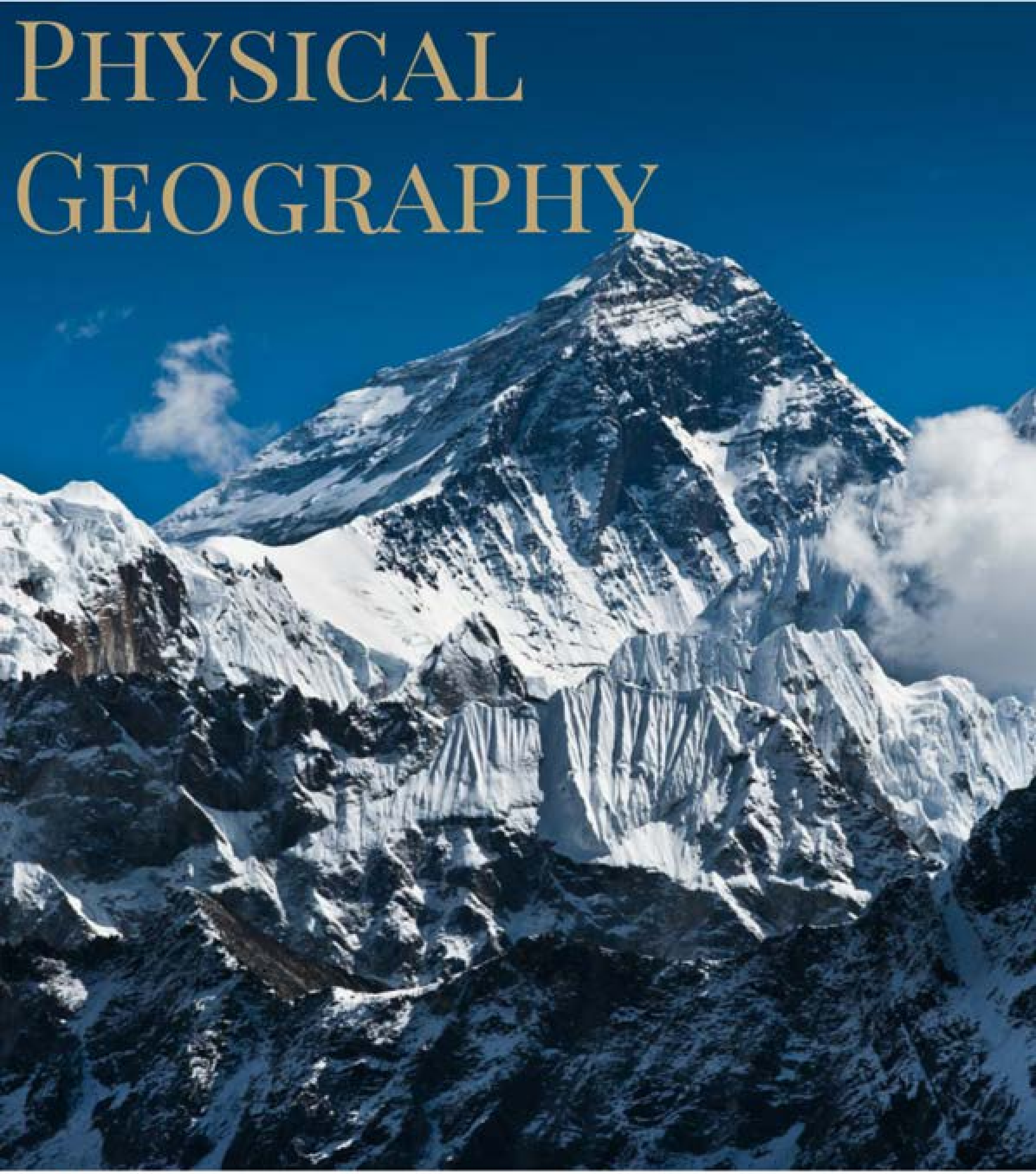
Physical Geography



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Physical Geography

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Origin of the earth

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- **Earlier theories**
  - Geocentric Theory
    - This theory in its final form was given by Ptolemy of Alexandria, Greece.
    - 1. The earth is at the centre of the universe.
    - 2. Sun, the stars and all other heavenly bodies revolve around the earth.
  - Heliocentric Theory
    - This theory was first propounded by Nicolas Copernicus of Poland in his book "De Revolutionibus Orbium Coelestium"
    - 1. Sun is at the centre of the universe.
    - 2. Earth and other planets revolve around the Sun.
    - Galileo Galilei and Sir Issac Newton supported this theory against Geocentric theory.
- **Modern theories**
  - Buffon's Hypothesis
    - Proposed by Comte de Buffon, a French naturalist
    - Earth originated as the result of a collision between the sun and a comet
  - Gaseous Mass Theory
    - Proposed by Immanuel Kant
    - Earth and other planets originated from a rotating nebular mass of gas
    - This theory is based on Newton's laws of gravitation.
  - Nebular hypothesis
    - Proposed by Laplace de Marquis in his book "Exposition du systeme du monde"
    - 1. Intensely hot and rotating Nebular gaseous mass cooled.
    - 2. Rotation and subsequently its centrifugal force increased further due to decrease in volume of the mass.
    - 3. Due to centrifugal force, a ring of mass separated out of nebula and transformed into planetary bodies
  - Planetesimal Hypothesis
    - Proposed by T. C. Chamberlain & F. R. Moulton
    - A star passed by the Sun and drew out some material which later condensed into planetary bodies.
  - Tidal Hypothesis
    - Proposed by Jeans James and Jeffreys, H
    - Tides of gaseous mass from the sun, created as a result of higher gravitational force from an approaching star, condensed to form planets
  - Electromagnetic Hypothesis
    - Proposed by Dr. Hannes Alfven
    - 1. Electromagnetic field around the sun attracted the dust and gaseous mass
    - 2. The dust and gaseous mass revolved around the Sun and condensed into planets.
    - 3. At a later stage the planets grew their own magnetic fields around them.
  - Binary Star Hypothesis
    - Proposed by Russell and Lyttleton
  - Super Nova Hypothesis
    - Proposed by Hoyle and Lyttleton
  - Revised Nebular Hypothesis
    - Proposed by Otto Schmidt of Russia and Carl Weizascar of Germany
    - 1. The sun was surrounded by solar nebula containing hydrogen, helium and dust
    - 2. The friction and collision of particles led to the formation of a disk-shaped cloud
    - 3. The planets were formed through the process of accretion from the clouds
  - Big Bang Theory
    - "Expanding universe hypothesis"
    - Edwin Hubble, in 1920, provided evidence that the universe is expanding.
    - Big bang took place 13.7 billion years before the present.
    - Explosion of a small mass at an extremely high density and temperature, led to the origin of the universe
    - The expansion still continues and; as it expands, some energy is converted into matter.
    - There was a rapid expansion within fractions of a second after Big bang and thereafter, the expansion has slowed down
    - Within 300,000 years from the Big Bang, temperature dropped to 4,500 K and gave rise to atomic matter
    - Expansion of the universe is supported but not the expansion of galaxies.

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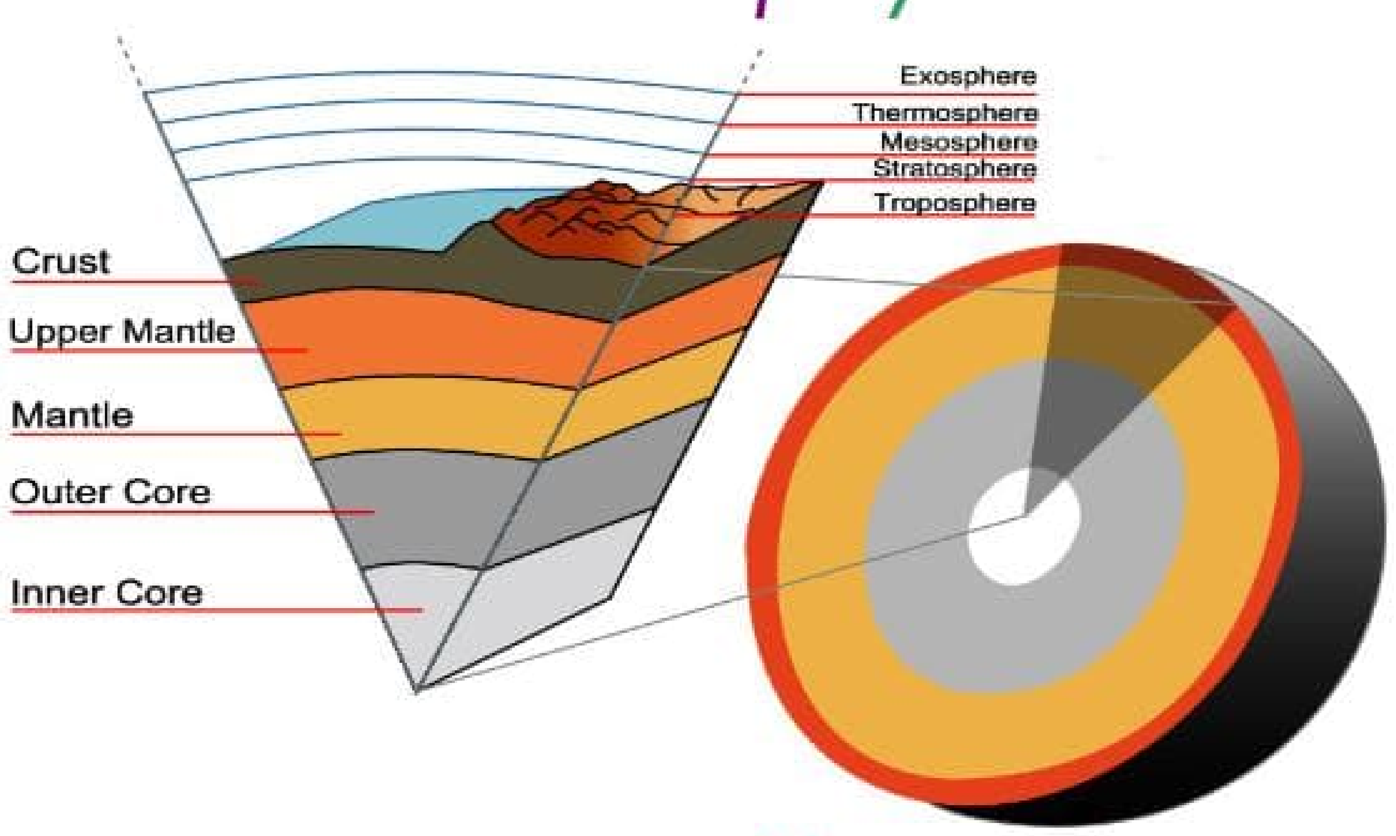

- **shape of the earth**
  - Oblate spheroid
    - slightly flattened at the poles and bulging at the equator.
- **Layers of the Earth**
  - 1. Crust
    - Outermost layer of the Earth
      - 1. Continental crust
      - 2. Oceanic crust
    - Composition
      - made of solid rocks
      - made of the lighter elements
        - silicon, aluminium and oxygen
        - known as **sial or felsic**.
      - Elements by percentage
        - 1. Oxygen 47%
        - 2. Silicon 28%
        - 3. Aluminium 8%
        - 4. Iron 5%
        - 5. Calcium 3.5%
      - Compounds by percentage
        - 1. Silica
        - 2. Alumina
        - 3. Lime
  - 2. Mantle
    - layer below the crust
    - Composition
      - Made of
        - silicon, oxygen and Magnesium
        - known as **sima or mafic**.
      - The density of the Mantle increases gradually with depth.
    - Layers
      - 1. Upper mantle
        - solid base of the crust
        - made of the heavy rock peridotite.
      - 2. Upper aesthenosphere
        - layer is fluidic due to high pressure and temperature
        - leads to movement of continental plates
      - 3. Lower aesthenosphere
      - 4. Lower mantle
  - 3. Core
    - Innermost layer of the earth
    - Composition
      - core is made of solid iron and nickel
      - known as **nife**
    - Layers
      - 1. Outer core
        - molten layer below the mantle
      - 2. Inner core
        - Solid
          - due to high pressure
- **Discontinuities**
  - are the boundaries between layers of earth
    - found by analysis of the seismic waves
  - 1. Conrad discontinuity
    - Between Upper crust and Lower crust
    - named after Victor Conrad
  - 2. Mohorovicic discontinuity
    - Between Crust and Aesthenosphere
    - named after Andrija Mohorovicic
    - It lies at a depth of about
      - 20 miles under the continents
      - 4 to 6 miles under the oceans.
  - 3. Repetti discontinuity
    - Between the upper mantle and the lower mantle
  - 4. Gutenberg discontinuity
    - Between lower mantle and the core
  - 5. Lehman discontinuity
    - Between outer core and the inner core
- **Important points**
  - Lithosphere = Crust + Upper mantle
    - Oceanic lithosphere
    - Continental lithosphere
  - Thickness of continental crust is higher than oceanic crust
  - Mantle is the largest layer by mass and volume, followed by crust and core respectively
  - Earth's density increases gradually from crust to core
  - Oceanic crust is denser than continental crust

Rotation of the Earth
Movement
Earth rotates on its axis from west to east
the reason for the apparent motion of the sun from east to west
Earth rotates once in every 23 hours, 56 minutes, 4.0916 seconds
Apparent rotations
From the North Pole, the direction of Earth's rotation is perceived as counterclockwise or anticlockwise direction.
From the South Pole, the direction of Earth's rotation is perceived as clockwise direction.
Velocity of the rotations
The rotational velocity at the poles is almost equal to zero
The greatest rotational velocity is found at the Equator
The rotational velocity at the 60° latitudes is equal to half of the velocity found at the equator
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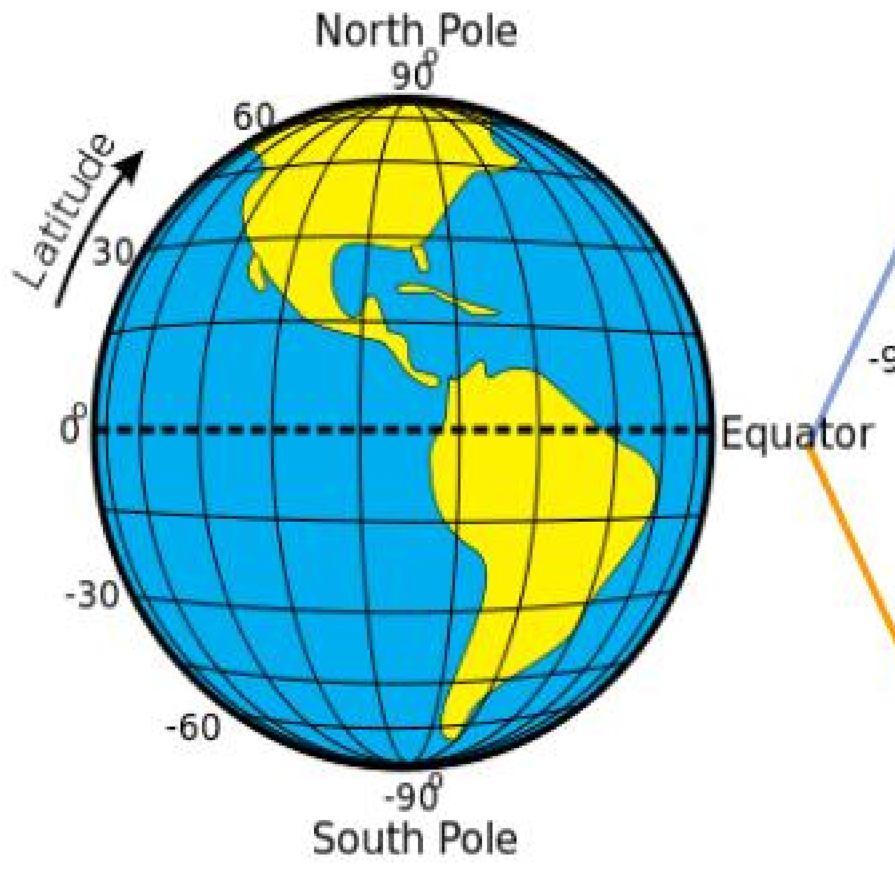
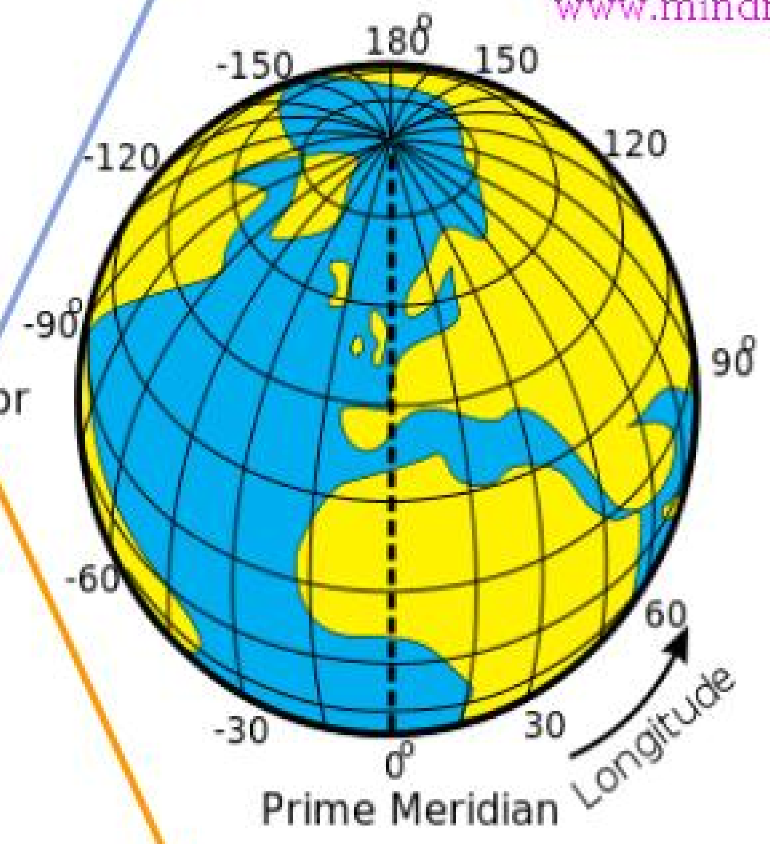
Effects
1) Day and night
Part of earth facing the sun experiences day
Part of earth facing away from the sun experiences Night
The line around the Earth separating the light and dark halves is called "The circle of illumination"
2) Circulations
Atmospheric circulation
Circulation of atmosphere along its layers
Coriolis force
Oceanic circulation
Movement of waters in ocean
Ocean cycle
takes 10,000 years to complete a cycle





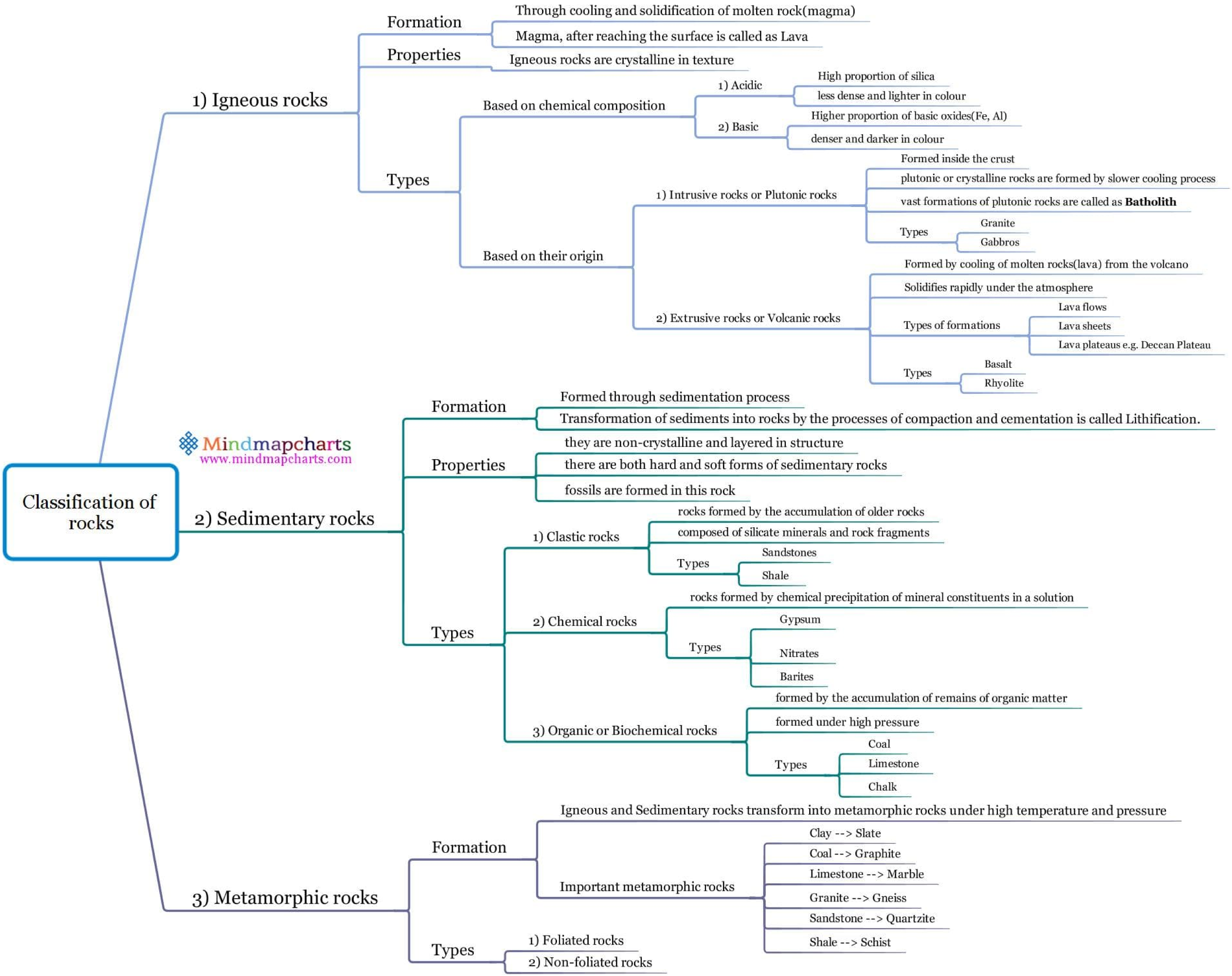
- **Latitude**
  - Latitudes are imaginary lines around the Earth parallel to the equator
    - also called as 'parallels'
  - Characteristics
    - Latitudes gradually decrease in size from the equator(Great circle) towards the pole
    - Degree of latitude is greater at the pole(111.7 km) than at the equator(110.7 km)
  - Measurements
    - Latitude of a place is the angular distance measured either north or south from the equator
    - Distance between the latitudes are constant
    - The length of 60° latitude is half the length of the Equator.
    - The length of 75° latitude is 1/4th of the length of the Equator.
  - Important Latitudinal lines
    - Arctic circle - 66 1/2° N
    - Tropic of cancer - 23 1/2° N
    - Equator - 0°
      - largest of all latitudes
      - also called as zero degree latitude
    - Tropic of Capricorn - 23 1/2° S
    - Antarctic circle - 66 1/2° S
  - Sample Calculation
    - What is the distance 12 degrees north of equator?
    - Solution: 12 x 111.044(average value of a degree latitude) = 1332.5 km
- **Longitude**
  - Longitudes are series of semi-circles passing from north to south direction crossing the equator
    - also known as Meridians
  - Characteristics
    - All meridians are equal in length
    - Meridians extend up to 180° from the east and west of Prime meridian
    - All meridians cross the equator at right angle
    - Degree of longitude is greater at the equator(111.3 km) and decreases gradually towards the Pole(0 km)
  - Zero degree meridian or Prime Meridian
    - Chosen in 1884
    - Prime meridian divides the sphere into two hemispheres
    - Passes through the Royal Astronomical Observatory at Greenwich, London
    - Greenwich Meridian has been adopted internationally as the Standard meridian.
  - Measurements
    - Longitude of a place is the angular distance between a point on any meridian and the prime meridian at Greenwich
    - Longitude of a place is measured either east or west from the Prime meridian
    - Positive longitudes - Longitudes counted west of Prime meridian are called positive longitudes.
    - Negative longitudes - Longitudes counted east of Prime meridian are called negative longitudes.

Revolution of the Earth

- **Movement**
  - Earth revolves round the sun once in every 365.256363004 days
  - Plane of Ecliptic
    - Earth revolves around the sun in an elliptical orbit called "Plane of ecliptic"
    - Earth's equator makes an angle of 23 and 1/2 degrees with the plane of the ecliptic.
      - responsible for change in seasons
    - Earth's axis is inclined at an angle of 66 and 1/2 degrees with the plane of the ecliptic
  - The speed of the Earth revolution along its orbit is 107,000 kph or 29·72 km/s.
- **Effects**
  - 1) Variations in length of day and night
    - Poles experience 6 months of days and 6 months of nights
    - Tropics experience almost equal length of day and night
  - 2) Change of seasons
    - four divisions of the year into spring, summer, autumn, and winter marked by particular weather patterns and daylight hours
  - 3) Distance between Earth and Sun
    - The distance between Earth and Sun varies, due to the elliptical shape of the Earth's orbit around the sun
    - a) Perihelion(3rd January) - The Earth is closest to the sun(≈147 million km)
    - b) Aphelion(4th July) - The Earth is farthest from the sun(≈152 million km) .
    - Change in distance between the Earth and the Sun does not cause any change in the length of day or night.
  - 4) Equinoxes
    - Two days, where the sun is vertically overhead at the equator.
    - 1) Vernal Equinox(21st or 22nd March) - Sun starts to move towards Tropic of cancer
    - 2) Autumnal Equinox(22nd or 23rd September) - Sun starts to move towards tropic of Capricorn
    - Insolation energy is equal in both hemispheres
  - 5) Solstices
    - Either of the two times of the year when the sun is at its greatest distance from the celestial equator
    - 1) Summer solstice
      - Falls on June 21st or 22nd
      - Sun is vertically overhead at the tropic of cancer
      - Longest day and shortest night at Northern hemisphere
      - Insolation energy is greater in Northern hemisphere
    - 2) Winter solstice
      - Falls on December 21 or 22
      - Sun is vertically overhead at the tropic of Capricorn
      - Longest day and shortest night at Southern hemisphere
      - Insolation energy is greater in Southern hemisphere
  - 6) Leap Year
    - Earth takes 365 and 1/4 days to complete one revolution = 365 days and 6 hours
    - Every 4th year the fraction of 6 hours from the previous 3 years is cumulated and added as 29th of February to form the Leap year(366 days).

Time and International date line

- **International Date line**
  - It is the 180° longitude line where the date changes by one day when crossed.
  - Adopted at the International Meridian Conference held in Washington in 1884.
  - A day is
    - gained when crossed from west to east
    - lost when crossed from east to west
- **Time**
  - Time advances in eastward direction and decreases in westward direction
  - Places east of Greenwich gain time and places west of Greenwich lose time
  - Units
    - 1 Revolution of earth = 360° or 24 hours
    - 15° = 1 hour
    - 1° = 4 minutes
  - Time zones
    - World is divided into 24 Standard Time Zones
    - Each zone differs by 15°(1 hour)
    - Countries with highest number of time zones
      1. France - 12 time zones
      2. Russia - 11 time zones
      3. UK = 9 time zones
      4. Australia = 8 time zones
      5. Canada = 6 time zones
- **Kinds**
  - Sidereal Time
    - Sidereal time is the time measured by the diurnal motion of stars
    - The Sidereal day is also divided into 24 hours, each hour into 60 minutes and each minute into 60 seconds.
  - Apparent Solar Time
    - Apparent solar time is the time as measured by the apparent position of the sun in the sky
    - Sun dial is used to measure the apparent solar time.
    - Apparent solar day is not of uniform length and hence, it is not synchronous with regular clock speed
  - Mean solar time
    - Time measured based on the diurnal motion of the mean sun is called 'Mean solar time' or Mean Time
    - Mean sun is an imaginary sun moving uniformly along the celestial equator to make a solar day of uniform length
    - Mean solar time was devised to rectify the drawback in Apparent solar time.
    - Mean solar day is divided into 24 hours, each hour into 60 minutes and each minute into 60 seconds.
    - Two systems
      - Civil time
        - Ante Meridian - From midnight to noon
        - Post Meridian - From noon to midnight
      - Astronomical time
        - Starts at zero hours and ends at 24th hour.
    - Since 1st January 1925, Mean Solar Day began at midnight which was at noon prior to that.
  - Standard time
    - It is the uniform time for places in approximately the same longitude, established in a country or region by law
    - India Standard Time(IST) = 82.5° east = UTC+05:30 (Universal Time Coordinated.) .
    - IST location: 82.5° E longitude, in Shankargarh Fort mirzapur ,(25.15°N 82.58°E), Allahabad, U.P.
    - Local mean time of the places on the
      - eastern side of Prime meridian is later than standard time
      - western side of Prime meridian is earlier than standard time


Classification of rocks
1) Igneous rocks
Formation
Through cooling and solidification of molten rock(magma)
Magma, after reaching the surface is called as Lava
Properties
Igneous rocks are crystalline in texture
Types
Based on chemical composition
1) Acidic
High proportion of silica
less dense and lighter in colour
2) Basic
Higher proportion of basic oxides(Fe, Al)
denser and darker in colour
Based on their origin
1) Intrusive rocks or Plutonic rocks
Formed inside the crust
plutonic or crystalline rocks are formed by slower cooling process
vast formations of plutonic rocks are called as **Batholith**
Types
Granite
Gabbros
2) Extrusive rocks or Volcanic rocks
Formed by cooling of molten rocks(lava) from the volcano
Solidifies rapidly under the atmosphere
Types of formations
Lava flows
Lava sheets
Lava plateaus e.g. Deccan Plateau
Types
Basalt
Rhyolite
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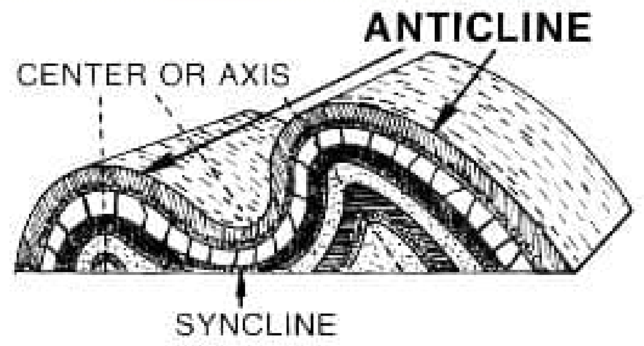
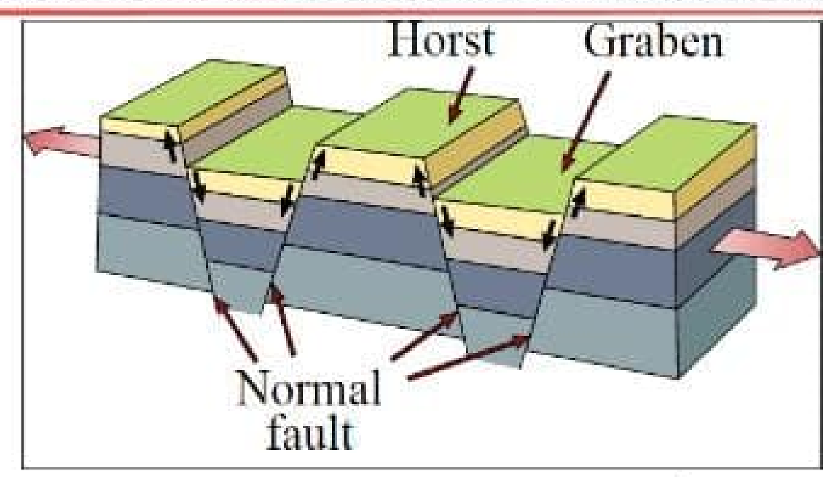
2) Sedimentary rocks
Formation
Formed through sedimentation process
Transformation of sediments into rocks by the processes of compaction and cementation is called Lithification.
Properties
they are non-crystalline and layered in structure
there are both hard and soft forms of sedimentary rocks
fossils are formed in this rock
Types
1) Clastic rocks
rocks formed by the accumulation of older rocks
composed of silicate minerals and rock fragments
Types
Sandstones
Shale
2) Chemical rocks
rocks formed by chemical precipitation of mineral constituents in a solution
Types
Gypsum
Nitrates
Barites
3) Organic or Biochemical rocks
formed by the accumulation of remains of organic matter
formed under high pressure
Types
Coal
Limestone
Chalk
3) Metamorphic rocks
Formation
Igneous and Sedimentary rocks transform into metamorphic rocks under high temperature and pressure
Important metamorphic rocks
Clay --> Slate
Coal --> Graphite
Limestone --> Marble
Granite --> Gneiss
Sandstone --> Quartzite
Shale --> Schist
Types
1) Foliated rocks
2) Non-foliated rocks

Mountains

- **Orogeny**
  - Orogenesis refers to the forces and events leading to a large structural deformation of the Earth's lithosphere due to tectonic plates.
  - Continental plate is crumpled and pushed upwards to form mountain ranges
  - Orogenesis involves
    - Folding, faulting, volcanic activity, igneous intrusion and metamorphism to form mountains
  - Forms of mountains
    - 1. Mountain ridge
      - chain of mountains or hills that form a continuous elevated crest for some distance
    - 2. Mountain range/barrier/belt/chain/system
      - geographic area containing numerous geologically related mountains
      - e.g. Himalayas, Alps, Andes etc...
- **Types**
  - 1) Fold Mountains
    - Continental crust floating above the mantle is forced upward to form hills, plateaus or mountains
    - Fold mountains are formed when
      - two plates collide under stress
      - there is an imbalance in weight of overlying rocks
      - there are variations in mantle flow
      - there is an intrusion of magma
    - Fold mountains are formed under compressive forces



    - Crust is folded into
      - 1) Syncline
        - Trough or Downfold of the crust
      - 2) Anticline
        - Crest or Upfold of the crust
    - Many active volcanoes are found in fold mountains
    - Major fold mountains
      - Himalayas in Asia
      - Alps in Europe
      - Andes in South America
      - Rockies in North America
      - Urals in Russia
  - 2) Block or Fault mountains
    - Block mountains are formed when the crust rifts or faults
    - Block mountains are formed under both tension and compressive forces
    - One side of the fault rises relative to the other forming a mountain



    - Formations
      - The uplifted blocks form block mountains or horsts
      - The dropped blocks form graben and rift valleys
    - Major Block mountains
      - Rift valley in Africa
      - Narmada river Valley in India between the Vindhya and Satpura horsts.
      - Rhine valley in Europe
      - Vosges mountains in France
      - Black forest in Germany
  - 3) Volcanic mountains
    - Formed when molten rock or lava erupts, and piles upon the surface
    - Types
      - Shield Volcano
      - Strato volcano
      - Dome mountains
    - Major Volcano mountains
      - Mount Fuji in Japan
      - Mount Pinatubo in the Philippines
      - Navajo Mountain in the United States
      - Mount Catopaxi in Ecuador
  - 4) Plateau or Erosion mountains
    - Formed by denudation or weathering forces
    - Large mountains are subjected to the agents of erosion (water, wind, ice, and gravity) which results in plateaus
    - Major plateaus of erosion
      - Deccan plateau

Plateau
Basics
A relatively flat highland is called as plateau
Plateaus are also known as tablelands
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Types
1. Continental plateau
Also known as Tectonic or Intermontane plateau
Formed by the upliftment of earth due to plate tectonics
They are vast and have almost uniform altitude
Plateau enclosed by fold mountains are called intermont plateau
e.g. Tibetan plateau is enclosed by Himalayas and Kunlun mountains
2. Volcanic or lava plateau
lava flows in the form of successive layers of sheets and cools to form volcanic plateau
Important lava plateau
Deccan plateau
Columbian plateau
3. Border plateau
Formed along the borders of Mountain ranges
e.g. Piedmont plateau, Colorado plateau
4. Dissected or erosional plateau
Plateaus are worn down by the weathering processes to form the dissected plateau
e.g. Scottish islands

Plains

- Basics
  - Plains are extensive tracts of level or undulating open land
  - Plains are generally lower in altitude
- Types
  - 1. Structural plains
    - Structurally depressed lowlands are called structural plains
    - these plains are extensively flat
    - e.g. Plains of Russia, USA, Argentina etc...
  - 2. Depositional plains
    - Depositional plains are formed by the deposition of materials brought by various agents of transportation
    - these plains are highly fertile
    - Types
      - Alluvial plains
        - A flat resulting from repeated deposits of alluvial material by running water
      - Flood plains
        - A low plain adjacent to a river formed by river sediments
      - Deltaic plains
        - Nile delta
        - Ganges delta
      - Loess plain
        - A fine-grained unstratified accumulation of clay and silt deposited by the wind over hills, plains and valleys
      - Outwash plain
        - formed by the deposition of sand and gravel of glacial sediments
        - not fit for cultivation
      - Drift plain
        - formed by the deposition of boulders and clay of glacial sediments
        - Partly cultivable
      - Coastal plains
        - Marine swamps
          - Low land that is seasonally flooded
        - Tidal lowlands
  - 3. Erosional plains
    - Formed by the gradual erosion of landforms by the agents of erosion
    - Erosional agents include rain, wind, river, glacier, ice etc...
    - Types
      - Peneplains
        - a more or less level land surface representing an advanced stage of erosion
      - Pediplains
        - an extensive plain formed in a desert by the coalescence of neighbouring pediments.
      - Desert plains
      - Ice scoured plains

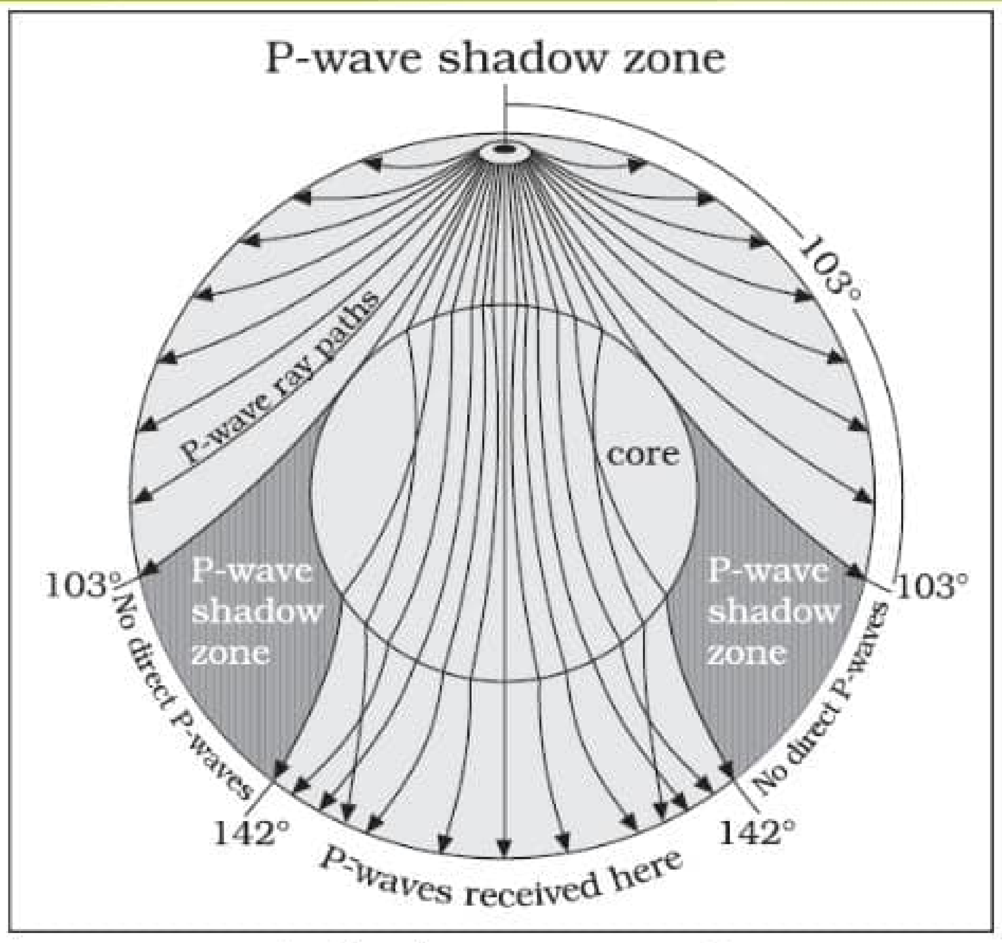
Volcanism

- **Origin**
  - Volcano erupts from the fissure in the earth's crust through which molten lava and gases flows out
  - Volcanic Process
    - i. The less dense crust floats above the denser mantle
    - ii. Mantle contains a weaker zone called Asthenosphere with molten rock materials
    - iii. The molten rock material called magma moves towards the crust
    - iv. Magma opens the crust and henceforth flows as lava
    - v. The continuous flow of lava results in larger volcanic mountains
  - Volcano exerts lava flows, pyroclastic debris, volcanic bombs, ash, dust and gases
  - Gases include CO2, nitrogen compounds, sulphur compounds and minor amounts of chlorine, hydrogen and argon.
- **Types of lavas**
  - Acidic lavas
    - are light coloured and rich in lighter elements such as silica
    - flow slowly with heavy explosions
    - form steep cone volcanoes
  - Basic lavas
    - are brightly coloured and rich in iron and magnesium
    - flow smoothly without explosions
    - form wider volcanoes with relatively flat dome or shield
- **Types of volcanoes**
  - Based on periodicity of eruption
    - 1. Active volcano
      - Volcanoes which erupt frequently or erupted in the recent past
      - e.g. Mt. Etna, Mt. Saint Helens
    - 2. Dormant volcano
      - Volcanoes which are known to erupt and has the signs of eruption in the future
      - e.g. Mt. Kilimanjaro
    - 3. Extinct volcano
      - Volcanoes without any active signs of eruption are called extinct
  - Based on form
    - 1. Shield Volcanoes
      - largest of all the volcanoes on the earth
      - mostly made up of basaltic lava
      - these volcanoes are not steep
      - they are characterised by low explosions
      - lava moves in the form of a fountain and develops into cinder cone.
    - 2. Composite Volcanoes
      - characterised by eruptions of cooler and more viscous lavas than basalt.
      - also called as Strato-volcanoes
      - often result in explosive eruptions
    - 3. Calderas
      - most explosive type of volcanoes
      - during explosive eruption they collapse on themselves rather than building any tall structure.
      - collapsed depressions are called calderas.
    - 4. Flood Basalt Provinces
      - These volcanoes outpour highly fluid lava that flows for long distances
      - Individual flows may extend for hundreds of km with thickness of around 50 metres.
      - Deccan Traps covering most of the Maharashtra plateau is a larger flood basalt province
    - 5. Mid-Ocean Ridge Volcanoes
      - Volcanoes in the oceanic areas
- **Distribution of volcanoes**
  - Most volcanoes are found in three well defined belts
    - 1. Circum-Pacific belt
      - mountains of south America to Alaska
      - Aleutian Islands to Japan
      - Philippines
      - Indonesia
      - New Zealand.
    - 2. Mid-World Mountain belt
      - Alps in Europe
      - Asia Minor
      - Himalayan region
    - 3. African Rift Valley belt
  - Volcanoes in India
    - There is only one dormant volcano in India located at Narcondam in Andaman and Nicobar Islands..
  - Volcanoes occur along coastal mountain ranges, on islands and in the mid-oceans.
  - Most of the active volcanoes are found in the Circum-Pacific region and hence called as 'Pacific Ring of Fire'
  - Most of the volcanoes in the African rift valley are extinct
  - Mt. Cameroon is the only active volcano in Central West Africa

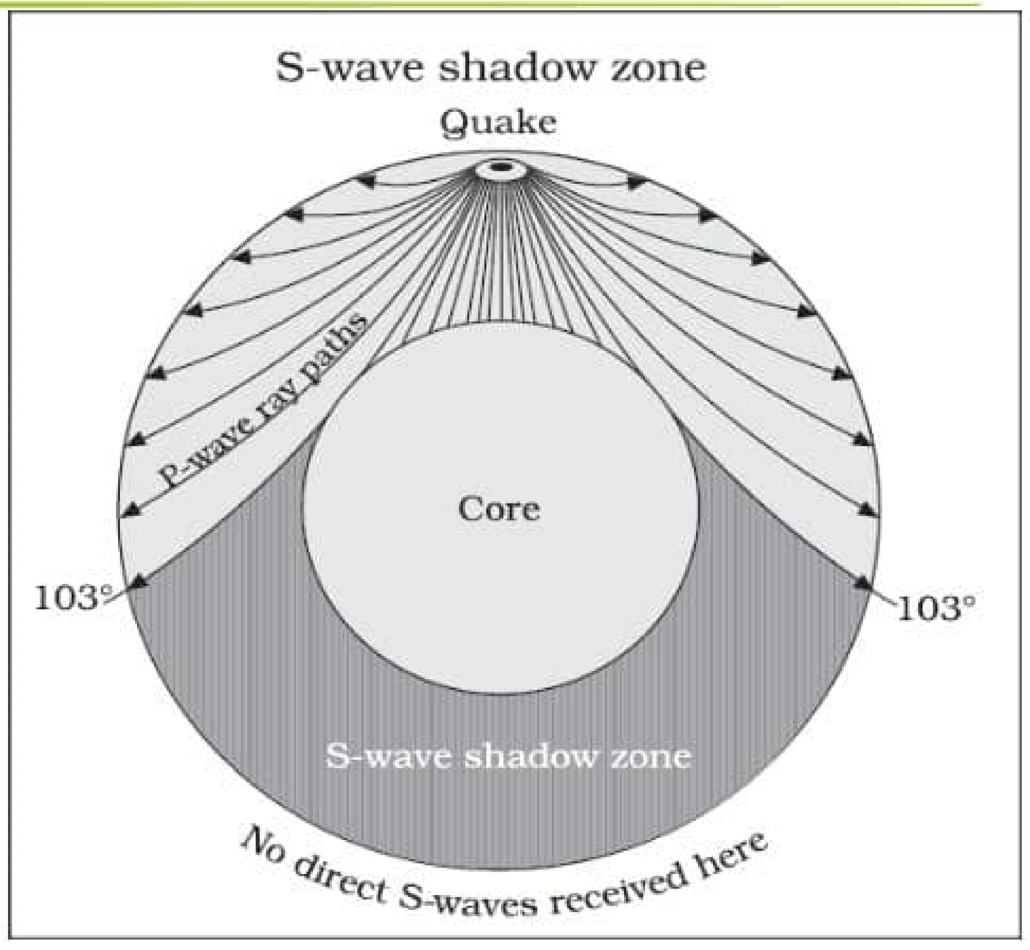
Seismic waves

- **Basics**
  - Waves generated by the earthquake are called seismic waves
  - Study of earthquake is called Seismology.
  - Speed of seismic waves
    - in crust is around 2-8 Km per second
    - in mantle is around 8-13 Km per second
  - Instruments used to measure seismic waves
    - Seismograph
    - Accelerometer
    - Geophone
    - Hydrophone
- **Earthquake Waves**
  - Characteristics
    - The velocity of waves changes as they travel through materials with different densities.
    - Waves travel with higher velocity in denser materials
    - Waves change their direction as they reflect or refract across materials with different densities.
  - 1. Body waves
    - generated due to the release of energy at the focus
    - Body waves travel through the body of earth in all directions
    - Two types
      - P-waves
        - P-waves are faster and are the first to arrive at the surface
        - also called as primary waves
        - P-waves are similar to sound waves
        - They vibrate parallel to the direction of waves
        - They travel through gaseous, liquid and solid materials
      - S-waves
        - S-waves arrive at the surface with some time lag
        - also called as secondary waves
        - they can travel only through solid materials
        - S-waves vibrates in the direction perpendicular to the wave direction
        - S-waves are more destructive than P-waves
        - used by scientists to understand the structure of the interior of the earth.
  - 2. Surface waves
    - body waves interact with the surface rocks and generate new set of waves called surface waves.
    - Surface waves travel along the surface.

- **Shadow Zone**
  - areas where the earthquake waves are not reported
  - for each earthquake, there exists an altogether different shadow zone.



  - 1) shadow zones of P-waves



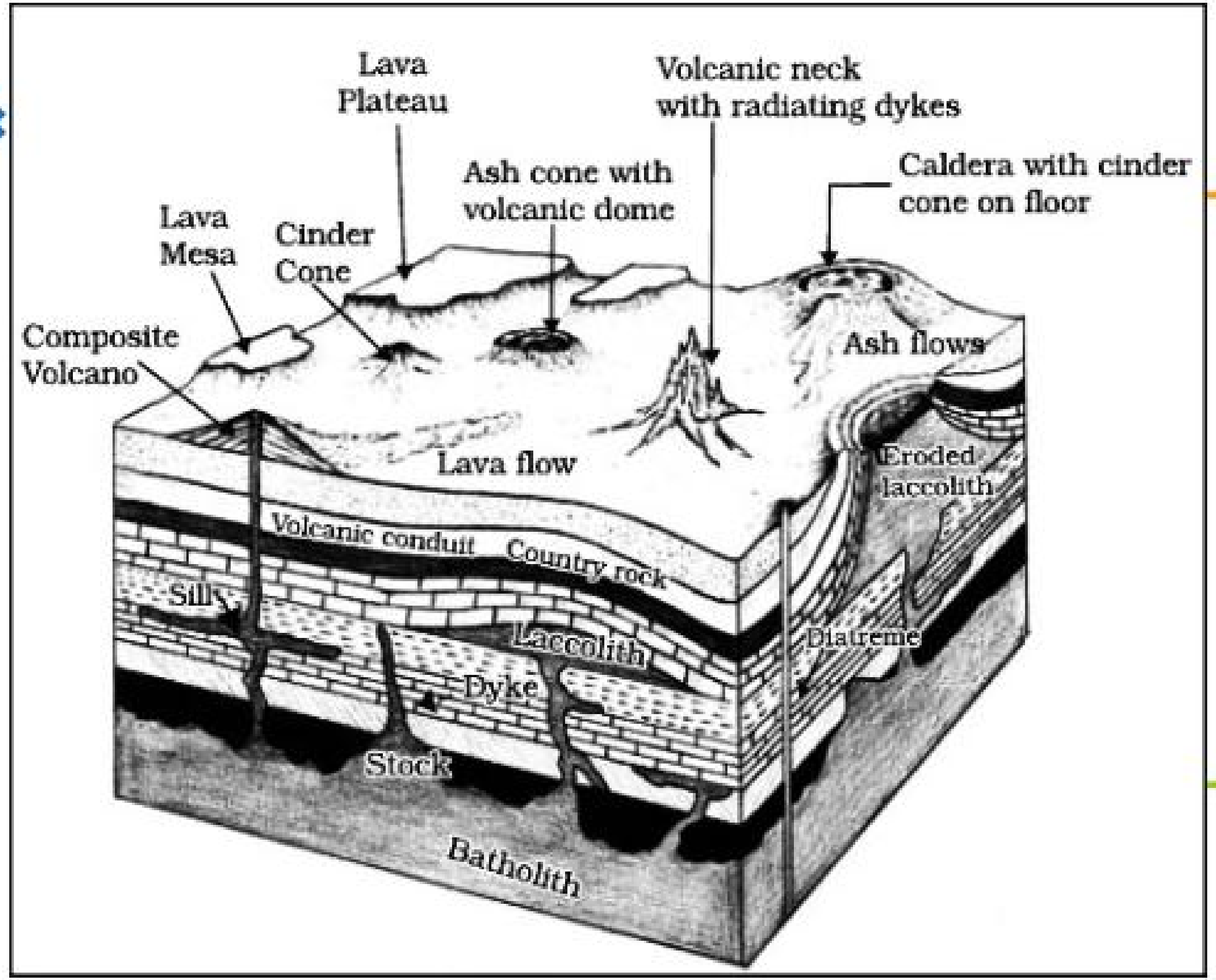
  - 2) shadow zones of S-waves
  - observations
    - seismographs located within 105° from the epicentre, recorded the arrival of both P and S-waves.
    - seismographs located beyond 145° from epicentre, recorded P-waves, but not S-waves.
    - zone between 105° and 145° from epicentre is the shadow zone for both the types of waves.
    - entire zone beyond 105° does not receive S-waves
    - The shadow zone of S-wave is much larger than that of the P-waves.

Earthquake

- **Origin**
  - Shaking and vibration at the surface of the earth is called earthquake
  - Earthquake releases energy, which generates waves that travel in all directions.
  - Earthquake results from the underground movement along a fault plane or from volcanic activity
  - Process
    - i. Rocks along a fault tend to move in opposite directions.
    - ii. But the overlying rock strata presses and locks them together
    - iii. at some point they overcome the friction and the blocks get deformed and slide past one another abruptly
    - iv. This results in the release of energy, and the energy waves travel in all directions
  - Terms
    - Focus/Hypocentre
      - The point where the energy is released is called the focus of an earthquake or hypocentre.
    - Epicentre
      - The point on the surface, nearest to the focus, is called epicentre.
      - It points directly above the focus.
      - It is the first point to experience the waves.
    - Magnitude of earthquake
      - Quantitative measure of the size of the earthquake at its source
    - Intensity of earthquake
      - severity of earthquake shaking
      - intensity is variable over the area affected by the earthquake
        - high intensities near the epicentre
        - lower intensities away from the epicentre
- **Types of Earthquakes**
  - 1. Tectonic earthquakes
    - due to sliding of rocks along a fault plane.
  - 2. Volcanic earthquakes
    - confined to areas of active volcanoes
  - 3. Collapse earthquakes
    - due to intense mining activity
  - 4. Explosion earthquakes
    - due to the explosion of chemical or nuclear devices.
  - 5. Reservoir induced earthquakes
    - earthquakes that occur in the areas of large reservoirs

- **Measurement of earthquakes**
  - Earthquakes are measured using a device called Seismograph
  - Earthquakes are scaled either according to the magnitude or intensity of the shock.
  - 1) Magnitude scale
    - known as the Richter scale.
    - Richter Magnitude Scale measures the amount of seismic energy released by an earthquake.
    - Richter scale is a base-10 logarithmic scale developed by Charles Richter and Beno Gutenberg
    - magnitude is expressed in absolute numbers, 0-10.
  - 2) Intensity scale
    - intensity is assessed using a descriptive scale called Modified Mercalli Intensity Scale.
    - The intensity scale takes into account the visible damage caused by the event.
    - The range of intensity scale is from 1-12.
- **Earthquakes in India**
  - Causes
    - Movement of Indian plate towards the Asian continental plate at the rate of 45 mm per year
    - Rotation of Indian plate in anticlockwise direction.
    - Convergence of Indian plate with Tibetan plate
  - Seismic zones of India
    - Four zones
      - Zone - II - Low damage risk zone
      - Zone - III - Moderate damage risk zone
        - Andaman and Nicobar islands
        - parts of Kashmir
        - Western Himalayas
      - Zone - IV - High damage risk zone
        - Delhi
        - Bihar
        - Indo-Gangetic plain
        - Jammu
      - Zone - V - Highest risk zone
        - Kashmir
        - Punjab
        - Himalayas
        - Northeastern states
        - Rann of Kutchch
      - Zone I has been removed

Volcanic landforms



Intrusive Forms

- Sill: a flat (usually horizontal) mass of igneous rock between two layers of older sedimentary rock
- Dyke: a vertical intrusion of igneous rock cutting across existing layers of rocks
- Laccolith: a mass of igneous rock, typically lens-shaped, that has been intruded between rock strata causing uplift in the shape of a dome
- Lopolith: a large saucer-shaped intrusion of igneous rock.
- Phacolith: A small lenticular igneous intrusion, shaped by folding in an anticline
- Batholith: Large mass of intrusive igneous rock believed to have solidified deep within the earth

Extrusive forms

- Crater
- Cinder cones
- Ash flows
- Lava flows
- Crater lakes
- Calderas
- Parasitic cones

Weathering

- **Basics**
  - Weathering is the gradual disintegration of rocks by the combined action of exogenic and endogenic forces of earth
  - Weathering elements include wind, temperature, rainfall, frost, fog, ice etc...
  - Weathering contributes significantly to soil formation
  - Various processes of weathering helps in producing different colours and properties of soil
- **Types**
  - 1) Physical Weathering
    - disintegration of rocks without any chemical change
    - 1. Block disintegration
      - disintegration of rocks by expansion and contraction of the rocks due to temperature variations
      - high diurnal range of temperature causes successive expansion and contraction of the rocks
    - 2. Exfoliation
      - peeling of rocks due to intense heating of outer layers of the rock
    - 3. Frost Action
      - alternate freezing and melting of water inside the joints of the rocks, splits them into fragments
  - 2) Chemical weathering
    - change in the rocks through formation of new compounds
    - Chemical processes include oxidation, hydrolysis, and acid solution.
    - 1. Oxidation
      - atmospheric oxygen reacts with the rock to produce oxides.
    - 2. Carbonation
      - removal of rocks through carbonic acid
    - 3. Hydration
      - absorption of water by the minerals of the rock
      - volume of the rock increases and the grains lose their shape
    - 4. Solution
      - dissolution of minerals in water
  - 3) Biotic weathering
    - 1. Plants
      - Plants contribute to both mechanical and chemical weathering
      - Growth of roots disintegrates the rocks
    - 2. Animals
      - Hooves of animals break the soil and thus assist soil erosion
      - Burrowing animals like earthworms, rats, rabbits, termites and ants breakdown the rocks
      - Earthworms can convert 10 to 15 tonnes of rock mass into good soil and bring it to the surface
    - 3. Man
      - Man breaks lot of rocks for construction, agriculture and mining activities

Soil Erosion

- **Definition**
  - Removal of soil at a greater rate than its replacement by natural agencies is called soil erosion.
- **Types**
  - 1. Wind Erosion
    - Winds carry away vast quantity of fine soil particles and sand from deserts and spread it over adjoining cultivated land and thus destroy their fertility.
    - Thar Desert is spreading wind erosion over parts of Gujarat, Haryana, Punjab and Rajasthan.
  - 2. Sheet erosion
    - Water when moves as a sheet takes away thin layers of soil
    - common along the river beds and areas affected by floods
  - 3. Rill Erosion
    - Removal of surface soil by running water
  - 4. Gully Erosion
    - Water moves as channels down the slope and takes away the soil forming gullies
    - These lands are called bad lands or ravines.
    - Ravines are common in Chambal and Yamuna river basins in U.P. and M.P.

Continental Drift

- **Facts**
  - The gradual movement and formation of continents is called continental drift
  - Conceived by the German scientist Alfred Wegener
  - Indian sub-continent has broke away from Gondwanaland during cretaceous period
- **Continental Drift theory**
  - About 280 million years ago, there was a super continent(entire landmass of earth) called Pangea
  - The huge water body surrounding the Pangea was known as Panthalasa
  - Pangea broke into Laurasia (Angaraland) and Gondwanaland in the Carboniferous period
  - Both of them drifted away and in between a shallow sea emerged known as Tethys sea.
- **Evidences for Continental Drift**
  - 1. Jig-saw-fit of continents
    - Coasts of continents could be fit like jigsaw puzzle
  - 2. Geological similarities
  - 3. Coal and Vegetation evidences
    - South America, Africa, India and Australia were together in geological past.
  - 4. Evidences from paleomagnetism
    - study of direction of magnetic fields in magnetic materials aligned during their crystallization at specific periods
    - Magnetic minerals in magma like haematite, magnetite etc... get aligned with the magnetic pole of the earth
    - Confirmed the theory of continental drift
  - 5. Sea floor spreading
  - 6. Glacial deposits

Plate tectonics

- **Process**
  - i. Solid mantle and upper crust together forms the lithosphere.
  - ii. The lithosphere is broken into several blocks known as plates, which moves over the Asthenosphere(molten mantle)
  - iii. Plates move due to Convectional current initiated by radio-active minerals, 100 to 250 km below the surface
  - iv. Plates move continuously with relative direction of movement called as plate tectonics
- **Plates**
  - 1. 7 major plates
    - 1. Eurasia and the adjacent oceanic plate
    - 2. Africa with the eastern Atlantic floor plate
    - 3. India-Australia-New Zealand plate
    - 4. Pacific plate
    - 5. North American plate
      - with western Atlantic floor separated from the South American plate along the Caribbean islands
    - 6. South American plate and
      - with western Atlantic floor separated from the North American plate along the Caribbean islands
    - 7. Antarctica and the surrounding oceanic plate
  - 2. 20 minor plates
    - important minor plates
      - (i) Cocos plate : Between Central America and Pacific plate
      - (ii) Nazca plate : Between South America and Pacific plate
      - (iii) Arabian plate : Mostly the Saudi Arabian landmass
      - (iv) Philippine plate : Between the Asiatic and Pacific plate
      - (v) Caroline plate : Between the Philippine and Indian plate (North of New Guinea)
      - (vi) Fuji plate : North-east of Australia.
  - The major and minor plates together constitute the whole surface of the earth
- **Plate boundaries**
  - (i) Divergent boundary
    - Diverging currents produce tension at the contact-zone of crust leading to fracture
    - This process pushes the plates in opposite direction and creates a zone called "zone of construction"
  - (ii) Convergent boundary
    - Converging currents produce compression at the contact-zone of crust leading to collision
    - i. When both are continental plates, collision leads to mountain formation
    - ii. When both are maritime plates, then the collision leads to formation of trenches and Island volcanic arcs(Japan, Indonesia etc...)
    - iii. When continental and maritime plates collide, continental plate subdues the maritime plate forming volcanic landforms
    - In all three situations, surface area is reduced, therefore, this is also known as "zone of destruction".
  - (iii) Fracture or transform boundary fault
    - Transform fault is the one when two adjacent plates slide past each other
    - Direction of movement may be along or against but they move parallel to each other.
    - There is no construction or destruction of areas and hence, it is known as "zone of preservation".
  - Earthquakes and Volcanoes are widely distributed and concentrated along the plate boundaries

River

- **Definition**
  - Path followed by a river is called its course or its valley.
  - The course of a river is divided into three sections
- **River course**
  - 1. The upper course or the stage of youth
    - Begins from the source of the river in hills or mountains
    - Weathering leads to formation of 'V' shaped valleys.
    - gorges, rapids, cataracts, cascades and waterfalls are also formed
    - A canyon is a very deep gorge e.g. Grand Canyon of Colorado river
    - Brahmaputra and Indus forms deep gorges(i.e. a river valley with almost vertical sides) in India
  - 2. The middle course or the stage of maturity
    - Lateral corrosion widens the 'V' shaped valley.
    - Alluvial fans and Meanders are formed along the course
  - 3. The lower course or the stage of old age
    - Heavy deposition of sediments in lower plains
    - Flood plains, Ox-bow lakes, Deltas, Levees and estuaries are formed
- **Facts**
  - Favourable conditions for Delta formation
    - (1) large amount of sediments
    - (2) coast with less tidal activity
    - (3) shallow sea, adjoining the delta
    - (4) no strong current at the river mouth
  - Ganga-Brahmaputra Delta is the largest delta in the world.
  - River discharge its water through several channels called distributaries.
  - Tributary is a river or stream flowing into a larger river
  - Rivers emptying into sea with the shape of a gradually widening mouth cutting deep inland are called estuaries
  - Narmada and Tapi form estuaries when they join the Arabian Sea.

Underground water and Landforms

- **Water forms**
  - Artesian well
    - water rises automatically under its own pressure to the surface
  - Springs
    - Springs are surface outflow of ground water through an opening in a rock underhydraulic pressure.
  - Hot springs
    - Springs with hot water outflow are called hot springs
    - occurs in areas of active or recent vulcanism.
    - Hot springs in India
      - Jammu and Kashmir
      - Himachal Pradesh - Manikaran in Kulu Valley, Tatapani near Shimla
      - Jharkhand - Rajgir and Sitakund
      - Uttarakhand - Badrinath
      - Assam
      - Haryana - Sohna
  - Geysers
    - Springs emitting hot water and steam in forms of fountains or jets at regular intervals are called geysers
    - water is forced out by steam pressure at intervals.

- **Landforms**
  - The distinctive topography formed due to the action of underground water in limestone region is known as Karst topography
  - on the surface
    - Sink holes
      - A sinkhole is a funnel-shaped depression in a region of limestone or chalk terrain
    - Swallow holes
      - They are cylindrical in shape lying underneath the sinkholes at some depth
      - surface streams often enter the sinkholes and then disappear underground through swallow holes
  - underground
    - Caverns
      - Caverns are interconnected subterranean cavities in bedrock formed by the corrosion of limestone
      - Caverns in India
        - Dehradun in Uttarakhand
        - Almora in Kumaon Himalayas
        - Kotamsar in Chhattisgarh
    - Stalactites
      - Solid conical depositional features hanging from the cavern's roofs are called stalactites.
      - They are formed by the evaporation of water containing limestone in solution
    - Stalagmites
      - Broad conical pillars developing on the floor of the caverns are called stalagmites
      - They are formed by the evaporation of water dripped from the stalagmites containing limestone in solution

Wind and Sea wave landforms

- Wind landforms
  - 1. Erosional landforms
    - (i) Mushroom Rocks
      - Erosion of stratified rock with alternate layers of hard and soft rock
    - (ii) Wind Eroded Basins
  - 2. Depositional landforms
    - (i) Sand Dunes
      - (a) Barchan
        - isolated heap of free sand
        - also called as Crescent dunes
      - (b) Seif Dunes
        - long, narrow ridges of sand lying parallel to the direction of the prevailing winds
        - Common in Thar desert
    - (ii) Loess
      - A fine-grained unstratified accumulation of clay and silt deposited by the wind
      - Mostly carried in large quantities by dust storms
- Sea wave landforms
  - 1. Erosional landforms
    - (i) Sea Cliff
      - Impact of the sea waves erodes the lower part of coastal rocks more rapidly than the upper part
      - The upper part of the rock projects out towards the sea and fall into the sea under its own weight, leaving a vertical wall called cliff
    - (ii) Sea Caves
      - differential erosion creates a hollow in the lower part of the rock leading to the formation of caves.
    - (iii) Sea Arches
    - (iv) Sea Stacks
  - 2. Depositional landforms
    - (i) Beach
    - (ii) Sand Bar
      - deposits of sand and gravel laid down by waves and currents form an embankment called sandbar
    - (iii) Spit
      - one end of sandbar extended into the sea is called a spit.
    - (iv) Lagoon
      - ends of sandbar join to enclose a part of the sea water between the coast and the bar forming a lake of saline water called lagoon.
      - lagoons are also formed by wave erosion
      - Lagoons in India
        - Vembanad lake in Kerala
        - Chilka and Pulicat lakes

Glaciers and landforms

- Snowfields
  - Permanently snow covered regions are called snowfields
  - Snow accumulates and compacts to form Glaciers
  - Snowfields occur in polar regions and on high mountainous areas.
  - Snowfields are always found above the snow line(imaginary line above which there is permanent snow)
  - Factors affecting snow line are
    - latitude
    - amount of snowfall
    - direction of winds
    - slope of the land
- Glaciers
  - great mass of ice moving under its own weight is called a glacier.
  - Velocity of glacier is very low and it moves from a few centimetres to a few metres in a day.
  - Types of Glaciers
    - 1. Continental glaciers
      - A thick ice sheet covering vast area of land is called a continental glacier.
      - found mainly in Antarctica and Greenland
    - 2. Valley glaciers
      - Large mass of ice moving down from the high mountainous regions into valleys is called a valley glacier
      - also called as mountain glacier
  - Glaciers in India
    - The longest glacier in India is the Siachen Glacier in Karakoram range which is 72 kilometres long
    - Ganga river originates from Gangotri glacier(25 Km long)
    - Yamuna river originates from Yamunotri glacier
- Glacial landforms
  - 1. Erosional landforms
    - (i) Cirque
      - bowl shaped depression at the head of a valley or on a mountainside, formed by glacial erosion.
    - (ii) U - shaped Valley
      - Valley formed in a manner resembling the shape U is called U - shaped valley
      - These valleys are relatively straight with flat floor and nearly vertical sides.
    - (iii) Hanging Valley
      - Valley of the tributary glacier hanging downwards at the point of its confluence with the main valley is called a hanging valley.
  - 2. Depositional landforms
    - Deposits of glaciers are called as moraines
    - (i) Terminal moraine
      - Glacier deposits at the end of the valley glacier in the form of a ridge is called terminal moraine
    - (ii) Lateral moraine
      - Deposits on either side of a glacier is called lateral moraine.
    - (iii) Medial moraine
      - Moraines formed on the confluence of two glaciers are called medial moraines
    - (iv) Ground moraine
      - Deposits left behind in areas once covered by glaciers are called ground marines.

Ocean basins and submarine relief

- **Ocean Basins**
  - (a) Continental shelf
    - The shallow submerged extension of continent is called the continental shelf.
    - The width of the continental shelf ranges between a few kilometres to more than 100 kilometres
    - The continental shelf off the eastern coast of India is much wider than that of the western coast.
    - Formation of continental shelf
      - i. erosional deposits of ocean
      - ii. deposits of rivers
      - iii. retraction of ice sheets
    - Largest continental shelf: Siberian shelf in the Arctic ocean(1500 Kms)
    - Economic importance
      - Abundant in fishes
      - Minerals such as sand and gravel
      - Petroleum and natural gas
  - (b) Continental slope
    - The steep descent of the seabed from the continental shelf to the abyssal zone
    - Inclination of continental slope is around 5 degrees.
    - It extends between the depth of 180 to 3600 metres.
    - Sea life such as plankton and fishes are far less here than on the continental shelf
    - Sedimentary deposits on the continental slope gives rise to formation of continental rise
  - (C) Continental rise
    - Connects the continental slope with the Abyssal plains
    - it represents the final stage in the boundary between continents and the deepest part of the ocean.
    - continental rise consists mainly of silts, muds, and sand, and can be several hundreds of miles wide
  - (d) Abyssal plains
    - Abyssal plains are extremely flat and featureless plains of the deep ocean floor
    - Abyssal plains cover major portion of ocean floor between the depth of 3000 m to 6000 m
    - It is a major reservoir of biodiversity
  - (e) Ocean deeps or trenches
    - These areas are the deepest parts of the oceans
    - They occur at the bases of continental slopes and along island arcs
    - Trenches are associated with active volcanoes and strong earthquakes
    - They are significant in the study of plate tectonics
    - Pacific ocean has maximum number of trenches
    - Deepest trench
      - Mariana trench
        - Location: West pacific ocean
        - Deepest point: Challenger deep
    - Steepest trench
      - Tonga trench
        - Location: South pacific ocean
        - Deepest point: Horizon deep
- **Submarine relief**
  - 1. Mid-Oceanic Ridges
    - Mountain systems beneath the ocean waters are known as submarine ridges.
    - They are linear belts occurring near the middle of the oceans and are also called mid-oceanic ridges.
    - These ridges are intersected by faults.
    - The Mid-Atlantic Ridge is the largest mid-oceanic ridge running north to south in Atlantic-Ocean.
    - Earthquakes and Volcanic eruptions occur frequently in mid-oceanic ridges
  - 2. Seamount
    - Submerged volcanoes with sharp tops called seamounts
    - e.g. Hawaii and Tahiti Islands
  - 3. Guyots
    - A flat topped seamount or inactive volcano flattened by erosion and covered by water is called Guyot
    - more than 10,000 seamounts and guyots exist in the Pacific Ocean
  - 4. Submarine Canyons
    - Submarine canyons are deep valleys cut across the continental shelves and slopes
    - e.g. Godavari canyon, Hudson canyon
  - 5. Atoll
    - These are low islands found in the tropical oceans consisting of coral reefs surrounding a central depression.

Ocean Salinity

- **Basics**
  - Salinity is the measure of total content of dissolved salts in sea water
  - Salinity is calculated in grams per kilogram and expressed as parts per thousand(ppt)
  - Sea water with salinity of 24.7 % is demarcated as brackish water.
- **Factors affecting ocean salinity**
  - i. Evaporation
  - ii. Precipitation
  - iii. Outflow of rivers
  - iv. Freezing and thawing of ice
  - v. Wind
  - vi. Ocean currents
  - vii. Temperature
  - viii. Density
- **Distribution of salinity**
  - Salinity in open ocean ranges between 33% and 37%
  - Salinity in landlocked sea is as high as 41%
  - Salinity decreases in northern hemisphere because of the influx of melted water from the Arctic region
  - Average salinity of northern hemisphere is higher than southern hemisphere
  - The highest salinity is recorded between 15° and 20° latitudes
  - The average salinity of the Indian Ocean is 35 %
  - The low salinity is observed in the Bay of Bengal due to influx of river water by the river Ganga
  - Salinity increases with depth and there is a distinct zone called the halocline
  - High salinity seawater sinks below the lower salinity water, which leads to stratification of ocean waters
  - Arabian Sea shows higher salinity due to high evaporation and low influx of fresh water.
  - Maximum salinity (37 %) is observed between 20° N - 30° N and 20° W - 60° W.
  - The North Sea records higher salinity due to more saline water brought by the North Atlantic Drift
  - Baltic Sea and Black Sea records low salinity due to influx of river waters in large quantity.

Ocean temperature

- **Factors Affecting Temperature Distribution**
  - (i) Latitude
    - the temperature of surface water decreases gradually from the equator towards the poles
    - The mean annual temperatures in tropical seas(27°C) is higher than poles(1.8°C)
  - (ii) Unequal distribution of land and water
    - the oceans in the northern hemisphere receive more heat than southern hemisphere.
    - This is due to the larger extent of land in northern hemisphere than southern hemisphere
  - (iii) Prevailing wind
    - winds blowing from the land towards the oceans drive warm surface water away form the coast
    - This results in the upwelling of cold water from below and longitudinal variation in temperature.
  - (iv) Ocean currents
    - warm ocean currents raise the temperature in cold areas while the cold currents decrease the temperature in warm ocean areas.
    - e.g. Gulfstream(warm current), Labrador current(cold current)

- **Facts**
  - The process of heating and cooling of the oceanic water is slower than land
  - The maximum temperature of the oceans is always at their surfaces
  - Enclosed seas
    - in the low latitudes record relatively higher temperature than the open seas
    - in the high latitudes have lower temperature than the open seas
  - The highest temperature is not recorded at the equator but slightly towards north of it.
  - The temperature falls very rapidly up to the depth of 200 m and decreases gradually thereafter
  - Region below the sea surface from where, there is a rapid decrease in temperature is called thermocline.
  - The average temperature is
    - 22°C at 20° latitudes
    - 14° C at 40° latitudes
    - 0° C near poles

Tides

- **Basics**
  - Tides are periodic rise and fall of the sea level due to the attraction of the moon and sun
  - Tides are generated by the gravitational force between earth, sun and moon
- **Tides**
  - Flood tide
    - The incoming tide towards the land is called flood tide or high tide.
    - flood tide is a high tide
  - Ebb tide
    - Tide going out or withdrawn, is an ebb tide (low tide).
    - ebb tide is a low tide.
- **Types of Tides**
  - i. Spring tide
    - Generated, when the sun and the moon are in a straight line as on a new moon or a full moon day.
    - Combined force of the sun and the moon pulling together at the same time in the same direction produces spring tide
  - ii. Neap tide
    - During the first quarter and the third quarter, the gravitational force of the sun and the moon is at right angle
    - At this time, the two pulls are opposing each other and cancel or neutralize each other's forces producing a weak tide called as neap tide
- **Factors affecting the size of tides**
  - i. Location of the sun, the moon and the earth in relation to each other(Straight or Right angle)
  - ii. Variation of distances between the sun and the moon from the earth
- **Advantages of tides**
  - 1. Tidal power
  - 2. Increased fish catch during the new and full moon days
  - 3. Desiltation of river mouths
  - 4. Increased impetus to the ships at tidal bores
- **Facts**
  - Moon exerts twice the gravitational pull of the sun on the earth.
  - Coastal areas experience two high tides and two low tides per day
  - Enclosed water bodies experience only one high tide and one low tide per day called as diurnal tides
  - Regular interval between two high tides or between two low tides is 12 hours and 25 minutes
  - Each day the high tide arrives about 51 minutes later than on the previous day due to delayed rising and setting of the moon by 51 minutes.
  - Gravitational attraction of the moon is more effective on the earth than the gravitational attraction of the sun.
  - Highest spring tide occurs when the moon is closest to the earth

Ocean currents

- Facts
  - The steady flow of ocean water in a prevailing direction over great distances
  - The average speed of current is between 3.2 km to 10 km per hour
  - Ocean currents
    - with higher speed are called stream
    - with lower speed are called drift
- Types of ocean currents
  - Warm currents
    - Warm currents flow from equatorial regions towards poles
    - They have higher surface temperature
  - Cold currents
    - Cold currents flow from polar regions towards equator
    - They have lower surface temperature
- Origin and circulation
  - i. Change in density
    - Temperature
      - Sea water's density varies with temperature.
      - The higher the temperature of water, the lesser will be the density.
      - Warm and less dense waters of the equator moves towards the poles
      - Cold and high dense waters of the poles move towards the equator.
    - Salinity
      - Higher salinity increases the density of the water and the water sinks.
      - Water with lower salinity flows on the surface of the high salinity water.
      - Water with higher salinity flows towards the less dense water.
  - ii. Rotation of the Earth
    - Ocean water is affected by Coriolis force and follows the Ferrel's Law.
    - Ocean currents follow
      - clockwise direction in the northern hemisphere.
      - anti-clockwise direction in the southern hemisphere
  - iii. Direction of planetary Winds
    - Ocean currents change their direction according to the change in the direction of winds in the latitude
    - Ocean currents follow the direction of planetary winds such as easterlies, westerlies etc..


Currents of Atlantic ocean
Atlantic Circuit
Labrador current(cold current)
South equatorial current(Warm current)
Joins
joins north equatorial current
Brazil Current
joins north equatorial current
Florida current
Gulf stream
North Atlantic drift
Norwegian current
Canary current
West wind drift(Cold current)
Benguela Current
Falkland current
meets
East Greenland current(cold current)
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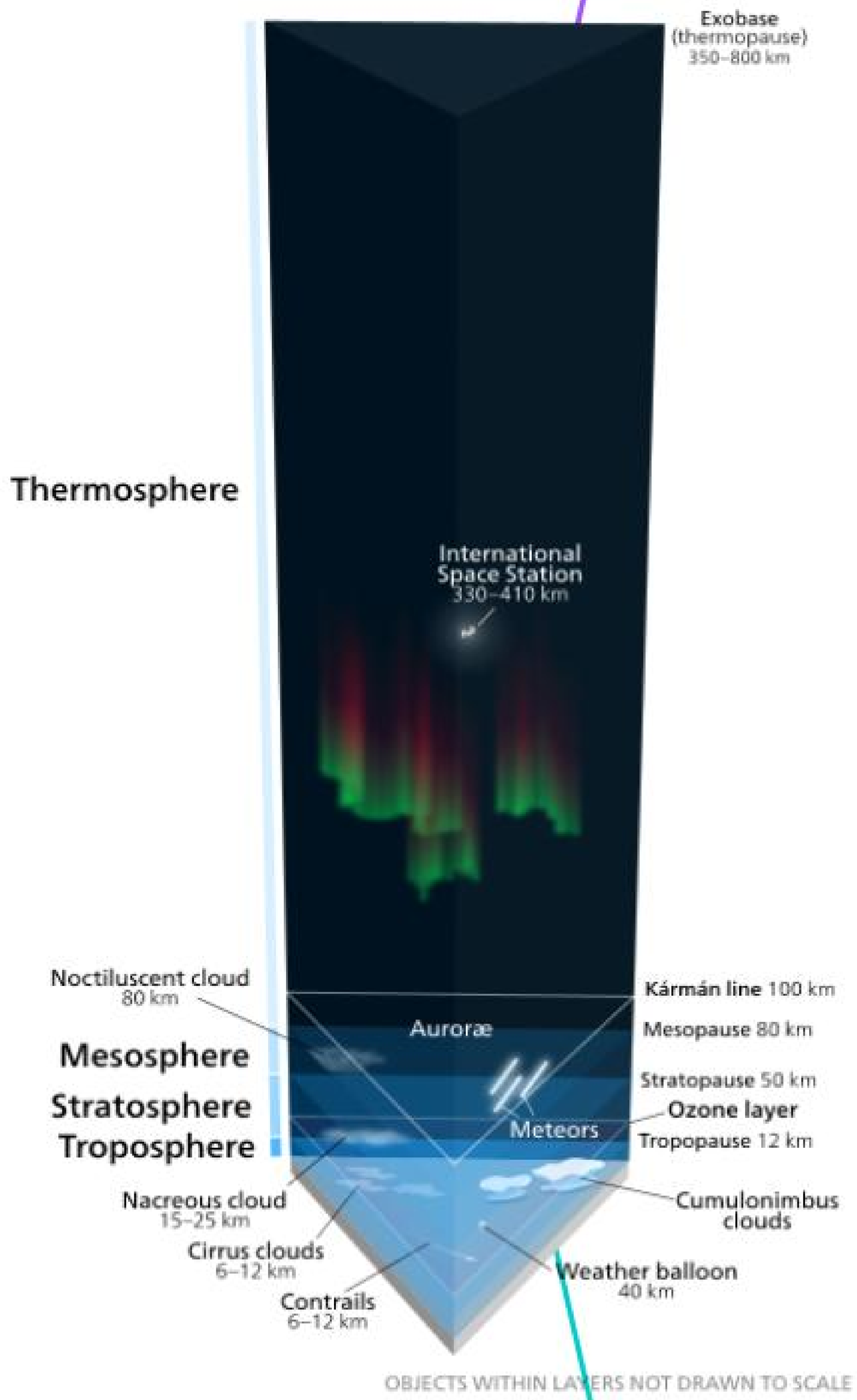
Significance of Atlantic currents
Warm currents
Gulf stream
Florida current
North Atlantic drift
Norwegian current
Canary current
Guinea current
Cold currents
East Greenland Current
Labrador Current
Falkland Current
Benguela Current

Composition of Atmosphere

- 1. Gases
  - Atmosphere consists a mixture of different types of gases
  - Composition
    - Nitrogen - 78.08%
    - Oxygen - 20.95%
    - Argon - 0.93%
    - Carbon dioxide - 0.036%
    - Neon - 0.002%
    - Helium - 0.0005%
    - Krypton - 0.001%
    - Xenon - 0.00009%
    - Hydrogen - 0.00005%
  - Nitrogen and Oxygen together makeup 99% of the gases of atmosphere.
  - 99% of the total mass of the atmosphere is confined to the height of 32 km from the earth's surface
  - Carbon dioxide and water vapour are found only up to 90 km from the surface of the earth.
  - Ozone
    - It is limited to the ozone layer found between 10 and 50 km above the earth's surface
    - acts as a filter and absorbs the ultra-violet rays radiating from the sun
- 2. Water vapour
  - Gaseous form of water present in the atmosphere is called water vapour.
  - Water vapour is the source of all kinds of precipitation.
  - Water vapour formation
    - Evaporation
      - oceans
      - seas
      - rivers
      - ponds
      - lakes
    - Transpiration
      - plants
      - trees
      - living beings
  - Concentration
    - Its maximum amount in the atmosphere could be up to 4 percent.
    - Maximum amount of water vapour is found in hot-wet regions
    - Least amount is found in the dry regions
    - Amount of water vapour decreases gradually from low latitudes to high latitudes.
  - Significance
    - It absorbs part of insolation from the sun and preserves the earth's radiated heat
    - It acts like a blanket allowing the earth neither to become too cold nor too hot.
- 3. Dust particles
  - found in the lower layers of the atmosphere
  - dust particles help in the condensation of water vapour to form droplets by sticking around these dust particles.



- **Basics**
  - Atmosphere is divided in to five layers based on their temperature and density
  - 97% of the atmosphere is limited to the height of 30 kilometres.
  - Kármán line, at 100 km (62 mi), or 1.57% of Earth's radius, is often used as the border between the atmosphere and outer space.
- **Layers**
  - (a) Troposphere
    - Lowest layer of the atmosphere
    - Extends about 18 kms on the equator and 8 kms on the poles.
    - The troposphere contains roughly 80% of the mass of Earth's atmosphere.
    - Fifty percent of the total mass of the atmosphere is located in the lower 5.6 km of the troposphere
    - Depth of Troposphere is maximum at equator than poles due to
      - 1. hot convection currents over the equator
      - 2. less dense air at the equator
      - 3. larger gravitational pull over the air at the poles than the equator
      - 4. larger centrifugal force at the equator
      - 5. increased water vapour due to insolation at the equator
    - All kinds of weather changes takes place within this layer
    - Temperature decreases gradually with increase in altitude
      - because, troposphere is mostly heated through energy transfer from the surface.
      - temperature decreases at the rate of 1°C for every 165 m of height.
    - The average rate of temperature change is about 6.5°C per 1000 meters. This is called the average lapse rate
    - The upper limit or Transition zone of the troposphere is called tropopause.
    - Temperature at the tropopause is
      - -60°C over the equator
      - -45°C over the poles.
    - Only layer that can be accessed by propeller-driven aircraft.
  - (b) Stratosphere
    - Extends about 50 kms from the earth surface
    - It is called as stratosphere due to its stratification into warm upper layers and cold lower layers.
    - Ozone layer lies within the stratosphere
      - 90% of the ozone in Earth's atmosphere is contained in the stratosphere.
    - Temperature
      - i. remains constant up to the height of 20 kms
      - ii. after 20 kms, it increases gradually(due to the presence of ozone) with increase in the height
      - This rise in temperature is caused by the absorption of ultraviolet radiation (UV) radiation from the Sun by the ozone layer
    - The stratospheric temperature profile creates very stable atmospheric conditions
      - almost completely free of clouds and other forms of weather
      - Weather related incidents do not take place in this layer.
    - The air blows horizontally without much turbulence and is ideal for flying of aircrafts
      - highest layer that can be accessed by jet-powered aircraft.
  - (c) Mesosphere
    - Extends upto 30 kms from stratosphere
    - Temperature goes on decreasing with increase in altitude.
    - It is the coldest place on Earth and has an average temperature around −85 °C
    - The upper limit of mesosphere is known as the mesopause
    - Polar-mesospheric noctilucent clouds are the highest clouds in the atmosphere which are visible to the naked eye
    - Meteors fall and burn in this layer.
    - It is too high above Earth to be accessible to aircraft and balloons, and too low to permit orbital spacecraft.
  - (d) Thermosphere
    - Extends upto the height of 400 kms from the surface of the earth
    - This layer is completely cloudless and free of water vapour.
    - Temperature starts increasing again with increasing height in this layer
    - Temperature inversion in the thermosphere occurs due to the extremely low density of its molecules.
    - Lower part of the thermosphere, from 80 to 550 kilometres above Earth's surface, contains the ionosphere.
    - Electrically charged currents flows in the air in this sphere and hence called as Ionosphere
    - Radio waves are reflected back on the earth from this sphere
    - aurora borealis and aurora australis are occasionally seen in the thermosphere.
      - formed due to the ionisation of atmosphere by solar radiation
      - ionization in the mesosphere largely ceases during the night
    - International Space Station orbits in this layer, between 320 and 380 km
  - (e) Exosphere
    - last layer of the atmosphere located above ionosphere
    - extends beyond 400 km above the earth(there is no boundary, merges with the outer space).
    - Density of air is very sparse in the exosphere
    - mainly composed of extremely low densities of hydrogen, helium and heavier molecules of nitrogen, oxygen and co2
    - exosphere doesn't behave like a gas, and the particles constantly escape into space
    - aurora borealis and aurora australis sometimes occur in the lower part of the exosphere
    - exosphere contains most of the satellites orbiting Earth

Insolation

- **Facts**
  - Incoming solar radiation through short waves is termed as insolation.
  - Amount of insolation received on the earth's surface is far less due to
    - small size of the earth
    - distance from the sun
  - water vapour, dust particles, ozone and other gases present in the atmosphere absorb a small amount of insolation
  - amount of insolation received on the earth's surface is not uniform, it varies from place to place and from time to time
- **Distribution of Insolation**
  - Tropics receive the maximum annual insolation.
  - Insolation gradually decreases from tropics towards the poles.
  - Insolation is more in summer than winter
- **Factors influencing Insolation**
  - (i) The angle of incidence.
    - When the sun is almost overhead, the rays of the sun are vertical, giving more amount of insolation at that place
    - When sun's rays are oblique, angle of incidence is small, resulting in less amount of insolation
    - Rays striking at a large angle, follows a longer path in atmosphere and is subjected to greater amount of reflection and absorption of heat
  - (ii) Duration of the day
    - The longer the duration of the day, the greater is the amount of insolation and vice versa
  - (iii) Transparency of the atmosphere.
    - Cloud cover and dust particles, reflects the insolation.
    - Water vapour absorbs the insolation
  - (iv) Rotation of earth on its axis
    - Inclination of earth(661/2 degrees) varies the amount of insolation received on various latitudes
- **Heating and cooling of the Atmosphere**
  - i. Radiation
    - Major amount of heat energy coming to and leaving the earth is in the form of radiation
    - Atmosphere is transparent to short waves and opaque to long waves.
    - Long wave terrestrial radiation heats up the atmosphere more than the incoming short wave solar radiation
  - ii. Conduction
    - Conduction takes place when two bodies of unequal temperature are in direct contact with one another.
    - Air in the surface gets heated and gradually the heat is transmitted to the upper layers in contact
  - iii. Convection
    - Vertical heating of the atmosphere is known as convection
    - Heated air in the surface rises vertically in the form of currents and transmits the heat to the atmosphere.
    - The convective transfer of energy is confined only to the troposphere.
  - iv. Advection
    - The transfer of heat through horizontal movement of winds is called advection
    - Diurnal variations in mid-latitudes are significantly affected by advection
    - Local winds such as, "Loo" is caused by advection
- **Terrestrial Radiation**
  - Earth gets heated by receiving short wave energy and radiates the energy back to the atmosphere in long wave form.
  - Portion of long wave radiation is absorbed by carbon dioxide and the other green house gases and reflected back to the earth.
  - This contributes indirectly to the addition of energy to the atmosphere
  - Remaining energy is reflected back to space thereby maintaining the optimal temperature of earth

Heat Budget

- Facts
  - The annual mean temperature on the surface of the earth is always constant
  - Balance between insolation and terrestrial radiation is termed as heat budget of the earth
- Latitudinal variation
  - Latitudinal heat balance
    - The amount of insolation received is directly related to latitudes
    - Insolation creates an imbalance of heat at different latitudes
    - Winds and ocean currents, transfer the heat from surplus heat regions to deficit heat regions
  - Tropical region
    - Amount of insolation received is higher than the amount of terrestrial radiation, resulting in surplus heat
  - Polar region
    - Amount of insolation received is lesser than the amount of terrestrial radiation, resulting in heat deficit
- Let the incoming solar radiation be 100 units
  - 35 units are reflected back into space before reaching the earth's surface
    - 6 units by atmosphere
    - 27 units by clouds
    - 2 units by snow and ice
  - 65 units
    - 51 units reach the earth's surface
    - 14 units are absorbed by the various gases, dust particles and water vapour
    - Earth radiates back the 51 units in the form of terrestrial radiation
      - 34 units are absorbed by the atmosphere
      - 17 units directly go to space
    - Atmosphere radiates 48(14+34) units of absorbed radiation back to space
    - 48+17=65 units
  - Total outgoing radiation: 65+35=100 units

Factors responsible for uneven distribution of temperature

- Factors
  - 1. Latitude
    - Angle of incidence of sun's rays decreases gradually from equator towards the poles
    - Due to this, higher temperatures are found in tropical regions and decreases gradually towards the poles
  - 2. Land and Sea Contrast
    - Land gets heated and cooled more rapidly than water
    - Temperature is relatively higher on land during day and it is higher in water during night
    - During summer the air above land has higher temperature than the oceans
    - During winter the air above oceans has higher temperature than landmasses
    - Snow covered polar regions warms very slowly because of the large amount of reflection of solar energy
    - Vegetation covered land does not get excessively heated because of evaporation of water from the plants
  - 3. Relief and Altitude
    - Relief features such as mountains, plateaus and plains affect the distribution of temperature
    - Temperature decreases gradually from the sea level
    - The air at lower altitude is warmer than that of higher altitude because of its closeness to the heated surface of the earth
    - Rate of decrease of temperature also varies with time of a day, season and location
  - 4. Ocean Currents
    - Warm currents and cold currents distributes the temperature accordingly
  - 5. Winds
    - Winds transfer heat from one region to another through advection.
  - 6. Vegetation Cover
    - vegetation cover absorbs much of sun's heat and prevents quick radiation from the earth
    - Annual range of temperature in equatorial regions is about 5°C while in hot deserts, it is as high as 38°C.
  - 7. Nature of the Soil
    - Black, yellow and clayey soils absorb more heat than sandy soils.
    - Heat radiates more rapidly from sandy soils than from black, yellow and clayey soils
  - 8. Slope and Aspect
    - Amount of insolation varies with the Angle of the slope and its direction.
    - Temperature in gentle slopes is higher than steep slopes
    - southern slopes of the Himalayas are warmer than the northern ones

Temperature distribution

- **Basics**
  - Distribution of temperature on earth's surface is uneven
  - Isotherms
    - Imaginary lines on a map joining the places of equal temperature, reduced to sea level are called Isotherms
    - Isotherms are regular and widely spaced in the southern hemisphere due to large expanse of water in southern hemisphere.
    - Isotherms are irregular and closely spaced in northern hemisphere due to large expanse of landmasses.
  - Annual range of temperature
    - Difference between the average temperatures of warmest and the coldest months is known as annual range of temperature
    - Annual range of temperature is higher in the interior parts of the continents in middle and high latitudes of the northern hemisphere
    - Verkhoyansk in Siberia records 66°C, the highest annual range of temperature in the world because it is located in the interior parts of Asia
    - Equatorial regions have insignificant annual range of temperature
      - due to constant insolation throughout the year
    - Warm and cold ocean currents influence the annual range of temperature significantly
  - Seasonal extremes are most obvious in northern and southern hemispheres during January and July.
- **(a) Horizontal distribution**
  - Latitudinal distribution of temperature over the surface of the earth is called horizontal distribution
  - January
    - Sun shines vertically overhead near the Tropic of Capricorn
    - Summer in southern hemisphere and winter in northern hemisphere
    - Landmass of northern hemisphere is cooler than oceans
    - High temperature is found over three regions
      - North-west Argentina
      - East-Central Africa
      - Central Australia
    - Isotherms
      - bend towards poles when they cross the oceans in northern hemisphere and towards equator when they cross the landmasses
      - bend towards equator when they cross the oceans in southern hemisphere and towards poles when they cross the landmasses
  - July
    - Sun shines vertically overhead near the Tropic of Cancer
    - Summer in northern hemisphere and winter in southern hemisphere
    - High temperatures are found in the entire northern hemisphere
    - Isotherm of 30°C passes between 10° N and 40° N latitudes
    - Isotherm covers the regions of South Western USA, the Sahara, the Arabia, Iraq, Iran, Afghanistan, desert region of India and China.
    - Isotherms
      - bend towards equator while crossing oceans and towards pole while crossing landmasses in northern hemisphere
      - bend towards poles while crossing oceans and towards equator while crossing landmasses in southern hemisphere
- **(b) Vertical distribution**
  - Temperature decreases gradually with altitude in troposphere
  - Rate of temperature decrease in troposphere is 6°C per km, extending to the tropopause.
  - This vertical gradient of temperature is called standard atmosphere or normal lapse rate
  - Actual lapse rate of temperature does not always show a decrease with altitude.
- **(C) Temperature Inversion**
  - Anomalous increase in temperature with height in the troposphere
  - Process
    - Step 1: quick radiation of heat from the earth's surface
    - Step 2: quick radiation results in cooling of the air near the earth's surface
    - Step 3: upper layers which lose their heat not so quickly are comparatively warm
    - Step 4: cooler air is near the earth and the warmer air is above(Inversion)
    - Result: Normal condition in which temperature decreases with increasing height, is reversed
  - The phenomenon of inversion of temperature is observed generally in intermontane valleys.
  - Farmers cultivate on upper slopes and avoid the lower slopes of the mountains to escape winters frost

Distribution of atmospheric pressure

- Facts
  - Atmospheric pressure on the surface of the earth is not uniform, it varies both vertically and horizontally
  - An isobar is a line connecting points that have equal values of pressure.
  - On an average air pressure decreases by 34 millibars per 300 metres increase in height.
  - Cooking in high mountainous areas takes long time because, low pressure reduces the boiling point of water
- (a) Vertical Distribution
  - The columnar distribution of atmospheric pressure is known as vertical distribution of pressure.
  - Lower layers are more dense due to the compressive pressure exerted by the mass of air in the upper layers
  - Higher layers are less compressed and, hence, they have low density and low pressure
  - Three factors determine the air pressure of a given place and at a given time
    - (i) Temperature of the air
    - (ii) Amount of water vapour present in the air
    - (iii) Gravitational pull of the earth
- (b) Horizontal Distribution
  - The distribution of atmospheric pressure over the globe is known as horizontal distribution of pressure
  - The spacing of isobars expresses the rate and direction of change in air pressure or pressure gradient.
  - Pressure gradient is the ratio between pressure difference and the actual horizontal distance between two points
  - Factors affecting the horizontal distribution of pressure
    - (i) Air temperature
    - (ii) The earth's rotation
    - (iii) Presence of water vapour
  - (i) Air Temperature
    - There is an inverse relationship between air temperature and air pressure.
    - The higher the air temperature, the lower is the air pressure.
    - Air pressure is low in equatorial regions and it is higher in polar regions
      - Hot air ascending in equatorial regions decreases the pressure in the region
      - In polar region, cold air is very dense hence it descends and pressure increases.
    - Pressure does not increase latitudinally in a regular fashion from equator to the poles
    - There are regions of high pressure in subtropics and regions of low pressure in the subpolar areas
  - (ii) The Earth's Rotation
    - The earth's rotation generates centrifugal force, which deflects the air from its original place, causing a decrease in air pressure
    - low pressure belts of the subpolar regions and the high pressure belts of the sub-tropical regions are created as a result of the earth's rotation.
  - (iii) Pressure of Water Vapour
    - Air with higher quantity of water vapour has lower pressure and vice versa
    - Important
      - Continents experience low pressure in summer and high pressure in winter
      - Oceans experience low pressure in winter and high pressure in summer

Pressure belts

- Facts
  - ITCZ
    - Inter Tropical Convergence Zone (ITCZ)
    - is the area encircling the earth near the equator where the northeast and southeast trade winds come together
    - is known by sailors as the doldrums
    - ITCZ moves back and forth across the equator following the sun's zenith point
    - When the ITCZ is situated north of the equator, the southeast trade wind changes to a southwest wind as it crosses the equator.
    - Longer term changes in the ITCZ can result in severe droughts or flooding
  - Pressure belts shift northward in July and southward in January
  - High pressure belts are dry while low pressure belts are humid
- Pressure belts
  - (i) Equatorial Low Pressure Belt
    - Formation
      - Step 1: Sun shines almost vertically on the equator throughout the year
      - Step 2: Air gets warm and rises over the equatorial region and produces equatorial low pressure
    - This belt is termed doldrums(the zone of calm) due to its erratic weather patterns with stagnant calms and violent thunderstorms.
    - Equatorial low pressure belt extends from equator to 10°N and 10°S latitudes.
    - Horizontal movement of air is absent in equatorial region due to excessive heating and only convectional currents occur

  - (ii) Sub-tropic High Pressure Belts
    - Sub-tropical high pressure belts extend from the tropics to about 35°latitudes in both the Hemispheres
    - 2 Belts
      - North sub-tropical high pressure belt(northern hemisphere)
      - South sub-tropical high pressure belt(southern hemisphere)
    - Formation
      - Step 1: Sun shines almost vertically on the equator throughout the year
      - Step 2: Air gets warm and rises over the equatorial region
      - Step 3: Up rising air of the equatorial region is deflected towards poles due to the earth's rotation
      - Step 4: After becoming cold and heavy, it descends into sub-tropic regions with high pressure
    - Regions of divergence
      - Winds from these areas diverge towards equatorial and subpolar low pressure belts.
    - Calm conditions with feeble and variable winds are found here
    - These belts or latitudes are also called horse latitudes.
    - Warm and dry conditions of horse latitudes is responsible for formation of temperate deserts.
  - (iii) Sub-polar Low Pressure Belts
    - Extends between
      - 45°N latitude and the Arctic Circle in the northern hemisphere(North sub-polar low pressure belts)
      - 45°S latitude and the Antarctic Circle in the southern hemisphere(South sub-polar low pressure belts).
    - Winds from sub-tropical and the polar high belts converge here to produce cyclonic storms or low pressure conditions
    - The zone of convergence is also known as polar front.
    - Convergence of subtropical and polar winds result in the formation of cyclones in the sub-polar regions
  - (iv) Polar High Pressure Belts
    - High pressure is found in polar regions
    - 2 Belts
      - North polar high pressure belt(northern hemisphere)
      - South polar high pressure belt(southern hemisphere)
    - Winds from these belts blow towards sub-polar low pressure belts.

Winds

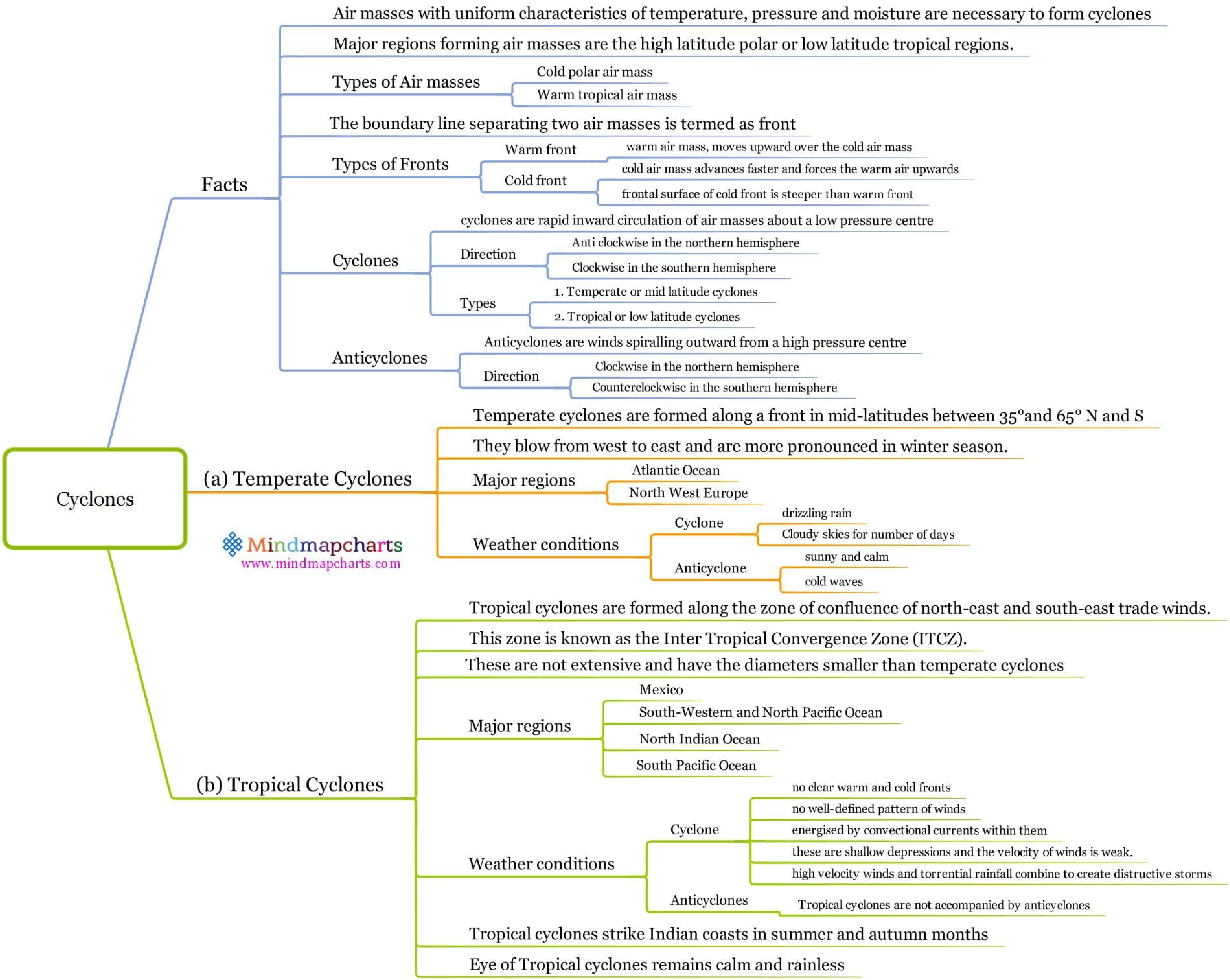
- Facts
  - Horizontal movement of air in response to difference in pressure is termed as wind
  - Vertical movement of air is called air current
- Factors affecting wind
  - (i) Pressure Gradient
    - Pressure gradient and speed of the wind is higher, if the difference in air pressure between the two points is High
    - Pressure gradient and speed of the wind is lower, if the difference in air pressure between the two points is Low.
  - (ii) Coriolis Effect
    - Winds get deflected from their original paths due to the deflection in wind direction caused by the earth's rotation on its axis.
    - Ferrel's' law - Coriolis force tend to deflect the winds in
      - northern hemisphere towards their right
      - southern hemisphere towards their left
    - Coriolis force is absent along the equator but increases gradually towards the poles.
    - Coriolis force is maximum at poles
- Types of winds
  - (a) planetary winds or permanent winds
  - (b) periodic winds and
  - (c) local winds

Planetary winds

- **Facts**
  - Planetary or permanent winds blow from high pressure belts to low pressure belts in the same direction throughout the year
  - As the trade winds tend to blow mainly from the east, they are also known as the Tropical easterlies
- **i. Easterlies**
  - Blows from sub-tropical high pressure areas towards equatorial low pressure areas
  - Also called as trade winds - ‘to blow steadily and constantly in the same direction'
  - Trade winds
    - North-east trade winds
    - South-east trade winds
  - In northern hemisphere trade winds move away from the subtropical high in north-east direction
  - In southern hemisphere the trade winds diverge out of the sub-tropical high towards the equatorial low from the southeast direction
- **ii. Westerlies**
  - Winds that move poleward from the sub-tropical high pressure belt
  - Also termed as antitrade winds due to their direction opposite to trade winds
  - Due to Coriolis force
    - westerlies in the southern hemisphere are deflected towards left and blow from the north-west(North-west westerlies)
    - westerlies in the northern hemisphere are deflected towards right in south-west direction(South-west westerlies)
  - Westerlies blow with higher force in southern hemisphere than in northern hemisphere due to absence of land
  - Velocity of westerlies increase towards south and become stormy.
  - Based on their velocity towards poles, westerlies are classified into
    - Roaring forties between 40° S latitudes
    - Furious fifties in 50°S latitudes
    - Shrieking sixties in 60° S latitudes
- **iii. Polar easterlies**
  - Polar easterlies blow from polar regions towards sub-polar low pressure regions
  - Direction of winds is from
    - north-east to south-west in the northern hemisphere
    - south-east to north-west in the southern hemisphere.

Periodic and Local winds

- **Periodic winds**
  - Monsoon Winds
    - The word 'Monsoon' has been derived from the Arabic word 'Mausim' meaning season
    - The winds that reverse their direction with the change of seasons are called monsoon winds
    - During
      - summer the monsoon winds blow from sea towards land
      - winter the monsoon winds blow from land towards seas.
    - Monsoon winds are found in
      - India, Pakistan, Bangladesh, Myanmar, Sri Lanka, North Australia, China and Japan
- **Local winds**
  - These are winds that affect local weather and are confined to the lower levels of the troposphere.
  - (i) Land and Sea Breezes
    - Land and sea breezes are prevalent on the narrow strips along the coasts or lake.
    - Sea breeze
      - Sea breeze begins to develop shortly before noon and generally reaches its greatest intensity during mid-day to late afternoon
      - Formation
        - Step 1: differential heating of land and water produces low and high pressures.
        - Step 2: a local low pressure area is developed on land
        - Step 3: Sea breeze or high pressure winds blow from the water surface towards the low pressure land surface
    - Land breeze
      - Formation
        - Step 1: During night, the land and the air above it cools more quickly than the nearby water body.
        - Step 2: land develops high pressure area while the sea develops a low pressure area
        - Step 3: wind begins to blow from land (high pressure) towards sea (low pressure)
  - (ii) Mountain and Valley Breezes
    - Valley breeze
      - Formation
        - Step 1: Mountain slopes are heated more than the valley floor
        - Step 2: Pressure becomes low over the slopes while it is comparatively high in the valleys below.
        - Step 3: Gentle wind begins to blow from valley towards slopes as valley breeze
    - Mountain breeze
      - Formation
        - Step 1: After sunset, the rapid radiation takes place on the mountain slopes
        - Step 2: high pressure develops more rapidly on slopes than on the valley floor
        - Step 3: Cold and dense air of mountain slopes starts moving down towards the valley floor as mountain breeze
  - (iii) Hot Winds
    - 1. Loo
      - Loo are hot and dry winds
      - Blow over the northern plains of India and Pakistan in the months of May and June
      - Blows from west to east and they are usually experienced in the afternoons
      - Their temperature varies between 45°C to 50°C.
    - 2. Foehn
      - Foehn is strong, dusty, dry and warm local wind which develops on the leeward side of the Alps
      - The temperature of the winds vary from 15°C to 20°C which help in melting snow.
      - Foehn makes pasture land ready for animal grazing and help the grapes to ripe early
    - 3. Chinook
      - Chinook or snow eater is the hot and dry local wind moving down the eastern slopes of the Rockies in U.S.A. and Canada
      - They help in melting the snow earlier and keeping the grasslands clear of snow.
  - (iv) Cold Winds
    - 1. Mistral
      - Mistrals are cold, dry and high velocity local winds originating on the Alps
      - They move over France towards the Mediterranean Sea through the Rhone valley
      - They bring down temperature below freezing point in areas of their influence.



Cyclones
Facts
Air masses with uniform characteristics of temperature, pressure and moisture are necessary to form cyclones
Major regions forming air masses are the high latitude polar or low latitude tropical regions.
Types of Air masses
Cold polar air mass
Warm tropical air mass
The boundary line separating two air masses is termed as front
Types of Fronts
Warm front
warm air mass, moves upward over the cold air mass
Cold front
cold air mass advances faster and forces the warm air upwards
frontal surface of cold front is steeper than warm front
Cyclones
cyclones are rapid inward circulation of air masses about a low pressure centre
Direction
Anti clockwise in the northern hemisphere
Clockwise in the southern hemisphere
Types
1. Temperate or mid latitude cyclones
2. Tropical or low latitude cyclones
Anticyclones
Anticyclones are winds spiralling outward from a high pressure centre
Direction
Clockwise in the northern hemisphere
Counterclockwise in the southern hemisphere
(a) Temperate Cyclones
Temperate cyclones are formed along a front in mid-latitudes between 35°and 65° N and S
They blow from west to east and are more pronounced in winter season.
Major regions
Atlantic Ocean
North West Europe
Weather conditions
Cyclone
drizzling rain
Cloudy skies for number of days
Anticyclone
sunny and calm
cold waves
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(b) Tropical Cyclones
Tropical cyclones are formed along the zone of confluence of north-east and south-east trade winds.
This zone is known as the Inter Tropical Convergence Zone (ITCZ).
These are not extensive and have the diameters smaller than temperate cyclones
Major regions
Mexico
South-Western and North Pacific Ocean
North Indian Ocean
South Pacific Ocean
Weather conditions
Cyclone
no clear warm and cold fronts
no well-defined pattern of winds
energised by convectional currents within them
these are shallow depressions and the velocity of winds is weak.
high velocity winds and torrential rainfall combine to create distructive storms
Anticyclones
Tropical cyclones are not accompanied by anticyclones
Tropical cyclones strike Indian coasts in summer and autumn months
Eye of Tropical cyclones remains calm and rainless

Humidity

- **Facts**
  - Proportion of water vapour varies from zero to four percent by volume in the atmosphere
  - The amount of water vapour present in the air affects standing crops favourably.
  - Amount of water vapour present in gaseous form in the atmosphere is called humidity
  - Humidity indicates the degree of dampness or wetness of the air
  - Absolute humidity is variable and changes from place to place and with change in time
  - The capacity of holding water vapour of an air increases with the increase in its temperature
  - The temperature at which a given sample of air becomes fully saturated is called the dew point or saturation point
- **Humidity of the air is expressed as**
  - (i) Absolute humidity
    - Absolute humidity is the ratio of the mass of water vapour actually in the air to a unit mass of air, including the water vapour.
    - It is expressed in grams per cubic metre of air.
  - (ii) Relative humidity
    - The ratio of the amount of water in the air at a give temperature to the maximum amount it could hold at that temperature
    - It is expressed as percentage
    - The relative humidity of an air at saturation point is 100%
    - Relative humidity
      - increases when the temperature of the air decreases or when more moist air is added to it
      - decreases when the temperature of the air increases or when less moist air is added to it

Evaporation and condensation

- Evaporation
  - Evaporation is the change in state of water from liquid to gaseous form.
  - Latent heat
    - Heat required to convert a solid into a liquid or vapour, or a liquid into a vapour, without change of temperature
    - Latent heat consumed in changing water into gaseous form is released when water vapour changes into water or ice.
    - Energy released during the release of latent heat causes significant changes in weather
  - Transpiration
    - loss of water from leaf and stem tissues of growing vegetation.
    - combined losses of moisture by evaporation and transpiration is termed as evapo-transpiration.
  - Factors affecting evaporation
    - (i) Accessibility of water bodies
      - Rate of evaporation is higher over the oceans than on the continents.
    - (ii) Temperature
      - the rate of evaporation is more in summers than in winters
    - (iii) Air moisture
      - Arid or dry air increases the rate of evaporation.
    - (iv) Wind
      - allows evaporation to continue as long as the wind keep blowing saturated air away and bring drier air
    - (v) Cloud cover
      - indirectly controls the process of evaporation by preventing solar radiation and reducing air temperatures at a place.

- Condensation
  - Condensation is the process by which atmospheric water vapour changes into water or ice crystals
  - The temperature of the air falls in two ways
    - cooling around small particles(hygroscopic nuclei) suspended in the atmosphere such as smoke, salt and dust particles
    - cooling due to rising of air into the higher altitudes
  - Process
    - Step 1: the temperature of saturated air falls below dew point
    - Step 2: the air cannot hold the amount of humidity which it was holding earlier at a higher temperature
    - Step 3: extra amount of humidity changes into water droplets or crystals of ice
  - Condensation takes place in two situations
    - when dew point is below freezing point or 0° C
      - Frost
      - Snow
    - when the dew point is above freezing point
      - Dew
      - Mist
      - Fog
      - Smog
  - Forms of condensation
    - (i) Dew
      - Dew is the tiny drops of water that form on cool surfaces at night, when atmospheric vapour condenses
      - Favourable conditions
        - clear sky
        - little or no wind
        - high relative humidity
        - cold long nights
      - Process
        - Step 1: solid objects become rapidly cold due to terrestrial radiation
        - Step 2: this brings the temperature of air down below dew point
        - Step 3: extra moisture of the air gets condensed and deposited on these objects
    - (ii) Frost
      - Frost is the deposition of small white ice crystals on the ground or other surfaces when the temperature falls below freezing.
      - condensation of extra moisture takes place in the form of very minute particles of ice crystals.
      - the air moisture condenses directly in the form of tiny crystal of ice.
      - Frost effects crops such as potato, peas, pulses, grams, etc...
    - (iii) Mist
      - a cloud of tiny water droplets suspended in the atmosphere at or near the earth's surface
      - Limits visibility to a lesser extent than fog; strictly, with visibility remaining above 1 km.
    - (iv) Fog
      - a thick cloud of tiny water droplets suspended in the atmosphere at or near the earth's surface
      - Restricts visibility to a greater extent than mist; strictly, reducing visibility to below 1 km.
    - (v) Smog
      - fog or haze intensified atmospheric pollutants such as smoke, dust, carbon monoxide, sulphur dioxide and other fumes
      - Smog frequently occurs in large cities and industrial centres causing respiratory illness.
    - (vi) Cloud
      - Clouds are visible mass of water or ice particles suspended at a considerable altitude
      - Liquid or solid water accounts for less than 10 parts per million of the cloud volume

Precipitation

- **Facts**
  - Form of precipitation depends on the method of formation and temperature during the formation
- **Forms of Precipitation**
  - (i) Drizzle
    - Very light rain; stronger than mist but less than a shower
    - Drizzle is composed of fine drops of water with diameter less than 0.5 mm.
  - (ii) Rain
    - When the droplets of size 0.5 mm are widely spaced, then it is called rain.
  - (ii) Snowfall
    - Precipitation falling from clouds in the form of ice crystals
    - Condensation takes place below freezing point (-0°C) and the water vapour changes directly into ice crystals.
    - Snowfall is common in Western Himalayas and mid and high latitude regions in winter.
  - (iii) Sleet
    - Sleet is frozen rain, formed when rain before falling on the earth, passes through a cold layer of air and freezes
    - It's usually a combination of small ice balls and rime
  - (iv) Hail
    - Precipitation of ice pellets of frozen rain, when there are strong rising air currents in showers from cumulonimbus clouds.
    - diameters range from 5 mm to 50 mm and falls either isolated or in irregular lumps
    - Hailstones are composed of a series of alternating layers of transparent and translucent ice.

Types of Rainfall

- (a) Convectional Rainfall
  - Conventional rainfall is common in equatorial region where it is a daily phenomenon in the afternoon
  - Formation
    - Step 1: heating of the earth's surface in tropical region results in vertical air currents
    - Step 2: air currents, lift the warm moist air to the upper layers of atmosphere.
    - Step 3: temperature of humid air starts falling below dew point continuously forming clouds
    - Step 4: clouds cause heavy rainfall along with lightning and thunder
- (b) Orographic or Relief Rainfall
  - Orographic rainfall occurs where air rises and cools against a topographic barrier
  - Region lying on the leeward side of the mountain receiving less rainfall is called rain-shadow region
  - Formation
    - Step 1: air rises and cools against a topographic barrier
    - Step 2: temperature falls below dew point and clouds are formed
    - Step 3: clouds cause widespread rain on the windward slopes of the mountain range
    - Step 4: winds cross over the mountain range and descend along the leeward slopes leaving less rainfall.
- (c) Convergence or Cyclonic Rainfall
  - Convergence rainfall is produced where air currents converge and rise
  - Tropical regions
    - the vertical lifting and mixing of opposing air masses with contrasting temperatures causes convectional Rainfall
  - Frontal Rainfall
    - Step 1: two large air masses of different densities and temperature meet
    - Step 2: the warmer moist air mass is lifted above the colder one.
    - Step 3: the rising warm air mass condenses to form clouds, which causes extensive down pour
    - Frontal rainfall is associated with thunder and lightning and may persist for a whole day or even longer.

Distribution of precipitation

- Facts
  - land receives lesser amount of rainfall than the oceans
  - Precipitation decreases from equatorial region towards the polar region.
  - Coastal areas adjacent to cold currents are drier than coastal areas near warm currents
- 1. Regions of Heavy Precipitation
  - regions receiving more than 200 cm of annual precipitation
  - Regions include
    - Equatorial coastal areas of tropical zone
    - Coastal regions of temperate zone.
- 2. Regions of Moderate Precipitation
  - regions receiving more than 100 to 200 cm of annual precipitation
  - Regions include
    - Eastern coastal regions of sub-tropical zone
    - Coastal regions of the warm temperate zone
- 3. Regions of Less Precipitation
  - regions receiving more than 50 to 100 cm of annual precipitation
  - Regions include
    - Interior parts of tropical zone
    - Eastern interior parts of temperate zone.
- 4. Regions of Scanty Precipitation
  - regions receiving less than 50 cm of annual precipitation
  - Regions include
    - Tropical, temperate and cold deserts of the world
    - Rain shadows regions
    - Interior parts of continents
    - Western margins of continents along tropics
      - Reason: easterlies become dry winds
    - Western margins of continents along high latitudes
      - Reason: polar winds are cold and dry

Factors Affecting Rainfall Distribution

- (i) Moisture supply
  - Equatorial and tropical regions receive heavy rainfall due to highest evaporation
  - Coastal areas have more moisture than interior parts of continents
  - Frigid regions have very low evaporation hence very scanty precipitation
- (ii) Wind direction
  - Winds blowing from sea to land cause rainfall
  - Land bearing winds are dry
  - Winds blowing from
    - higher to lower latitudes will get heated and give no rain
    - lower to higher latitudes get cooled and cause rainfall
  - Sub-tropical deserts have very little rainfall because they have off-shore winds
- (iii) Ocean currents
  - Warm currents carry warm moist winds which cause rainfall
  - Cold current carries cold dry winds without moisture which doesn't cause rainfall.
- (iv) Presence of mountain
  - Mountains cause rainfall on the windward side and rain shadow on the leeward side
- (v) Pressure belts
  - Areas of low pressure attract rain bearing winds
  - Areas of high pressure does not attract rain bearing winds.
- (vi) Seasons
  - Equatorial regions receive conventional type of precipitation throughout the year
  - Western parts of temperate lands receive cyclonic and Orographic type of precipitation through westerlies.
  - Coramandel Coast of India receives precipitation only in winter

Weather and Climate

- Weather
  - Weather is the state of atmosphere at a particular place and time influenced by the interaction of elements such as temperature, pressure, wind, humidity, heat, etc...
  - weather is expressed as sunny, hot, warm, cold, fine, etc... based upon the atmospheric conditions
  - weather changes very often
  - A place can experience different types of weather conditions in a year
- Climate
  - The weather in some location averaged over some long period of time is called as climate
  - average of these weather conditions is calculated from the data collected for several years
  - Climate of a region is more or less permanent.
  - A place can experience only one type of climate

Factors affecting climate

- Latitude
  - Distance from the equator: The places near the equator are warmer than the places in higher latitudes
  - Vertical rays in equatorial regions are concentrated over a small area than the slanting rays in higher latitudes
  - Lower latitudes receive higher temperature, as the vertical rays pass through a shorter distance in the atmosphere before reaching the earth's surface.
- Altitude
  - The temperature decreases with altitude
- Distance from the Sea
  - Coastal regions have low range of temperature and high humidity due to moderating effect of the seas
  - Moderating effect of seas: slower heating and cooling of water in seas positively influences the temperature and humidity
  - Interior regions of the continent do not experience the moderating effect of the sea and have extreme temperatures
  - The places far from the sea or interior regions of continents have higher range of diurnal and annual temperatures

- Prevailing Winds
  - On-shore winds bring the moisture from the sea and cause rainfall
  - Off-shore winds coming from the land are dry and cause evaporation
  - Indian monsoon
    - on-shore summer monsoon winds bring rains
    - off-shore winter monsoon winds are dry
- Cloud Cover
  - Regions with cloudless skies experience higher range of temperatures
  - Regions with cloudy skies experience small range of temperatures
- Ocean Currents
  - Winds blowing over warm current carry warm air to the interior and raise the temperature of the inland areas
  - Winds blowing over cold current carry cold air to the interior and create fog and mist
  - Warm ocean currents raises the temperature in coastal areas and also causes rainfall
  - Cold currents lower the temperature in coastal areas and causes fog
- Aspect
  - mountain slopes facing the sun are warmer than the slopes facing away from the sun
- Slope
  - Gentler slope raises the temperature of air above them
  - Steeper slopes lowers the temperature of air above them
- Nature of the Soil
  - Sandy soils are good conductor of heat while black clay soils absorb the heat quickly
  - deserts are hot in the day and cold in the night.
- Vegetation cover
  - bare surface re-radiate the heat easily
  - forest areas have lower range of temperature throughout the year
- Direction of Mountain Chains
  - The mountain chains act as natural barrier for the wind
  - Himalayas blocks the
    - moisture laden monsoon winds from crossing over to Tibet(reason for which northern plains of India get rains)
    - polar cold winds from entering into India

Climatic Types

- **Koeppen climate**
  - Most widely used system of climatic classification is developed by Vladimir koeppen
  - It is based upon the climatic factors and also the relationship of climate with the vegetation
  - Koeppen classification divides world into five climatic groups and sub-divided into 13 climatic types.
  - He introduced the use of capital and small letters to designate climatic groups and types
  - Four of the climatic groups are based on temperature and one on precipitation
    - Humid climates - A, C, D and E
    - Dry climates - B
  - Seasons of dryness are indicated by the small letters
    - f - no dry season
    - m - monsoon climate
    - w - winter dry season
    - s - summer dry season
  - The small letters a, b, c and d refer to the degree of severity of temperature.
- **Climatic Groups**
  - (1) Tropical humid climates
    - 1. Af - Tropical rain forest
      - Found near the equator
      - Major areas
        - Amazon Basin in South America
        - Western equatorial Africa
        - Islands of East Indies
      - Temperature is uniformly high
      - Annual range of temperature is negligible
      - Temperature- Max - 30°C; Min - 20°C
      - Vegetation: Tropical evergreen forests
    - 2. Aw - Savanna Climate
      - Found north and south of Af type climate regions
      - Annual rainfall is less than Af and Am climate types
      - wet season is short while the dry season is longer
      - Temperature is high throughout the year
      - Diurnal ranges of temperature are greatest in the dry season.
      - Vegetation
        - Deciduous forest
        - Tree-shredded grasslands
    - 3. Am - Monsoon Climate
      - Major areas
        - Indian sub-continent
        - North Eastern part of South America
        - Northern Australia
      - Heavy rainfall in summer but dry Winter.
  - (2) Dry climates
    - 4. Bw - Desert Climate
      - Extends over large latitudes from 15° - 60° north and south of the equator
      - Also found in the areas of subtropical high due to less rainfall caused by
        - subsidence
        - inversion of temperature
      - Maximum temperature in the summer is very high.
    - 5. Bs - Steppe Climate
      - subtropical steppe receives slightly more rainfall than the desert
      - sparse grasslands grow in steppe climate
  - (3) Warm temperate climates
    - 6. Cs - Mediterranean Climate
      - Major areas
        - areas around Mediterranean sea
        - west coast of continents in subtropical latitudes
      - Climate includes hot, dry summer and mild, rainy winter
      - average temperature in summer is around 25° C and in winter below 10°C
    - 7. Cfa - Humid subtropical
      - Found in eastern parts of the continent in subtropical latitudes
      - rainfall throughout the year
      - Thunderstorms in summer and frontal precipitation in winter
      - Mean monthly temperature in summer - 27°C, and in winter - 5°-12° C.
    - 8. Cfb - Marine west coast Climate
      - located poleward from the Mediterranean climate on the west coast of the continents
      - Due to marine influence, the temperature is moderate
      - In winter it is warmer than for its latitude.
      - annual and daily ranges of temperature are small.
      - Precipitation occurs throughout the year from 50-250 cm.
  - (4) Humid mid-latitude climate
    - 9. Dw - Taiga Climate
      - occurs mainly over North-eastern Asia.
      - Poleward summer temperatures are lower and winter temperatures are extremely low
      - many places experience below freezing point for up to seven months in a year.
      - Precipitation occurs in summer
      - The annual precipitation is low from 12-15 cm.
    - 10. Df - Humid continental
      - Cold climate with humid winter
      - occurs poleward of marine west coast climate and mid latitude steppe.
      - annual ranges of temperature are large
      - weather changes are abrupt and short.
    - 11. The Continental Climate
  - (5) Polar climates
    - 12. Et - Tundra Climate
      - Vegetation - low growing mosses, lichens and flowering plants
      - region of permafrost where the sub soil is permanently frozen.
      - Very long duration of day light in summers
    - 13. Ef - Ice-cap Climate
      - Found over interiors of Greenland and Antarctica
      - temperature is below freezing point.
      - very little precipitation

Seasons

- Basics
  - Season is a period of the year characterized by particular climatic features and weather patterns
  - Seasons occur as a result of inclination, rotation and revolution of the earth.
- Seasons
  - Summer
    - Summer solstice marks the beginning of summer season.
    - On June 21, the sun reaches its northernmost point touching the tropic of Cancer.
    - Northern hemisphere experiences summer as it is inclined towards the sun.
    - In the northern hemisphere days get longer while the nights get shorter.
    - Southern hemisphere experiences winter as it is inclined away from the sun
    - In the southern hemisphere days get shorter while the nights get longer.
  - Autumn
  - Winter
  - Spring
- Regional variations
  - Seasons are insignificant on or near the equator due to same temperature throughout the year.
  - Oceanic influence reduces the seasonal variations in coastal regions.
  - Polar regions have two seasons
    - Long winter
    - Short summer.
  - Temperate regions follow 4 seasons
- India follows 3 seasons
  - Summer
  - Winter
  - Rainy
- Indian Meteorological Department recognizes 4 seasons
  - Cold weather season (December to February)
  - Hot weather seasons (March to May)
  - Advancing monsoon season or rainy season (June to September)
  - Retreating monsoon season (October to November)