with Mediterranean Sea.
Strait of Otranto	Italy and Balkan Peninsula	Adriatic Sea with Ionian Sea.
Bosporus Strait	Istanbul and Anatolia Peninsula (Turkey)	Black Sea with Sea of Marmara.
Strait of Kerch	Kerch (Ukraine) and Russia	Sea of Azov with Black Sea.
Dardanelles Strait	Balkan Peninsula and Antolia Peninsula	Sea of Marmara with Aegean Sea.

Important Rivers of Europe



Other River of Europe	Outflow	City/ Located
Rhone • It flows through Lake Geneva of Switzerland • Its tributary Saone meet near Lyon of France	(Gulf of Lions)	Lyon (France)
Ebro (Spain) Cantabarian Mountain	Mediterranean Sea	Zaragoza (Spain)
Guadalquivir (Spain)	Atlantic Ocean.	Seville (Spain)
Tagus (Spain and Portugal)	Atlantic Ocean	Lisbon (Portugal)
Douro • Douro basin is known for wine (Port wine) in west Portugal.	Atlantic Ocean	Oporto (Portugal)
Weser • Flows in Germany. • Bremerhaven (Germany) lies on its mouth.	North Sea	Bremen (Germany)
Elbe • River flows in Germany • Hamburg (Germany) is located on its mouth.	North Sea	Dresden and Magdeburg
Oder • Follows almost the border of Germany of Polant/Baltic Sea/Stettin		
Wista (Vistula) • Flows in Poland	Baltic Sea	Warsaw, the capital city.

NORTH FLOWING RIVERS FROM WEST TO EAST	INFORMATION
Onega, N. Dvina, and Mezen	Flows through European Plain into the White Sea.

SOUTH EAST FLOWING RIVER	SOURCE	OUTFLOW	CITY LOCATED
Volga (Europe's longest river, 3,690km)	Valdas Plateau	Caspian Sea	Saratov, Volgograd
Don	Tula (Black Sea)	Sea of Azov Rostov.	
Dnepr	Valdai Hill	Black Sea	Kiev, Dnepropetrovsk
Dnester	--	Black Sea	--

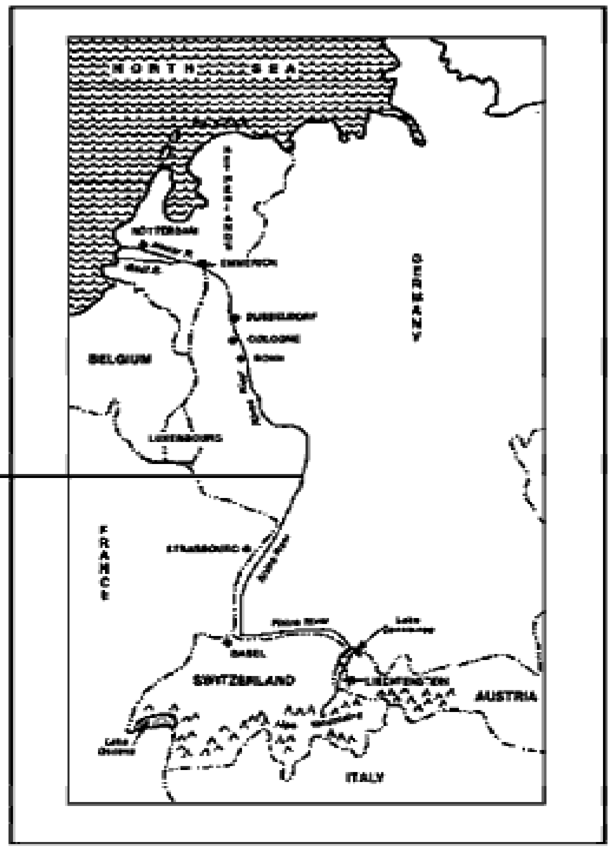
Danube If flows in Middle Europe through Austria, Slovakia Hungary and the northern part of Yogoslavia and Romania. It is the only river in the world which touches or corsses right countries.	Black Forest (Germany)	Black Sea	Black Sea Linz, Viena , Budapest, Belgrade

RHINE

Source : Alps (Switzerland), south of Lake Constance

Outflow: North Sea

- It flows in the rift valley through Switzerland, Liechtenstein, Austria, Gernmany, and Netherlands, where the delta is located.
- From the city of Brussels it turns north and serves as the boundary between France and Germany.
- Cities located : Mannheim, Ludwig, Shafen, Heidelberg, Wieshaden, Mainz, Dusseldorf, Cologne. Four are on important Rhine tributaries-Essen on the Ruhr, Wuppertal on the Wupper. Frankfurt on the Main, and Stuttgart on the Neckar, Bonn (Germany) and Rotterdam (Netherland).
- The busiest inland water way of Europe.



Kjolen Mountain
- Running in north-south direction along the border of Norway and Sweden.

Pennine
- The Central upland region of Great Britain.

Cantabarian
- Mountain chain lying in northern Spain.
- Extends in east-west direction.

Sierra Morena, Sierra Nevada
- The Guadalquivir river drains between these two mountain chains of Spain.
- Sierra Nevada contains country's highest peak Mulhacean (3,478m).

MOUNTAIN VESUVIUS

A volcanic mountain lying in Neples (Italy.)

APPENNINES

Mountain chain extending from the western Alps to the southern tip of mainland in Italy.

An example of limestone hillls, which is well known for wine (Asti) in piedmont district of Italy.

VOSGES

Lies in France and separate it from Italy.

An example of Block mountain.

ALPS

Lies in the south-eastern part of France and separates it from Italy.

Mount Blanc (4,807 m) is the highest peak of Alps, lies in France.

The Alps acts as giant watershed in Switzerland.

MOUNT ETNA

A volcanic mountain of Sicily (Italy.)

Example of parasitic volcanic cone.

DINARIC ALPS

	Lies along the north-east coast of Adriatic Sea.
CARPATHIAN Runnin in northwest-southeast direction in the countries of Poland, Ukraine and Romania. **BALKAN** Runs in east-west direction in Bulgaria. **PINDUS** The barren limestone chain, runnine north west-southeast and rising to 2,500 m. Constitutes the principal mountian chain of Greece. **URAL** Average height between 500 and 800 m. Forms the natural boundary between Asia and	**CAUCASUS** Lies to the north of Georgia, Azerbaijan. Separates Asia from Europe. Mount Elbrus in the Caucasus is the highest mountain peak of Europe. **BLACK FOREST** Block mountain of Germany. **MOUNT STROMBOLI** An example of composite volcanic cone. Known as the 'Light house of the Mediterranean'.

Important Peninsulas

NAME	INFORMATION
Iberian Peninsula or Spanish Plateau	Surrounded by Bay of Biscay, Mediterranean Sea and Atlantic Ocean.
Balkan Peninsula Kola Peninsula	Surrounded by Black Sea, Aegean Sea, and Adriatic Sea. Consist of Bulgaria, Macedonia, Albania and Greece. Surrounded by White Sea and Arctic Ocean in Russia.

IMPORTANT MINERAL RESOURCES

Europe is the leading producer of iron-ore in the world. The countries with large deposits of iron ore are Russia, Ukraine, Sweden and France. Minerals deposits of copper, lead, zinc, manganese and nickel are found in eastern Europe and European Russia.

Lignite

Several European countries are investigating in lignite mineral industry, despite the fact that the industry faces declining profit margins in competition with low-carbon energy production. The global lignite production is approximately one billion metric tons in 2012, with major production coming from Europe, the continent accounts for roughly 40% in lithium reserves. The Kosovar lignite mines are operated at one of the most strategic lignite deposits in Europe, due to its geological conditions.

In terms of lignite production, Greece ranks seventh worldwide and third in EU after Germany, based on the total lignite reserves in the country and the planned future consumption rate, it is estimated that the reserves in the country could last for more than 45 years. Poland is one of the largest lignite reserves in the EU, with around 1.4 billion tons of lignite in the country, and an additional 22.1 billion tons in economic reserves.

Gold

The northern part of Europe, in particular Sweden and Finland, has shown to be an area with an abundance and large potential for gold mining. According to the magazine Tekniikka ja Talous, Finland has overtaken Sweden to become one of the largest producer of gold in Europe, which is located in Kittilä and is owned by the Canadian company Agnico Eagle, will be expanded out and, as a result, its production will increase to 6,000 kilograms per year. In the 13th and 14th centuries, Bohemia was one of the main regions of gold production in Europe.

Coal

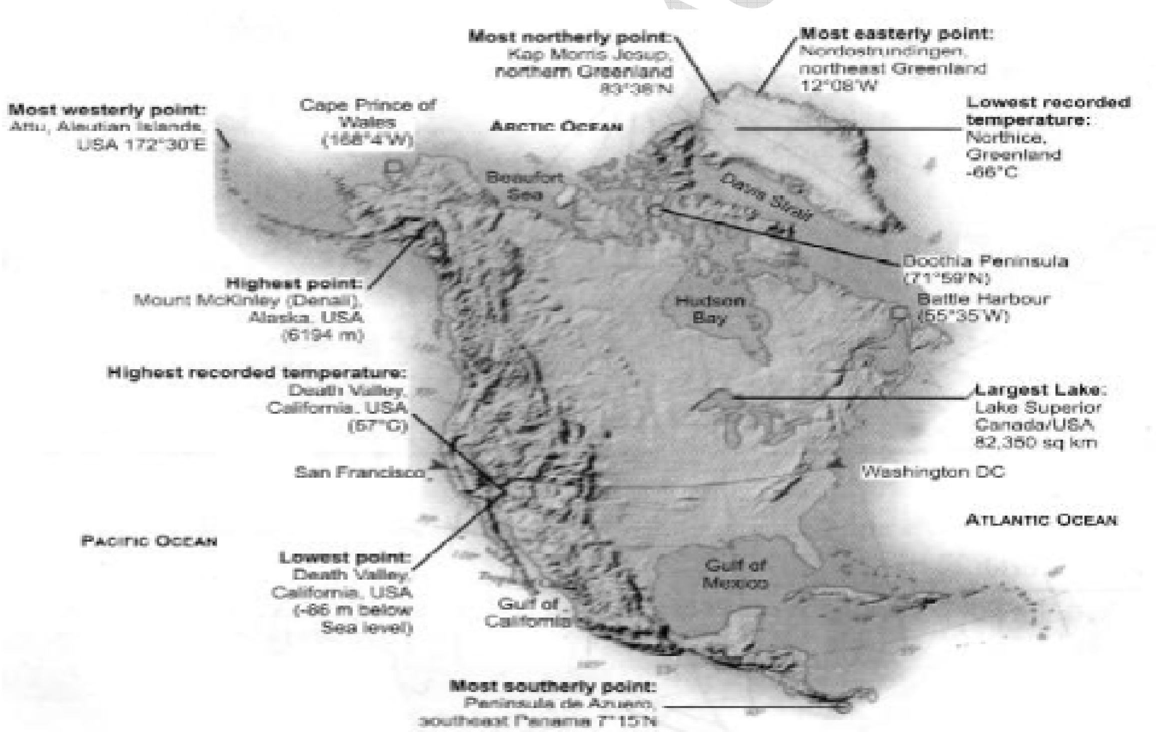
The total production of coal in Europe is about 15.14 million tons, translating to 3.9% of the total coal produced in the world, coal is preferred as a source of energy, due to its low cost compared to petroleum and natural gases. Europe's coal industry continues its downward spiral as 25% of EU countries have now shut down its mines to the energy source, scientist estimate that more than 80% of global coal reserves should stay unburned in order to limit global warming to 2 °C (36 °F).

Iron ore

Sweden accounts for 91% of the continent's ore, in 2014 Swedish ore production broke a new record for the fifth year in a row; the increase was 2% from the previous year, and production amounted to almost 89.1 million tons. Of all the global market mining of ore, eastern Europe was the smallest region accounting around just 1% of the market, the use of robots in the metal ore mining industry is improving the efficiency and productivity of mines and reduces operational costs. The EU metallic mining sector produces a wide range of ores yielding metal substances.

➢ NORTH AMERICA – PHYSICAL GEOGRAPHY AND MINERAL RESOURCES

- **Area:** 2,42,38,000 sq. km (including Greenland and the Caribbean Islands).
- **Population:** 13.6 million
- **Latitude:** 70 12° N to 830 38° N
- **Longitude:** 120 08° W to 1720 30° W
- **Situation:** North America is surrounded by the Atlantic Ocean in the east, Gulf of Mexico in the south, the Pacific Ocean in the west and the Arctic Ocean in the north. To the north it is separated from the easternmost tip of Siberia by the Bering Strait. Size : third largest continent after Asia and Africa.



NORTH AMERICA - PHYSICAL

Important Seas, Bays and Gulfs

Name	Location and Related Information	Part of Ocean
Beaufort Sea	North of Canada.	Arctic Ocean
Gulf of Boothia	Between Boothia Peninsula and Baffin Island, North of Canada	Arctic Ocean
Baffin Bay	Between Greenland and Baffin Island.	Atlantic Ocean
Hudson Bay	North of Canada.	Atlantic Ocean
James Bay	North of Canada.	Atlantic Ocean
Labrador Sea	East of Labrador, Canada.	Atlantic Ocean
Gulf of St. Lawarance	Northest of USA St. Lawrence River drains.	Atlantic Ocean
Bay of Fundy	Between New Brunswick and and Nova Scotia. Site of highest tides.	Atlantic Ocean
Chesapeake Bay	Between Virginia and Maryland (Longest offshore bar in the world	Atlantic Ocean
Gulf of Mexico	East of Central America Mississippi River drains.	Atlantic Ocean
Gulf of Campeche	East of Mexico.	Gulf of Mexico, Atlantic Ocean
Gulf of Darien	Between Panama City and South America.	Caribbean Sea, Atlantic Ocean
Caribbean Sea	Eastof Central America, known for hurricane generation.	Atlantic Ocean
Gulf of Panama	Between Central America and South America	Pacific Ocean
Coronado Bay	West of Costa Rica.	Pacific Ocean
Gulf of California	Between Lower California and Western Mexico. Colorado river drains.	Pacific Ocean
Gulf of Alaska	South of Alaska.	Pacific Ocean
Bering Sea	West of Alaska. Between North America and Asia.	Pacific Ocean
Ellesmere Island, Queen Elizabeth Islands, Parry Islands, Banks Island, Victoria Island (Third largest island of the Arctic Ocean), Prince of Wales Island	North of Canada	Arctic Ocean
Baffin Island (Second largest island of the Arctic Ocean)	Representative example of ice cap, a type of continental glacier, many serrated granitic ridges.	Arctic Ocean

Name	Location and Related Information	Part of Ocean
Southampton Island, Coats Island, Mancel Island, Ottawa Island, Belcher Island	North to South in Hudson Bay	
Anticostal Island	Gulf of St. Lawrence.	Atlantic Ocean
Cape Breton Island	Navascotia Region known for coal fields.	Atlantic Ocean
Florida Keys	Many small islands of coral origin, situated to the south of Miami between Cuba and Miami Region of sponges harvesting which support a thriving spong industry.	Atlantic Ocean
Bahama Island	Coral Island, SE of Florida	Atlantic Ocean
Caicos Island (U.K.)	SE of Bahama Island	Atlantic Ocean
Vancouver Island	West of Canda.	Pacific Ocean
Queen Charlotte Island	North of Vancouver Island	Pacific Ocean
Alexander Archi-pelago (A group of island that lie in close proximity)	West of Canada	Pacific Ocean
Kodiak Island	Gulf of Alaska	Pacific Ocean
St. Lawrence Island (Near Bering Strait) Nunivak Island	Bering Sea.	Pacific Ocean
Aleutian Island	Extend south-southwest for 1800 km from Alaska Peninsula	Pacific Ocean
Hawaiian Island (Part of the USA)	Lie in the northern limits of the tropics in the North Pacifir Ocean. • Consisit of 8 main, 15 small-uninhabited islands. • Island's Capital Honolulu is known as "The cross roads of the Pacific.	Pacific Ocean

Important Straits

Strait : A narrow sea passage that links two larger area of seas.

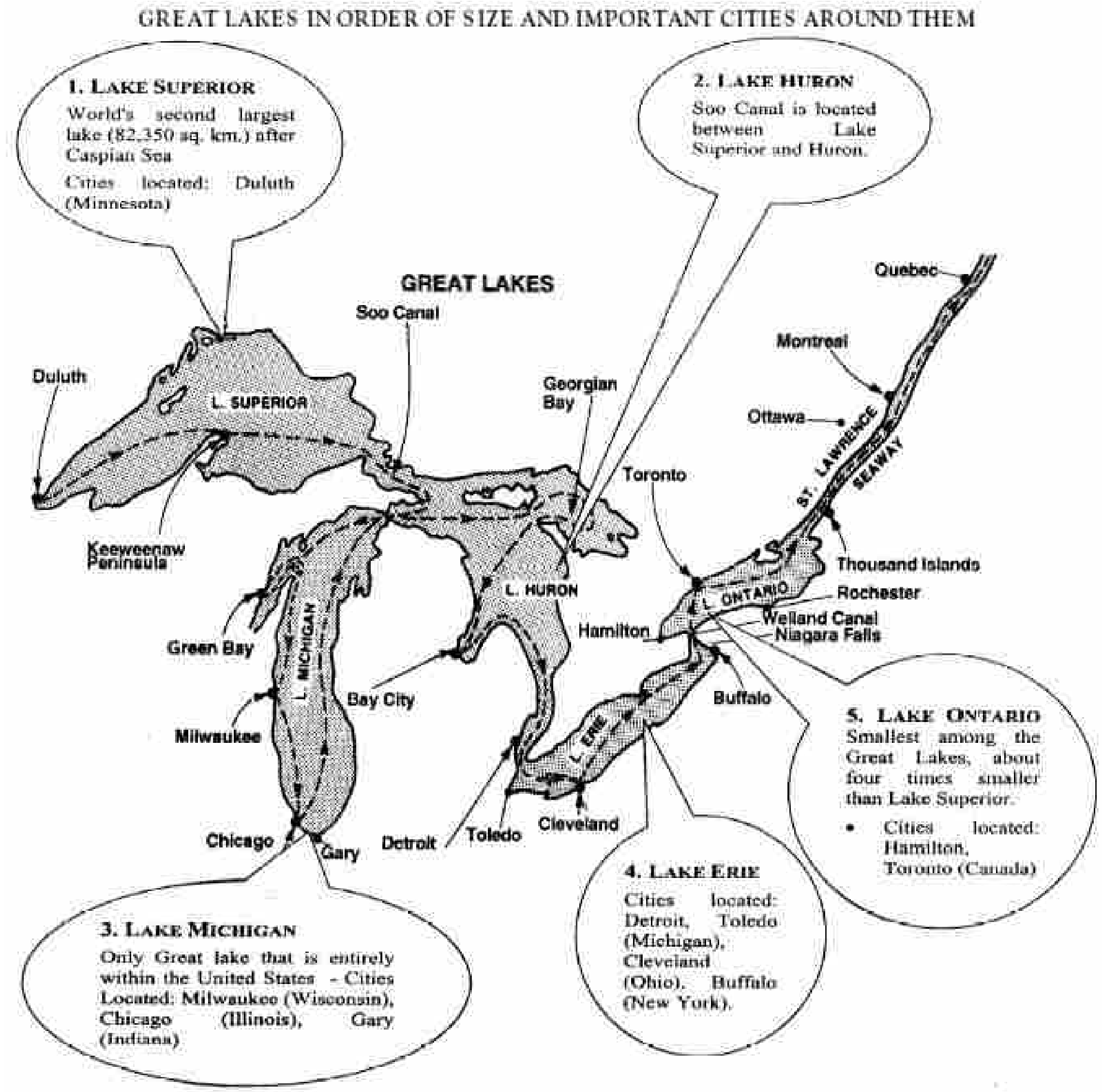
Name	Separates	Connects
Nares Straits	Greenland and Ellesmere Island	Arctic Ocean and Baffin Bay
Davis Strait	Greenland and Baffin Island	Baffin Bay and Labrador Sea.

Name	Separates	Connects
Hudson Strait	Baffin Island and Ungava Peninsula (Qubec)	Hudson Bay and Labrador Sea.
Belle Isle Strait	Labrador and New Foundland	Gulf of St. Lawrence and Atlantic Ocean
Florida Strait	Florida and Cuba.	Gulf of Mexico and Atlantic Ocean
Yucatan Strait	Yucatan Peninsula (NE Mexico) and Cuba	Gulf of Mexico and Atlantic Ocean
Juan de Fucca Strait	Washington and Vancouver Island	
Bering Strait	Chukchi Peninsula, Russia (Asia) and Alaska (North America)	

Important Lakes

1. ***Great Bear Lake:*** Lake of North West Territories through which Arctic Circle pass. At Port Radium valuable deposits of pitchblende exist.
2. ***Great Slave Lake:*** Lake lies in the North West Territories of Canada. On the shore copper and gold are worked.
3. ***Athabasca Lake:*** Uranium city lies on the north shore of lake, where pitch-blende is found.
4. ***Reindeer Lake:*** Water flow north-eastwards to Hudson Bay via the Churchill River.
5. ***Lake Winnipeg:*** Lake of Manitoba is a remnant of glacial Lake Agassiz Saskat-chewan River drains into the lake. Also the water flows north eastwards and Hudson Bay via Nelson River.

6. Great Lakes (HOMES)	
(i) L. Superior (S)	Information
(ii) L. Michigan (M)	Connected to the Atlantic Ocean by the St. Lawrence Seaway, to the
(iii) L. Huron (H)	Gulf of Mexico via the Illinois water way and the Mississippi River,
(iv) L. Erie (E)	and to New York through the Hudon River.
(v) L. Ontario (O)	
7. Great Salt Lake:	Located in Utah (U.S.A) Remnant of Fresh lake called Bonneville.
8. Lake Mead:	Located in Navada (U.S.A.) Reservoir of Hoover and Boulder dam of Colorado River.
9. Lake of the Ozark	Located in Missouri (U.S.A.)
10. For Peck Lake:	Located in Montana (U.S.A.)



GREAT LAKES IN ORDER OF SIZE AND IMPORTANT CITIES AROUND THEM
1. LAKE SUPERIOR
World's second largest lake (82,350 sq. km.) after Caspian Sea
Cities located: Duluth (Minnesota)
2. LAKE HURON
Soo Canal is located between Lake Superior and Huron.
GREAT LAKES
Soo Canal
Quebec
Montreal
Duluth
L. SUPERIOR
Georgian Bay
Ottawa
ST. LAWRENCE SEAWAY
Toronto
Keeweenaw Peninsula
Thousand Islands
L. HURON
L. ONTARIO
Rochester
Welland Canal
Niagara Falls
Hamilton
Green Bay
L. MICHIGAN
Bay City
Buffalo
Milwaukee
L. ERIE
5. LAKE ONTARIO
Smallest among the Great Lakes, about four times smaller than Lake Superior.
• Cities located: Hamilton, Toronto (Canada)
Chicago
Gary
Detroit
Toledo
Cleveland
4. LAKE ERIE
Cities located: Detroit, Toledo (Michigan), Cleveland (Ohio), Buffalo (New York).
3. LAKE MICHIGAN
Only Great lake that is entirely within the United States - Cities Located: Milwaukee (Wisconsin), Chicago (Illinois), Gary (Indiana)

Important Rivers

Rivers of Canada

Important Rivers	Source	Outflow
Mackenzie (longest river of Canda)	Head of Finlay River (British Columbia)	Beaufort Sea.
Yukon	Junctionof Lewes and Pelly Rivers	Bering Sea.
Nelson	Head of Bow Rier (Canada)	Hudson Bay.
Saskatchewan	Rocky Mountain	L. Winnipeg
Peace (Bennete Dam is located on the Peace river)	Stikine Mountain	Lake Athabaska

RIVERS OF USA

Important Rivers	Information	Source	Outflow
Mississippi-Missouri River	• Deha - Bird's Foot Delta (New Orleans is located) • St. Louis is located on the confluence of Mississippi and Missouri River. • Major tributaries are the Ohio (eastern) and the Arkanas (western) • One of the world's largest watershed which includes atleast 25 states.	Red Rock of Montana	Gulf of Mexico.
St. Lawrence River	• Busiest inland wateway in North America. • Iroquois dam and locks, and Niagara Falls are located.	Lake Ontario	Gulf of St. Lawrence.
Colorado River	• Tributaries : Little Colorado, • Green river and River Gita • Hoover and Boulder Dam are the main dams on Colorado River. • Imperial valley (an area of inland drainage) of the Colorado River is an important region for cotton cultivation	Grand Country	Gulf of California
Columbia River	• Snake River is the main or biggest tributary of Columbia River. • Part of the basin is situated in Washington, Idaho, and Canadian Province of British Columbia. • The longest river or USA which drains into the Pacific Ocean. • Grand Coulee, Bonnevile and Chief Joseph are main dams on Columbia River.		Pacific Ocean
Sacramento River	• It flows through Central Valleys and Shasta, Keswick, etc. are main dams on the Sacramento River.	Cascade and Sierra Nevada Mountains	Pacific Ocean
San Joaquin River	• Friant Dam is built on it.	Cascade and Sierra Nevada Mountains	Pacific Ocean
Rio Grande River	• It forms the natural boundary between USA and Mexico		Gulf of Mexico

Important Mountain Ranges

Brook's Range

- Located in Northern Alaska. Extends in the east-west direction and is a continuation of the Rockies.

The Alaska and Aleutian Ranges

- Terminate in the Aleutian islands, are part of the Pacific Mountain Systems.
- Mount McKinley (6194 m) is the highest peak of North America is in the Alaska Range.

Western Cordillera

They are made up of three almost parallel ranges, running north to south.

(i) **Coast Mountains**

- Mount Logan (6050 m) in the Yukon Territory (Canada) is the second highest peak of North America.

(ii) (a) **Cascade Range**

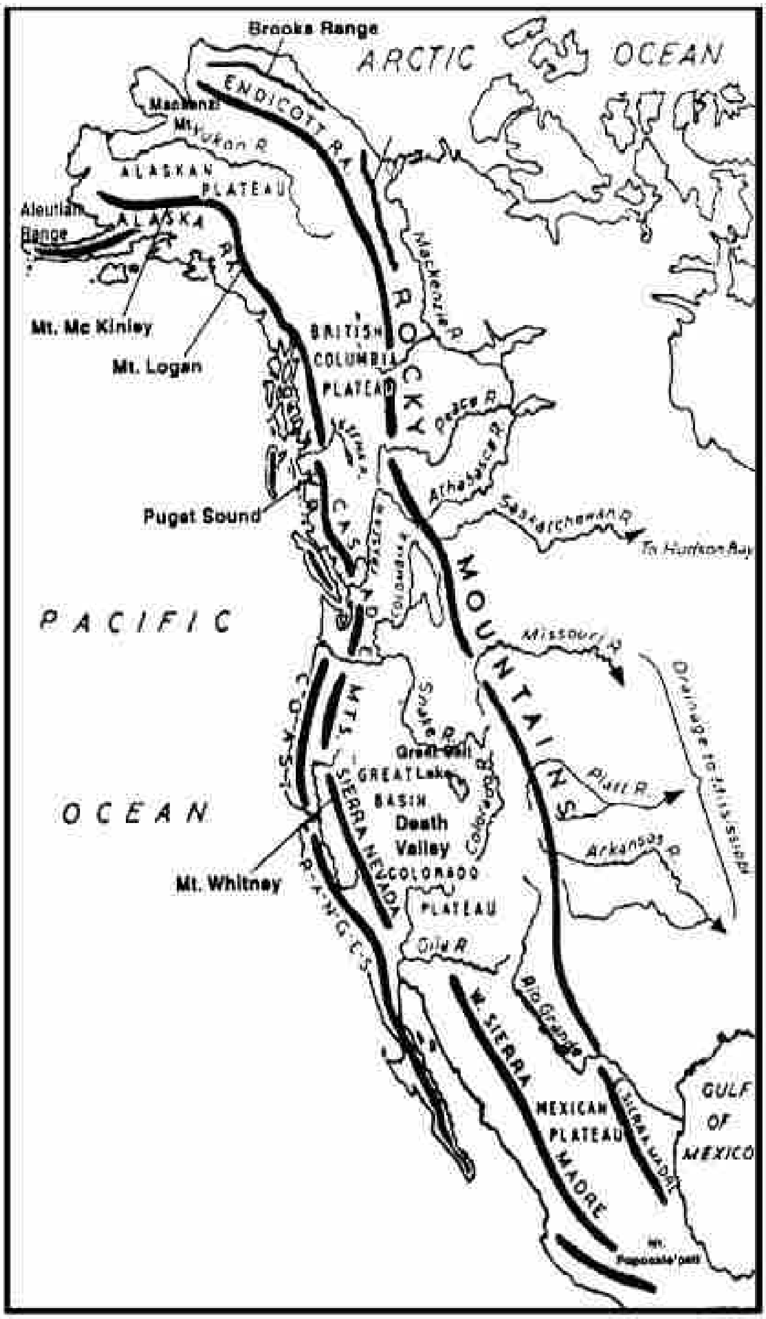
- East of Coast Mountain, running from the North California to Washington.
- Mount Whitney (4418 m) is the highest peak of USA.

(b) **Sierra Nevada**

- From south of Cascade Range to southern California along the Pacific coast.

(iii) **Rocky Mountains**

- Lies east of the Cascade range and Sierra Nevada, running from Alaska to Mexico and is over 4000 m.
- It is the easternmost and is the highest range among the western Cordilleras.
- West of the Rockies lies a region of table-lands, basins, canyons and deserts.



San Andreas fault - World's largest minifestation of surface transform fault.
Aniakchak in Alaska - Active volcano
Popocate petl in Mexico - Active volcanoes
Puget Sound - Depression between mainland and the islands.

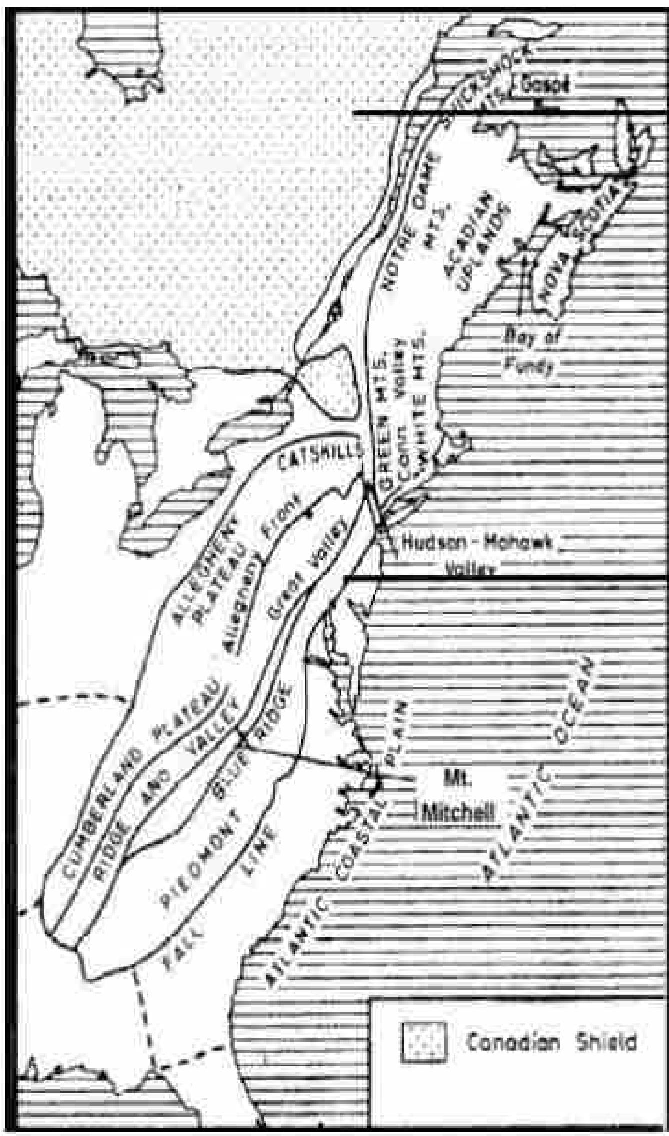
Wasatch Mountain • Located in Utah • An example of Block Mountain	**Sierra Madre Occidental** • Located in the Western Mexico	**Western Coastal Plain** • It is bordered by the Pacific Ocean with a 2,080 km coast and 12,369 km shoreline • Pacific coastal plain is much narrower than the eastern coastal plain • Pacific coastal plain is much narrower than the eastern coastal plain • California, Oregon and Washington lies along the Pacific coast.
Henry Mountain • Located in Utah. • An example of Laccolith.	**Sierra Madre Oriental** • Located in the E	

Important Plateaus and Basins

Name	Information
Intermontane Plateau (Partly or fully enclosed by mountain)	• West of Rockies lies a region of plateaus, basins and deserts.
Yukon-Kushokun Basin	• Located between the Brooks and Alaska Range. • An intermontane plateau or basin which is dissected by many rivers.
Columbai-Snake Plateau	• Occupies western Washington between the Rocky and Cascade Mountains. • An example of Lava Plateau or Plateau of Accumulation which is formed of Basalt. • The chief rivers draining in this region is the Columbia and its tributary Snake river on which Grand Coulee dam (washington) is located.
Great Basin	• Located between Sierra Nevada in the west and Wasatch Mountain on the Rockies in the east. • It is really a pleateau, which has been Block-faulted, Block sections of the Plateau now form Block mountain. Some of the depression of Great Basin have no external drainage. • An example of ***Basin and Range*** type of Topography.
Colorado Plateau	• An intermontane plateau which is located between the Rocky Mountain and Sierra Nevada, is a hot desert region. In some parts flat topped mesas and buttes are found.
Maxican Plateau	• Located between Sierra Madre Occidental and Sierra Madre Oriental in Mexico. Some parts have Basin-and-Range landscape.

Death valley	• Lies west of the Rockies Mountain in California. • Deepest point (85 m below sea-level) of North America. • Highest diurnal range of temperature in the world is recorded here.

San Jauquin Valley	• Lies between California and Rockies in California. • Friant dam is located.
Central Lowlands	• Descends from the Rockies Mountain in the form of steps. • Many lacustrine lakes are located. • Relatively undisturbed by the crustal movements of the earth.
Great Plains	• Structural plains formed by the River Mississippi and River Missouri.
Gulf Coastal Plain	• Region of wheat cultivation in summer and winter. • Plain formed by the Mississippi-Missouri river system.



Canadian Shield

- Region of northeast Canada, including Laurentian Plateau.
- Made of Precambrian rocks, very rich in mineral resources.
- Some hollows carved by ice sheet make deranged drainage system.

Laurentian Plateau

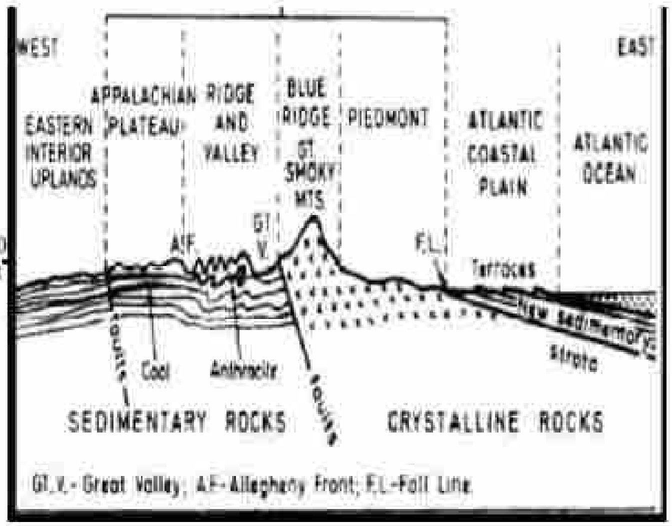
- Part of Canadian Shield, situated to the North west of Gulf of St. Lawrence.

Appalachian Mountain System

- Remains of ancient fold mountain
- Liest along the Atlantic coast, extending southwards from Quebec (Canada) to Central Albama (U.S.A.)
- Highest peak - Mount Mitchell on Blue Ridge (North Carolina)
- Orogeny - Caledonian.
- An example of mountain system, formed in a single period includes the smaller ranges such as the Poconos, Adirondack mountains and, further south, the Allegheny, Blue Ridge, and Great Smoky Ranges.

Adirondack Mountain

- Joined to Canadian Shield and is located between Lake Ontario and Gulf of St. Lawrence.



A general section across the Appalachians and the bordering areas.

- Geologically rich iron ore (magnetic) region.

Blue Ridge

- An example of mountain ridge which was formed due to local folding and faulting from the adjoining regions.

Appalachian Plateau

- An uplifted peneplain which comprised of Cumberland Plateau (Kentucky), Allegheny Plateau.

Cumberland Plateau

- West of Applachian Mountains in Kentucky.

Important Peninsula

Ungava Peninsula

- Located in North Canada, which is surrounded by Hudson Bay and Hudson Strait.

Yucatan Peninsula

- Deepest place of Mexico
- An example of Karst of Limestone togography.

Kenai Peninsula

- Lies between Cook Inlet and the Gulf of Alaska in Alaska (U.S.A.)
- Known for its petroleum resources.

Atlantic Coastal Plain

- It is bordered by the Atlantic Ocean with a coastline (3,329 km) and a (46,143 km) shoreline.
- Northeastward flowing streamof warm water is Gulf Stream moderate the climate of region and make it an important region for fishing.

MINERAL RESOURCES

North America has rich reserves of the major mineral deposits. The chief resources and the distribution in briefly brought out below.

Coal

USA has the second largest reserves of coal. The Appalachians contains huge coal deposits and account for 90% of coal output of the country. The Appalachian coalfields are in Indiana and have the second largest coal reserves of USA. The Gulf coast region has coalfields in Arkansas, Texas and Mississippi. The Rocky Mountains have huge deposits of lignite and bituminous coal. In Canada, coal deposits are in Manitoba and Saskatchewan.

Iron Ore

The Mesabi Ranges in Minnesota have huge deposits of iron ore. Iron are deposits are near Birmingham in Alabama, in Chattanooga in Tennessee, in Cornwall in Pennsylvania and in Canada, large reserves are in South Quebec and the shield areas of Newfoundland like Schefferville, Labrador city, Bell Island.

Oil and Gas

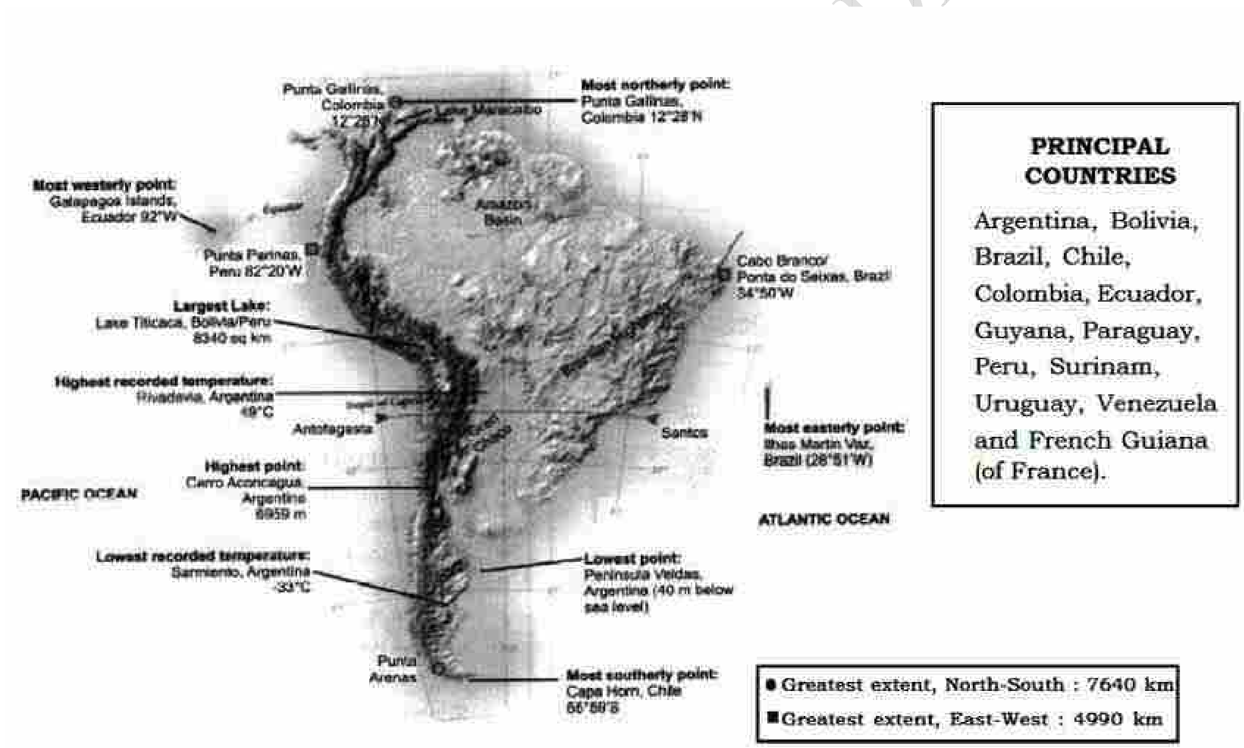
The largest reserves of oil and gas are in the Mid-Continent region in Kansas, Texas, Oklahoma, Louisiana and New Mexico. The Gulf Coast region is the second largest producer with oilfields (both onshore and offshore) in Texas, Mississippi, Southern Arkansas and Louisiana. The Appalachians from Pennsylvania to Tennessee had large reserves in the past which have been exploited. The Rocky Mountains includes oilfields in Wyoming, Utah and Colorado. Large reserves of natural gas in the USA are in Gulf Coastal Region of Texas and Louisiana. The Shale gas potential is huge in Colorado. In the west, the oilfields are in San Joaquin Valley of California. Canada has some of the largest reserves of natural gas in Alberta and British Colombia. Bituminous sands containing oil occur in large reserves in Athabasca river valley of Alberta.

Rocky Mountains

The Rocky Mountain region is known for vast resources and rich mineral deposits including copper, lead, gold, silver, tungsten, uranium, and zinc. Coal, petroleum and natural gas are mineral fuels found. Old mine tailings are present in the Rocky Mountain landscape.

➢ SOUTH AMERICA – PHYSICAL GEOGRAPHY AND MINERAL RESOURCES

- **Area**: 1,7835,000-sq. km (approximately)
- **Latitude:** 12028'N to 55059'S
- **Longitude**: 28051'W to 920W
- **Size and Shape:** Fourth largest continent and roughly triangular in shape.
- **Situation:** Situated to the south of North America, mostly in the Southern Hemsphere. It is surrounded by the Caribbean Sea in the north, Atlantic Ocean in the east, Antarctic Ocean in the south and Pacific Ocean in the west.
- **Extent:** North-South: 7640 km East-West : 4990 km
- South America as well as Mexico, Central America and West Indies are collectively known as Latin America.



Important Gulfs, Peninsulas and Straits

NAME	INFORMATION
Gulf of Guayaquil	• West of Ecuador in the Pacific Ocean.
Gulf of Penas	• Southern Chile in the Pacific Ocean.
Gulf of San Jorge	• East of Argentina in the Atlantic Ocean.
Gulf of San Matias	• North of Valdes Peninsula (Argentina) in the Atlantic Ocean.
Taitao Peninsula	• Surrounded by Gulf of Penas and the Pacific Ocean in Southern Chile.
Valdes Peninsula (Argentina)	• Lowest part of South America surrounded by Gulf of San Matias (North), Gulf of San Jose (West), Gulf of Nuero and the Atlantic Ocean.
Magellan's Strait	• Separates southern end of South America, the Tierra Del Fuego.
Drake Passage	• Strait between South America and Antarctica.

Important Lakes

NAME	LOCATION
Lake Maracaibo (12,950 sq. km)	• North of Venezuela, is one of the major oil producing region. • Largest lak of South America.
Lake Titicaca (12,500 feet above sea level)	• Situated between Bolivia and Peru. • Highest navigable lake in the world.
Lake Popo	• Lies in the Altiplano (high Plateau between the Andes mountain chain) in Bolivia.
Galapagos Islands	• Home of many unique species of reptiles (turtles), birds and fishes.

Important River Basins

Amazon River Basin

Source : Andes Mountain, Peru

Mouth : Macapa (Brazil) in the Atlantic Ocean

- 6,500 km long river flowing through Peru and Brazil to the Atlantic Ocean.
- World's second longest river after Nile and has the greatest volume.
- Madeira is the largest tributary of the Amazon River.
- The river basin is covered with dense equtorial firest which are locally called ***Selvas.***
- Rubber was first discovered in its wild state as Para rubber in the Amazon basin.
- ***Guicas*** practice subsistence agriculture in the river basin.

Orinoco River Basin

Source : Guiana highlands.

Mouth : Enters the Atlantic Ocean via huge delta.

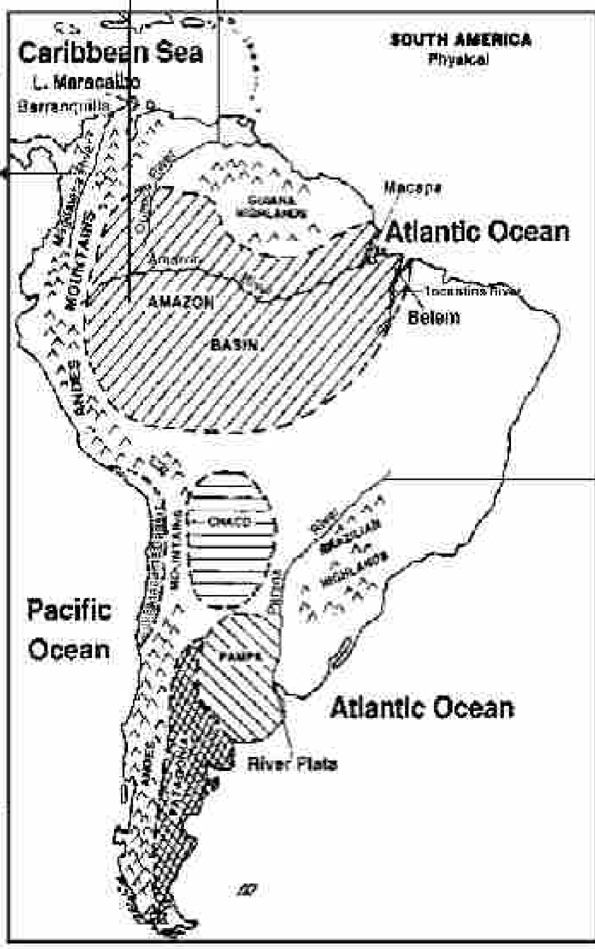
- The river basin is covered with Llanos, Savanna like vegetation.
- Angel Falls, the highest in the world is located on the river.

Magdalena River Basin

Source : Andes Mountain.

Mouth : Caribbean Sea at the Colombian City of Barranquilla.

- It flows through the rift valley between cordillera Oriental and the Cordillera Occidental of the Andes mountain.
- Oil is found in the Caribbean coastal lowlands of river basin.



Parana River Basin

Source : Brazilian Highlands.

Outflow : Rio-de La Plata.

- It flows through Brazil, Paraguay and Argentina and forms the boundary between Paraguay and Brazil.
- World's largest waterfall (in terms of volume) Iguazo located on Parana.
- Serves as an outlet to the sea for Paraguay.
- ***Itaipu, the*** largest dam of South America, is located on the river.

La Plata

- Nearly 30 km long estuary which looks like a river, lies between Urugay and Argentina.
- An estuary into which Parana and Uruguay River fall.

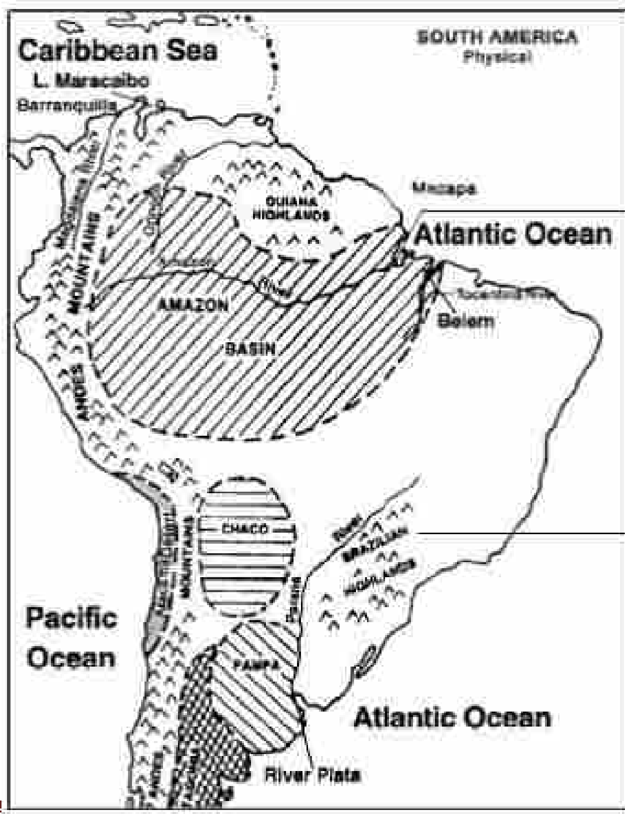
THE WESTERN MOUNTAINS

- Forms the second highest mountain system in the world, next to the Himalaya.

The Andes Mountain System

- Aconcagu (6960 m), an extinct volcano is hte highest peak of Western Hemisphere lies in Argentina.
- A part of seven countries; Venezuela, Colombia, Ecador, Bolivia, Peru, Chile and Argentina.
- The Andes range is widest in Bolivia (640 km) and comprises two chain (Cordillera Occident al and Oriental); the Altiplano (high plateau) lies between these two chains.
  (i) Cordillera Occidental
  (ii) Cordillera Central
  (iii)Cordillera Oriental
- Three parallel north-south ranges of the Andes dominate the western part of Colombia with altitudes between 3,000 m and 5,000m.
- The two parallel north-south ranges of the Andes dominate the Central Ecuador.

Chimborazo (6,310 m) is the highest peak of Ecuador and Mt Ojas del Salado the highest active volcano in the world, is in Argentina.



GUIANA HIGHLANDS

- Located in the northern part of Brazil and extending into Guyana, Surinam and French Guina.
- Highlands upto 3,000 m high is the densely forested region.
- Picoda Neblina (3,014m), the Brazil's highest peak, is in the highlands.

BRAZILIAN HIGHLANDS

- Rising from Brazil's Atlantic coast and levels off into high towards the western side of Brazil.
- Rich in mines, coffee plantation, and cattle ranches.
- Highland region is characterized by coniferous forest while the drier region is covered with Savanna-like grassland (Campos).

BOLIVIAN PLATEAU OR THE ALTIPLANO

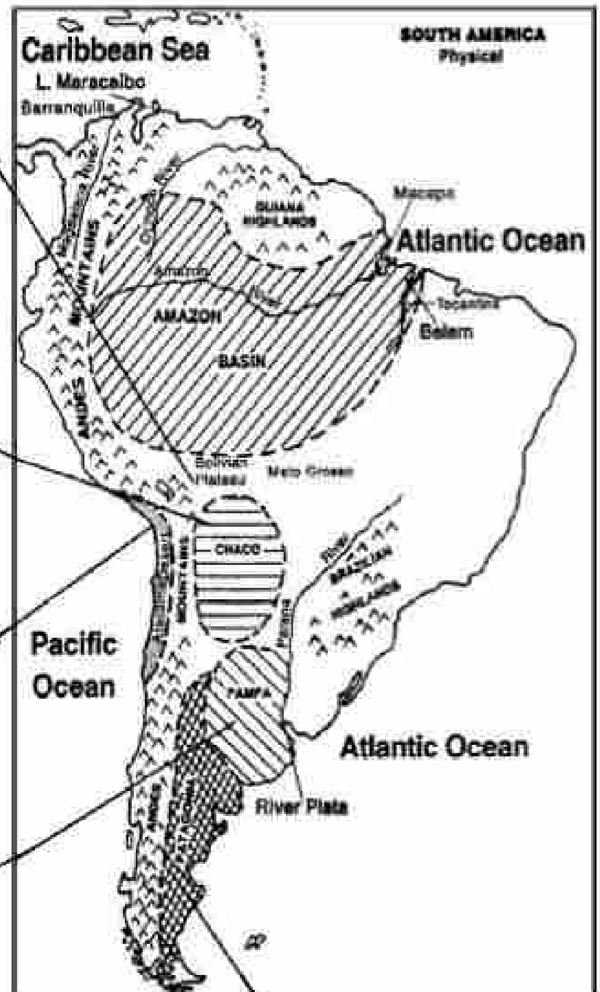
- An example of intermontane plateau which lies between the two chains of the Andes Mountains in Bolivia.
- Region with rich deposits of tin.

PLATEAU OF MOTO GROSS

- Highlands of Brazil.

GRAN CHACO

- A great lowland centred on western Paraguay, northern Argentina, and south eastern Bolivia.
- It has warm temperate forest and grassland to the south of Selvas.
- Dry scrubland used mainly for cattle rearing.
- It means 'The Hunting Land' in the local language.



ATACAMA DESERT

- A coastal desert in Chile.
- The world's driest desert.
- It contains a number of salt lakes.
- Rich in gold, nitrate (caliche), copper and sulphur.

PAMPA

- Vast monotonous temperate grassland that covers about 20% area of Argentina's heartland.
- One of the world's greatest agricultural regions for grain and beef.
- Alfa-Alfa, a nutritious leguminous grass is grown for commercial grazing.

PATAGONIA PLATEAU

- Piedmont plateau of the Southern Argentina, rain shadow region with little rain called |atagonia desert.
- Grazing land for sheep and cattle.

MINERAL RESOURCES

The mining industry is one of South America's most important economic engines. The continent contains about one-fifth of the world's iron ore reserves. **Iron and steel** (an iron product) are used in construction and machinery throughout the world.

More than one-quarter of the world's known **copper** reserves are in South America, mostly in Peru and Chile. Valued at $26.9 billion in 2009, copper accounts for nearly one-third of the exports of Chile, the world's largest copper exporter. Copper is used in electrical wiring and equipment because it is a good conductor of heat and is resistant to corrosion.

Other important metal deposits include **tin**, used to solder metallic surfaces; **lead**, used in construction, batteries, and bullets; and **zinc**, used as an anti-corrosion agent. Brazil, Peru, and Bolivia are major producers of tin. Lead and zinc deposits are found primarily in higher elevations of Peru, Bolivia, southern Brazil, and northern Argentina.

South America is home to some deposits of oil and natural gas, which are drilled for energy and fuel. Oil and gas extraction is the dominant industry of Venezuela, with major deposits found around Lake Maracaibo and the El Tigre region. The oil sector accounts for about one-third of Venezuela's total gross domestic product (GDP).

Oil fields were brought into production in the early 1970s in the Peruvian portion of the Amazon basin west of Iquitos. Argentina and Chile share significant deposits bordering the Strait of Magellan in Patagonia and Tierra del Fuego. Additionally, Argentina has traditional oil-producing regions around the Patagonian city of Comodoro Rivadavia. Brazil has limited offshore oil and gas reserves.

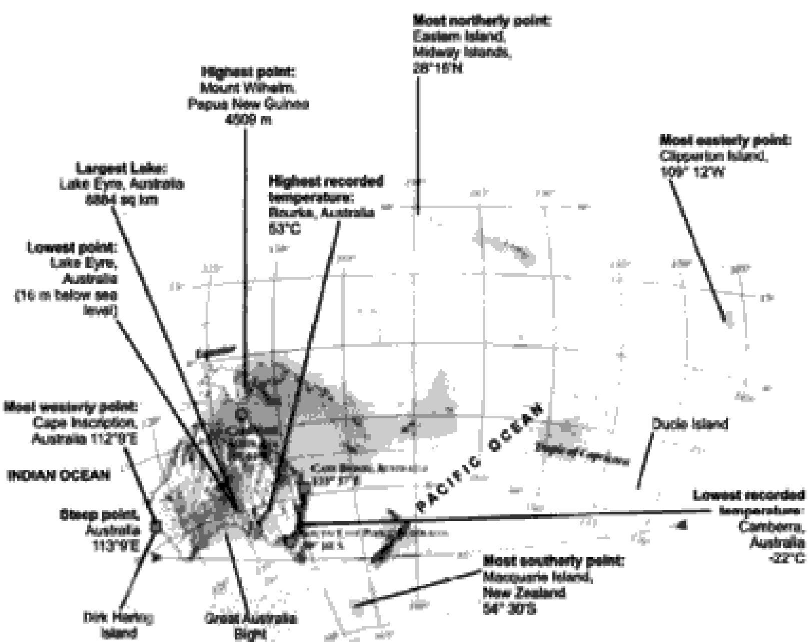
Colombia has long been self-sufficient in oil and gas production, with primary areas in the central Magdalena River valley and the Putumayo area adjacent to its border with Ecuador.
South America is poor in coal. Colombia exports coal from La Guajira Peninsula and the lower Magdalena River basin south of Barranquilla, and Argentina has limited quantities of good-quality coal at El Turbio in the extreme south.

Brazil produces relatively small quantities of coal in its southern states, while areas in northwestern Venezuela and south of Concepción in Chile also have coal mines that once supplied fuel for steamships.

AUSTRALIA – PHYSICAL GEOGRAPHY AND MINERAL RESOURCES

- **Area:** 76,86,850 sq. km
- **Population**: 18.7 million
- **Capital:** Canberra
- **Latitude:** 28015'N 54030'S
- **Longitude:** 112009'E 109012'W
- **Situation:** Australia, the only continent that is also a country. It lieS between the Indian and Pacific Oceans. It is surrounded by Timor Sea in the northwest, Arafura Sea dn Gulf of Carpentaria in the north, Great Barrier Reef in the northeast and Great Australian Bright in the south. To the south east of mainland lies the mountainous island of Tasmania.
-

Island Continent, Austrlia (Australis), literally called Southern Continent, is the smalles of all the continents. Comprises Australia, New Zealand and other Islands. One of the most sparsely populated and urbanized nation.



PRINCIPAL STATES AND TERRITORIES

It is divided into six states and two centrally administered territories of which Western Australia is the largest stae while New South Wales is the most populous. It also includes the island of Tasmania.

Western Australia, Northern Territory, Queensland, South Australia, New South Wales, Victoria, Tasmania

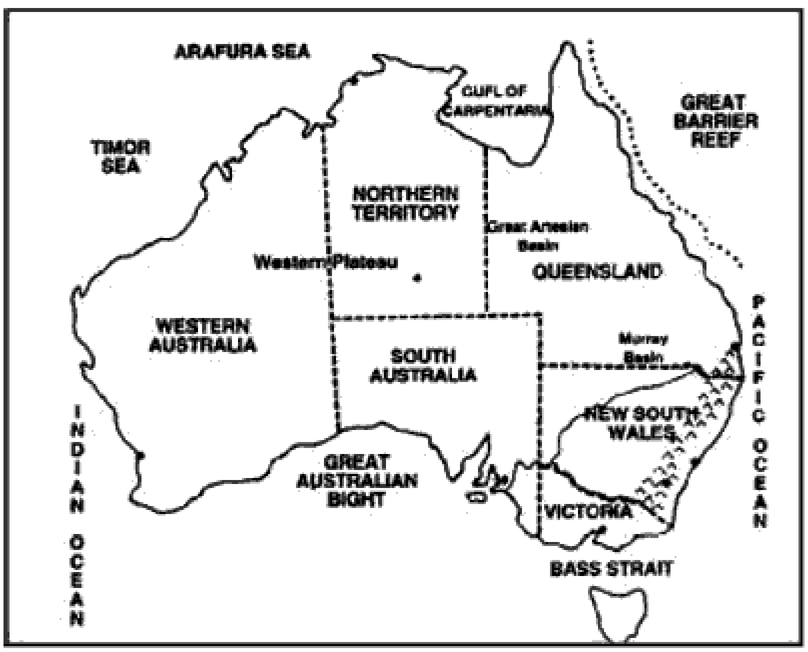
- Greatest extent, North-South : 3200 km
- Greatest extent, East-West : 4000 km

AUSTRALIA — PHYSCIAL

Major Physiographic Regions of Australia is—The Great Dividing Range, Central Lowlands and Western Plateau.

The Great Dividing Range

- The most elevated part of Australia, also known as Eastern Highlands, extends from Cape York Peninsula (Queensland) to Victoria and continues beyond the Bass Strait into Tasmania.
- Example of block-fault mountains, nowhere wider than 161 km and at places as narrow as 48 km.
- Major source of minerals, timber, water and hydel-power.
- Name was given for its function of dividing watersheds, which determines the direction of flow of many rivers



Central Lowlands

- Located along the western flanks of the Great Dividing Range from Gulf of Carppentaria in the north of the Great Australian Bight in the South.
- Consists series of basins, low lying land, lakes and old lake beds.
- Surface of Lake Eyre is the lowest in the region at about 12 m below sea level. The region contains two large basins the Great Artesian Basin and the Murray Darling Basin.

The Western Plateau Region

- A shield made in Pre Cambrian era rich in mineral resources.
- Australia's largest structural unit—a high tableland.
- Contains the desert regions—Great Sandy, Gibson and Great Victoria deserts.
- Fringe area consists of low lying mountains ranges and vast basins along the coasts.

AUSTRALIA—WEST

Western Australia

Major Physiographic Regions

Desert Landscape : Great Sandy desert in the north west, Gibson desert in the central part lying to the south of Lake Disappointment and Great Victoria desert extending into South Australia.

Highlands and Mountains

Darling Range

- Running in north-south direction in the south west of Western Australia.
- Kimberley Plateau-lies to the north of Great Sandy Desert
- Mount Gold Worthy, Mount Whaleback and Mount Tom Price : Major region of iron ore reserves in Western Australia.

Cities of Western Australia

PERTH

Situated on the Swan River, 19 km from the sea.
Capital of Western Australia.
Manufacturing centre of iron-steel, vehicles, machinery and textiles.

FREMANTLE

Situated on the mouth of Swan River, largest port of Western Australia.

KALGOORLIE, COOLGARDIE

These two cities are located in the

Northern Territory

Major Physiographic Regions

Desert Landscape: Tanani desert in the north, Simpson Desert, in the south east of Alice Springs.

HIGHLANDS AND PLATEAUS

Macdonnel Ranges and Barkley Tableland.
Ayres Rock
Situated in the Northern Territory of Australia.
Zone of the largest monolithic rock, named as Uluru.
A giant red rock, rises about 348 m.
Important cities

southern region of Western Australia. One of the important centre of gold mining in the world. Situated to the north-west of western Australia. **PILBARA** Situated to the north-west of western Australia. Known for its iron ore reserves.	**DARWIN** The capital and the chief port of the north coast which exports timber, grain and meat. Also known for its ore reserves. City is called 'Australia's front door'. **ALICE SPRING** Situated in the southern part of Northern Territory and connected by rail with Adelaide. has large reserves of oil and gas.

South Australia (Major Physiographic Regions)

Great Victoria Desert

- Situated in the West of South Australia. Musgrave Range
- The mountain ranges of northern region.

Flinders Range

- The mountain ranges of south, south-east.
- An example of Block Mountain.

Lake Eyre

- Nearly 12 m below sea level.
- Deepest point of Australia.

Important Cities

ADELAIDE

- Situated on the St. Vincent Gulf.
- Capital and the chief port on the southern coast.
- Well-developed agricultural industries, such as fruit canning, flour-miling, dairy industries and woolen textiles.

WHYALLA

- Major centre of iron and steel industry.

AUSTRALIA—EAST

Major Physiographic Regions **Great Dividing Range** Runs parallel from the Cape York Peninsula (Queensland) to Victoria and continues beyond Bass Strait into Tasmania. **Australian Alps** Lies in the south-east of New South Wales. It includes the continent's highest peak, Mount Kosciusko (2,230 m).	**Murray Darling Basin** River basin formed by the Australia's largest river system Murray and its tributary Darling. Snowy River Scheme, Tully Falls and Shannon are major hydel power schemes. Great Barrier Reef The world's largest coral reef. Extends over a very ridge like feature off the north east coast of Queensland, up to Tropic of Capricorn.

New South Wales

SYDNEY
Australia's oldest and largest city.
Built on the low hills of the Pacific coast.
The capital and the major port of New South Wales.
Major centre of iron-steel, paper and printing, and chemical industries.
Known for lead-zinc and silver mines.

NEW CASTLE
Situated to the south of Sydney on the coast of Pacific.
It is a sea port and an industrial town.
Major centre of iron-steel, non-ferrous metals and textile industries.

BROKEN HILL
Situated in the western part.
Known for lead-zinc and silver mines.

Major Physiographic Regions

BRISBANE
Situated near the Ipswich coal fields.
Capital and chief harbor of Queensland.
Major industrial city and a manufacturing centre of locomotives, machinery and processed foods.

IPSWICH
Centre of lignite and sub-bituminous coal mining.

MOUNT ISA
Major centre of lead and zinc mining.

WEIPA
Known for its bauxite deposits, one of the largest in the world.

Victoria

This state is situated in the south east of Australia, and the Murray River divides it from New South Wales.

MELBORNE

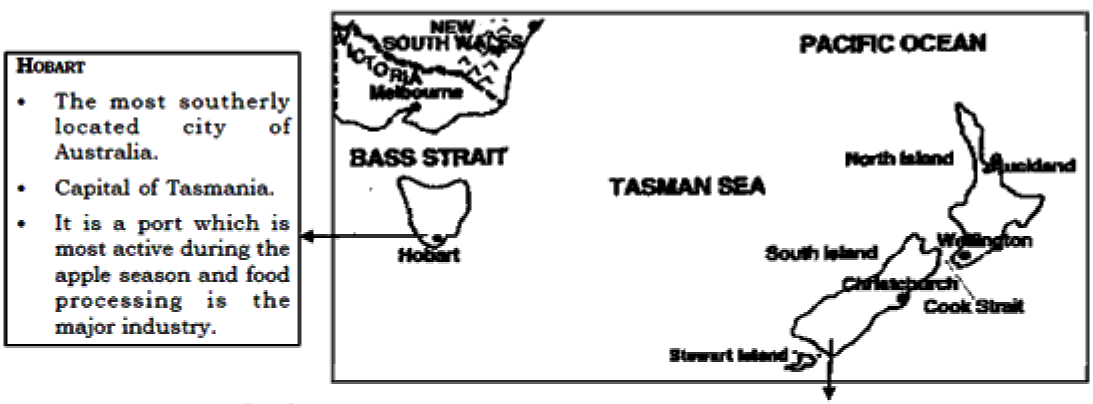
- The capital of Victoria.
- Country's second largest city and also former capital of Australia.
- Centre of major industries based on Gippsland's lignite coal and hydel power from the Snowy river scheme.
- Chemicals, ship-building, aircraft, engineering, railway equipments and motor vehicles are the major industries.

GIPPSLAND

- Centre of lignite and sub bituminous coal mining.
- Australian Capital Territory.

CANBERRA

- Nation's capital, situated to the south of Sydney.
- It is mainly administrative city.



NEW ZEALAND

- **Area:** 2,69,057 sq. km (excluding dependencies)
- **Population:** 3.8 million
- **Capital:** Wellington
- **Longitude**: 166010'-178020'E
- **Latitude**: 34005'-47020'S
- **Situation:** The three main island of New Zealand are situated to the south east of Australia and 10,000 km west of Chile in the South Pacific Ocean. The two larger islands, North and South Islands are long and narrow and the third, Stewart Island, is the smaller one.

Physical features

Southern Alps

The mountains of the South Island, includes the country's highest peak, Mount Cook (3,764 m).

Canterbury Plains

- The most extensive plains, an example of Piedmont Alluvial plain crossed by rivers cover 12,500 km of the South Island's east coast.
- The chief farming region in New Zealand.

MOUNT EGMONT

- An extinct volcano in south-west of North Island.
- Situated to the north of central volcanic plateau of North Island.

WELLINGTON

- Situated on the southern tip of the North Island.
- Country's capital and also the southernmost capital city of the world.
- An important sea port on the Cook Strait.
- Cattle rearing and dairy are the main economic activity around this city.

AUCKLAND

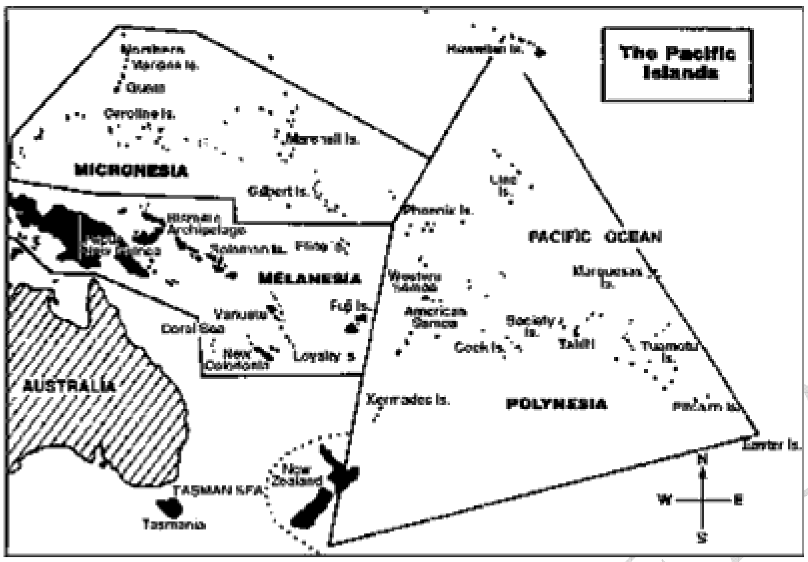
Biggest city of the country and also the largest port on the coast of North Island.

CHRISTCHURCH

Major industrial centre of the South Island.

THE PACIFIC ISLANDS

Scattered across the Pacific Ocean, between 1300W at a distance of 11,265 km are thousands of islands with a total land area of 2,60,0001 sq. km excluding New Zealand and New Guinea. They are made up of three main groups: Melanesia, Micronesia and Polynesia.



Important Independent Islands

Micronesia (Tiny Islands)	Polynesia (Many Islands)
Consists of four smaller group of islands, they are Northern Mariana, Caroline, Marshall and Gilbert islands (now Kiribati). Guam (Mariana) is the largest island of Micronesia. It is an important US military base and tourist destination. **Federal states of Micronesia** **Area:** 702 sq. km. **Population:** 1,31,500 **Capital** : Palikir Formerly known as Caroline islands, is an archipelago of western Pacific. **Kiribati (Gilbert and Ocean Island)** **Area:** 861 sq. km. **Population :** 85,501	The group of islands within the “triangle” is known as Polynesia. It includes Tuvalu, Samoa, Cook Islands, and Easter islands, French Polynesia, Nive, Pitcairn Islands, Tokelau, Wallis and Futuna. **TUVALU** **Area:** 26 sq. km. **Population:** 10,588 **Capital:** Funafuti Formerly known as Ellice Islands World’s fourth smallest independent state. It is a scattered group of nine small atolls in the Western Pacific Ocean. Melanesia (Black Islands) It is the most westerly Pacific island group. Lies between the equator and the Tropic of Capricorn, it is divided politically into Irian

Capital : Tarawa
These islands are spread over a vast area in South West Pacific.
Has a high grade phosphate deposit. Agriculture and fishing are the main occupations.

Nauru

Area: 21.1 sq. km.
Population: 10,605
Capital: Yaren district
World's third smallest independent state.
Lies to the south of equator in the Central Pacific Ocean.
It is a coral island with huge deposits of phosphate.

Barat and Papua New Guinea - the Bismarcks, Solomon Islands, New Caledonia, Fiji Island and Vanuatu.

Important Islands of Melanesia

PAPUA NEW GUINEA

Area: 4,62,840 sq. km.
Population: 4.8 million
Capital: Port Moresby

- The largest island of Melanesia.
- Consists of eastern part of New Guinea and adjacent islands.

FIJI

Area: 18,270 sq. km.
Population: 812,918
Capital: Suva
Fiji's largest island Viti Levu constituting more than half of the land area of the country.

SUVA

- It is located in the southeast coast of Viti Levu.
- It is the country's capital and the largest city of Melanesia.
- Country's light industrial centre and leading port.

SOLOMON ISLANDS

Area: 2,89,000 sq. km.
Population: 4,55,429
Capital: Honiara
Situated to the east of Papua New Guinea in the Southwest Pacific Ocean.

NEW CALEDONIA

Capital: Noumea

- Minerally very rich, having deposits of nickel, chrome, cobalt, iron, gold, silver and copper.

Capital: Port-Vila

- It is a tourist destination offering unspoilt beaches and peaceful environment.

MINERAL RESOURCES

Iron ore - Australia was the world's second largest supplier in 2015 after China, supplying 824 million metric tonnes, 25% of the world's output.

Nickel - Australia was the world's fourth largest producer in 2015, producing 9% of world output.

Aluminium – Australia was the world's largest producer of bauxite in 2015 (29% of world production), and the second largest producer of alumina after China.

Copper – Australia was the world's 5th largest producer in 2015

Gold – Australia is the second largest producer after China, producing 287.3 metric tonnes in 2016, 9.2% of the world's output.
Silver – In 2015 Australia was the fourth largest producer, producing 1,700 metric tonnes, 6% of the world's output.

Uranium – Australia is responsible for 11% of the world's production and was the world's third largest producer in 2010 after Kazakhstan and Canada.

Diamond – Australia has the third largest commercially viable deposits after Russia and Botswana. Australia also boasts the richest diamantiferous pipe with production reaching peak levels of 42 metric tons (41 LT/46 ST) per year in the 1990s.

Opal – Australia is the world's largest producer of opal, being responsible for 95% of production.

Zinc – Australia was second only to China in zinc production in 2015, producing 1.58 million tonnes, 12% of world production.

Coal – Australia is the world's largest exporter of coal and fourth largest producer of coal behind China, USA and India.

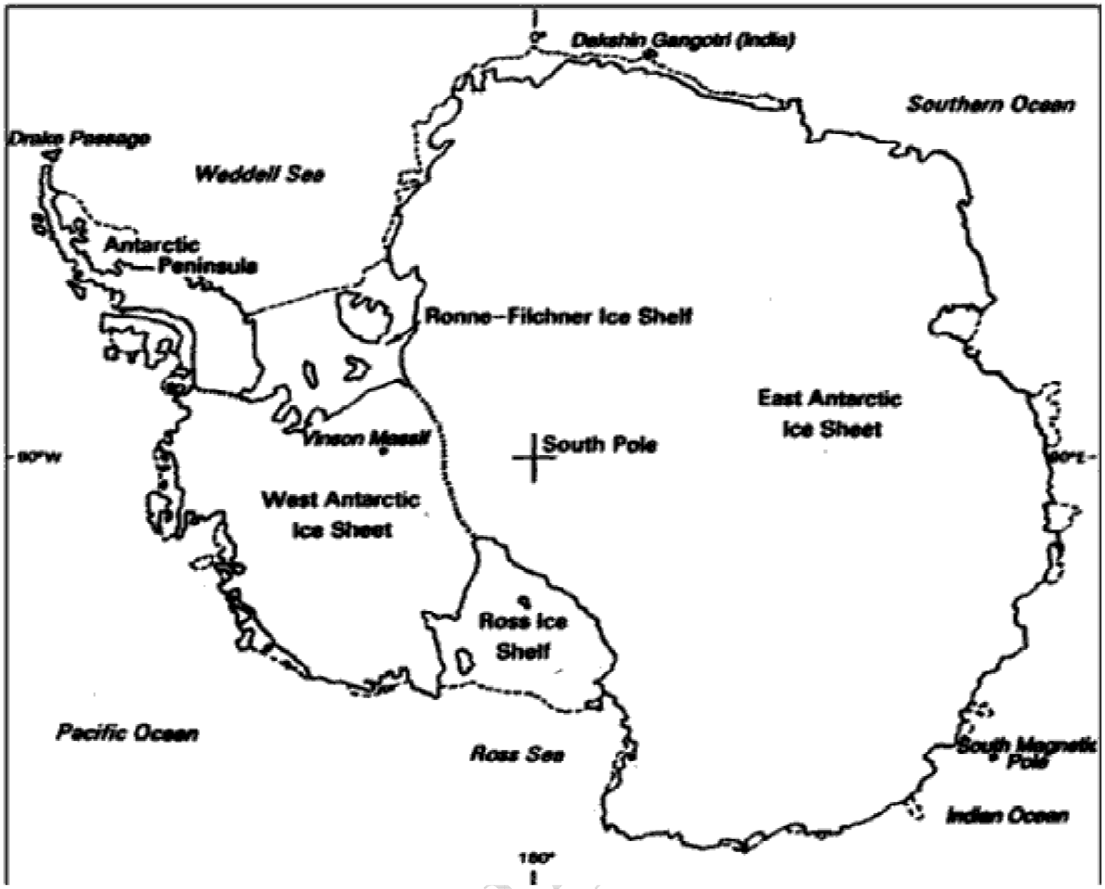
Oil shale – Australia has the sixth largest defined oil shale resources.

Petroleum – Australia is the twenty-ninth largest producer of petroleum.
Natural gas – Australia is world's third largest producer of LNG and forecast to be world leader by 2020.

Rare earth elements – In 2015 Australia was the second largest producer after China, with 8% of the world's output.

➢ ANTARTICA – PHYSICAL GEOGRAPHY AND MINERAL RESOURCES

- **Area:** 1,40,00,000 sq. km
- **Population:** Uninhabited
- **Size :** Fifth largest continent.
- **Situation :** Antartica, centred on the South Pole, is situated 960 km from South America, 2,700 km from Australia and 4,000 km from South Africa. It is surrounded by Southern or Antarctic Ocea, formed the southern waters of Pacific, Indian and Atlantic Ocean.
- **Shape :** Except for the deep indentations of the Ross and Weddell Seas and the projecting peninsula, the continent is roughly circular in shape.
- **Climate :** World's coldest continent and remains covered with very thick layer of ice, therefore, known as 'white continent'. Precipitation, in the form of snow (equal to 5 cm of rain) making Antarctica, one of the earth's great desert.



The Land : Antarctic Continent is the highest of all the continents, averaging 6000 feet in elevation. Ice sheet covers 95% of Antarctica, and exposed areas are rugges and mountainous. The principal mountain chain is Trans Antarctic which divides the continent in almost two equal parts. Ellsworth Mountain, fringing the coast, contains Antarctica's highest peak, the Vinson Massif (5,140m). Mt. Erebus, the only active volcano, is located on the Ross Island.

Some Notable Facts

- The only continent with no permanent population.
- It is linked to Tierra del Feugo by the submarine Scotia Ridge.
- It is a great scientific laboratory hence also called 'continent for science'.
- Three are valuable minerals like iron, copper, coal, petroleum in Antarctica but high costa involved makes exploitation of these resources uneconomic.
- Expedited by many, and first expedition by India in 1981-82 near Queen Maud region of Antarctica, and named it as Dakshin Gangotri (Mount Indira).
- Other countries have hase camps to carry out research throughout the year.
- South Magnetic Pole is located to the southeast of Greater Antarctica in the Indian Ocean.

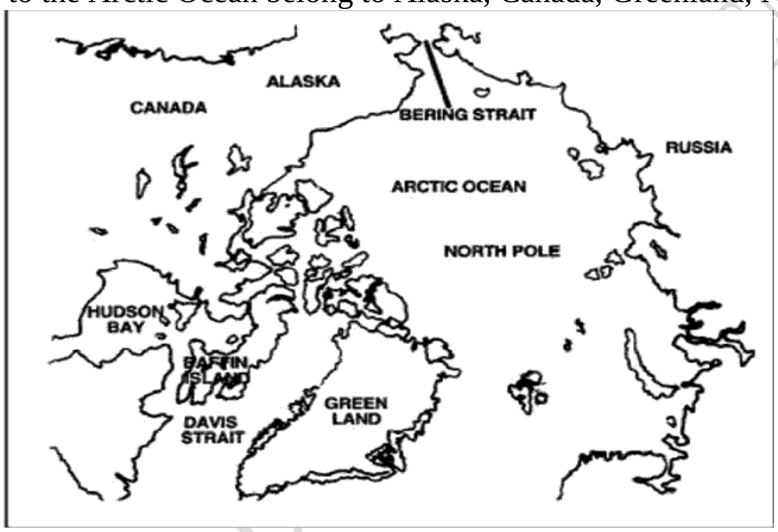
- World's largest glacier—Lambert is located here.
- The sheer weight of the ice has warped the continent downward so that much of the land of Antarctica lies below sea level.
- In 1985 at the South Polar Region an alarming discovery was made by British Antarctic Survey. An ozone hole (formed due to ozone depletion) was found over the polar atmosphere.

Arctic Ocean Region

It includes the Arctic Ocean and the North Polar Seas.

Arctic Ocean	North Polar Seas
Area: 12.9 million sq. km	**Area**: 14.8 million sq. km.

Lands adjacent to the Arctic Ocean belong to Alaska, Canada, Greenland, Norway and CIS

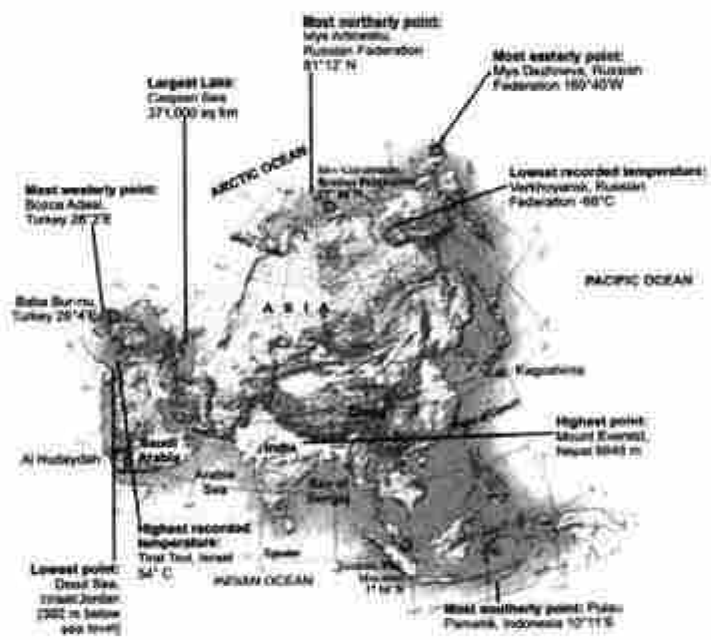


CHARACTERISTICS OF THE REGION

- Stationary polar ice. Olar ice is about 3 m thick and is located directly over the North Pole.
- Strong winds, high atmospheric pressure prevails.
- Absence of vegetation (only mosses and lichens at very few places may be found).
- The coldest place in the northern hemisphere is not the North Pole (because of moderating influence of Arctic Ocean) but 2,414 km south for North Pole (Siberian town of Verkhoyansk).
- Polar Bear is the best known animal in the Arctic Region.
- Huge Alaskan oil reserves is the most important resources of the region.
- The Arctic fringe and offshore islands are part of CIS territory and it is a very sensitive are with aircraft and missile detection devices. Now the region is becoming new home for many Russian scientists.

➢ ASIA – PHYSICAL GEOGRAPHY AND MINERAL RESOURCES

- **Area:** 43,608,000 million sq. km (30% of total land surface of the earth.)
- **Population:** 3588.9 million
- **Latitudes:** 10011'S to 81012'N
- Only some of the Indonesian group of Islands is located to the south of equator in the Southern Hemisphere.
- **Longitude:** 2602'E to 169040'W in the east crossing 1800 longitude.
- **North-South Extent:** 6,440 km East-West Extent : 9,650 km



Size : Largest continent in the world, 13 times larger than India.

Situation : The continent of Asia is situated entirely in the northern hemisphere except some of the islands of Indonesia. To the north of it lies the Arctic Ocean, a frozen sea, to the east the Pacific Ocean, to the south the Indian Ocean and to the west lies Mediterranean Sea. It is separated from Europe by the Ural Mountains, the Caspian Sea, the Black Sea, the Caucasus Mountains and the Strait of Dardanelles in the west and from Africa by the Red Sea and the Isthmus of Suez while the Bering Strait separates it from North America.

- Greatest extent, North-South : 6440 km
- Greatest extent, East-West : 9650 km

ASIA - PHYSICAL

Important Seas

Name	Location	Part of Ocean
Kara Sea, Laptev Sea, and East Siberian Sea	North of Russia	Arctic Ocean
Bering Sea	Northerst of Russia	Pacific Ocean
Sea of Okhotsk	East of Russia	Pacific Ocean
Sea of Japan	West of Japan	Pacific Ocean
Yellow Sea	West of Korea	Pacific Ocean
East China Sea	East of China	Pacific Ocean
South China Sea	South of China	Pacific Ocean
Sulu Sea	West of the Philippines Island	Pacific Ocean
Celebes Sea	North of Celebes Island	Pacific Ocean
Banda Sea	East of Celebes Island	Pacific Ocean
Flores Sea	South of Celebes Sea	Pacific Ocean
Molucca Sea	East of Celebes Island	Pacific Ocean
Java Sea	North of Java	Pacific Ocean
Timor Sea	Northwest of Australia	Pacific Ocean
Arafura Sea	North of Australia	South Pacific Ocean
Bay of Bengal	East of the Indian Peninsula	Indian Ocean
Arabian Sea	West of the Indian Peninsula	Indian Ocean
Red Sea	Separates Asia from Africa	Indian Ocean

Important Gulfs

Name	Location	Part of Ocean
Gulf of Ob	Between Yamal Peninsula and Gyda Peninsula	Arctic Ocean
Gulf of Chihli	East of China	Yellow Sea (Pacific Ocean)
Gulf of Tonkin	Eastof Vietnam	South China Sea (Pacific Ocean)
Gulf of Thailand	South of Thailand	South China Sea
Persian Gulf	Separates Arabian Peninsula from the Plateau of Iran	Indian Ocean
Gulf of Oman	Between Iranian Plateau	Indian Ocean

	and Oman	
Gulf of Aden	Between Somalia and Yemen	Indian Ocean
Gulf of Aquaba	Between Aquaba (Jordan) and Sinai Peninsula (Egypt).	Red Sea
Severnaya Islands	North of Russia	Arctic Ocean
New Siberian Islands	North of Russia	Between Laptev Sea and East Siberian Sea, Arctic Ocean
Wrangel Islands	North of Russia	East Siberian Sea, Arctic Ocean
Kurile Islands An extension of the volcanic Kamchatka Peninsula	Between Kamchatka Peninsula and Hokkaido Island	Pacific Ocean
Ryukyu Island An example of submerged island.	Between Kyushu and Taiwan	Pasific Ocean
Bonin Island	East of Ryuky Island	Pasific Ocean
Babuyan Islands	Between Taiwan and Luzon (Philippines)	Pasific Ocean
Spartly and Parcel Islands	A group of atolls in South China Sea	Pasific Ocean
A disputed group of islands claimed by China, Vietnam, Malaysia, Taiwan, Philippines, Brunei because of the vast reserves of oil beneth these islands		
The Philippines archipelago	Lying 1200 km east of Vietnam and 150 north of the equator. **Luzon.** The largest and the important island of the Philippines is known as the 'Rice Bowl of Philippines'. Mount Mayon, the only active volcano of the Philippines, is located in the Luzon. Good quality cigar tobaco is grown in the northern Luzon (mainly Cagayan	P

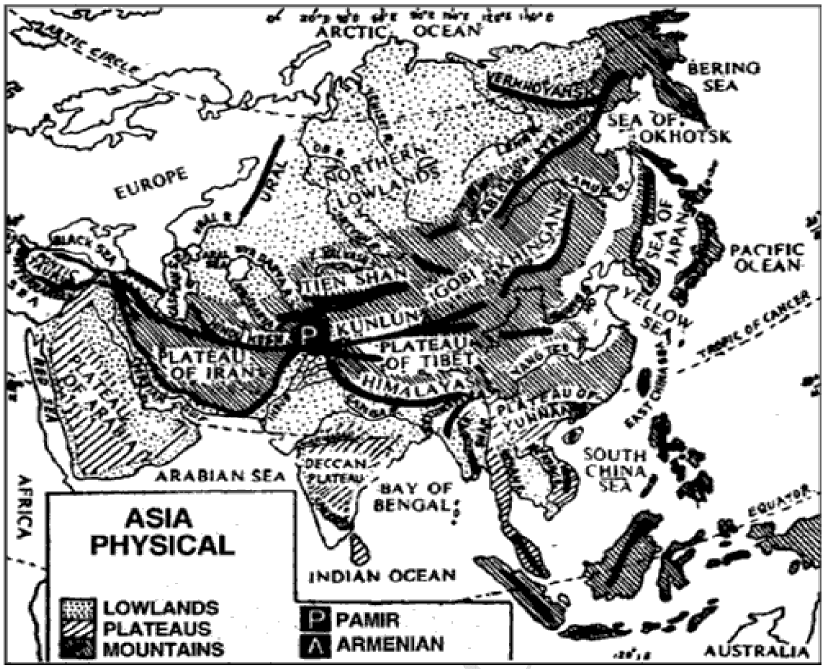
	Valley). Igorot tribe lives in the northern region of island. Mindano Island Second largest island located in southern part of the Philippines. Mount Apo, a dormant volcano on Mindano, is the country's highest peak.	

Important Straits

Name	Separates	Connects
Bering Strait	Asia and North America	East Siberian Sea with Bering Sea
La Parouse Strait	Sakhalin Island and Hokkaido Island	Sea of Okhotsk with Sea of Japan
Tata Strait	Eastern Russia and Sakhalin	Sea of Okhotsk with Sea of Japan
Korea Strait	South Korea and Kyushu (Japan)	Yellow Sea with Sea of Japan
Formosa Strait (Taiwan Strait)	Taiwan and China	East China Sea with South China Sea
Luzon Strait	Taiwan and Luzon (Philippines)	South China Sea with Pacific Ocean.
Makassar Strait	Borneo (Kalimantan) and Celebes Island	Celebes Sea with Java Sea.
Sundra Strait	Java and Sumatra	Java Sea with India Ocean
Malacca Strait One of the great shipping corridors of the world	Malaya Peninsula and Sumatra	Java Sea with Bay of Bengal
Strait of Jahore	Singapore and Malaysia	South China Sea with strait of Malacca
Strait of Hormuz	UAE and Iran	Persian Gulf with Gulf of Oman.
Strait of Bosporus	Asia and Europe	Black Sea with Sea of Marmara.
Strait of Dardanelles	Asia and Europe	Sea of Marmara with Mediterranean Sea

Important Mountains

The Himalayan Mountain Range	Lies to the north of Indo Gangetic Plain, is an example of mountain range which formed in the same age with same process. An example of fold mountain of Alpine orogeny. Mount Everest (8,848 m) is the highest peak, located in Nepal.
Karakoram Range	Lies in the north of the Himalaya. Godwin Austen (K2) is the highest peak of Karakoram
Kailash Range	East of Karakoram Range in Tibet.
Kunlun Shan Range	Lies to the north of Tibet Plateau and to the South of the desert basin of Tarim in China.
Tienshan	Lies to the north of Tarim basin
Great Khingan Mountain	The Tien Shan extends to the north east and reaches the Amur River under the name of Great Khingan Mountains.
Altai Mountain Hangay Mountain Sayan Mountain	Lies to the north of Tienshan in succession in a more or less east-west direction.
Yablonovy Range, Stanovoy Range, Dzhugzur Range and Kolyama Range	Lies to the north east of Atlai Range in the eastern Siberia.
Verkhoyansk Range	Lies to the east of the Lena River separates Central Siberian Plateau from the eastern Siberian regio.
Pegu Yoma	The Irrawaddy and Sittang are divided in their middle course by this mountain range.
Arakan Yoma	Running southwards, is the western range of Myanmar. A range of the Himalaya which further countinues through the Andaman and Nicobar Islands, Sumatra, Java and other Indonesian islands.



The Mountain Regions to the West of the Pamir

Hindukush Mountains	Running westwards from the Pamir Knot to the Elburz Mountains in Iran.
Elburz Mountains	Hindukush Mountain joins the Armenian Knot near the Caspian Sea under the name of Elburz Mountains in Iran.
Sulaiman Range	It proceeds southwards from the Pamir Knot along the border between Pakistan and Afganistan. The most famous pass across this mountain wall is the Khyber, linking Pakistan with Afghanistan.
Kirthar Range	Sulaiman Range takes the name of Kirthan in the south.
Makran Range	Kirthan Range turns westward on the Arabian Sea coast and assumes the name of Makran.
Zagros	Running to the northwest of Makran, ultimately ends up in the Armenian Knot.
Pontic Mountain Range	Running to the northwest of Armenian Knot in Turkey.
Taurus Mountain Range	Running to the southwest of Armenian Knot along the Mediterranean coast in Turkey.

Important Plateaus and Basins

NAME	INFORMATION
Ladakh Plateau (Inter- montane Plateau)	Lies between the Karakoram in the north and the Himalayas in the south.
Tibet Plateau (Inter-montane Plateau)	Enclosed to the south by the Himalays, to the north by the Kunlun Shan Range is the highest tableland (4,800 m) of Tibet. The largest plateau in the world with an average altitude of 4,250 m.
Yunan Plateau	Lies to the southeast of the Tibet Plateau is separated from the fertile Szechuan basin by the range of mountains.
Takla Makan Desert Plateau and Tarim Basin	An intermontane desert basin lies between the Tienshan in the north and Kunlun Shan in the south. Convectie and 'Karaburan' blows in the arid regions.
Pamir Plateau	Situated to the northwest of the Indian sub-continent. Meeting point for the central Asian mountain ranges which make up the skeleton of the continent. The highest plateau of the world with an altitude of 4,900 m is also known as 'roof of the world'.
Armenian Plateau	Situated between the Caspian Sea and Black Sea. Pamir-like plateau from where many mountain ranges spread out, therefore called the Armenian Knot.
Iranian Plateau	The central desert plateau of Iran is enclosed by Zagros in the south and west and Elburz in the north.
Mongolian Plateau	A high plateau between 1,500 and 1,800 m above sea level, is situated between the Khinghan in the east, Altunshan and Tien Shan in the south, Altai in the west and Yablonovy in the north.
Urfan Basin	Lies to the west of Mongolian Plateau.
Aldan Plateau	Lies to the north west of Stanovoy Mountain
Indo-China Plateau	Region of Southeast Asia, extends over Vietnam, Laos, Cambodia, Thailand and Myanmar.
Shan Plateau	Lies between Pegu Yoma and Arkan Yoma in the eastern part of Myanmar. The Salween River flows through the plateau. Region important for precious stone (Rubies), silver, lead, and tin and tungsten.
Deccan Plateau	Lies to the south of Indo Gangetic plain, between the Eastern Ghats and Western Ghats. North western part of Deccan Plateau is an example of lava Plateau or Plateau of accumulation
Baluchistan Plateau	A desert plateau (900 m high) situated to the west of Kirthar Range
Arabian Plateau	An example of titled block extending over the entire Arabian Peninsula.
Plateau of Antolia of	Enclosed between Pontic Mountain Ranges in the north west and Tauras

Asia Minor or Turkey	in the south west. A vast plateau with an average height of 1,200 m, broken by ridges and volcanic outcrops. The main rivers draining off the plateau are Tigris and Euphrates.
Loess Plateau	The Plateau region is surrounded by Great Plain in the east, Qining Mountains in the south and Ordos Plateau in the north. Loess is the wind borne fine dust, deposited beyond the deserts limits and is the fine loam, rich in lime. Shansi and Shensi region of loess plateau is known for its extensive coal reserves. The Hwang Ho flows through loess land.
Dzungarian Basin	Relatively low lying land between the Tien Shan and Altai Range in Mongolia. A sort of door between China and Mongolia in the east and Tarim lowland in the west.
Mesopotamian Plain	Formed by the Tigris and Euphrates River in Iraq. One of the major regions where wheat, barley, tobacco and cotton is grown.
Gobi Desert	Situated to the southeast of Mongolians Plateau and extends into China. Aridity due to interior location shows the features of undulating sand sea as well as barren sheets or rock and stone.

Important Land Regions

Manchurian Plain	Formed by the Amur River and its tributaries in the northern part of China. Important cities Anshan, Shenyag and Fushun of Mukden Triangle are located.
Great Plain of China	Formed by the Hwang-Ho and Yangtze Kiang Rivers in the eastern China.
Turanian Plain	Formed by the two principal Asian rivers, the Amu Darya and Syr Darya. It is an example of Basin plain which covers the region of Turkmenistan, Uzbekistan and Kazakhstan.
West Siberian Plain	It extends over 3,200 km eastwards from the Urals to the Yenisey River and is one of the largest lowlands in the world.
Taaidam Basin	Lies between Altun Shan and Kunlun Shan and to the north east of Central Tibetan Plateau The major region of oil fields.
Szechuan Basin	Situated to the north of Yunan Plateau is the fertile basin where the Yangtze Kiang River is joined by three major tributaries known as the Red Basin because of its coloured sandstone. Red basin of Szechuan is the leading rice producing region and is called the ‘Rice Bowl of China’.
	THE DESERT LANDSCAPE OF SAUDI ARABIA

Rub-al-Khali	Largest continuous sand desert in the southern part of Saudi Arabia. It is also called 'Empty Quarter'.
Al Nafud Desert	Deserts land in the north eastern region of Saudi Arabia.
	THE DESERT LANDSCAPE OF IRAN
Dash-I-Kavir	Largest Salt desert of the world situated in the northern Iran.
Dasht-I-Lut	Barren desert of Iran situated in the eastern part of country.

Important Lakes

NAME	INFORMATION
Lake Baikal	Located in the southern part of eastern Siberia and to the west of Yablonovy Range in Russia. Source of the Lena River. It is the deepest continental body of water on Earth having a maximum depth of 1,620 m.
Lake Balkash	Located in Kazakhastan. North of the Lake is Karaganda coal basin.
Aral Sea	Located between Kazakhstan and Uzbekistan Two principal Asian rivers, the Amu Darya and Syr Darya flow through semi arid depression into the sea.
Lake Van Golu	The largest lake of Turkey. One of the saltiest lake in the world.
Lake Turnool	The northernmost extent of East African Rift Valley. Located in the Anatolia Peninsula of Turkey.
Lake Asad	Located in Syria.
Dead Sea	It is an example of rift valley lake which lies along the West Bank of Jordan. One of the deepest points of Asia is the world's lowest lake. The Jordan river flows into the Dead Sea, which has no outlet, and evaportation balances the inflow
Sea of Gallilee	Lava flow blocked the Jordan Valley and formed an elongated lake in Israel. The lave-blocked lake is linked to the Dead Sea through the Jordan River.
Lake Tonle Sap	Located in central lowland of Cambodia.
Lake Toba	Situated in Sumatra (Indonesia). An example of crater of caldera lake.
Lop Nor	Salt lake in China, site of numerous nuclear testing. Tarim river drains into the lake.
Caspian Sea	The largest lake in the world which is five times larger than the Lake Superior. It separates Europe from Asia.

Important Rivers

NAME	SOURCE	OUTFLOW
NORTH FLOWING RIVERS FROM WEST TO EAST IN RUSSIA		
Ob Tributaries : Irtysh, Tobolsk	Altai Mountain	Gulf of Ob
Yenisey	Tannuala Mountain	Arctic Ocean
Lena	Lake Baikal	Arctic Ocean
Kolyma	Kolyma Range	East Siberain Sea
EAST FLOWING RIVERS (FROM NORTH TO SOUTH)		
Amur **Tributary**: Sungari River.	Confluence of Shika Argun River.	Tatar Strait
Yalu Forms a well defined border between North Korea and the Eastern Russia		Korea Bay (Yellow Sea)
Hwang Ho	Tibetan Plateau	The river's course was diverted away into the Gulf of Pohai instead of the Yellow Sea.
Yangtse Kiang It is the longest river of Asia. It flows through Szechuan basin. Shangai and Wuhan, are the important cities of China lying along the river.	Tibetan Plateau	East China Sea.
Si Kiang More than half of the total silk production in China comes from the Yangtse Kiang and Si Kiang deltas.	Eastern Yunan (China)	South China Sea.
EAST FLOWING RIVERS (FROM NORTH TO SOUTH)		
About 75% of the Chinese live in fertile river basin of Hwang Ho, Yangtse Kiang.		
SOUTH FLOWING RIVERS		
Mekong It flows through China, Thailand-Laos border, Cambodia and Vietnam over 4,160 km to South China Sea. Longest river in South East Asia. In Laos, the Mekong forms the western boundary with Thailand. Phnom Penh and Ho Chi Minch cities are situated on the bank of river. Mekong valley of south Vietnam is	Tibetan highlands	South China Sea

devoted to rice cultivation. Delta: Arcuate, is (characterised by funnel shaped distributaries, stabled by growth of mangrove vegetation) lying in Vietnam.		
Chao Phraya City located : Bangkok The principal river of Thailand. The river's delta has rich alluvial soil which is used almost entirely for rice and has very high density of population.		Gulf of Thailand
Salween It flows through China & Shan Plateau (Myanmar) over 2,090 km. Longest river of Myanmar.	Tibetian highlands	Gulf of Martaban
Irrawaddy Tributary : Chindwin City located : Mandalay Major river of the country referred to as the 'Life lije of Myanmar' Central basin between Irrawaddy and Chindwin around Mandalay is very important for wheat and cotton cultivation. Delta region of Irrawaddy and Sittang, known as the 'Rice Bowl of Mayanmar'.	North Myanmar	Bay of Bengal
Brahmaputra Brahmputra is called Tsang-Po in Tibet before entering in India.	Rises in galcier about 100 km south east of Mansarovar Lake	Bay of Bengal
SOUTH FLOWING RIVERS		
It enter Bangladesh near Bhubri.		
Ganga In the upper course Alaknanda and Bhagirathi River meet at Devprayag and from Ganga	Gangotri Glacier	Bay of Bengal
Indus One of the world's largest rivers flow south-eastwards acros the country then drain into Arabian Sea through Attock plains of Pakistan	Mansarovar lake	Arabian Sea
Tigris and Eupharates These two rivers dominate Iraq and flow		Persian Gulf

south-eastwards across the country then drain into the Persian Gulf via a combined estuary. They meet at Shatt-al-Arab in Iraq.		
Amu Darya and Syr Darya The principal rivers of Central Asia flow in to the Aral Sea through the semi and depression.		

MINERAL RESOURCES

Coal:

World's coal reserves are quite large, estimated at 4.5 trillion metric tons, and probably will last a long time as we increasingly utilize newer forms of energy. Asia's share of reserves is about one-eighth of the world, which is more than adequate for its current needs. The distribution of the fields is, however, uneven. China, Russia and the Central Asian republics contain the largest reserves, while those of India, Indonesia, North Korea, Taiwan and Japan are more modest. China and India are the major producers.

Petroleum and Natural Gas:

Two- thirds of the world's proven oil and natural gas reserves lie in Asia. This proportion is likely to go up as new fields are discovered, particularly on islands bordering East Asia, and island-chains in Southeast Asia, many of which have geologic formations that indicate good prospects of petroleum reserves. Several of the fields explored during the last thirty years or so have already begun to yield oil, e.g., in Sumatra, Kalimantan, Java, and islands in South China Sea.

Uranium:

Asia's reserves of this important mineral critical to the generation of nuclear energy for commercial and defense needs, is small and limited mostly to China and India. The production of nuclear energy and its consumption is largely in the hands of a comparatively few industrialized countries such as the U.S.A., Russia, Japan, Canada, the United Kingdom, France, Germany, Italy and Australia. Among Asian nations, Japan is the largest consumer, which utilizes about 10 percent of all the nuclear energy produced in the world.

Metallic Minerals:

Iron Ore:

Iron-ore reserves of the world are very extensive, estimated to be over 65 trillion metric tons, of which less than 1 percent is annually mined. On account of the increasing use of plastics, and recycling of scrap metals, the world's supply of this useful metal is going to last for a long time. Asia's reserves amount to nearly one-eighth of the worlds. Nearly all Asian nations contain some deposits of the ore; China and India contain most of it. South Korea, Taiwan, Malaysia, Sri

Lanka, Kazakhstan, and Turkey have also fairly large deposits, although production in these countries is limited. China and India, together, account for one-fifth of the world's annual output.

Ferro Alloy Metals:

With the exception of manganese, tungsten, chromite and vanadium, Asia's reserves of ferroalloys are limited, but the production is fairly extensive amounting to almost one-half of the world's tungsten, one-eighth of manganese, and one-sixth of the world's chromite. China, South Korea, Mongolia, North Korea, Myanmar, Kazakhstan, and Tajikistan are the principal producers of tungsten. Turkey, India and the Philippines are the major chromite producers. China and India are important producers of manganese.

Nonferrous Metals:

Reserves of tin and bauxite are abundant in Asia, while those of copper are moderate. Four Asian countries: Malaysia, Indonesia, Thailand and China account for nearly one-half of the world's tin production. The reserves of bauxite are fairly large, about 12 percent of the world. India, China, the Philippines, and Malaysia are the chief producers but production is limited (about 6 percent of the world's total output).

Precious Metals:

Traditionally, gold was obtained mainly from the alluvial stream deposits and many Asian countries (Myanmar, Indonesia, Cambodia, and China) were its important producers. The current production is insignificant like other precious metals such as silver and platinum. South Africa, Russia, U.S.A., Canada and China are the world's major producers. China and the Philippines are Asia's major gold producers. Japan, North Korea, South Korea, Taiwan and Tajikistan also have some gold ore reserves. Asia's production of silver and platinum is negligible. Japan is the only country of some consequence that produces silver (about 2 percent of the world's production).

Nonmetallic Minerals:

Reserves of asbestos, gypsum, mica, phosphates, rock salt and sulphur are relatively large. Russia and India are the principal producers of mica; China, Jordan and Israel of rock phosphates; Israel of potash and Iraq of sulphur.

Energy Resources: Waterpower:

A large portion of Asia's surface is blessed with circumstances favorable for the development of waterpower and for irrigation in terms of the nature of its terrain, volume of water in rivers, existence of waterfalls, etc. Nearly a quarter of the world's potential is estimated to exist in the continent, but only one-fifth of the world's total capacity is developed, and thus a good deal remains undeveloped. Although water resources of China, India, Japan, Pakistan, Bangladesh, Myanmar, Sri Lanka, Indonesia, the Philippines, Laos and Vietnam are potentially abundant, only Japan has been able to fully exploit its waterpower resources.