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INDEX

Origin and Evolution of Earth

Origin of Universe:

Big Bang Theory/Expanding Universe Hypothesis:

By Edwin Hubble.

- All the matter was a tiny ball of unimaginably small volume, with infinite temperature and infinite density.
- At the Big Bang the "tiny ball" exploded violently with huge expansion.
- Within 300,000 years from the Big Bang, temperature dropped to 4,500 K (Kelvin) and gave rise to atomic matter. The universe became transparent.

Star Formation:

- Due to uneven distribution of matter and energy in the early universe led to initial density differences in gravitational forces and it caused the matter to get drawn together bases for development of galaxies.
- A galaxy starts to form by accumulation of hydrogen gas in the form of a very large cloud called N***ebula*** (Nebula is localised clumps of gas).

That led to formation of gaseous bodies there by formation of stars.

Formation of Planets:

Stages in the Development of Planets:

- The stars are localized lumps of gas within a nebula, gravitational force within the lumps lead to formation of a core to the gas cloud and a huge rotating disc of gas and dust developed around the gas core.
- Gas cloud -> condenses->matter around the core develops into small->round objects by the process of cohesion->***planetesimals***.
- These large number of small planetesimals accrete to form a fewer large bodies in the form of **planets.**

Solar System:

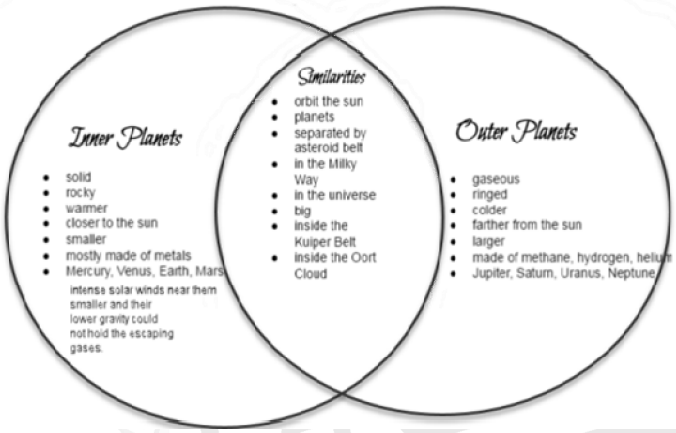
- Our solar system consists of the sun (the star), 8 planets, 63 moons, millions of smaller bodies like *asteroids* and *comets* and huge quantity of dust-grains and gases.
- Mercury, Venus, Earth and Mars are called as the **Inner planets/Terrestrial planets**, as they lie between the sun and the belt of asteroids the other four planets are Jupiter, Saturn, Uranus and Neptune, are called as the **outer planets/ Jovian planets**.

- **Sun**–The solar atmosphere consists of the **photosphere, chromosphere**, and the **corona**.
  - **Photosphere** is the bright outer layer of the Sun that emits most of the radiation.
  - Just above the photosphere is the **Chromosphere**. It is relatively a thin layer of burning gases.
  - **Corona i**s a distinctive atmosphere of plasma that surrounds the Sun and other celestial bodies.
  - A dark patch on the surface of the Sun is known as **Sunspot.**
  - **Solar Wind** is a stream of energized, charged particles, primarily electrons and protons, flowing outward from the Sun.
  - **Solar flares** are a magnetic storm on the Sun which appears to be a very bright spot and is a gaseous surface eruption.

- **Mercury**– smallest, closest, 36 million miles, 88 days revolution.
- **Venus**– twin planet of earth.
- **Earth** – Discussed in detail in later part. Satellite moon (revolves eastward once in 27 days).
- **Mars** – dark patches, it possesses an atmosphere of mostly carbon dioxide. Its red colour comes from iron oxide (rust) in its soil.
- **Jupiter** – Largest outer planet; composed of hydrogen, helium and methane. It has circular light

and dark band with outer rings, 12 satellites, very cold (–130°C). Planet with highest number of moons.

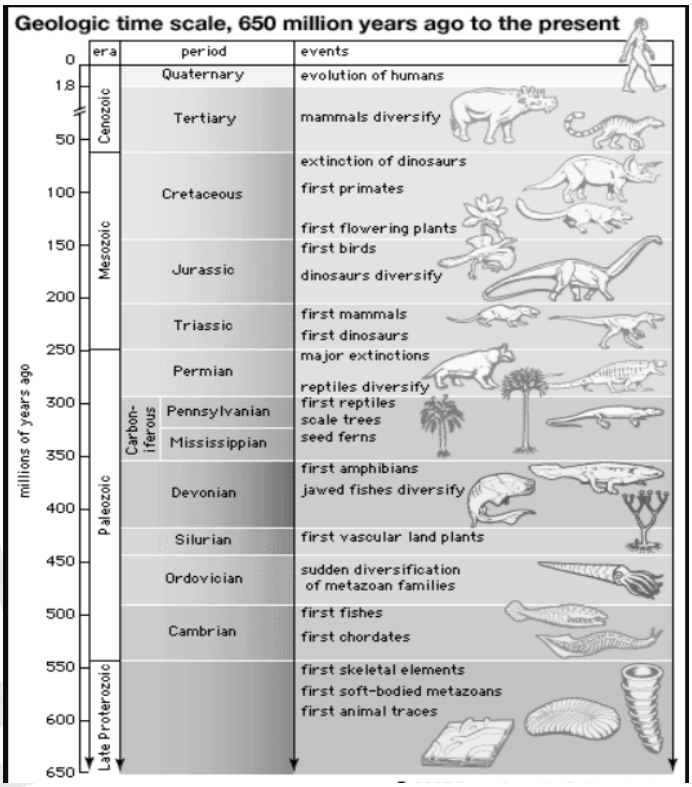
- **Saturn**–3 rings, 9 satellites, second largest, revolution takes 29.5 years. It is composed mostly of hydrogen, and helium.
- **Uranus –** bluish-green, 50 times large and 15 times heavy, 5 satellites, orbits east to west.
- **Neptune** – 2 satellites, colder, Uranus and Neptune are called the twins of the outer solar system.
- **Pluto** – planetoid, orbits in 247 years.



- The **Kuiper Belt** is a great ring of debris similar to the asteroid belt, but consisting mainly of objects composed **Primarily of Ice.**

- **Celestial Bodies:** Any natural body outside of the Earth's atmosphere.
- **Asteroids:** Small rocky body (Planet Debris) orbiting the sun. Large numbers of these, ranging enormously in size, are found between the orbits of Mars and Jupiter.
- **Comets:** A celestial object consisting of a nucleus of ice and dust and, when near the sun, a 'tail' of gas and dust particles pointing away from the sun.
- **Meteors/Meteoroids:** A meteor is an asteroid or other object that burns and vaporizes upon entry into the Earth's atmosphere; meteors are commonly known as "shooting stars." If a meteor survives the plunge through the atmosphere and lands on the surface, it's known as a meteorite.

Geological Time Scale:



Interior of the Earth and Associated Factors

Evolution of Earth

Evolution of Lithosphere:

- The earth was mostly in a volatile state during its primordial stage.
- Due to gradual increase in density the temperature inside has increased.
- As a result the material inside started getting separated depending on their densities.
- This allowed heavier materials (like iron) to sink towards the centre of the Earth and the lighter ones to move towards the surface. With passage of time it cooled further and solidified and condensed into a smaller size.
- This later led to the development of the outer surface in the form of a crust.

Evolution of Atmosphere:

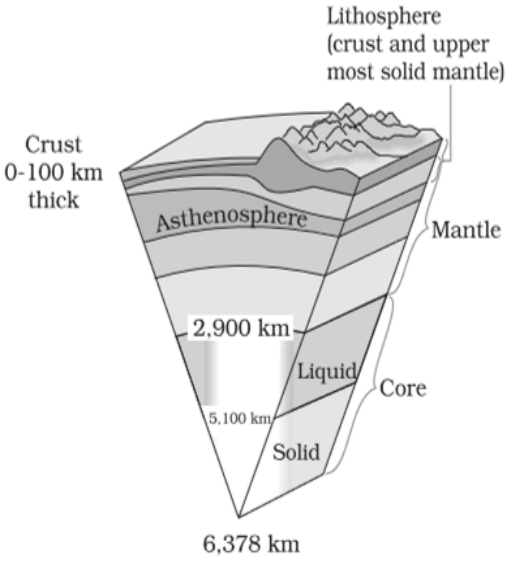
- There are three stages in the evolution of the present atmosphere.
- First stage, is marked by the loss of primordial atmosphere.
- Second stage, the hot interior of the earth contributed to the evolution of the atmosphere.
- Finally, the composition of the atmosphere was modified by the living world through the process of photosynthesis.
- The early atmosphere largely contained water vapour, nitrogen, carbon dioxide, methane, ammonia and very little of free oxygen.
- The process through which the gases were outpoured from the interior is called **degassing**.
- Continuous volcanic eruptions contributed water vapor and gases to the atmosphere.

Evolution of Hydrosphere:

- As the earth cooled, the water vapour released started getting condensed.
- The carbon dioxide in the atmosphere got dissolved in rainwater and the temperature further decreased causing more condensation and more rain.
- The rainwater falling onto the surface got collected in the depressions to give rise to oceans.
- The earth's **oceans were formed within 500 million years from the formation of the earth**.
- However, around 2,500-3,000 million years before the present, the process of photosynthesis got evolved. Life was confined to the oceans for a long time.
- Oceans began to have the contribution of oxygen through the process of photosynthesis. Eventually, oceans were saturated with oxygen, and 2,000 million years ago, oxygen began to flood the atmosphere.

Structure of Earth:

- The structure of the earth's interior is made up of several **concentric layers**. Broadly three layers can be identified—**Crust, Mantle** and the **Core**.



Crust:

- Crust is the outer thin layer with a total thickness normally between **30-50 km**. The thickness of the crust varies under the **oceanic -thinner (5-30 Km)** and **continental areas- thick (50-70 Km).**

- The continental crust is thicker in the areas of major mountain systems.
- It forms **5-10 per cen**t of the earth's volume.
- **Mohorovicic (Moho) discontinuity** forms the boundary **between crust and asthenosphere.**
- The **continents** are composed of **sial (**silicon &aluminium) while the **oceans** are composed of **sima** (silicon & magnesium).

Mantle:

- The mantle extends to a depth of **2,900 km.** 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 as thenosphere. It is in **solid state.**
- The density of mantle varies between 2.9 and 3.3.
- It is composed of solid rock and magma.
- The **upper portion of the mantle** is called **Asthenosphere**. It is considered to be extending up to 400 km. It is the **main source of magma** and is more fluidic in nature**.**
- It forms **83 per cent** of the earth's volume.

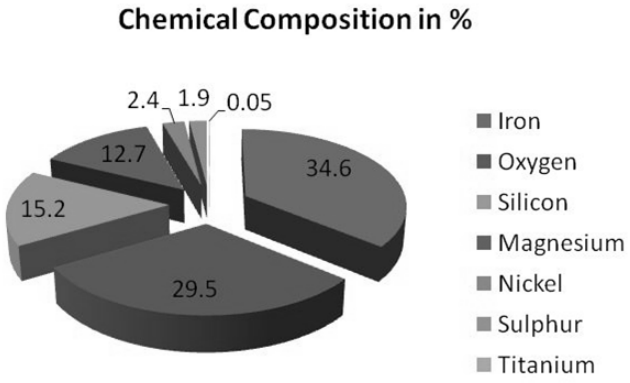
Core:

- Lies between **2900 km and 6400 km** below the earth's surface.
- Accounts for **16 per cent** of the earth's volume.
- Core has the heaviest mineral materials of highest density.
- It is composed of **nickel and iron [Nife**].
- The **outer core** is **liquid** while the **inner core** is **solid**.
- **Gutenberg Discontinuity** lies between the mantle and the outer core.

Composition of Earth Crust:

Sl. No.	Elements	By Weight(%)
1.	Oxygen	46.60
2.	Silicon	27.72
3.	Aluminium	8.13
4.	Iron	5.00
5.	Calcium	3.63
6.	Sodium	2.83
7.	Potassium	2.59
8.	Magnesium	2.09
9.	Others	1.41

Chemical Composition of the Earth:



Sources of information about earth interior,

1. **Direct sources**- surface rock obtained by **mining** and **volcanic eruptions.**
2. **Indirect sources**-

- **Analysis of properties of matter** like temperature, pressure and density of material.
- **Meteors** these solid bodies structure and material is similar to earth.
- **Gravity anomaly** which gives us the information about distribution of mass of material in the crust of earth.
- **Magnetic surveys** gives information about magnetic material distribution in crustal portion.
- **Seismic activity** important source about interiors of earth.

Motions of Earth:

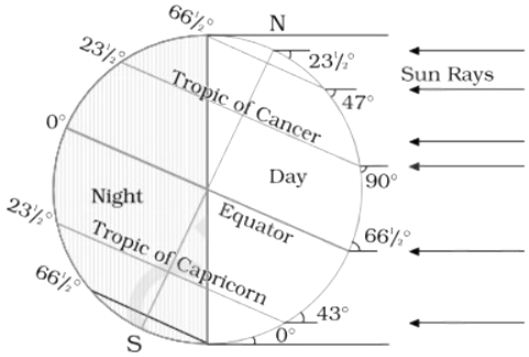
Rotation of Earth:

- Earth **rotates along its axis** from west to east.
- It takes approximately 24 hrs to complete on rotation.
- **Days** and **nights** occur due to rotation of the earth.
- The circle that divides the day from night on the globe is called the **circle of illumination**.
- Earth rotates on a tilted axis. Earth's rotational axis makes an angle of 23.5° with the normal i.e. it makes an angle of 66.5° with the orbital plane. **Orbital plane** is the plane of earth's orbit around the Sun.
- Rotation Movement of earth on its axis – 24 hours – **Earth day**.

Revolution of Earth:

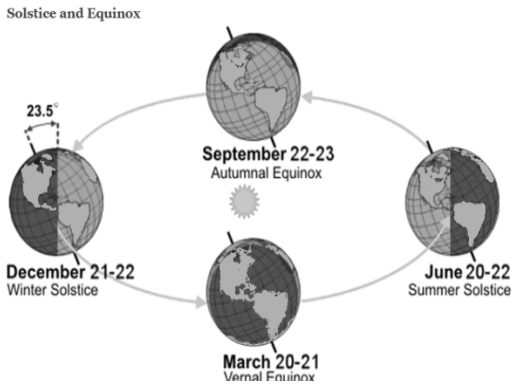
- The motion of the earth **around the sun** in its orbit is called revolution. It takes 365¼ days (one year) to revolve around the sun. Six hours saved every year are added to make one day (24 hours) over a span of four years. This surplus day is added to the month of February. Thus every fourth year, February is of 29 days instead of 28 days. Such a year with 366 days is called a leap year.
- Revolution leads to change in Seasons.

Latitudes and longitudes:



Latitude	Longitude
• The angular distance of a place **north or south** of the earth's **equator** • Equator = 0° Latitude • Latitudes are named south and north of equator • Their **length decreases from equator to poles** • Equator has the maximum length also called as great circle • Equator, Tropic of Cancer 23.5° N, Tropic of Capricorn 23.5° S, Arctic circle 66.5° N, Antarctic circle 66.5° S, North Pole 90° N and South Pole 90° S are important latitudes • They help in determining the **intensity of sunlight** received at a point • They divide earth into torrid, temperate and frigid zones • Distance between latitudes remains same.	• The angular distance of a place **east or west of the Greenwich meridian**, • Prime meridian = longitude • Longitudes are named east or west of prime meridian • **All longitudes are equal in length** • Prime meridian 0° and International Date Line 180° E or 180° W are important longitudes • Used to determine **time and date** at a location. • Distance between two longitude decreases as we move towards pole.
Both are used to determine the location of a point on earth. The location is identified with Co-ordinates	

Seasons



Summer Solistice:

- 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**.

Winter Solistice:

- 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 and it experiences winter**. This position of the earth is called the **winter solstice**.

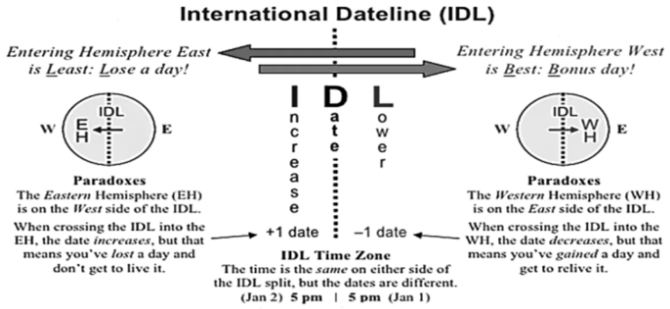
Equinox:

- 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**.
- **Rotation →Days and Nights.**
- **Revolution → Seasons.**

Greenwich Meridian Time:

- Equator is centrally placed between the poles, any meridian could be taken to begin the numbering of longitude.
- It was decided in 1884, by international agreement, to choose as the **zero meridian** the one which passes through the **Royal Astronomical Observatory at Greenwich, near London.**
- This is the Prime Meridian (0°) from which all other meridians radiate eastwards and westwards up to 180°.
- They help to determine local time.
- One revolution of 360° earth takes 24hours, therefore in 1hour it traverse 15° or in **4 mins 1°**
- Places **east of Greenwich** see the sun earlier and gain time (**EAST-GAIN-ADD**), whereas places **west of Greenwich** see the sun later and lose time(**WEST-LOSE-SUBSTRACT**).

International Date Line



- The International Date Line serves as the **"line of demarcation"** between two consecutive calendar dates. It passes through the mid-Pacific Ocean and roughly follows a 180 degrees at the Bering Strait, Fiji, Tonga and other islands longitude, north-south line on the Earth. It is located halfway round the world from the prime meridian.
- International Date Line is 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** and while crossing the dateline from **west to east he gains a day.**

Indian Standard Time:

The **standard meridian of India** is the 82.5º east **longitude** which passes through Allahabad. This is five and a half hours ahead of 0º **meridian** (Greenwich).

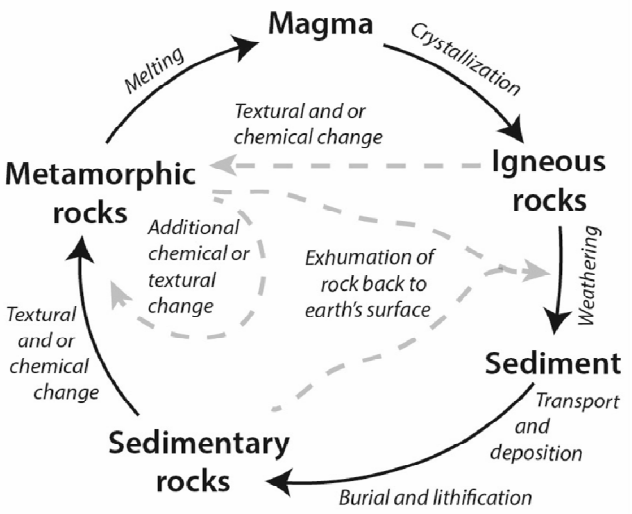
Day Light Saving:

- Many parts of North America and Europe follow what is called Daylight Saving Time (DST).
- It's a practice by which all the clocks in these places are moved forward by an hour during the summer months and brought back during the winter to utilise the long-lasting sunlight in summer and save energy.
- India follows a single time zone of 82.5°E, Northeast region are demanding for a separate time zone as the sun rises as early as four in the morning and in winter it sets by four in the evening.

Rocks

They are aggregates or a physical mixture of one or more minerals. Feldspar and quartz are the most common minerals found in all type of rocks.

The Rock Cycle



Classification of Rocks:

- Igneous rocks
- Sedimentary rocks
- Metamorphic rocks

Types of rocks	Features of the rocks
1.Igneous rocks	• These are primarily **formed** out of **magma** and **lava** and are known as primary rocks. • Granite, gabbro, pegmatite, basalt, etc., are some of the examples of igneous rocks. • **Igneous rocks** are **crystalline** in **structure**. • **Extrusive rocks**: These are formed by rapid **cooling** of the lava thrown **out** during volcanic eruptions. Ex: Basalt - The Deccan traps. • **Intrusive rocks**: Sometimes, the molten matter is not able to reach the surface and **instead** cools **down** very **slowly** at great **depths**. Slow cooling allows big-sized crystals (large grains) to be formed. Granite is a typical example.
2.Sedimentary rocks	• Formed as a result of **denudation** (weathering and erosion). • These deposits through **compaction** turn into rocks. This process is called **lithification**. • Cover 75 per cent of the earth's crust but **volumetrically** occupy **only 5** percent. • These rocks consist of layers in which **fossils** of **plants** and **animals** are present. • Different varieties of sandstone are spread over Madhya Pradesh, eastern Rajasthan, parts of Himalayas, Andhra Pradesh, Bihar and Orissa. Depending upon the mode of formation, they are classified into 1. **Mechanically formed** — sandstone, conglomerate, limestone, shale, loess etc. 2. **Organically formed** — coal, some dolomites, and some limestones, form from the accumulation of plant or animal debris. 3. **Chemically formed** — such as rock salt, iron ore, chert, flint, some dolomites, and some limestones.
3.Metamorphic rocks	• Form under the action of **pressure**, **volume** and **temperature** (PVT) changes. • Metamorphism occurs when rocks are forced down to lower levels by **tectonic or recrystallisation** and **reorganization** of materials. • In the process of metamorphism in some rocks grains or minerals get arranged in layers or lines called as foliation or lineation. **Some Examples of Metamorphism:** $Granite \xrightarrow{Pressure} Gneiss$ $Clay, Shale \xrightarrow{Pressure} Schist$ $Sandstone \xrightarrow{Heat} Quartzite$ $Clay, Shale \xrightarrow{Heat} Slate \xrightarrow{Heat} Phyllite$ $Coal \xrightarrow{Heat} Anthracite, Graphite$ $Limestone \xrightarrow{Heat} Marble$

Note:

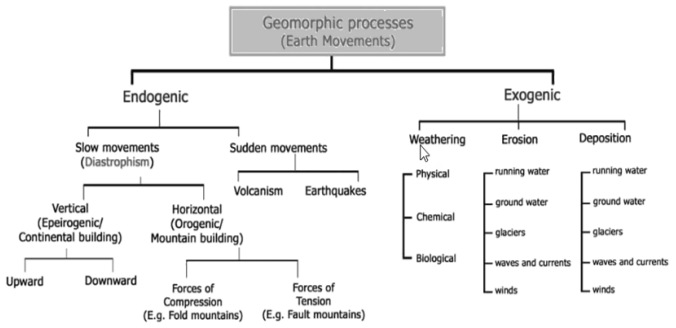
Most Abundant- Igneous > Metamorphic > Sedimentary Rocks.

Geomorphology

- Geomorphology is the study of the physical features of the surface of the earth and their relation to its geological structures.
- **Geomorphic Process** - The formation and deformation of landforms on the surface of the earth are a continuous process which is due to the continuous influence of external and internal forces.

Earth Movements and Landforms:
Earth is undergoing deformations due to,

1. The heat generated by the radioactive elements in earth's interior.
2. Movement of the crustal plates due to Tectogenesis.
3. Forces generated by rotation of the earth.
4. Climatic factors like winds, precipitation, pressure belts etc.



Based on the above diagram we can see earth movements can be majorly classified into,

1. **Endogenetic Movement**
2. **Exogenetic Movement**

1. Endogenetic Movements*:*

- **Movements inside the earth's crust** or interaction of matter and temperature generates these forces.

The earth movements are mainly of two types: **Diastrophism/ slow** and the **sudden movements**.

- The energy emanating **within the earth** by **radioactivity, rotational and tidal forces, friction and primordial heat** from early earth are the main force behind these movements.
- This energy due to geothermal gradients and heat flow from within induces **diastrophism (slow movements)** and **volcanism (sudden movements)** in the lithosphere, thereby causing PVT (pressure, volume and temperature) changes.

Diastrophism/ Slow Movements:

- Diastrophic forces refer to forces generated by the movement of the solid material of the earth's crust.
- All processes like **plate tectonics, orogenisis, epirogenisis, earth quake** etc., that **move, elevate or build up** portions of the earth's crust come under diastrophism.

Epirogenic Or Continent Forming Movements:

- Epirogenic movement is **vertical movement** of the earth along the radius of earth crust.
- It is **continental building process** which involves **uplift** or **warping/subsidence** of large parts of the earth's crust.

Uplift:

- Due to vertical movement of the earth some earth crust emerges there by leading to elevations /upliftment.
- Raised beaches, elevated wave-cut terraces, sea caves and fossiliferous beds above sea level are evidences of uplift.

Ex: The Sierra Nevada in North America, Black Forest Mountains in Germany are examples of uplift mountains. Raised beaches along the Kathiawar, Nellore, and Thirunelveli coasts.

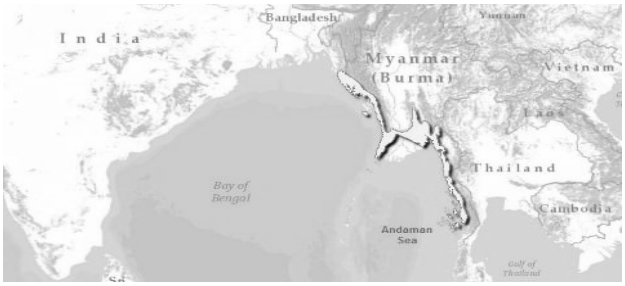
Subsidence:

- Due to vertical movement of the earth some earth crust submerges there by leading subsidence.

Ex: 1. Mammoth cave system in Kentucky, Karst topography in southern china, Andes of South America.

2. Presence of peat and lignite beds below the sea level in Thirunelveliand the Sunderbans is an example of subsidence.

3. The Andamans and Nicobars have been isolated from the Arakan coast by submergence of the intervening land.



Orogenic or the Mountain-Building Movements:

- Orogenic movements are horizontal movements which involves **mountain building** through severe folding and faulting, act **tangentially** to the earth surface.
- These horizontal movements can be through forces of compression and forces of tension.

1. Forces of Compression:

- Are the forces which push rock strata against a hard plane from one side or from both sides. These compressional forces lead to the bending of rock layers and thus lead to the formation of **Fold Mountains.**

  Ex: Himalayas, the Rockies (N. America), the Andes (S. America), the Alps (Europe) etc.

2. Forces of tension:

- Work horizontally, but in opposite directions. Under intense tensional forces, the rock stratum gets broken or fractured which results in the formation of cracks and fractures in the crust. The displacement of rock upward or downward from their original position along such a fracture is termed as **faulting**. Faulting results in rift valleys and block mountains.

  Ex: Vindhya and Satpura Mountains, rift valleys of Nile, Narmada and Tapi etc.

Note: Earthquake and volcanoes are covered in detail later chapters.

Theories of Endogenetic Forces:

Continental Drift Theory:

- This theory was suggested **by Alfred Wegener** in 1920's.
- According to Wegener's Continental Drift Theory, there existed one **biglandmass** which he called **Pangaea** which was covered by one **big ocean** called **Panthalassa**.
- A sea called **Tethys** divided the Pangaea into two huge landmasses: **Laurentia** (Laurasia) to the north and **Gondwanaland** to the south of Tethys.
- Drift started around 200 million years ago (Mesozoic Era), and the continents began to break up and drift away from one another.

Force for Continental Drift:

The drift was in two directions,

1. **Equator wards** due to the interaction of forces of **gravity, pole-fleeing force and buoyancy**
2. **Westwards** due to **tidal currents** because of the earth's motion. Tidal force is due to the attraction of the moon and the sun that develops tides in oceanic waters.

Evidence in support of Continental Drift:

- South America and Africa seem to fit in with each other, especially, the bulge of Brazil fits into the Gulf of Guinea.
- Greenland seems to fit in well with Ellesmere and Baffin islands.
- The west coast of India, Madagascar and Africa seem to have been joined.
- North and South America on one side and Africa and Europe on the other fit along the mid-Atlantic ridge.
- The Caledonian and Hercynian mountains of Europe and the Appalachians of USA seem to be one continuous series.

Criticism:

- Coastlines are a temporary feature and are liable to change.

- Continental Drift Theory shifts India's position too much to the south, distorting its relation with the Mediterranean Sea and the Alps.
- The mountains do not always exhibit geological affinity.

Convectional Theory:

- **Arthur Holmes** in 1930s discussed the possibility of **convection currents in the mantle**.
- These currents are generated due to **radioactive elements causing thermal differences in mantle.**
- According to this theory, the intense heat generated by radioactive substances in the mantle seeks a path to escape, and gives rise to the formation of convention currents in the mantle.
- Wherever **rising limbs** of these currents meet**, oceanic ridges** are formed on the sea floor and wherever the **falling limbs** meet, **trenches** are formed.

Sea Floor Spreading:

- The idea that the seafloor itself moves as it expands from a central axis was proposed by **Harry Hess**.
- Continued with convectional theory ie., intense heat tries to escape leads to convectional current meeting of rising limbs causes ridges and falling limbs trenches.
- Seafloor spreading is a process that occurs at mid-ocean ridges, where new oceanic crust is formed through volcanic activity and then gradually moves away from the ridge.
- Seafloor spreading helps explain continental drift in the theory of plate tectonics.
- When oceanic plates diverge, tensional stress causes fractures to occur in the lithosphere, basaltic magma rises up the fractures and cools on the ocean floor to form new sea floor.
- Older rocks will be found farther away from the spreading zone while younger rocks will be found **nearer to the spreading zone.**

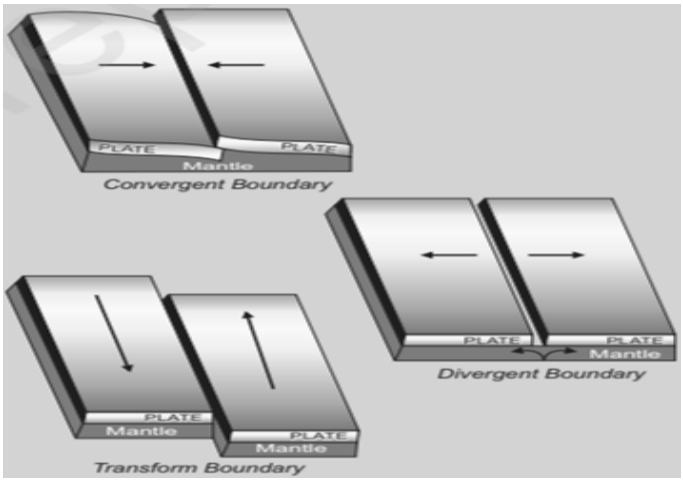
Plate Tectonic Theory:

- In 1967, McKenzie and Parker suggested the theory of plate tectonics.
- According to the theory of plate tectonics, the earth's lithosphere is broken into distinct plates which are floating on asthenosphere (upper mantle). 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.
- Lithospheric plates (crustal plates, tectonic plates) vary from minor plates to major plates, continental plates (Arabian plate) to oceanic plates (Pacific plate), sometime a combination of both continental and oceanic plates (Indo-Australian plate).

Rates of Plate Movement

- The Arctic Ridge has the slowest rate (less than 2.5 cm/yr.), and the East Pacific Rise in the South Pacific [about 3,400 km west of Chile], has the fastest rate (more than 15 cm/yr.).
- Indian plate's movement during its journey from south to equator was one of the fastest plate movements.

Types of Plate Boundaries:



Boundary interaction	Features of the interaction
1.Divergence forming Divergent Edge or the Constructive Edge	• In plate tectonics, a **divergent boundary** or **divergent plate boundary** (also known as a **constructive boundary** or an **extensional boundary**) is a linear feature that exists between two tectonic plates that are moving away from each other. Interaction of this type leads to formation of mid-oceanic trenches and rift valleys. • Earthquakes are common along divergent edges.
2.Convergence forming Convergent Edge or Destructive Edge	• In this kind of interaction, two lithospheric plates collide against each other. The zone of collision may undergo crumpling and folding and folded mountains may emerge. • This is an orogenic collision. **Himalayan Boundary Fault** is one such example. • When one of the plates is an oceanic plate, it gets embedded in the softer asthenosphere of the continental plate and as a result, **trenches** are formed.
3. Transform fault	• Formed when two plates move past each other. • In this kind of interaction, two plates grind against each other and there is no creation or destruction of landform but only deformation of the existing landform. Example: San Andreas Fault (USA).

Convergent boundaries are of 3 types,

1. **Ocean-Ocean Convergent Plate Boundary**
   When two oceanic plates meet and collide against each other, the denser of the two plates is pulled under the other and is subducted. It descends into the asthenosphere leading to generation of new magma. The resulting body of many volcanoes and volcanic rocks is called an **island volcanic arc**.

   Examples of such arcs are Japan, the Philippines, the Tonga Islands, the Aleutian Islands, and the West Indies Islands etc.

2. **Ocean-Continental Convergent Boundary:**
   When an oceanic plate collides with a continental plate, the oceanic plate is always pulled under and subducted because it is denser than the continental plate. When the oceanic plate is subducted under the continental plate, it leads to the generation of new magma, which upwells and forms volcanoes on the non-subducting plate, or the continental plate. The resulting body of such an interaction leads to the formation of continental volcanic arcs.

   The most visible **example** is Andes Mountains off the west coast of the U.S.

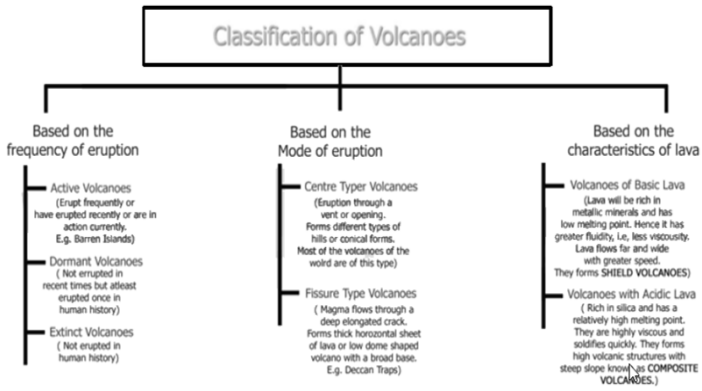
3. **Continent-Continent convergent Boundary**
   When the continent and continent converge, the crust at both the sides is too light and buoyant to be subducted, so neither plate is subducted in continent-continent convergent boundary. Both continental masses press against the other, and both become compressed and ultimately fused into a single block with a folded mountain belt forming between them.
   Example: Himalayas.

Volcanoes

- **Volcanism** includes the movement of molten rock (magma) onto or toward the earth's surface.
- A **volcano** is formed when the molten magma in the earth's interior escapes through the crust by vents and fissures in the crust, accompanied by steam, gases (hydrogen sulphide, sulphur dioxide, hydrogen chloride, carbon dioxide) and pyroclastic material.

Pyroclastic-adjective of or denoting rock fragments or ash erupted by a volcano, especially as a hot, dense, destructive flow.

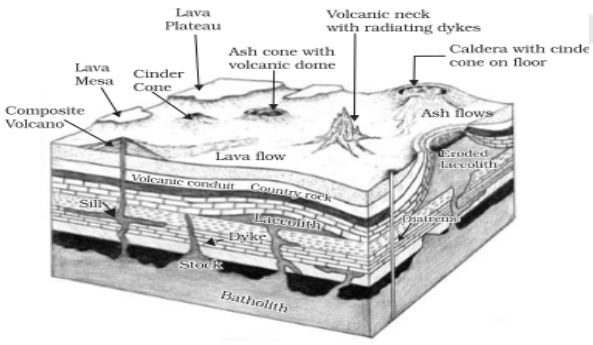
Classification of Volcanoes:



Types of Lava:

1. **Acidic** – light coloured, highly viscous, flow slowly, steep-sided, lead to explosion throwing out pyroclasts or bombs, forming spine or plug at craters.
2. **Basic**– hottest, highly fluid, rich in iron and magnesium, lack silica, dark colour, highly fluid, flow quietly, forms thin sheets and spread over large area forming shield or dome.

Volcanoes are also classified as **Intrusive** and **Extrusive** landforms.



Intrusive Landforms:

Sometimes, the molten matter is not able to reach the surface and instead cools down very slowly at great depths. Slow cooling allows big-sized crystals (large grains) to be formed. Granite is a typical example. These rocks appear on the surface only after being uplifted and denuded.

- Molten magma intrusion horizontally along the bed of sedimentary planes is called **Sills.**
- Molten magma intrusion vertically along the walls of igneous rocks are called as **Dykes**.

Types of igneous intrusions,

1. **Laccolith**- igneous mound with a dome shaped upper surface.
2. **Lopolith-** saucer shaped
3. **Phacolith**-lens shaped mass of igneous rock
4. **Batholith**- huge mass of igneous rock

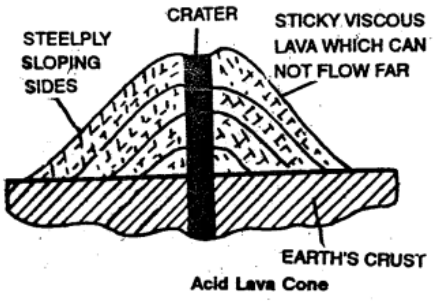
Extrusive Landforms:

hot magma from inside the Earth flows out (extrudes) onto the surface as lava or explodes violently into the atmosphere to fall back as pyroclastics. This is as opposed to intrusive rock formation, in which magma does not reach the earth surface.

Various extrusive landforms are,

- Lava Plains and Basalt Plateaux fluid – Snake basin, USA; Deccan; Iceland
- Lava domes or shield volcanoes – volcanic cones – Mauna Loa and Kilauea.
- Ash and cinder cones – less fluid – large crater and steep slope – small volcano in groups – Mt. Nauvoo (Naples) and Mt. Paricutin (Mexico) Lava tongues and lava dammed lakes – confined in valleys Lava bridges .
- Lava tunnels
- Volcanic dust – fine particles.
- Dust and Ash – black snow.

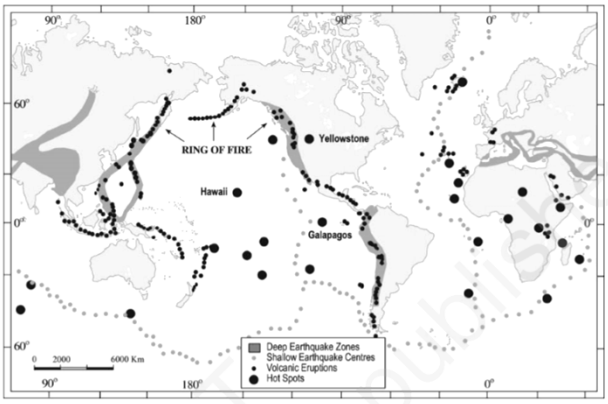
Composite Cones are most commonly called as Stratocones with main conduit and subsidiary dykes and pipes.



- Mt. Etna (Sicily, Italy) best example of parasitic cone.
- Interesting composite volcano-Mt. Stromboli (Lighthouse of Mediterranean).

Distribution of Volcanoes:

- Circum-Pacific ring of fire or Pacific ring of fire includes2/3rd of world volcanoes. Although there are a few active volcanoes found along the Atlantic, Mediterranean costs.



Geyser and Hot Springs:

- **Geyser** – fountain of hot water and superheated steam from earth beneath in which water is heated beyond boiling point with explosion.
- World major geyser are concentrated in Iceland, Rotorua (N. Island, New Zealand), Yellowstone National Park (USA) – Old Faithful world's best known geyser.
- **Hot Springs or thermal springs** – water rises to the surface without any explosion and consist of dissolved minerals. Ex: Hawaii and Japan.

Earthquakes

- An earthquake is the shaking or trembling of the earth's surface, caused by the sudden movement of a part of the earth's crust resulting in release of energy that creates seismic waves.
- It occurs when the surplus accumulated stress in rocks in the earth's interior is relieved through the weak zones over the earth's surface in form of kinetic energy of wave motion causing vibrations (at times devastating) on the earth's surface.
- **Focus** - The place of origin of an earthquake inside the earth.
- **Epicentre** - Point on the earth's surface vertically above the focus. Maximum damage is caused at the epicentre.
- **Wave Velocity** - 5 to 8 km per second through the outer part of the crust but travel faster with depth.
- **Isoseismic Line** - A line connecting all points on the surface of the earth where the intensity is the same.
- Earth quake magnitude is measured by **Richter scale**, intensity is measured by **Mercalli.**

Causes:

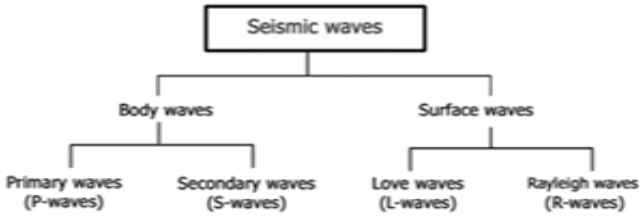
1. Compressional or tensional stresses built up at the margins of the huge moving lithospheric plates.
2. Sudden release of stress along a fault, or fracture in the earth's crust.
3. Constant change in volume and density of rocks due to intense temperature and pressure in the earth's interior.
4. Human induced earth quake

Earthquake Waves:

- Seismic waves are produced when some form of energy stored in Earth's crust is suddenly released, due to slipping of land, these waves will travel in all directions.

Types of Seismic Waves

- Earthquake waves are 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.
- Body waves interact with the surface rocks and generate new set of waves called **surface waves**, these waves move along the surface and are also more destructive (Rayleigh) than body waves

Body Waves:

There are **two types of body waves -**

1. **Primary waves or P waves** (longitudinal)

- Also called as the longitudinal or compressional waves.
- Analogous to sound waves.
- Particles of the medium vibrate along the direction of propagation of the wave.
- P-waves move faster and are the first to arrive at the surface.
- These waves are of high frequency.
- They can travel in **all mediums**.
- Velocity of P waves in Solids > Liquids > Gases.
- Their velocity depends on shear strength or elasticity of the material.

2. **Secondary waves or S waves** (transverse)(least destructive).

- Also called as transverse or distortional waves.
- Analogous to water ripples or light waves.
- S-waves arrive at the surface with some time lag.
- A secondary wave cannot pass through liquids or gases.
- These waves are of high frequency waves.
- Travel at varying velocities (proportional to shear strength) through the **solid** part of the Earth's crust, mantle.

Surface Waves:

1. **L waves:**

- Confined to the surface of the crust, Love waves produce entirely horizontal motion. They are much slower than body waves but are faster than Rayleigh.

2. **Rayleigh waves:**

- These waves follow an elliptical motion.
- A Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean. Because it rolls, it moves the ground up and down and side-to-side in the same direction that the wave is moving.
- Most of the shaking felt from an earthquake is due to the Rayleigh wave.

Earthquakes and Plate Tectonics:

- As per Plate tectonics earthquakes are a consequence of inter-plate interaction, along the **convergent boundary. Compressive forces** crush and cause earthquakes, while along **divergent boundary tensile forces** stretch and snap the earth creating earthquakes.
- Earthquakes can also be due to plate motions and the friction of lithospheric plates while they drift along asthenosphere.
- **Divergent boundaries and convergent boundarie**s between two continental plates will only have **shallow focus earthquake.**
- **Intermediate and deep focus earthquakes** are almost entirely limited to **ocean floor subduction**.

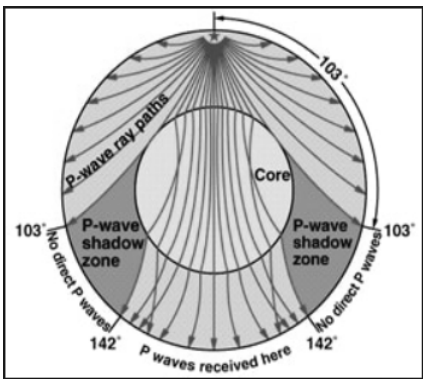
Propagation of Earthquake Waves in Earth's Interiors:

- The velocity of waves changes as they travel through materials with different elasticity. The more elastic the material is the higher is the velocity. Their direction also changes as they reflect or refract when coming across materials with different densities.
- **P-waves** vibrate **parallel** to the direction of the wave. As a result, it creates density differences in the material leading to stretching and squeezing of the material.
- 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.

Emergence of Shadow Zone:

The seismic shadows are the effect of seismic waves striking the core-mantle boundary. *P* and *S* waves radiate spherically away from an earthquake's **hypocenter** (or focus) in all directions and return to the surface by many paths. *S* waves, however, don't reappear beyond an angular distance of ~103° (as they are don't pass through

liquid material) and *P* waves don't arrive between ~103° and 140° due to refraction at the mantle-core boundary.



Distribution of Earthquakes:

- Coincides with volcanoes distribution

Exogenic Movements:

- Exogenic processes are a direct result of stress induced in earth materials due to various forces that come into existence due to sun's heat.
- Earth materials become subjected to **molecular stresses** caused due to **temperature changes**.
- **Chemical** processes normally lead to **loosening of bonds** between grains.
- **Temperature and precipitation** are the two important climatic elements that control various processes by inducing stress in earth materials.
- **Denudation-** the process of wearing away the earth that causes general lowering and levelling out of the surface.

Denudation Involves 4 Processes:

1. **Weathering-** gradual disintegration of rocks by atmospheric or weather forces.
2. **Erosion –** active wearing of earth surface by agents like water, wind, ice etc.
3. **Transportation-** removal of eroded debris to new positions.
4. **Deposition –** dumping of debris in certain parts of earth.

- Warm wet climate promotes rapid chemical weathering while dry climate provide good conditions for physical weathering.

Chemical Weathering:

- Extremely slow and gradual decomposition of rocks due to exposure to air and water
- Regolith **-** mineral remains of decomposed rocks.
- When a soil cover on the rock exists, chemical weathering of the rock enhances because the soil absorbs rain water and keeps the underlying rock in contact with this moisture.

Types of Chemical Weathering:

1. **Solution**

- Many minerals are dissolved by water especially with rain water which contains enough carbon dioxide to make it a weak acid.

Ex: in limestone region, rocks made of calcium carbonate get dissolved in rain water, widening joints resulting in crumbling of rocks.

2. **Oxidation:**

- Weathering by reaction of oxygen in presence of air and water with minerals present in the rock.
- Ex: rocks contain certain amount of iron, which in contact with air changes into iron oxide leading to rust.

3. **Decomposition by Organic Acids**

- Soils consist of certain bacteria which thrive on the rock surface, they produce acids when dissolved in water.
  Ex: Microorganisms, mosses or lichens.

Physical Weathering:

- Also known as Mechanical Weathering, it is physical disintegration of rocks.

Types of Physical Weathering,

1. **Temperature Changes**

- Mainly in dry desert areas, hot at day and cold by night, Leads to expansion and contraction of rock setting up stresses in the rock. Finally leading to its disintegration.

2. Repeated Wetting and Drying

- Stresses are naturally greatest near the surface and where there are sharp angles in the rock, finally it leads to peeling off of rock's outer layer called as exfoliation.
- Exfoliation also takes place by repeated wetting and drying of rocks surface as during wetting its outer layer absorbs moisture and expand; when they dry this moisture evaporates and they quickly shrinks, finally leading to peeling of outer layer of the rock.

3. Frost

- At high altitudes and cold climates where during day cracks and joints inside rock fill with water and during night they get frozen. With repeated freeze /thaw cycles, rock breaks into pieces.

4. **Biotic Factors**

- Vegetation grows into crevices of rock cracks or in courtyards as plant grows roots penetrate weaken the rock.

Mass Movement:

- Movement of weathered material down the slope due to gravitational forces
- Movement can be slow or sudden, depending on the slope gradient, weight of debris and lubricating moisture supplied by rainwater.

Types of mass movements are,

1. Soil creep

- Slow and gradual process continuous movement of downhill slopes.
- Common in damp soils where water act as lubricant.

2. Soil Flow:

- Soil is saturated with water and individual particles are suspended in water, they start moving like a liquid.

3. Landslides (Slumping and Sliding):

- Occur on steep slopes, slope undercut by river or sea or by lubricating action of rain water.
- Slumping is permeable layer overlie over impermeable clay, which acts as a slippery surface.

Ground Water:

- Hydrological cycle is process of circulation of water between land, sea and atmosphere.
- Ground water plays major role in weathering and mass movement.

Volume of ground water depends on climate,

- **Dry climate** – precipitation is evaporated quickly and little moisture percolate into ground.
- **Humid areas** – most water runs off and sinks into ground.
- **Porous Rocks** – sandstone – many pore spaces exists (water is absorbed and stored)
- **Permeable or pervious rocks** - allow water to pass through them.
- **Impermeable** – Clay is highly porous as made of many fine particles but spaces are very smalland particle cannot move.

Water Table:

- Water moves down by gravity and reach impermeable layer through which it cannot pass. If no outlet is there, water accumulates above impermeable rocks and saturates the rocks. Water store in the permeable rock is known as **aquifer.** Surface of saturated area is called water table.
- Water table is far below surface in hill tops but close to surface in valleys and flat low lying areas causing water logging.

Springs

- A **spring** is a point at which water flows from an aquifer to the Earth's surface. It is a component of the hydrosphere.
- Minerals become dissolved in the water as it moves through the underground rocks. This is why spring water is often bottled and sold as mineral water.

Wells

- Hole is bored until it reaches water table of permanent depth with continuous flow of water.

- Aquifer is saturated to the brim of the basin. Water is trapped in the aquifer under pressure and when well is bored, pressure of water downwards forces the water up the bore hole to gush as fountain. After sometime pressure decreases and pumping is not required.
- This water is **unsuitable** for agriculture as it is hot and contains lots of mineral salts.

Islands and Coral Reefs

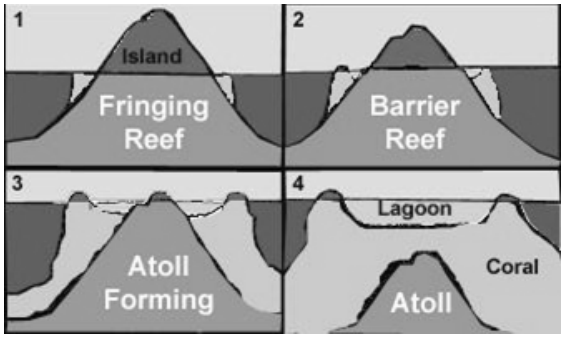
- Land surrounded by water on all sides, may occur individually or in group called as islands.

Coral Reefs:

- Coral Polyps – calcareous algae, shell forming creatures and lime secreting plants live in large colonies. When polyp die, skeleton are cemented into coralline limestone.
- Non reef building species – precious coral of Pacific Ocean & Red coral of Mediterranean Sea.
- Conditions for coral formation-

1. Survive best in warmer tropical seas.
2. Water temperature must not be below 68°F.
3. Not flourish in cold currents due to upwelling of cold waters from depth that cools the warm water surface.
4. Depth of water should not exceed 30 fathoms or 180 feet as beyond it sunlight is too faint.
5. Shallow water of less than 100 feet is ideal.
6. Water should be saltish and free from sediments - corals are best developed on seaward side of reef – abundant supply of clear oxygenated water.

Types of Coral Reefs:



1.Fringing Reefs: Lies close to coast and extend outwards from mainland separated by shallow lagoon – widest when fringing protruding headland but absent when facing mouth of stream.

2. Patch Reef: Patch Reefs are isolated outcroppings (patches) of coral that are in close proximity to each other but are physically separated by sand rings.

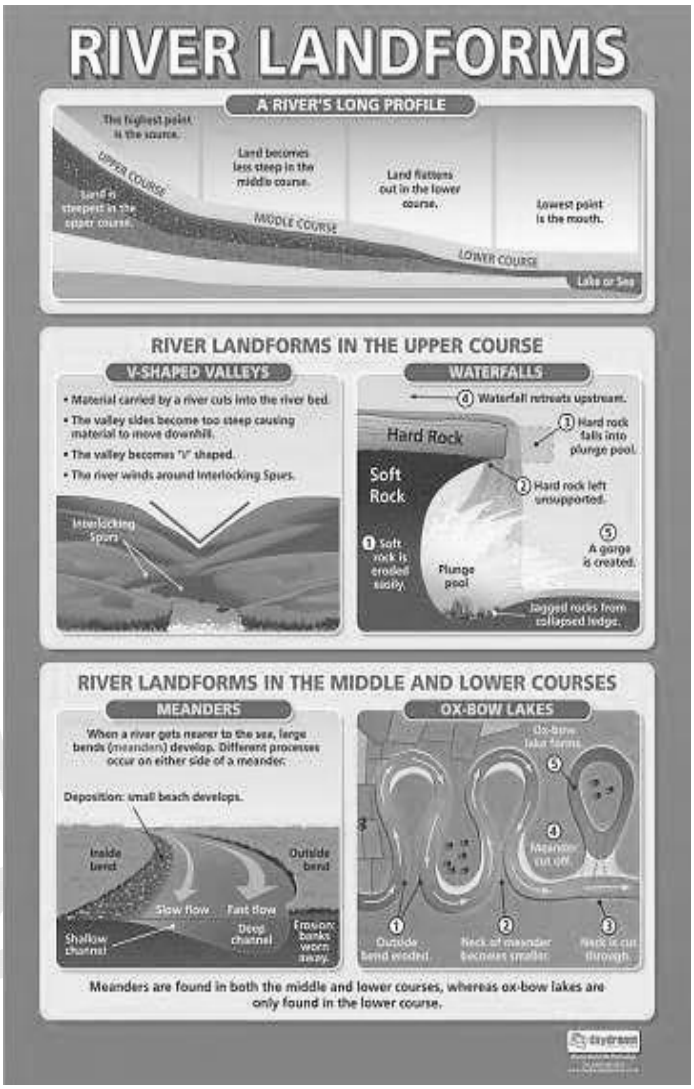
3. Barrier Reefs: Separated by wider and deeper channel – partially submerged has narrow gaps at several places to allow water. Great Barrier Reef off the coast of Queensland.

4. Atolls: Circular and enclose shallow lagoon without any land in centre.

Landforms

Landforms Created by Running Water: Course of a River

The young stage	• Predominant action is vertical corrosion (**corrosion**- it is the gradual destruction of materials by chemical and/or electrochemical reaction with their environment). • Gorges and canyons are formed during this stage (A **canyon** or **gorge** is a deep cleft between escarpments or cliffs resulting from weathering and the erosive activity of a river). • **River capture**- river capture is natural diversion of the headwaters of one stream into the channel of another, typically resulting from rapid head ward erosion by the latter stream). • **Rapids, cataracts and waterfalls**- **Rapids** are stream sections with extremely strong currents, numerous obstacles, and steps in their streambeds. A **waterfall** is a vertical drop in a streambed. Both are sites of vigorous erosion. Rapids often form where resistant bedrock confines a stream to a narrow channel, and forces an increase in water velocity.
Middle or valley course	• **Meanders** -a winding curve or bend of a river. • River cliffs and slip-off slopes.
Lower or plain course	• **Flood plains**- An area of low-lying ground adjacent to a river, formed mainly of river sediments and subject to flooding. • **Ox-bow lakes**- it is a U-shaped lake that forms when a wide meander from the main stem of a river is cut off, creating a free-standing body of water. • **Delta**- a triangular tract of sediment deposited at the mouth of a river, typically where it diverges into several outlets.



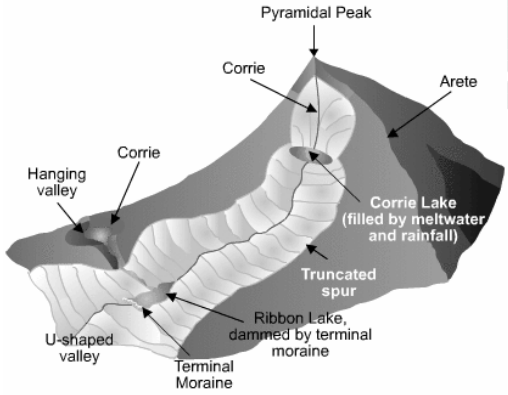
Landforms of Glaciations: Glaciers

- A glacier is a large, perennial accumulation of crystalline ice, snow, rock, sediment, and often liquid water that originates on land and moves down slope under the influence of its own weight and gravity.
- Only two major ice caps are present today- Antarctica and Greenland
- At the foot of the mountain glacier, several glaciers may converge to form an extensive ice-mass called **piedmont glacier**

Landforms of Glaciations:

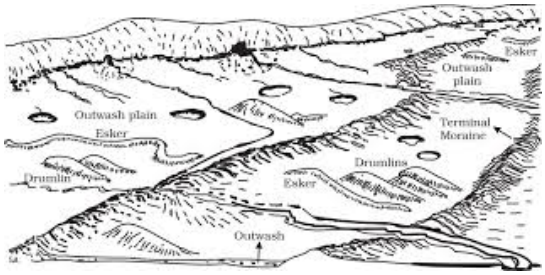
1. Corrie, cirque	It is a **depression** where snow accumulates
2. Aretes and pyramidal peaks	When two **corries** cut back on each other, knife-edged ridges are formed called arêtes
3. Bergschrund	At the head of a glacier when snow begins to leave the corrie, a deep vertical crack

	opens up called **bergschrund**
4. U-shaped glacial trough	A **U-shaped valley** is a geological formation characterized by high and steep sides and a rounded or flat valley bottom. **U-shaped valleys** are located all over the world, particularly in areas with high mountains, as this is where glaciers were able to form. Some examples of U-shaped valleys include Zezere Valley in Portugal, Leh Valley in India, and Nant Francon Valley in Wales.
5.Hanging valleys	**Hanging valleys**- it is a characteristic U-shape valley above their respective main valleys, and have a steep wall at the point where the two valleys meet. These valleys are found in regions of high altitude, particularly in mountainous regions. The valleys are natural crevices through which rivers flow, and at the cliff meeting point where the two valleys meet the rivers dramatically drop to form waterfalls.
6. Moraines	**Moraines** are formed from debris previously carried along by a glacier. Lateral **moraines** are formed at the side of the ice flow and terminal **moraines** at the foot, marking the maximum advance of the glacier.



Landforms of Glaciated Lowlands:

1.Roche mountains	It is glaciated bedrock surface, usually in the form of rounded knobs.
2. Craig and tail	**Craig** is a rocky hill or mountain, generally isolated from other high ground.
3. Boulder clay or glacial till	**Boulder clay** containing many large stones and boulders, formed by deposition from melting glaciers and ice sheets.
4. Erratic	An **erratic** is a piece of rock that has been eroded and transported by a glacier to a different area.
5. Drumlins	**Drumlins** are elongated, teardrop-shaped hills of rock, sand, and gravel that formed under moving **glacierice**.
6. Eskers	**Esker** is a long, winding ridge of stratified sand and gravel.
7. Outwash plains	It is a **plain** formed of glacial sediments deposited by melt water **outwash** at the terminus of a glacier.



Arid or Desert Landforms:

- Almost all deserts lie between 15 to 30 degree north and south of the equator.
- They lie in trade wind belt on the western part of the continents where trade winds are off-shore. They are bathed by cold currents. These currents are devoid of any moisture.

Distinct Desert Types:

1. Hamada or rocky desert	It is a type of **desert** landscape consisting of high, largely barren, hard rocky plateaus, where most of the sand has been removed by deflation.
2. Reg or stony desert	**Desert** surface covered with closely packed, interlocking angular or rounded rock fragments of pebble and cobble size.
3. Erg or sandy desert	An **erg desert** is a broad, flat area of desert covered with wind-swept sand with little or no vegetative cover.
4. Badlands	***Badlands*** are a type of dry terrain where softer sedimentary rocks and clay-rich soils have been extensively eroded by wind and water.
5. Mountain deserts	Found on plateaus and mountain ranges. **Steep slopes**, **sharp** and **irregular peaks** are common.

Landforms of Wind Erosion in Deserts:

1. Rock pedestals or mushroom rocks or gour	A **mushroom rock**, also called **rock** pedestal, is a naturally occurring **rock** whose shape, as its name implies, resembles a **mushroom**, by erosion and weathering.
2. Zeugen	A **Zeugen** is formed in desert area where alternating horizontal layers of hard and soft rocks occur.
3. Yardangs	a sharp irregular ridge of sand lying in the direction of the prevailing wind in exposed desert regions, formed by the wind erosion

	of adjacent material which is less resistant.
4. Mesas and buttes.	A **mesa** is an isolated, flat-topped hill or mountain with steep sides that is smaller in area than a plateau. A **butte** is also a flat-topped hill with steep sides, though smaller in area than a mesa.
5. Inselberg	An **inselberg** or **monadnock** is an isolated rock hill, knob, ridge, or small mountain that rises abruptly from a gently sloping or virtually level surrounding plain.
6. Ventifacts	a stone shaped by the erosive action of wind-blown sand.
7. Deflation hollows	**Dune deflation hollows** are where wind has removed sand down to a level where a layer of particles too heavy for the wind to move stabilizes the sand and prevents the surface being lowered further.

Landforms of Wind Deposition in Deserts:

1. Sand dunes	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	The surface 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.

Limestone and Chalk Landform:

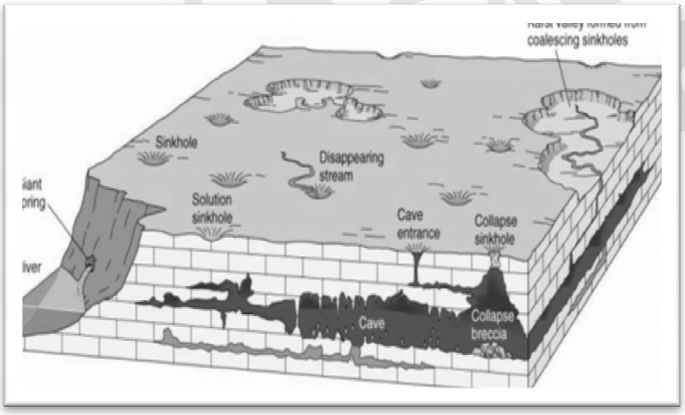
- Limestone and chalk are sedimentary rocks of organic origin derived from the accumulation of corals and shells in the sea. In its pure state, limestone is made up of calcite or calcium carbonate, but where magnesium is also present it is termed dolomite.
- Chalk is a very pure form of limestone, white, and rather soft.
- Limestone is soluble in rain-water, which, with carbon dioxide from the air, forms a weak acid. A region with a large stretch of limestone therefore possesses a very distinct type of topography. It is then termed a karst region.

Karst Region Characteristics:

Karst regions have a bleak landscape. There is general absence of surface drainage as most of the surface water has gone underground. For the greater part of their course, they cut their way along the joints and fissures of the rock wearing out a system of underground channels.

1. Limestone pavement	A **limestone pavement** is a flat expanse of exposed **limestone** formed by a combination of chemical weathering and erosion.
2. Grikes and clints	Pavements are made up of two separate but integral parts known as clints and grykes. **Clints** are the blocks of limestone

	that constitute the paving. **Grykes** are the fissures that isolate the individual clints.
3. Swallow holes	They are small depressions carved out by solution where rain water sinks into the limestone at the zone of weakness. It is also known as sinkholes.
4. Limestone gorges	These are created where the roof of a large underground cavern collapses, to create a steep sided gorge with a river running in the bottom.
5. **Resurgence**	When water flows down a swallow hole it flows underground along bedding planes and down joints.
6. Uvala	a closed karst depression, a terrain form usually of elongated or compound structure and of larger size than that of sinkholes.
7. Polje	It is an **elongated basin** having a flat floor and steep walls.
8. Stalacites	A ***stalactite*** is a type of formation that hangs from the ceiling of caves.
9. Stalagmites	A ***stalagmite*** is a type of rock formation that rises from the floor of a cave due to the accumulation of material deposited on the floor from ceiling drippings.



Coastal Landforms:

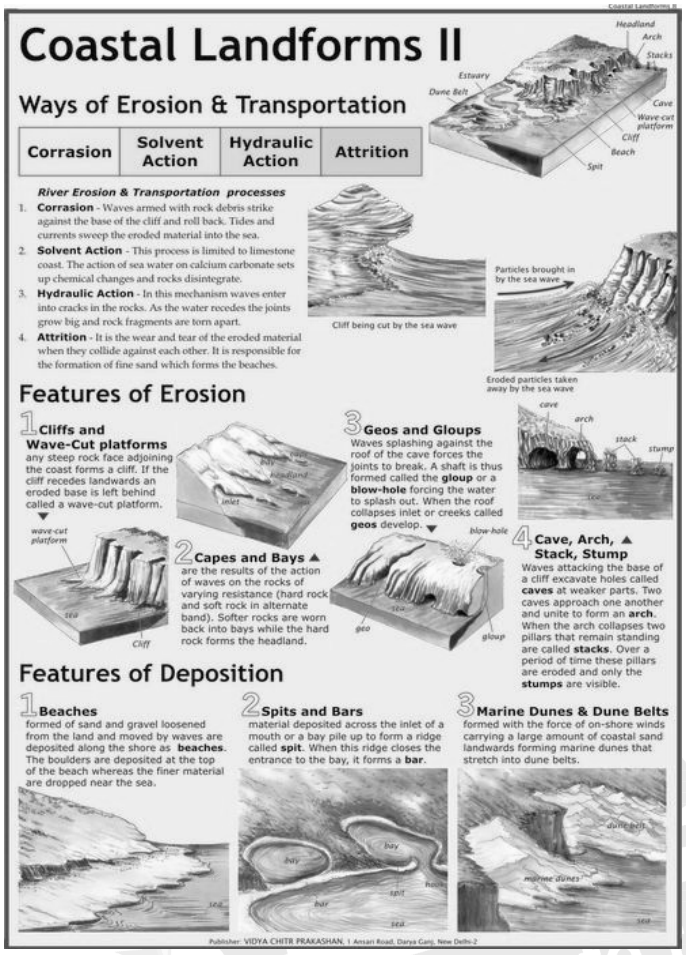
Coastal landforms, any relief features present along the coast.

Coastal features of Erosion:

1. Capes and bays	**Cape** is a piece or point of land, extending beyond the adjacent coast into a sea or lake. **Bay** is a body of water (especially the sea) more or less three-quarters surrounded by land.
2. Cliffs and wave cut platforms	**Cliffs** are formed as erosion landforms by the processes of weathering and erosion. Cliffs are usually formed by rock that is resistant to weathering and erosion. **Wave-cut platforms** form when destructive **waves** hit against the **cliff** face, causing an undercut between the high and low water marks, mainly as a result of abrasion, corrosion and hydraulic action, creating a **wave-cut** notch.
3. Cave, arch, stack and stump	**Caves** occur when waves force their way into cracks in the cliff face. The water contains sand and other materials that grind away at the rock until the cracks become a cave. If the cave is formed in a headland, it may eventually break through to the other side forming an **arch**. The arch will gradually become bigger until it can no longer support the top of the arch. When the arch **collapses**, it leaves the headland on one side and a **stack.** The stack will be attacked at the base in the same way that a wave-cut notch is formed. This weakens the structure and it will eventually **collapse** to form a **stump**.
4. Geous and gloups	**Geous** is an inlet, a gully or a narrow and deep cleft in the face of a cliff. **Gloupsa** blow hole, where a chimney has developed behind the cliff face, often above a cave, and spray is blasted out during high seas.

Coastal Features of Deposition:

1. Beaches	A **beach** is a landform alongside a body of water which consists of loose particles of rock, sand etc
2. Bars and spits	A **spit** is an extended stretch of beach material that projects out to sea and is joined to the mainland at one end. When the ridge of shingle beach which is armoured with pebbles is formed across the mouth of a river or the entrance to a bay it is called as **bar**
3. Marine dunes and dunes belt	With the force of on-shore winds, a large amount of coastal sand is driven landwards forming extensive marine dunes that stretch into dune belts



Types of Coasts:

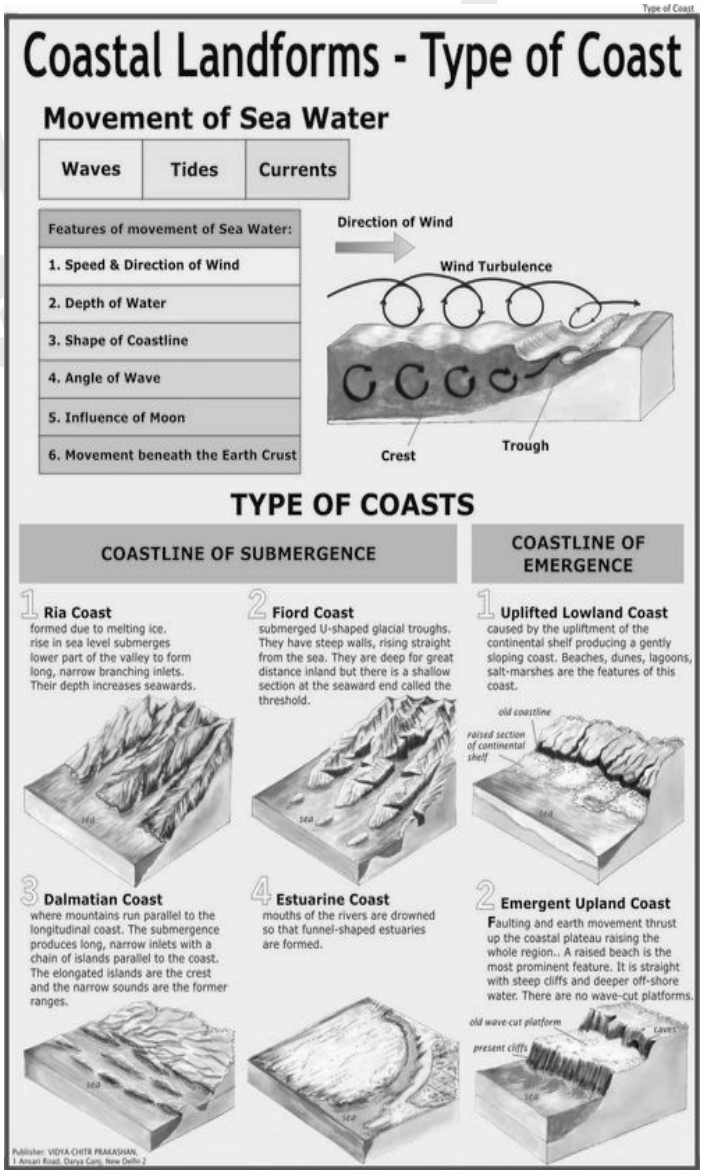
1. Coastlines of submergence	**Submergent Coasts** are those that have been flooded by ocean waters because of a relative rise in the elevation of sea level at that location.
2. Coastlines ofemergence	**Emergent coasts** are a result of local tectonic uplift of the land surface or a fall in the elevation of sea level because of a reduction in the water volume of ocean basins. Quite often, emergent coasts have rocky coastlines with cliffs and nearly flat platforms that extend inland where older coastal plains have been tectonically raised and are now elevated above the modern land and water interface.

Coastlines of Submergence:

1. Ria coasts	**Ria** is a coastal formation that was once a river valley. It is found along an un-glaciated land.
2. Fiord coasts	**Fiords** are submerged U-shaped glacial troughs. They mark the paths of glaciers that plunged down from the highlands.
3. Dalamation coasts	It a type of **coastline** formed when a continental fold region is submerged but its terrain basically preserves its correspondence to the tectonic structures.
4. Estuarine coasts	An **estuary** is a partially enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and with a free connection to the open sea.

Coastlines of Emergence:

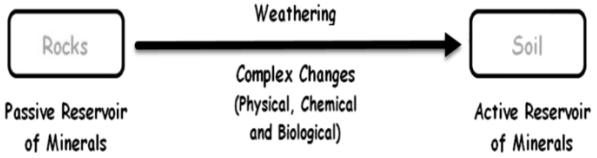
1. Uplifted lowland coast	The uplift of the continental shelf produces smooth, gently **sloping coastallowland**. The offshore waters are shallow with lagoons, salt-marshes and mud-flats
2. Emergent upland coast	Faulting and earth movement may thrust up coastal plateau so that the whole region is raised with consequent emergent features. A **raised beach** is the most significant example.



Soil

Soil Formation:

- Soil is a mixture of organic matter, minerals, gases, liquids, and organisms that together support life.
- It is usually formed from weathered rock or regolith changed by chemical, physical and biological process.



Soils Main Constituents:

- **Mineral Material** – It includes all minerals inherited from the parent material as well as those formed by recombination from substances in the soil solution.
- **Organic Matter** – It is derived mostly from decaying plant material broken down and decomposed by the actions of animals and microorganisms living in the soil. (Note: The end product of breakdown of dead organic material is called humus).
- **Air and Water**: They fill the voids in soil. Hence have reciprocal relationship since both compete for the same pore spaces.

Soil formation Process:

It involves 5 Main Processes:

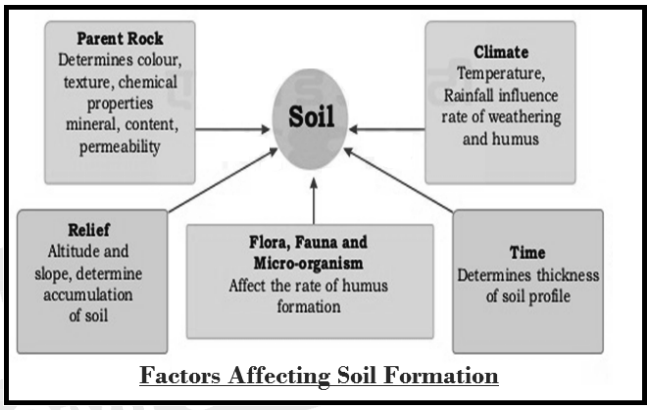
1. **Additions**: Most additions occur at the surface. The obvious ones include solar energy, water controlled by climate, and organic material derived principally from the vegetation.
2. **Losses:** Losses occur both from the surface and from the deep subsoil. Materials suspended or dissolved in water are the main forms of losses from the subsoil e.g. leaching.
3. **Translocation**: It refers to the physical movement of material within the soil. The material can be in the solid, liquid or gaseous form

For instance:

- Clay, organic matter and iron and aluminium hydrous oxides are commonly moved from the surface horizon to a subsurface horizon.
- Very dry climates salts are moved upwards in solution by capillarity
- Very cold climates solid mineral fragments are moved upwards by frost action.

4. **Transformation:** Involves the change of soil constituent without any physical displacement. Chemical and physical weathering and the decomposition of organic matter are included here.
5. **Organisms:** Organism, both plant and animal, play an important role in the development and composition of soil. Organisms add organic matter, aid decomposition, weathering and nutrient cycling.

Factors Controlling Soil Formation:



Factors Affecting Soil Formation

1. Parent Material:

- In most of the cases, the parent material determines the colouration, mineral composition and texture of the soil.

2. Climate:

- Temperature and rainfall are the most important factors in soil formation. They determine the effectiveness of weathering of the parent material.

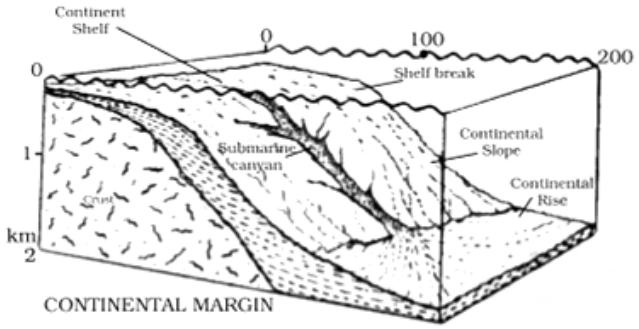
3. Topography:

- The relief is the most important factor for soil formation.
- Soil erosion on barren slopes is rampant and it hinders soil formation. Example: Chambal ravines, higher reaches of Himalayas where there is minimal or no forest cover (most on the steep southern slopes) etc.
- The areas of low relief or gentle slope generally experience deposition and have deep soils. Example: Indo-Gangetic plain.
- The exceptions in the plateau are river basins where the soil layers are sufficiently deep.

Oceanography

- **Oceans:** 70% or 140 million square miles area is comprised by oceans.
- **Oceanography:** Science of oceans and deep seas.

Relief of Oceans:



Continental Shelf:

- Seaward extension of continent from shoreline marked by 100 fathom.
- Shallowness enables sunlight to penetrate through the water and encourage growth of plants –**rich in plankton** and are **richest fishing grounds** in world – Grand banks off New found land, North Sea and Sunda Shelf.
- Limited depth and gentle slope keep out cold under current and increase height of tides. Greatest seaports like Southampton, London, Hamburg, Rotterdam, Hong Kong are on continental shelves.

Continental Slope:

- At the edge of continental shelf, abrupt gradient change 1 in 20.

Deep Sea Plain (abyssal plain)

- Undulating plain lies 2-3 miles below sea level and cover 2/3rd of ocean floor. Ithas plateau, ridges, trenches and basins in midst of oceans.

Deeps / Trenches:

- Trenches are narrow and steep sides depressions
- Trenches are formed when two plates of the Earth crust are moving together and one is being pushed down below the other.

Ex: Marina trench (challenger deep) is the deepest trench in the world situated in the North West pacific ocean near Philippines, is more than 11 km deep.

Oceanic Ridges:

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

Sea Mounts and Guyots:

- A ridge rising more than 1000 m above the ocean floor is called sea mount. Flat topped sea mounts are called Guyots.

Submarine Canyons:

- Submarine canyons are the deep gorges on the ocean floor and are restricted to the continental shelves, slopes, and rises.

Ocean Deposits:

- **Muds**: **Terrigenous deposits from land** deposited on continental shelf – blue, green or red muddepending on chemical content.
- **Oozes**: **Pelagic deposits form oceans** – shelly and skeletal remains of marine micro organisms with calcium or silica – have fine flour like texture.
- **Clays**: Mainly as red clay in deeper oceans due to accumulation of volcanic dust.

Salinity

- Degree of saltness in water.
- NaCl or common salt form 77% of dissolved mineral matter. Other salts include magnesium, calcium, potassium.
- Due to free movement, salts remain remarkably constant in all oceans and even at great depths– but degree of concentration varies.
- Average salinity is 35.2 parts per thousand.
- **Baltic Sea** (dilution of fresh water) – salinity is 7 parts per thousand.
- **Red Sea** – much surface evaporation and fewer rivers draining into it – salinity is 39 parts per thousand
- **Caspian Sea** – enclosed sea with salinity at 180
- **Dead Sea** it is around 250.

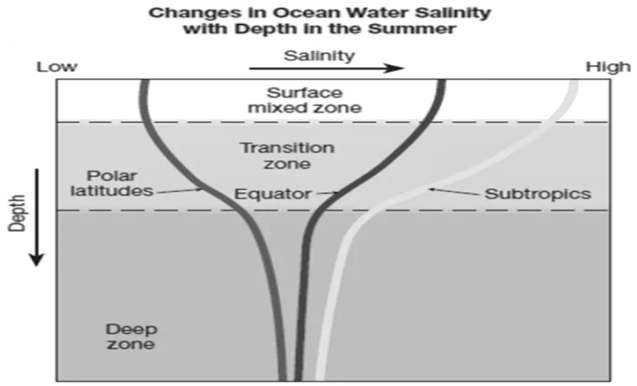
- **Lake Van** (Asia Minor) at 330 highest salinity.
- With high density in Lake Van and Dead Sea it is impossible to sink (beginner swimmers find it easier to float).

Salinity is Affected by:

1. **Rate of evaporation**: water fringing the High pressure belts of trade wind deserts have High salinity caused by high temperature and low humidity.

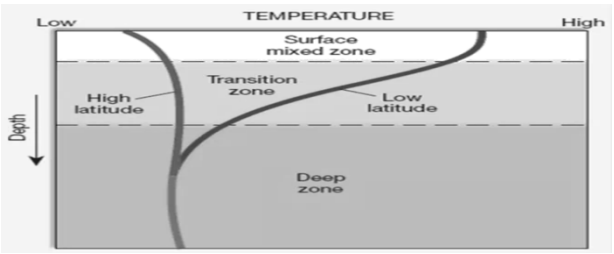
   Temperate oceans have low salinity due to lower evaporation & temperature.
2. **Fresh water is added by precipitation, streams and icebergs** – salinity is low in equatorial region due to heavy rainfall and high relative humidity.

   Baltic, Arctic and Antarctic waters have low salinity due to colder climate and little evaporation – as water is added by melting of icebergs and rivers.
3. **Degree of water mixing by currents**: Water does not mix freely with ocean waters in enclosed seas and salinity is high.



Temperature of Oceans:

- Annual range of temperature is much smaller – less than 10°F for open seas.
- **Cold current** as Labrador current **reduces surface water temperature**. **Warm current** like North Atlantic Drift **raises the temperature** making Norwegian coast ice free year round.
- Highest water temperature are seen in tropics – Red Sea with 85°F to 100°F.
- Temperature varies vertically with increasing depth 80% ocean waters have temperature 35°F to 40°F.



Movements of Ocean Currents:

- Circulate in regular pattern. Warm current flow from equatorial region to poles. Cold Currents flow from Polar Regions to equator and have low surface temperature.

Underlying factors

1. **Planetary Winds**:
- Trade winds which move equatorial waters poleward and westwards and warm eastern coast of continents. Ex: South Equatorial Current warms eastern coast of Brazil as warm Brazilian current.
- Westerlies in temperate are less reliable than trade Winds – result in north-easterly flow of water in north hemisphere, so Gulf Stream is driven to Western Europe.

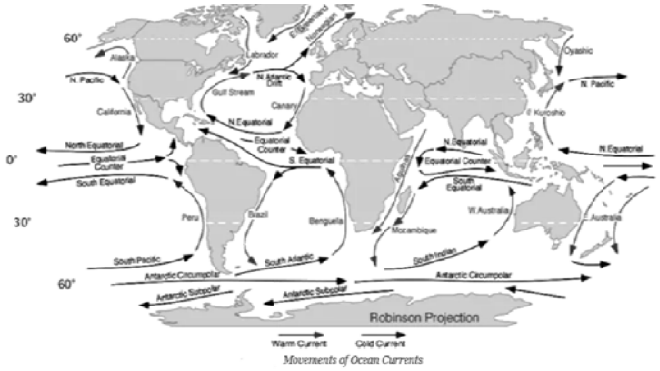
2. **Temperature:**
- **Warm water** are **lighter and rises** while **cold water** is **denser and sinks.**

3. **Salinity**:
- Water of high salinity are denser than water of low salinity. Low salinity water flow on surface of waters. High salinity water flows at the bottom.

4. **Earth's Rotation**:
- It deflects freely moving objects including ocean currents to right. In **north hemisphere it is clockwise** (Gulf Stream and Canaries Current) while in **south hemisphere it is anti-clockwise** (Brazilian current and West Wind drift).

5. **Land**:
- Landmass obstructs and diverts a current.
  Ex: tip of south Chile diverts West wind Drift northward as Peruvian current.

Major Ocean Currents of the World:



Movements of Ocean Currents

Warm Currents:

Name	Ocean	Description
Agulhas Current	Indian	The **Agulhas Current** is the western boundary current of the southwest Indian Ocean. It flows down the east coast of Africa.
Alaska Current	North pacific ocean	Southwestern warm water current off the coast of Alaska and west coast of Canada.
Brazil Current	South Atlantic ocean	Flows south along the Brazilian south coast to the mouth of the Río de la Plata.
East Australian Current	South pacific ocean	The **East Australian Current** (EAC) is the southward western boundary current that is formed from the South Equatorial Current (SEC) crossing the Coral Sea and reaching the eastern coast of Australia.
Equatorial Current	Pacific ocean	**Equatorial current**, ocean current flowing westward near the equator, predominantly controlled by the winds.
Gulf Stream	North Atlantic ocean	Warm ocean current originating in Gulf of Mexico along the east coast of the United States
Kuroshio Current	North pacific ocean	North-flowing warm current off the coast of Japan in the Pacific Ocean
North Atlantic Drift	North Atlantic ocean	The **North Atlantic Current** (**NAC**) warm western boundary current within the Atlantic Ocean that extends the Gulf Stream north-eastward.
North Pacific Drift	North pacific ocean	The North Pacific Current is a slow warm water current

Cold Currents:

Name	Ocean	Description
California Current	North Pacific Ocean	Southward flowing current off the west coast of the United States in the Pacific Ocean
Canaries Current	North Atlantic ocean	The **Canary Current** is a wind-driven surface current that is part of the North Atlantic Gyre.
Humboldt (Peru) Current	South pacific ocean	The Humboldt **Current**, also called the **Peru Current**, flows north along the western coast of South America
Labrador Current	North Atlantic ocean	Flowing from the Arctic Ocean south along the east coast of Canada
Oyashio (Kamchatka) Current	North Pacific ocean	Oyashio or the Kurile current, is a cold subarctic ocean current that flows south in the western North Pacific Ocean.
West Australian Current	Indian ocean	It is a cool surface **current** of the Southern Ocean and Southern Indian Ocean.
West Wind Drift	South pacific ocean	Surface oceanic current encircling Antarctica and flowing from **west** to east.

Ocean Resources:

- **Salt**

Salt is chemically known as sodium chloride. It is one of the most abundant minerals found in the ocean water. Salt can be either directly extracted or could be mines, depending upon different regions.

- **Potassium:**

Potassium is also one of the most abundant minerals like salt. Although Potassium cannot be directly extracted as salt.

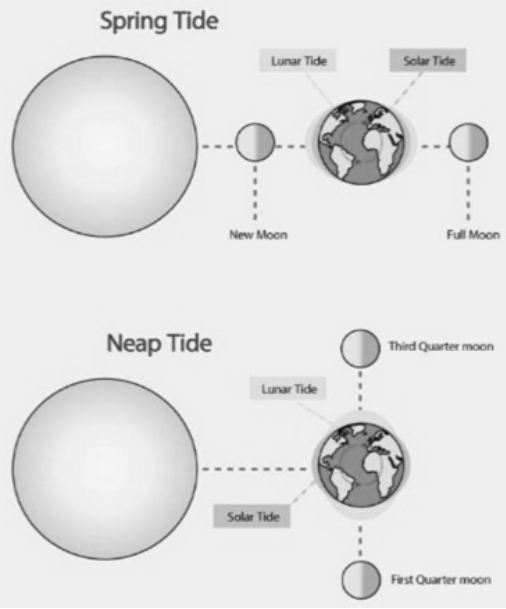
- **Sand:**
  The sea beaches can be understood as the residual deposits of sand.

- **Manganese Nodules:**

These nodules contain enormous amount of metal wealth. They can be looked upon as a huge potential to be used by human beings as a resource as and when technology is developed for harnessing these valuable metals.

- **Gold and Diamonds:**
- **Limestone and Gypsum**
- **Oil and Gas**

Tides

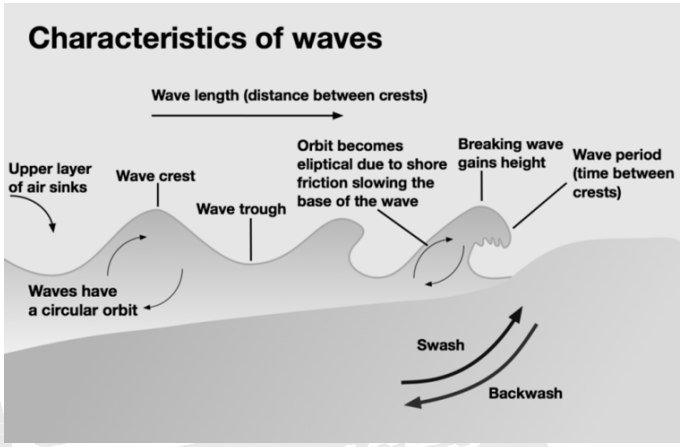


- Tides are periodical rise and fall of sea levels caused by the combined effects of the gravitational forces exerted by the Moon and the Sun, and the rotation of the Earth.
- **Surges** are movement of water caused by meteorological effects**.**
- A **spring tide** when sun, moon and earth are in straight line occurs on full moon day and new moon day. Highest height tide.
- **Neap tide** refers to a period of moderate tides when the sun and moon are at right angles to each other.

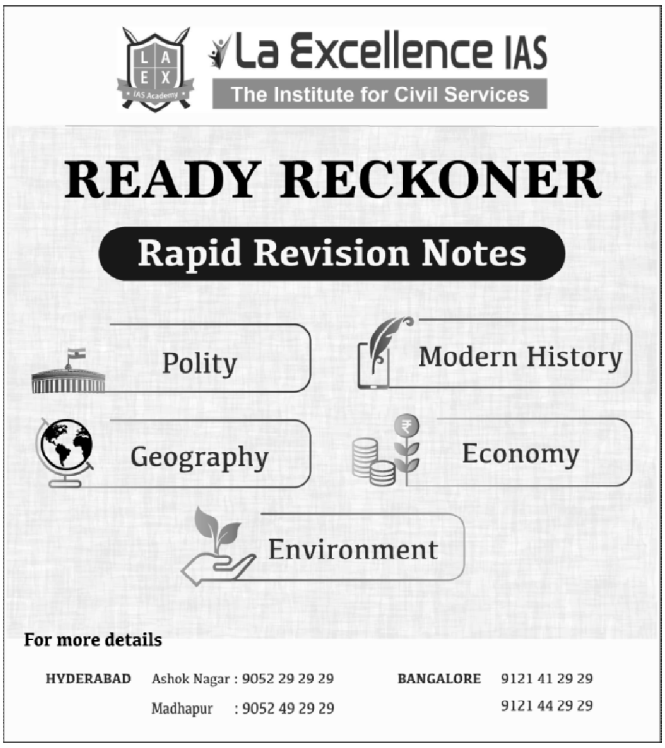
Tides helps in navigation, desilting, fishing, generation of electrical power.

Waves:

- **Waves are oscillatory movements** that result in the rise and fall of water surface. They are actually the energy, not the water as such, which moves across the ocean surface.



Note: waves and ocean currents are horizontal movement of ocean water, tides are vertical movement of ocean water.



Climatology

Weather: pertains to condition of atmosphere in any place or any time.

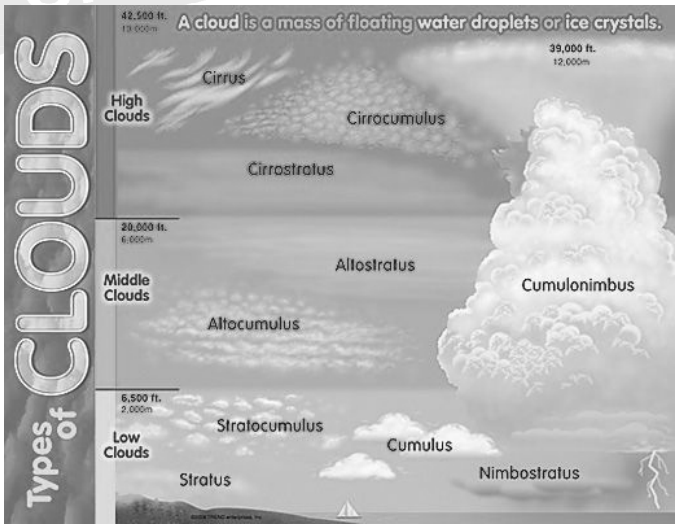
Climate: Average weather conditions of a specified area for a considerable time.

Elements of Weather and Climate:

- **Rainfall**: Form of precipitation(snow, sleet and hail) measured by rain gauge.
- **Humidity**:Dampness of the atmosphere. Measured using hygrometer.
- **Absolute humidity**:Amount of water vapour present in air**.**
- **Relative humidity**: the ratio between actual amount of water vapour and total amount the air can hold at that temperature.
  When relative humidity is 100% then air is said to be **saturated** and air temperature is at **dew point**.
- **Wind**: Air in motion with direction and speed.
- Wind direction is measured by wind vane or weather.
- Winds are named from direction where they blow as east wind blows from east to west.
- **Anemometer** is used to measure speed of wind .
- **Clouds**: After dew point cooling leads to condensation of water vapour in atmosphere – tiny drops will suspend as clouds – form, shape, height and movement tell us about the sky conditions.
- Cloud cover is expressed in eights or **oktas**.

Classification of Clouds:

High clouds 6000-1200m	Middle clouds 2100-6000m	Low clouds Below 2100 m	Clouds with great Vertical Extent 1500-9000m
CIRRUS Composed of small ice crystal, white, wispy and fibrous in appearance	**Alto-cumulus** Composed of water droplets in layers and patches	**Strato-Cumulus** Large globular masses, bumpy, looking, soft and grey in appearance regular and sometimes wavy pattern	**Cumulus** Round topped and flat based forming a whitish grey globular mass, consists of individual cloud units
Cirro-Cumulus Composed of ice crystals, but globular or rippled in appearance	**Alto-stratus** composed of water droplets, forming sheets of grey or watery looking clouds	**Nimbo-stratus** Dark grey and rainy looking, dense and shapeless, often gives continues rains	**Cumulonimbus** They have great vertical extent, white or black globular masses, whose rounded tops often spread out in the form of anvil. It is characterized by conventional rain, lighting and thunder
Cirro-Stratus Looks like a thin white, almost transparent sheet, which causes the Sun and Moon to have halos		**Stratus** These are low, grey and layered, almost fog like appearance ,bringing dull weather and often accompanied by drizzle	



Other Elements Pertaining to Visibility:

- **Haze**: visibility is less than 1.25 miles, due to smoke and dust in industrial area which causes unequal refraction of light.
- **Mist**: visibility greater than 1km less than 2km. Condensation of water vapour in air, forms drops of water to float above clouds at ground level.

- **Fog**: visibility less than 1 km. Water condensing on dust and other particles forming dense cloud near the ground surface.
  Fogs are more common over sea than land and most prevalent over coastal areas. Dense fogs are more in high and mid latitude rather than tropics.

  Dry interiors witness mist or haze.
- **Smog**: Fog and smoke together is called as smog.
- **Frost**: Forms on cold surfaces when condensation takes place **below freezing point (0° C)**.

Atmosphere:

- Atmosphere is composed of gases, water vapour and dust particles.
- **Gases**: carbon dioxide is transparent to incoming solar radiation and opaque to outgoing terrestrial radiation. It absorbs part of terrestrial radiation and reflects back the rest. Nitrogen is present highest by volume.

Constituent	*Formula*	*Percentage by Volume*
Nitrogen	N_2	78.08
Oxygen	O_2	20.95
Argon	Ar	0.93
Carbon dioxide	CO_2	0.036
Neon	Ne	0.002
Helium	He	0.0005
Krypto	Kr	0.001
Xenon	Xe	0.00009
Hydrogen	H_2	0.00005

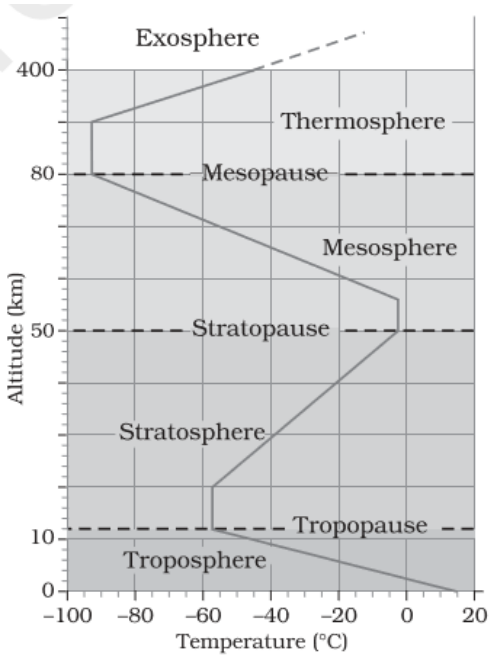
Water Vapour:

- Decreases with altitude. In warm and wet tropics it account for 4 %, in dry and cold areas less than 1%.
- It decreases from equator to poles.
- It acts as a blanket for earth by absorbing some incoming radiation and preserves earth radiated heat.
- It contributes to stability and instability of air.

Dust Particles:

- It includes sea salts, fine soil, ash, pollen, smoke soot etc.
- Higher concentration of dust particles are found in subtropical and temperate regions.
- These act as hygroscopic nuclei around which water vapour condenses to from clouds.

Structure of the Atmosphere:



Troposphere:

- Lower most layer of the atmosphere, with average height of 13km.
- Its thickness is greater at the equator (18km), because the heated air rises to greater heights by strong convectional currents. Whereas at the poles it is at 8km.
- It is associated with climatic and weather phenomena.
- The troposphere ends with the Tropopause.

Stratosphere:

- Found above troposphere, it is cloudless, thin air, without dust and vapour.
- The temperature in this layer remains constant for some distance but then rises, due to the presence of ozone (harmful ultraviolet radiation is absorbed by ozone).
- This layer is almost free from clouds and associated weather phenomenon, making conditions most ideal for flying aeroplanes. So aeroplanes fly in lower stratosphere, sometimes in upper troposphere where weather is calm.

Mesosphere:

- This is an intermediate layer beyond the ozone layer and continues up to an altitude of 80 km from the earth's surface.
- The temperature gradually falls to -100°C at 80 km altitude.
- Upper layer of Mesosphere is Meso pause.

Thermosphere

- In thermosphere temperature rises very rapidly with increasing height.
- Ionosphere- It contains electrically charged particles called as ions, which make short wave radio transmission possible over long distances. It extends between 80-400 km.
- Meteors burn in this region, thereby increasing the temperature.

Exosphere

- This is the uppermost layer of the atmosphere extending beyond the ionosphere above a height of about 400 km.
- The air is extremely rarefied and the temperature gradually increases through the layer.
- Light gases like helium and hydrogen float into the space from here. This layer coincides with space.

Insolation

- Insolation is the **incoming solar radiation(short wavelength- visible and UV radiations).**
- The earth absorbs short wave radiation during daytime and reflects back the heat received into space as **long-wave radiation (mostly infrared radiation)** during night.
- **Aphelion**: on 4th July earth is farthest from sun.
- **Perihelion:** On 3rd January, the earth is the nearest to the sun.

Variability of Insolation at the Surface of the Earth

- The factors that cause these variations in insolation are:

(i) **Rotation of earth on its axis**-earth makes an angle of 66.5 degree with the plane of it orbit around the sun.

(ii) **Angle of inclination of the sun's rays-**The higher the latitude, the less is the angle they make with the surface of the earth resulting in slant sun rays. The area covered by the vertical rays is always less than the slant rays.

(iii) **Duration of the day-**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.

(iv) 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.

(v) Configuration of land in terms of its aspects- sun facing slopes receive more vertical rays of sun, other side receives less insolation.

Note: Insolation received at the surface- Tropics> equator, continents > oceans, desert > other areas.

Heating and cooling of Atmosphere:

Three different ways**,**

1. **Conduction:** when two bodies of unequal temperature are in contact with one another, there is flow of energy from warm body to cooler body.

   Earth after being heated by insolation transmits heat to the lower layers of atmosphere in long wave form.

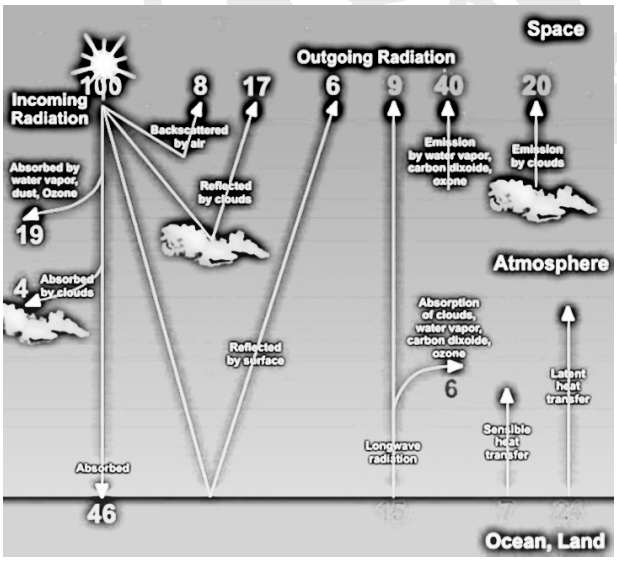
2. **Convection: Vertical heating of the atmosphere.** Air in contact with the earth rises vertically on heating, in the form of currents and further transmits heat to the atmosphere.

3. **Advection:** transfer of heat through **horizontal movement** of the air.

4. **Terrestrial radiation:** Earth heats up with incoming short waves solar radiation, and becomes a radiating body. It radiates energy to the atmosphere in the long wave form**.**

Heat Budget of the Earth:

- The earth as a whole does not accumulate or lose heat. It maintains its temperature. This can happen only if, insolation=terrestrial radiation. Balance between the two is called heat budget.
- This is why the earth neither warms up nor cools down despite the huge transfer of heat that takes place.



Albedo:

- Reflected amount of radiation from the earth surface.
- The value of albedo will be different for different surfaces.
- 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**".
- Highest albedo- snow > clouds> sand> grass> crops>forest.

Elements of Climate and Factors Affecting Them

The temperature of air at any place is influenced by

1. **Latitude**: The temperature of a place depends on the insolation received. Where ever there is vertical rays of sun, intense heating happens. Slant rays causes less heating and temperature also less.

2. **Altitude**: The atmosphere is indirectly heated by terrestrial radiation from below through conduction. The temperature generally decreases with increasing height. The rate of decrease of temperature with height is termed as the **Normal lapse rate**. It is 6.5°C per 1,000 m.

3. **Continentality**: Land is heated more quickly than water, because of higher specific heat of water. There by causing warm summers, cool winters and great temperature range for continental interiors.

4. **Ocean Currents and Air Mass**: Like the **land and sea breezes**, the passage of **air masses** also affects the temperature. The places, which come under the influence of warm air-masses experience higher temperature and the places that come under the influence of cold air masses experience low temperature.

   Similarly, the places located on the coast where the warm **ocean currents** flow record higher temperature than the places located on the coast where the cold currents flow.

5. **Slope, Shelter and Aspect**: Steep slope experiences a rapid change in temperature. Mountain ranges having East west alignment have higher temperature on south facing sunny slope (good for vine cultivation) than the north facing sheltered slope.

- Hot day followed by calm night ,air cools more rapidly over higher grounds and may induce cold heavy air to flow down the slope and accumulate in valley bottom pushing warm air upwards(temperature would be lower in valley than above this reversal of lapse rate is called as **Temperature Inversion**).

6. **Distance from the Sea:** Compared to land, the sea gets heated slowly and loses heat slowly. Land heats up and cools down quickly. Therefore, the variation in temperature over the sea is less compared to land. The places situated near the sea come under the moderating influence of the sea and land breezes which moderate the temperature.

7. **Natural Vegetation and Soil –**Thick foliage of Amazon cuts incoming insolation and sunlight does not reach ground.

- In day trees loose water by **evapo-transpiratio**n so the air above is cooled.
- Light soil reflects more heat than darker soil which is better absorbers.
- Dry soil like sand are more sensitive to temperature changes while wet soil retain moisture and warm up and cool down more slowly.

Inversion of Temperature:

Normally, temperature decreases with increase in elevation. It is called **normal lapse rate**. At times, the situations is reversed and the normal lapse rate is inverted. It is called **Inversion of temperature**.

A long winter night with clear skies and still air is ideal situation for inversion. The heat of the day is radiated off during the night, and by early morning hours, the earth is cooler than the air above. Over polar areas, temperature inversion is normal throughout the year.

Surface inversion promotes stability in the lower layers of the atmosphere. Smoke and dust particles get collected beneath the inversion layer and spread horizontally to fill the lower strata of the atmosphere. Dense fogs in mornings are common occurrences especially during winter season. This inversion commonly lasts for few hours until the sun comes up and begins to warm the earth.

The inversion takes place in hills and mountains due to air drainage. Cold air at the hills and mountains, produced during night, flows under the influence of gravity. Being heavy and dense, the cold air acts almost like water and moves down the slope to pile up deeply in pockets and valley bottoms with warm air above. This is called air drainage. It protects plants from frost damages.

Precipitation:

- The process of continuous condensation in free air helps the condensed particles to grow in size. When the resistance of the air fails to hold them against the force of gravity, they fall on to the earth's surface. So after the condensation of water vapour, the release of moisture is known as **precipitation**.
- In simple terms we can summarise precipitation as the following
- **Rainfall:** drop size more than 0.5 mm.
- **Virga**: raindrops evaporate before reaching the earth.
- **Drizzle**: light rainfall; drop size less than 0.5 mm.
- **Mist:** evaporation occurs before reaching the ground leading to foggy weather.
- **Snowfall:** fine flakes of snow fall when the temperature is less than 0°C.
- **Sleet**: frozen raindrops and refrozen melted snow; mixture of snow and rain or merely partially melted snow.
- **Hail**: precipitation in the form of hard rounded pellets is known as hail; 5 mm and 50 mm.

Types of Rainfall:

On the basis of origin, rainfall may be classified into three main types,

1. **Convectional 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. With thunder and lightning, heavy rainfall takes place.
   - Common in summer/ hot days/ equatorial regions/ earth's interiors.

2. **Orographic rainfall or relief rain**: When the saturated air mass comes across a mountain, it is forced to ascend and as it rises, it expands; the temperature falls, and the moisture is condensed.

   After giving rain on the windward side, when these winds reach the other slope, they descend, and their temperature rises, leeward slopes remain rainless and dry. Leeward side also called as rain shadow region.

3. **Cyclonic or Frontal Rain**: purely associated with cyclonic activity. Tropicl regions with cyclones and temperate regions with depressions. When two air masses with different temperatures meet, turbulent conditions are produced. Along the front convection occurs and causes precipitation. This is called Frontal rainfall.

Polar Vortex:

- The Earth's atmosphere has two polar vortices which are overlying the North and South Poles. Each polar vortex is a **persistent, large-scale, low-pressure zone**, that rotates **counter-clockwise** at the **North Pole** (called a cyclone) and **clockwise** at the **South Pole, i**.e., both polar vortices rotate eastward around the poles.
- These cold blasts of arctic air are bottled up by the strong jet stream or polar jet stream which is circulated at the high latitudes.
- Even though research claims that there is no direct relation between the Polar Vortex and Indian weather but the Arctic winds influence atmospheric circulations, weather systems, including the western disturbance.

Thunderstorms and Tornadoes:

Thunderstorms and Tornadoes are severe local storms. They are of short duration, occurring over a small area but are violent.

Thunderstorms:

Thunderstorms mostly occur on ground where the temperature is high with thunder and lightning. Thunderstorms are less frequent on water bodies due to low temperature.

Tornadoes:

From severe thunderstorms sometimes spiralling wind descends like a trunk of an elephant with great force, with very low pressure at the centre, causing massive destruction on its way. Such a phenomenon is called a tornado.

Tornadoes generally occur in middle latitudes. The tornado over the sea is called **water sprouts**.

Atmospheric circulation and weather systems

- Air expands when heated and gets compressed when cooled.
- The pressure decreases with height.

Factors affecting wind velocity and direction

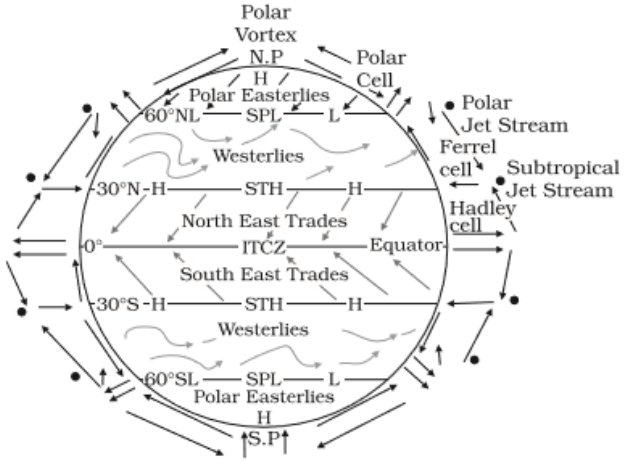
- Air in motion is called as **wind.** As wind blows from high pressure to low pressure it experiences combined effect of 3 forces, in addition to gravitational forces.

1. **Pressure gradient force**: Rate of change of pressure with respect to distance is PGF. Higher the PGF, more is the velocity of the wind and larger is deflection in direction of the wind.
2. **Frictional forces**: Wind at the surface experiences friction. It affects the speed of the wind.
3. **Coriolis force**: Rotation of earth about its axis affects wind direction. It deflects the wind to right in northern hemisphere and left in southern hemisphere.

- Coriolis force is directly proportional to the angle of latitude. It is maximum at the poles and absent at the equator.
- Since coriolis force is zero winds blows perpendicular to the isobars. Low pressure gets filled instead of getting intensified because of which **tropical cyclones does not originate near equator.**

Note: over **low pressure area** air will **converge and rise** and at the **high pressure area** air will **subside** from above and diverge at the surface.

General circulation of the atmosphere:



- The air at the Inter Tropical Convergence Zone (ITCZ) rises because of convection caused by high insolation and a low pressure. The winds from the tropics converge at this **low pressure zone**.
- The converged air rises along with the convective cell. It reaches the top of the troposphere up to an altitude of 14 km. and moves towards the poles. This causes accumulation of air at about 30° N and S. Part of the accumulated air sinks to the ground and forms a **subtropical high**.
- Another reason for sinking is the cooling of air when it reaches 30° N and S latitudes. Down below near the land surface the air flows towards the equator as the easterlies. The easterlies from either side of the equator converge in the Inter Tropical Convergence Zone (ITCZ).
- Such circulations from the surface upwards and vice-versa are called cells. Such a cell in the tropics is called **Hadley Cell.**
- In the middle latitudes the circulation is that of sinking cold air that comes from the poles and the rising warm air that blows from the subtropical high. At the surface these winds are called westerlies and the cell is known as the **Ferrel cell**.
- At polar latitudes the cold dense air subsides near the poles and blows towards middle latitudes as the polar easterlies. This cell is called the **polar cell**.
- These three cells set the pattern for the general circulation of the atmosphere. The transfer of heat energy form lower latitudes to higher latitudes maintains the general circulation.

Pressure Belts

There are distinctly identifiable zones of homogeneous horizontal pressure regimes or 'pressure belts'. On the earth's surface, the following are the various pressure belts

1. Equatorial low.
2. The sub-tropical highs.
3. The sub-polar lows.
4. The polar highs.

Equatorial Low Pressure Belt or 'Doldrums'

- Lies between 10°N and 10°S latitudes.
- Width may vary between 5°N and 5°S and 20°N and 20°S.
- This belt happens to be the **zone of convergence** of trade winds from two hemispheres from sub-tropical high pressure belts.
- This belt is also **called the Doldrums**, because of the extremely calm air movements.
- The position of the belt varies with the apparent movement of the Sun.
- Formation: As this region lies along the equator, it receives highest amount of insolation. Due to intense heating, air gets warmed up and rises over the equatorial region (convection).Whenever there is vertically upward movement of air, the region at the surface will be at low pressure. Thus the belt along the equator is called **equatorial low pressure belt**.
- Climate: This belt is characterized by extremely low pressure with calm conditions. Vertical winds (**convection**) carrying moisture form **cumulonimbus clouds** and lead to thunderstorms (convectional rainfall).

Sub-Tropical High Pressure Belt or Horse Latitudes

- The corresponding latitudes of sub-tropical high pressure belt are called horse latitudes.
- After saturation (complete loss of moisture) at the Inter Tropical Convergence Zone (ITCZ), the air moving away from equatorial low pressure belt in the upper troposphere becomes dry and cold. This dry and cold wind subsides at 30°N and S.
- So the high pressure along this belt is due to subsidence of air coming from the equatorial region which descends after becoming heavy. The high pressure is also due to the blocking effect of air at upper levels because of the Coriolis force.

The subsiding air is warm and dry; therefore, most of the deserts are present along this belt, in both hemispheres. This belt is frequently invaded by tropical and extra-tropical disturbances.

Sub-Polar Low Pressure Belt

- Located between 45°N and S latitudes and the Arctic and the Antarctic circles (66.5° N and S latitudes)

- These are dynamically produced due to

1. Coriolis Force produced by rotation of the earth on its axis,
2. Ascent of air as a result of convergence of Westerlies and polar easterlies.

- Due to a great contrast between the temperatures of the winds from sub-tropical and polar source regions, extra tropical cyclonic storms or lows' (temperate cyclones or frontal cyclones) are produced in this region

Polar High Pressure Belt:

- The polar highs are small in area and extend around the poles. They lie around poles between 80 – 90° N and S latitudes.
- The air from sub-polar low pressure belts after saturation becomes dry. This dry air becomes cold while moving towards poles through upper troposphere.
- The lowest temperatures are found over the poles.

Planetary Winds:

The winds blowing throughout the year from high pressure belts to low pressure belts in the same direction are called "**planetary or prevailing winds**".

Due to the effect of the rotation of the earth, the direction of the winds tends to deflect, instead of blowing directly from one pressure belt to another. These winds blow throughout the year and are controlled by the latitudinal pressure belts. They blow over vast area of continents and oceans.

The main planetary winds are:

1. Trade winds
2. Westerlies
3. Polar Easterlies

Planetary wind	Features
Trade winds	• Trade winds blow in a belt lying between 5°N-30°N in the northern hemisphere and 5°S-30°S in the southern hemisphere. • There is low pressure on the equator, while high pressure at the sub tropics. So, air moves from tropics toward equator. • The trade winds in the Northern-Hemisphere blow from the north-east direction due to the deflection of the wind caused by the rotation of the Earth and so are called North-East Trades. • Similarly, the trade winds in the Southern-Hemisphere blow from the South-East direction and thus called south-East Trades. • They are also known as Tropical easterlies.
Westerlies	• The Westerlies blow from sub tropical high pressure belts towards sub-polar low pressure belts. • The Westerlies of Southern Hemisphere blow with great strength and constant in direction than Northern Hemisphere. • Under the Coriolis force effect, the Westerlies become the South-Westerlies in the northern hemisphere and the North-Westerlies in the southern hemisphere. • Westerlies winds are named as roaring forties, furious fifties, screaming sixties based on the speed of the wind.
Polar easterlies	• The Polar easterlies are dry, cold prevailing winds that blow from the Polar high pressure belts to the Temperature low pressure belts. • They are extremely cold winds as they blow from the Tundra and Icecap regions. The Polar Easterlies are more regular in the southern hemisphere than in the northern hemisphere. • Unlike the Westerlies, the polar easterlies are often weak and irregular.

Local Winds:

- Local winds occur on a small spatial scale.The main types of local winds are: Sea breezes and land breezes, Anabatic and katabatic winds, and other local winds.

Due to differential heating of land surface, we have sea and land breeze,

- **Sea Breeze:** Day time – land gets heated - warm air rises up – Low pressure develops – sea being less warm, develops high pressure there by winds blow from sea to land causing sea breeze
- **Land Breeze:** Night – land cools faster than sea, high pressure over land, low pressure over ocean – winds blow from land towards sea.

- **Katabatic Wind:** It is the generic term for down slope winds flowing from high elevations of mountains, plateaus, and hills down their slopes to the valleys or planes below. It is adiabatically warmed.
- **Anabatic Wind:** Air flow travelling up a facing slope of an orographic surface.

Wind	Nature	Region
Land Breeze	Warm	Blows From Land to Sea
Chinook	Warm	Rockies (USA And Canada)
Fohn	Warm	Alps/Europe
Khamsin	Hot	Egypt
Harmattan	Hot	Sahara to Guinea Coast (Ghana, Nigeria etc.)
Brick Felder	Hot	Australia
Norwester	Hot	New Zealand
Black Roller	Hot	North America
Kalbaisakhi	Hot	North India
Sirocco	Hot	North Africa
Mistral	Cold	France to Mediterranean (Rhine valley)
Levanter	Cold	Spain
Blizzard	Cold	Siberia, Canada, USA
Bora	Cold	Yugoslavia
Southerly Buster	Cold	Australia
Sea Breeze	Cold	Blows from to land

Air Masses:

- When the air remains over a homogenous area for a sufficiently longer time, it acquires the characteristics of the area.
- The air with distinctive characteristics in terms of **temperature** and **humidity** is called an air mass. It is a large body of air having **little horizontal variation** in temperature and moisture.
- The main source regions are the **high pressure belts** in the **sub tropics (giving rise to tropical air masses)** and around the **poles (the source for polar air masses).**
- Areas with **high pressure but little pressure difference** or pressure gradient are ideal source regions for development of Air masses
- Tropical air masses are warm and polar air masses are cold.

Air Masses and Source Region:

There are five major source regions. These are:

1. Warm tropical and subtropical oceans;
2. The subtropical hot deserts;
3. The relatively cold high latitude oceans;
4. The very cold snow covered continents in high latitudes;
5. Permanently ice covered continents in the Arctic and Antarctica.

Influence of Air mass and World Weather:

- The air masses carry atmospheric moisture from oceans to continents and cause **precipitation** over landmasses
- They transport **latent heat**, thus removing the latitudinal heat balance.
- Most of the migratory atmospheric disturbances such as cyclones and storms originate at the **contact zone** between different air masses and the weather associated with these disturbances is determined by characteristics of the air masses involved.

Jet Stream:

- Jet streams are relatively **narrow bands** of **strong wind** in the upper levels of the atmosphere. The winds blow from west to east in jet streams but the flow often shifts to the north and south. Jet streams follow the boundaries between hot and cold air.
- Since these hot and cold air boundaries are most pronounced in **winter**, jet streams are the strongest for both the northern and southern hemisphere winters.
- The strongest jet streams are the **polar jets**, weaker is **subtropical jets.**

Jet Streams and its Influence on Indian Monsoons:

2. Somali Jet:

- The progress of the southwest monsoon towards India is greatly aided by the onset of Somali jet that transits Kenya, Somalia and Sahel.

- It strengthens permanent high near Madagascar and also helps to drive S-W monsoons towards India at a greater pace and intensity.
- The peculiar feature of Somali Current is **reversal in direction** with the onset of the summer monsoon.

3. Tropical easterly jet stream

- There are major high velocity winds in the lower troposphere called **low-level jets (LLJs).**
- In the tropics, the most prominent of these are the **Somali Jet** and the **African Easterly Jet [Tropical Easterly Jet].**
- The formation of TEJ results in the **reversal of upper air circulation patterns [High pressure switches to low pressure]** and leads to the quick onset of monsoons.
- **The easterly jet does not come into existence if the snow over the Tibet Plateau does not melt. This hampers the occurrence of rainfall in India.**

Cyclone:

Features of a Cyclone:

- It is large system of winds that circulates about a centre **of low atmospheric pressure in a counter-clockwise direction north of the Equator and in a clockwise direction to the south.**
- Cyclonic winds move across nearly all regions of the Earth except the equatorial belt.
- **Anticyclones**, wind systems that rotate about a high-pressure centre. Anticyclones are so called because they have a flow opposite to that of cyclones—i.e., an outward-spiralling motion, with the winds rotating **clockwise in the Northern Hemisphere and counter-clockwise in the Southern**.

Energy source of Cyclones:

- The fuel for a tropical cyclone is provided by a transfer of water vapour and heat from the warm ocean to the overlying air, primarily by **evaporation** from the sea surface.
- The temperature difference between the warm rising air and the cooler environment causes the rising air to become buoyant, further enhancing its upward movement.

Conditions ideal for the formation of cyclones:

- Sufficiently warm sea surface temperatures higher than 27 degree.
- Atmospheric instability.
- High humidity in the lower to middle levels of the troposphere.
- Enough Coriolis force to develop a low-pressure centre.
- A pre-existing low-level focus or disturbance.
- Low vertical wind shear.
- Upper divergence above the sea level system.

Anticyclones:

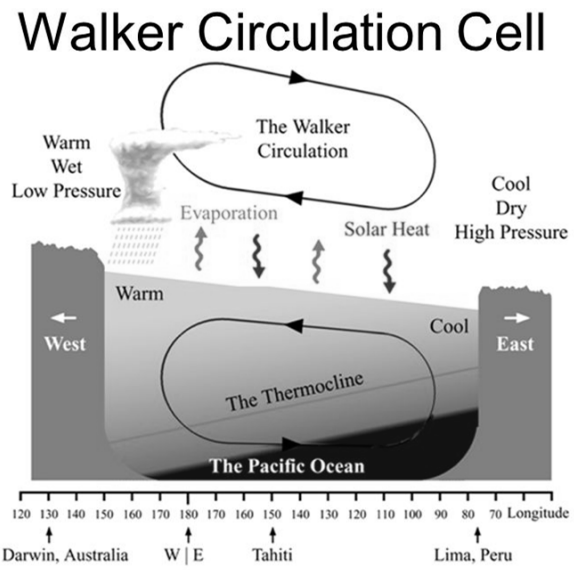
- An anti-cyclone, as a high pressure area is a large atmospheric circulation system with the wind flowing clockwise around it in the Northern Hemisphere, and counter-clockwise in the Southern Hemisphere.
- Anticyclones form from air masses cooler than their surrounding, leads to contraction of air making it denser, thereby increasing surface air pressure.
- **Calm** settled weather is usually synonymous with **anticyclones** in temperate latitudes. **Anticyclones** are typically relatively slow moving features.

Cyclones	Region
Typhoons	China Sea
Tropical Cyclones	Indian Ocean
Hurricanes	Caribbean Sea
Tornadoes	USA
Willy Willes	Northern Australia

El Nino Southern-Oscillation (ENSO):

El Nino and La Nina are opposite phases of what is known as *the* El Nino-Southern Oscillation *(***ENSO**) cycle. The ENSO cycle is a scientific term that describes the fluctuations in temperature between the ocean and atmosphere in the east-central Equatorial Pacific.

El Nino	• It refers to a **periodic warming** in sea surface temperatures across the central and east-central Equatorial Pacific, with increase in temperature of more than 0.5°Cfor at least five successive overlapping three-month seasons. • El Nino events occur irregularly at two- to seven-year intervals. • The warm ocean conditions in the equatorial Pacific induce large-scale anomalies in the atmosphere. Rainfall increases many fold in Ecuador and northern Peru, causing coastal flooding and erosion. • Strong El Nino events are associated with droughts in Indonesia, Australia, and north-eastern South America and with altered patterns of tropical storms in the tropical belt.
La Nina	• It is a cyclic counterpart to El Nino, consisting of a **cooling of surface waters of the Pacific Ocean** along the western coast of South America. • La Nina has less effect in Europe but it does tend to lead to milder winters in Northern Europeand colder winters in southern/western Europe, leading to snow in the Mediterranean region. Elsewhere in the world, areas that are affected by La Nina experience the opposite of the effects they experience with El Nino. • It does not occur as often as El Nino.



Indian Ocean Dipole (IOD)

- The **Indian Ocean Dipole** (**IOD**), also known as the Indian Nino, is an irregular oscillation of sea-surface temperatures in which the western Indian Ocean becomes alternately warmer and then colder than the eastern part of the ocean.
- The IOD involves an a periodic oscillation of sea-surface temperatures (SST), between "positive", "neutral" and "negative" phases.
- A **positive phase** sees greater-than-average sea-surface temperatures and greater precipitation in the western Indian Ocean region, with a corresponding cooling of waters in the eastern Indian Ocean, which tends to cause droughts in adjacent land areas of Indonesia and Australia.
- The **negative phase** of the IOD brings about the opposite conditions, with warmer water and greater precipitation in the eastern Indian Ocean, and cooler and drier conditions in the west.
- The IOD also affects the strength of monsoons over the Indian subcontinent.
- The IOD is one aspect of the general cycle of global climate, interacting with similar phenomena like the El Nino-Southern Oscillation (ENSO) in the Pacific Ocean.

Madden-Julian Oscillation:

- The **Madden–Julian oscillation** (**MJO**) is the largest element of the intra-seasonal (30- to 90-day) variability in the tropical atmosphere.
- Unlike a standing pattern like the El Nino–Southern Oscillation (ENSO), the Madden–Julian oscillation is a travelling pattern that propagates eastward, through the atmosphere above the warm parts of the Indian and Pacific oceans. This overall circulation pattern manifests itself most clearly as anomalous rainfall.
- Heavy tropical rainfall associated with the MJO shifts eastward from the eastern Indian Ocean to the western tropical Pacific.

World Climate

World Climatic Regions:

Hot, Wet Equatorial Climate: between 5-10 degree North and South of Equatorial Regions:

Rainfall	Vegetation	Life & Development	Factors Affecting Development
•Convectional Rainfall – mostly in Afternoon (one afternoon is equal to entire year rainfall in desert) Orographic or relief rainfall. •Cyclonic rainfall – convergence of air in Doldrums.	Variety: Evergreen hardwoods like mahogany, ebony; small palm trees; climbing lianas – epiphytic or parasitic; ferns, orchids and Lalangs. •Distinct Layer: thick canopy, struggle for sunlight. •Multiple Species: No pure strand; commercial exploitation is hard; hardwood don't float on water and haulage expensive (so tropical nations are timber importers).	•Amazon: Indian Tribes gather wild rubber. •Congo: Pygmies gather nuts •Malaysia: Orang Asli (Orang Asli are the indigenous people and the oldest inhabitants of Peninsular Malaysia) – cane products.	•Climate: high heat & humidity; sun-stroke; perspire and lose energy; malaria & yellow fever. •Bacteria & insect pests: injurious to crops, diseases; plague. •Jungle hinders development: Lalang (tall grass) & thick undergrowth choke crops •Deterioration of tropical soil. •Difficult lumbering & livestock farming.

Tropical Monsoon & Tropical Marine Climate:

Characteristics	•Seasonal Winds • Distinctive seasons 1. On shore wet monsoon – summer 2. Off shore dry monsoon –winter
Climate	Climate – Tropical Monsoon. Landmass is heated in summer in Northern Hemisphere, Low pressure develops in Indian mainland & High Pressure in Australia. Leading to Seasonal reversal of winds. Seasons – 1.Tropical Monsoon •Cool Dry (Oct to Feb), Hot Dry (March to June), Rainy (June to Sept),2. Retreating Monsoon – after mid Sept (North East monsoon).
	Climate – Tropical Marine •On east coast of tropical lands, Receive rain from trade winds all time .Favourable for habitation. Has severe tropical cyclones.
Vegetation	•Deciduous – dry period and shed leaves. •In regions of heavy rainfall – forest – open and less luxuriant than equatorial forest. •Summer – thorny scrub or savanna – scattered tree & tall grass. •Timber: durable hardwood – teak – Burma (3/4th of world production).
Locations	•Monsoon: India, Burma, Vietnam, Thailand, Laos, Cambodia, South China, North Australia.
	•Maritime: C. America, West Indies, NE Australia, Philippines, E. Africa, Madagascar, Guinea & East Brazil.

Savanna or Sudan Climate:

Characteristics	1.Transitional type of climate found between Equatorial forest and Hot deserts 2. Distinct Dry and wet season Transition, hot rainy and cold dry. Extreme diurnal temperature. Experiencing local hot wind- Harmattan. 3. Trade winds bring rain to coastal area – strong in summer and dry in continental interior (scattered tree and short grass).
Vegetation	•Tall grass – 6 to 12 ft. – elephant grass – **long roots, Short trees**, Parkland or bushveld. •Deciduous – acacia, Rain decreases – thorny scrub (Australia)-mallee, mulga, spinifex.
Human Life	Tribes – Masai – E. Africa, Nomadic – Kenya, Tanzania & Uganda •Kikiyu of Kenya – millet, banana, Hausa – N. Nigeria, Settled cultivators in Bauchi plateau. • Groundnut, banana, cotton, tobacco – leave it fallow Rotate crop in different fields.

Hot Desert & Mid-latitude Desert:

Characteristics	• Temperate desert, Scanty Rainfall, Hot Climate. • Cause of aridity- Offshore trade winds (trade wind desert) and located in interior region.
Vegetation	•Scrub and herbs, Dormant vegetation, Xerophytic or drought –resistant scrub cactus, thorns, trees are rare and date palms. •Leaves are waxy and leathery, needle shaped – reduce transpiration. •Cactus – thick succulent stems. •Seeds have thick and tough skin. •Salinity of soil – salt accumulates – hard pans. •Deficient in humus.
Mines	•Gold – Great Australian Desert• Diamond and copper – Kalahari Desert. •Caliche (sodium nitrate) – Atacama •Copper – Chuquicamata, Antofagasta, Iquique, Nevada •Silver –Mexico •Uranium – Utah •Oil- Sahara & Arab desert.
Life of Human	Bedouin of Arab: - Best nomadic herdsman, Trade- Caravan merchants, Oases people- Wander for water and pastures. Bushmen of Kalahari (Nomadic Hunters and Food Gatherers): skill to obtain water in desert – store in ostrich shell suck water from ground by hollow reed travel in family groups (sherms)

	Bindibu of Australia (Nomadic Hunters and Food Gatherers): Wooden stick – boomerangs, Women gather grass and roots, Lives in groups, Close to water supply, Houses called wurlies.
Locations	Sahara Desert -largest desert > Great Australian Desert. Atacama/Peruvian Desert – Driest desert Patagonian Desert – rain shadow position on leeward side of Andes.

Warm Temperate Western Mediterranean Climate:

Characteristics	Region: Western area between30 degrees to 45 degrees N and S. •Shifting of wind belts. •Winter rain with on shore westerlies (cyclonic, orographic rainfall),Dry Warm Summer with offshore trades (no rain, dry air, intense heat, low relative humidity). •Climate is transition between Trade wind hot desert (S) and Cool temperate maritime (N)
Local Winds	Hot Winds: •Sirocco- Hot, dry dusty wind – from Sahara – most frequent in spring – accompanied by depressions. •Chili – Tunisia •Ghibli – Libya •Leveche – Spain •Khamsin – Egypt & Malta •Gharbi – Adriatic & Aegean Sea – cause fog & rain – blood rain (red dust).
	Cold Winds: •Mistral – Cold wind from north – down to Rhone valley (40-80 miles/hr) – funnelling effect (b/w Alps & Central Massif) •Bora – cold north-easterly wind along Adriatic coast – difference in pressure b/w continental Europe and Mediterranean – occur in winter. •Tramontana – cold wind• Gregale – cold wind.
Natural Vegetation	•Trees with small broad leaves, no shade •Growth restricted to autumn and spring – good moisture and high temperature. •Mediterranean evergreen–open woodlands – evergreen oaks •Evergreen coniferous trees – pines, firs, cedar and cypress. •Mediterranean bushes – low bush in scattered clump – laurel, lavender, rosemary and scrubs.
Economic Development	•Mediterranean shorelands – cradle of civilization •Orchard framing – citrus fruits – orange, lime, lemon, citron, grapefruit – long roots to draw water in summer droughts •Olives – Hardy and long rooted – survive on poor limestone with scanty rainfall – versatile, species, oil, cooking, soap etc. •Nuts – chestnut, almond, walnut, hazelnut •Fruits – Peach, apricot, pear, plum, cherry, fig •Wheat – hard winter wheat – macaroni, spaghetti, vermicelli •Barley – important cereal. Viticulture – wine production – 3/4th from Mediterranean region Also known for fruit canning, flour milling & food processing

Warm Temperate Continental (Steppe) Climate:

Characteristics	Border desert and lie in interior of continents: Temperate Grasslands Lie on Westerly belt •Away from maritime influence and are treeless •South Hemisphere: Moderate climate •North hemisphere: extensive and continental
Locations	**Steppes: Black Sea to Altai** **•Prairies: Rockies and Great Lakes** **•Pampas: Argentina & Uruguay** **•S. Africa: b/w Drakensburg & Kalahari (Bushveld in north & Highveld in south)** **•Downs: Australia (Murray Darling Basin)**
Climate	•Continental, Temperature extremes-Summers are warm, Winters are cold, snow covered. Rainfall due to Convection and westerlies depression •Mildura: fringe of Mallee scrub of Great Australian Desert •local Winds: **Chinook (**USA)hot wind, melt snow covered areas around rockies •Fohn (Switzerland)
Natural Vegetation	•Scanty vegetation •Grass covered with differences in density and quality of grass Treeless with short grasses
Economic Development	•Prairies- most sparsely populated area of world, extensive mechanized wheat cultivation and granaries of world (wheat and maize) •Pampas: leading ranching region of world Extensive wheat cultivation: •Cool moist spring – early growth and light showers for ripening yield •Warm& sunny summer: harvesting and straw to be dried •Levelness–ploughing and harvesting easy •Greatest quantity of wheat per capita amongst world's wheat growing nations – greatest exporter of wheat Pastoral Farming: •Dairy products: milk, butter and cheese •Tuft grass ploughed up and replaced by sown alfalfa. •Pampas: lead world in export of beef, estancias (ranches) were established and linked to frigorific (meat processing factories) in coastal ports. •Australia: world's leading wool exporter (one third of total production). •Steppes: ranching for meat production.

Warm Temperate Eastern Margin (China) Climate:

Characteristics	•Modified monsoonal climate – Temperate monsoon or China type Also known as Gulf climate. •Seen in SE USA, New South Wales (Eucalyptus), Natal (cane sugar), Parana-Paraguay-Uruguay (maize). •Onshore trade winds year round – without monsoonal variation – Natal type Climate.

Climate	•Warm moist summer and cool dry winters, with strong maritime influence. •Uniform rainfall throughout the year (except Central China with distinct dry season) due to convection, orographic and occasional depressions. •Rain by convectional source or orographic rain in summer & by depressions in prolonged showers in winter.
3 Types of Regions	**China Type**: •Central and North China including South Japan. Continental in nature. •Intense heat in Heart of Asia creates low pressure in summer and brings SE monsoon, causing heavy rain. •Winter – pressure gradient between cold Mongolia , Siberia and warm Pacific , there is outflow of air as NW monsoon (cold and dry) •Has great annual range of temperature •Occurrence of **Typhoons** – intense tropical cyclone in Pacific Ocean and move westward bordering South China Sea during July to September.
	Gulf Type •SE USA – similar to China type – **with less monsoonal characteristics** •**No complete seasonal reversal of wind** as pressure gradient between America and Atlantic is less marked •Narrow range of temperature •**Heavy rainfall with no distinct dry period** – abundant moisture & excess cultivation of cotton (cotton belts) and maize (corn belts) •Thunderstorms in summer and hurricanes in September and October
	Natal Type •Includes Natal, Eastern Australia , Brazil-Paraguay-Uruguay and Northern Argentina , all **warm temperate eastern climate** in southern hemisphere •**No monsoonal characteristics** – narrowness of continent and dominance of maritime influence •South East Trade winds bring even distribution of rainfall –•Depression along southern edges lead to autumn or winter maximum (wettest month from March to July) •Small annual temperature range •Violent local storms-**Southerly Buster** (Cold wind along coast of New South Wales), **Pampero** (cold wind along Argentina and Uruguay**), Berg** (hot, dry wind in eastern Africa) – comparable to Fohn or Chinook – bring unpleasant high temperature and oppressive weather
Natural Vegetation	•**Eastern margins have more rainfall**. •Home to timber species, with broad leaved and deciduous forest at lowlands and conifers at highlands. Palm trees, chestnut, ironwood, blackwood and wattle trees, Eucalyptus, walnut, oak, pines, used
Economic Development	•Most productive and intensively tilled parts of earth. •World's greatest rice growing areas, warm wet and lowland favours rice cultivation.
	Agriculture in Gulf (USA): Export crops (rice in Mississippi delta), Corn (half of world's corn production, used to fattened animals)or Maize, cotton, cane sugar, market gardening. Gulf –tobacco is native crop. Cropping/ pastoral in Southern Hemisphere: cane sugar, cotton, tobacco, maize, produce from cattle and sheep. Famous for dairy products.

Warm Temperate Western Margin (British) Climate:

Characteristics	• Under permanent influence of Westerlies, Cyclonic activity, Oceanic influence • Also called North-West European Maritime Climate • N. America ,S. hemisphere – New Zealand, Tasmania and Chile
Climate	•Ideal climate for maximum comfort and mental alertness , equable climate with warm summers and mild winters •Warming effect of warm North Atlantic Drift and South Westerlies •Precipitation: Rainfall throughout the year. Western margins have highest rainfall (as rain bearing winds come from west), there by western slopes of Southern Alps have more rainfall compared to Canterbury plains (rain shadow area) .
Natural Vegetation	•Deciduous forest -Shed leaves in winters – to protect against snow and frost. •Valuable temperate hardwood: Oak, elm, birch, beech, poplar, Willows, Alder, Aspen •Other species – elsewhere – chestnut, maple, lime, eucalyptus, conifers.
Economic Development	•NW Europe: Little surplus for export and a net importer of food crop mainly wheat. •Fishing: Britain, Norway & British Columbia. •Netherlands: horticultural and Dairy Industry (Britain, Denmark). •Australia: High speed boats ply across Bass Strait and Tasmania named as garden state Mixed Farming. •Both arable farming (potato, wheat, barley, beet sugar, cash crop and fodder crop etc) and pastoral framing(pigs, poultry, sheep rearing).

Cool Temperate Continental (Siberian) Climate: Due to extreme climatic condition- cold pole of earth

Chara-cteristics	Broad E-W spread- Merge with Arctic tundra in north and Steppes in south. Also called sub artic. • Evergreen coniferous – continuous belt in north Called Taiga – Siberia. •Absent in South Hemisphere – narrowness of southern continents in high latitude and strong oceanic influence. •Coniferous (S. Hemisphere) only in mountain uplands.
Climate	•**Cold long winters and cool brief summers**, with rainfalls throughout the year. •Winds – Blizzards of Canada and Buran of Europe •Conifers – require little moisture and transpire less are best suited. •Low temperature, low evaporation & high relative humidity. •Permanent snowfields are absent (as in Alps & Himalayas) due to melting in spring & summer Frozen rivers are thawed causing rise in water level & floods.
Vegetation	•Greatest softwood production – USSR, USA< Canada & Fennoscandia (Finland, Norway, Sweden). •Taiga (Siberia) – richest source of temperate softwood Occur in pure strands – good for commercial exploitation. 4 main species – Pine, Fir, Spruce & Larch. **Coniferous:** •Uniform, straight, tall•No annual replacement of new leaves .Food stored in trunks and bark is thick to protect trunk from cold. •Conical in shape to prevent snow accumulation •Leaves are small, thick, leathery and needle-shaped.
Economic Develo-pment	•Many areas are untouched in Canada, E. Europe and Asiatic Russia. Lumbering – transported to saw mills. Fur farms, paper making, matches, newsprint firms are well established.

Cool Temperate Eastern Margin (Laurentian):

Characteri stics	•Intermediate between British and Siberian climate •Both maritime and continental **Only in 2 Regions:** 1.NE USA, E. Canada or America Region and 2. E. Asia, E. Siberia, N. China, Manchuria, Korea & N. Japan – Asiatic Region. •**Absent in SH** – small section of continents, oceanic influence and climate is equable. •Only exception could be E. Patagonia- Westerlies don't reach causing aridity (rain shadow desert).
Climate	•**Cold dry winters** – temperature below freezing point, winds are dry westerlies from continental interior. •**Warm wet summers** (has cooling effect of offshore cold currents). •Rainfall – year-round.
Natural Vegetatio n	•Cool temperate forest. Coniferous trees north of latitude.Lumbering is main activity – timber as export item. •Fir,spruce and larch,oak, beech, maple, birch are the trees found.
	•Trees occur in pure stands – easy commercial exploitation Canada – greater reserve of coniferous softwoods.
Economic Developm ent	•Lumbering – timber, paper and pulp industries Agriculture – potatoes on podzolized soil, oats and barley. •Asiatic region –Soyabeans (N. China, Manchuria & Korea), groundnut, sesame, rapeseed, tung oil and mulberry. •Annapolis valley in Nova Scotia – world's most renowned region of apples. •Fishing- major activity in this region- as warm and cold current mixes. World's largest fishing ground on Grand Banks of Newfoundland. Sea weed cultivation, oyster cultivation etc is most common specifically in Japan (with rich plankton growth on continental shelves, upwelling of waters).

Arctic or Polar Climate:

Characteri stics	North of Arctic Circle: Ice-Caps – Greenland and highland of high latitude regions – permanent snow cover. •Tundra climate – lowlands with few ice free months – coastal Greenland, North Canada, Alaska and Arctic seaboard of Eurasia.
Climate	•Very low temperature •Winters – long and severe (weeks of continuous darkness). •Summers – cool and brief, Sun rays occur as faint rays – reflected by ground snow or ice melting. •Soil water is frozen and summer heat can thaw for 6 inch of soil. •Frost and blizzards are commonly seen. •Coastal Areas – Warm water meets cold land then thick fog develops. •Precipitation as snow in winters and varies from ice crystals to snowflakes. •Anticyclones over ice caps• Coastal areas – cyclones.
Vegetatio n	•Tundra type – few plants can survive – deficiency in heat, frozen soil. •No trees, Mosses, lichens and sedges are present. •Drainage is poor – subsoil is permanently frozen • Birch, willow and alder, reindeer moss, arctic flowers as arctic prairies are commonly found.
Human Activities	Confined to coasts: Plateaus and mountains are inhabitable and snow covered. •Semi-nomadic life: Eskimos – around 28,000 – hunters, fishers, food gatherers. **Nomads of Eurasia**: •Lapps – N. Finland and Scandinavia •Samoyeds in Siberia •Yakuts in Lena Basin •Koryak & Chuckchi in NE Asia. **Discovery of minerals**: •Gold – Alaska, •Nickel – Petsamo, USSR, •Petroleum – Kenai Peninsula, Alaska, •Copper – Rankin Inlet, Canada, •Coal – Spitsbergen and Alaska, •Iron Ore – Lake Superior & now Labrador (railway line to bring ores to St. Lawrence River); Kiruna and Gallivare in Sweden. •Trying to grow hardy cereals for local needs in Arctic lowlands with warm currents and higher temperatures.

Deepest Point on the Ocean:

Ocean	Deepest point
Pacific	Mariana Trench
Atlantic	Puerto Rio Trench
Indian	Java Trench
Arctic	Eurasian Basin

Important Canals of the World:

Canal	Connects
Panama	Pacific Ocean with Atlantic Ocean
Suez	Mediterranean Sea to Red sea
Erie	Atlantic Ocean to Great Lakes
Kein	North sea to Baltic Sea

Major lakes of the World

Lakes	Location
Caspian	Asia
Superior	Canada and USA
Victoria	Africa
Huron	Canada and USA
Tanganyika	Africa
Baikal	Russia
Great Bear	Canada
Aral	Kazakhstan
Great Slave	Canada

Highest /Lowest Point of Various Continents:

Continent	Highest point (m)	Lowest point (m)
Asia	Mt Everest (8850)	Dead Sea(-396)
Africa	MT Kilimanjaro (5951)	Lake Assal(-151)
North America	Mt Mckinley (6252)	Death Valley(-87)
South America	Mt Aconcagua (7026)	Valdes Peninsula(-40)
Antarctica	Vinson Massif (5189)	Bentley Subglacial Trench (-2538)
Europe	Mt El's Brus(5687)	Caspian Sea(-28)
Australian	Koscuisko	Lake Eyre(-16)

Largest Geographical Features in the World:

Feature	Name
Largest Continent	Asia
Largest Ocean	Pacific Ocean
Largest Bay	Bay of Bengal
Largest Gulf	Gulf of Mexico
Largest Peninsula	Arabian Peninsula
Largest Island	Greenland
Largest Coral Reef	Great Barrier Reef (Australia)
Largest and Highest Plateau	Pamir (Tibet, China)

Related Fact	Name of the Lake
Deepest lake in the world	Baikal (fresh water)in Russia
Largest fresh water lake	Lake Superior, between Canada and the USA
Largest lake in the world	Caspian Sea, bounded by Iran, Russia, Kazhakistan, Azerbaijan and Turkmenistan.
Saltiest lake in the world	Dead Sea bounded by Israel, Jordan and west bank
Lowest lake in the world	Dead Sea between Israel and Jordan
Largest lake in India	Sambhar lake in Rajasthan
Largest fresh-water lake in India	Kolleru lake in Andhra Pradesh
Largest coastal lagoon in India	Chilka lake in Orissa
Sriharikota island is located in	Pulicat lake in Andhra Pradesh
Country known as land of thousand lakes – Finland	

Canals and Straits:

Strait / Canal	Land Masses Divided	Water Bodies Joined
Suez Canal	Runs through Egypt	Mediterranean and Red Sea
Kiel Canal	Runs through Germany	North Sea and Baltic Sea
Bering Strait	Alaska and Siberia	Pacific and Arctic
Palk Strait	India and Sri Lanka	Bay of Bengal and Gulf of Mannar

Name of the Desert	Extends into Countries
Sahara desert	Algeria, Chad, Egypt, Libya, Mail, Mauritania, Morocco, Niger, Sudan, Tunisia
Atacama	Chile, Peru, Bolivia, Argentina
Kalahari Desert	Botswana, Namibia, South Africa
Arabian Desert	Jordan, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, UAE, Yemen
Gobi Desert	Mongolia, China
Great Victoria Desert	Australia
Patagonian Desert	Argentina, Chile
Thar Desert	India, Pakistan
TaklaMakan Desert	China
Syrian Desert	Saudi Arabia, Jordan, Syria, Iraq
Chihuahuan Desert	Mexico, United States
Great Basin Desert	United States
Mojave Desert	United States
Karakum Desert	Turkmenistan

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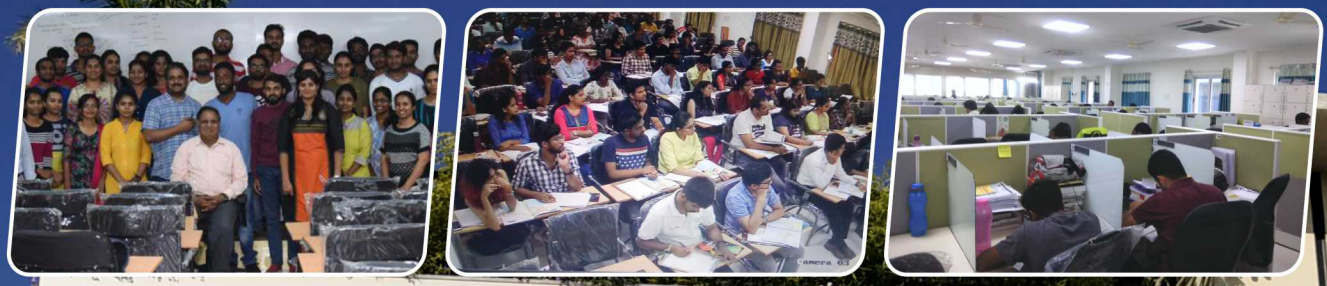

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