Edited BY

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ETHIOPIA

UNIT I

## CHAPTER.1 GEOGRAPHY AS ADISCIPLINE

*This unit deals with*

*1• Geography as an integrating discipline; as a science of spatial attributes*

*2• Branches of geography: importance of physical geography*

3. What is geography?
4. Relation between man and nature?
5. Development of geography
6. Relation between geography and other subjects
7. Geography answers the questions where? What? & Why?
8. Relation between Physical Geography and Natural Science'
9. Geography and social science relation.
10. Branches of Geography Based on Systematic Approach and Regional Approach
11. Physical geography and its importance.

**WHY SHOULD WE STUDY GEOGRAPHY?**

1. We live on the earth's surface
2. Our lives are affected many ways by our surroundings
3. We depend on the resources available from the earth surface
4. Primitive societies substituted on the plants and animals
5. Food , shelter, and dress are depending on the climate
6. Cropping pattern is based on climate of the place
7. To know the changes taken place throughout the geological time
8. To know the lands and people
9. Develop skills to convert globe to map
10. To have visual sense of the earth surface

**2. What are the recent techniques that helped the geographer to understand the earth's surface better?**

1. GIS& GPS
2. COMPUTER CARTOGRAPHY

**3. WHAT IS GEOGRAPHY?**

The earth consists of physical and cultural features. They are different from one place to another. This difference helped to understand the relation between physical and cultural features. Physical features provided the stage and human societies enacted the drama to develop their skills. With the use of skills and tools ,he modified the nature

1 ERATOSTHENES

"GEOGRAPHY IS THE DESCRIPTION OF THE EARTH".

**Who coined the term 'Geography' first?**

ERATOSTHENES, A GREEK SCHOLAR (276-194 BC)

**What is the origin of the word 'Geography'?**

The word derived from Greek language geo= earth , graphos=description.

Some scholars defined geography as the description of the earth as the abode of human beings.

**How can we say that the earth is 'multidimensional'?**

Many Sciences developed to describe the physical features of the earth such as Geology, Pedology, Oceanography Botany Zoology and Meteorology & Cultural features of the earth such as Economics, History, Sociology Political Science, Anthropology,

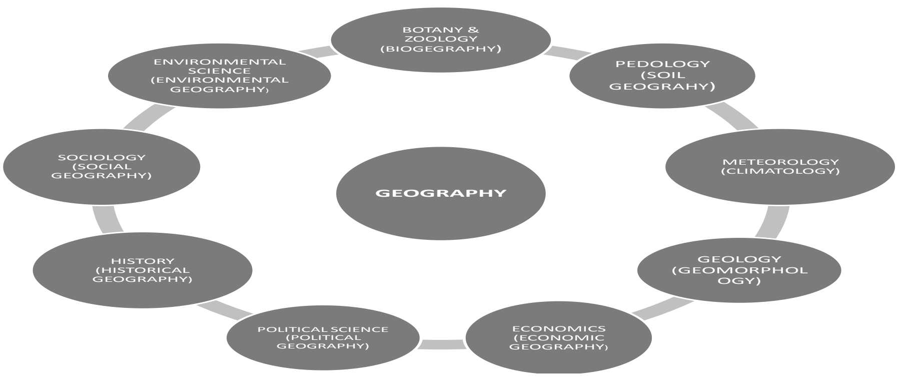
**How does Geography differ from other subjects?**

Geography differs from other subjects in terms of matter and methodology. Geography derives its data from Social Sciences and Natural Sciences.

**What do you mean by 'areal differentiation'?**
When there is similarity and dissimilarity among the physical and cultural features on the earth surface, it is called aerial differentiation.
**What do Geographers study?**
They study the variations and association of the features on the earth surface
e.g. Cropping pattern differs from place to place and it is due to difference in the climate, soil, demand, transport facility, capacity of the farmer.
A geographer also studies the cause and effect relationships.
The interaction between man and nature is highly dynamic and not static; so it is also called as the study of the relation between unstable earth and untrusting man.
**What is the relation between man and nature?**
Human is an integral part of nature and nature has imprints of man.
**What is the effect of nature on man?**
Food clothing, shelter and occupation of man are decided by the nature
**How does technology help man?**
--to loosen the shackles of the physical conditions.
--to develop resources and utilize them.
--to reach the higher needs of the life. It increased the production of the crops& mobility of labor.
**Describe the dialogue between nature and man.**
*You created the soil, I created the cup,*
*You created night, I created the lamp.*
*You created wilderness, hilly terrains and deserts;*
*I created flower beds and gardens.*
**Explain the changes occurred in the civilization of man in course of time?**
1. Man moved from stage of necessity to stage of freedom.
2. Created new possibilities from the nature
3. We find now humanized nature and naturalized man
4. Space got organized with the help of transport and communication.

**What does Geography study?**
Geography studies spatial organization and spatial integration.
**Which are the three questions concerned with Geography?**
What are the natural and cultural features found on the earth surface?
Where are these features found?
Why are these features found there?
**How can we say that Geography is an integrated discipline?**
It is a discipline of synthesis; it includes spatial and temporal synthesis.
Its approach is holistic in nature. it recognizes the fact that the world is a system of interdependence. The present world is a global village. The efficient transport and communication helped the world to become unified village. The audiovisual media helped the data to be enriched. Technology provided better chances of monitoring natural phenomena as well as the economic and social parameters.
**What is the basic objective of Sciences & Social Sciences?**
The basic aim of Science and Social Science is to understand the reality of the nature.
**Explain the relationship of Geography with other subjects?**

## 2 RELATION WITH OTHER SUBJECTS




How do other subjects help Geography as an integrated subject?

History helps in knowing the man-made activities; Physics helps to calculate the effect of climate on man. Economics helps to understand the effect of human activities on the development of the country. The geographical factors modified the course of history. The change in the climate has influence on the occupation.

## PHYSICAL GEOGRAPHY AND NATURAL SCIENCE

Define the relation of geography with Natural Science

All branches of physical Geography have close relation with Natural Sciences. Biogeography has close link with Zoology and Botany.

3ALEXANDER VAN HUMBOLDT

Mathematics and Arts also have contributed to the development of Geography to measure the area and dimensions of the earth. Cartography and projections are based on mathematics.

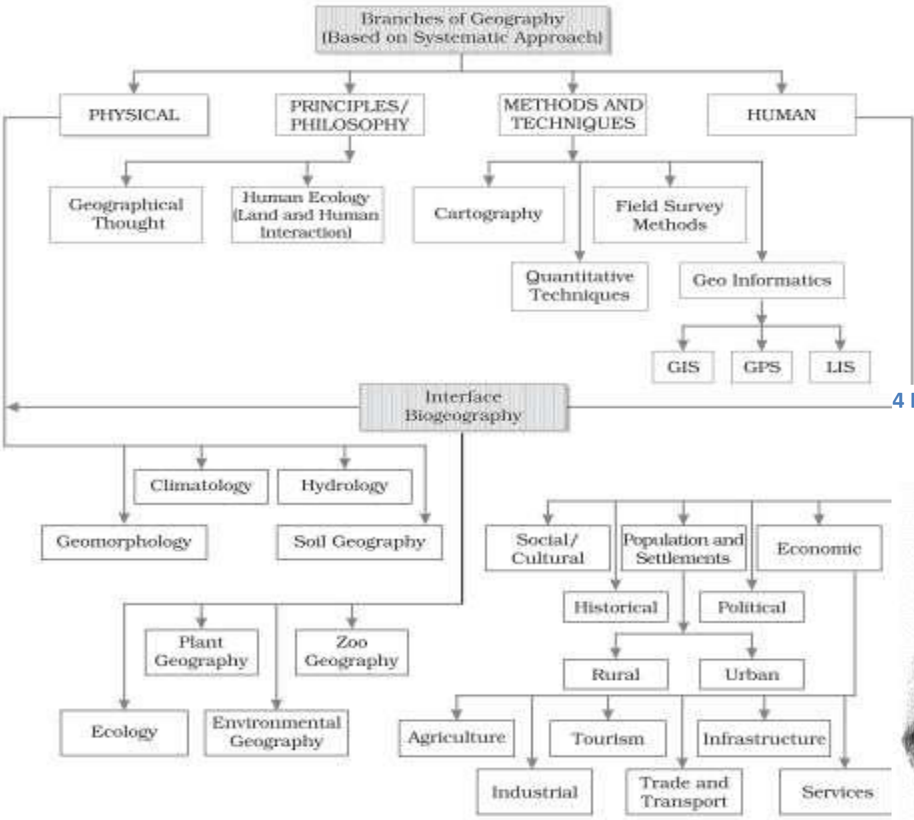
Explain the contribution of social science to the Human geography.

History of geographical thought is the mother of all branches of geography. Sociology, political science, economics provide the aspects of social reality. Population geography has close link with demography.

BRANCHES OF GEOGRAPHY

BASED ON SYSTEMATIC APPROACH INTRODUCED BY *Alexander Von Humboldt*, a German geographer (1769-1859

**ALEXANDER VAN HUMBOLDT**




4 KARL RITTER

**Figure 1.2 : Branches of geography based on systematic approach**

KARL RITTER (1779-1859)

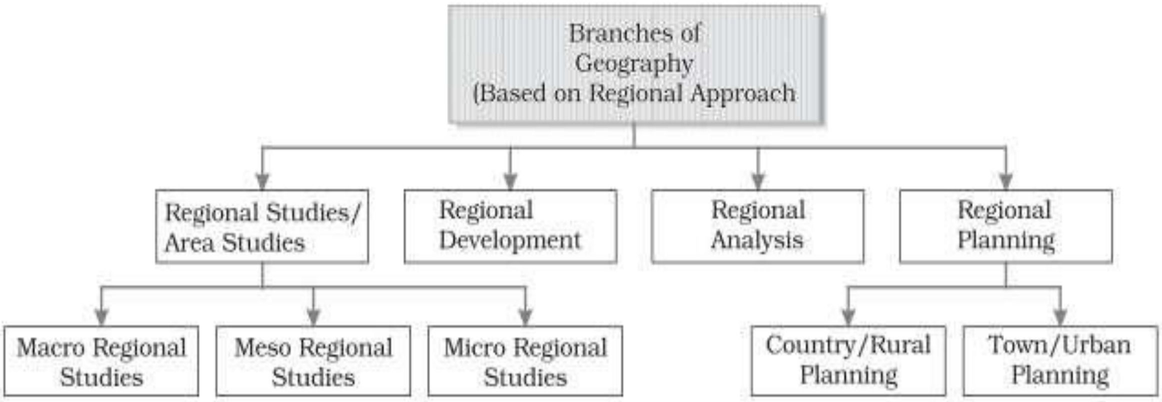



**Figure 1.3 : Branches of geography based on regional approach**

What is the importance of PHYSICAL GEOGRAPHY?

Physical geography includes study of Lithosphere, Atmosphere, Hydrosphere & Biosphere- each element is very important for human beings.

Landforms provide base for agriculture, industries, transport and communication, and settlements. Mountains provide water to rivers, forests-center for tourist spots.

Climate influences on the cropping pattern, livestock, food and clothes of the people.

limate and precipitation influence the type of forests. Oceans provide food, water transport, and influence the climate; they are the source of hydrological cycle

5 RICHARD HARTSHORNE


**What is Geography?**

Geography is concerned with the description and explanation of the areal differentiation of the earth's surface.

*Richard Hartshorne*

Geography studies the differences of phenomena usually related in different parts of the earth's surface.

*Hettner*

6 HETTNER

# CHAPTER-2 THE ORIGIN AND EVOLUTION OF THE EARTH

This chapter deals with

1. Origin of the earth 2. Early theories 3. Modern Theories 4 .Big Bang theory 5. The star formation 6. formation of planets 7. Our solar system 8. The moon 9 Evolution of the earth 10. Development of lithosphere 11. Evolution of Atmosphere and hydrosphere 12. Origin of life

7.NEBULA


Nebular hypothesis: There is evidence that the nebular hypothesis was first proposed in 1734 by Immanuel Kant, who was familiar with Swedenborg's work, developed the theory further in 1755.[4] He argued that gaseous clouds—nebulae, which slowly rotate, gradually collapse and flatten due to gravity and eventually form stars and planets. A similar model was proposed in 1796 by Pierre-Simon Laplace. It featured a contracting and cooling proto solar cloud—the proto solar nebula. As the nebula contracted, it flattened and shed rings of material, which later collapsed into the planets. While the Laplacian nebular model dominated in the 19th century, it encountered a number of difficulties. The main problem was angular momentum distribution between the Sun and planets. The planets have 99% of the angular momentum, and this fact could not be explained by the nebular model. As a result this theory of planet formation was largely abandoned at the beginning of the 20th century.

8ANGULAR MOMENTUM

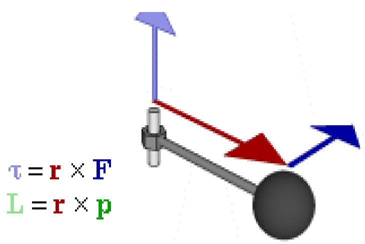
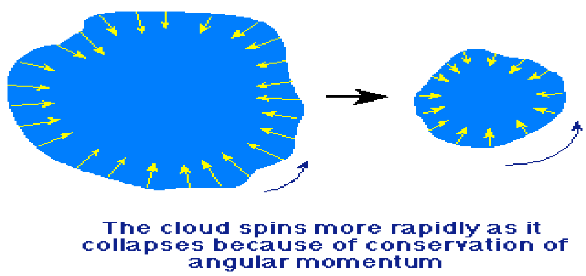
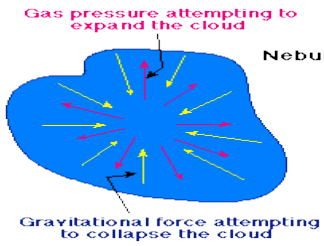



Figure 6angular momentum

The fall of the Laplacian model stimulated scientists to find a replacement for it. During the 20th century many theories were proposed including the *planetesimal theory* of Thomas Chamberlin and Forest Moulton (1901), *tidal model* of Jeans (1917), *accretion model* of Otto Schmidt (1944), *proto planet theory* of William McCrea (1960) and finally *capture theory* of Michael Woolfson. In 1978 Andrew Prentice resurrected the initial Laplacian ideas about planet formation and developed the *modern Laplacian theory*.[4] None of these attempts was completely successful and many of the proposed theories were descriptive. Sir Horald Jeffery **Nebular Hypothesis in its original form was proposed by Kant and Laplace in the 18th century.**

**The initial steps are indicated in the following figures .Collapsing Clouds of Gas and Dust-A great cloud of gas and dust (called a *nebula*) begins to collapse because the gravitational forces that would like to collapse it overcome the forces associated with gas pressure that would like to expand it (the initial collapse might be triggered by a variety of perturbations---a supernova blast wave, density waves in spiral galaxies, etc.).**



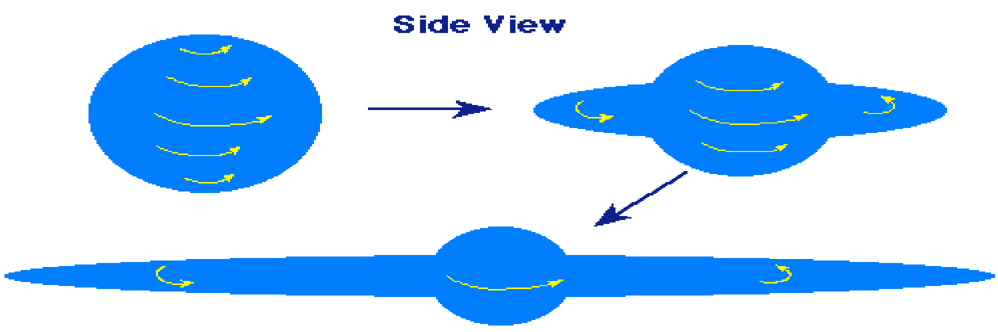




**It is unlikely that such a nebula would be created with no angular momentum, so it is probably initially spinning slowly. Because of conservation of angular momentum, the cloud spins faster as it contracts.**

**The Spinning Nebula Flattens Because of the competing forces associated with gravity, gas pressure, and rotation, the contracting nebula begins to flatten into a spinning pancake shape**

**In the Nebular Hypothesis, a cloud of gas and dust collapsed by gravity begins to spin faster because of angular momentum conservation**

**with a bulge at the center, as illustrated in the following figure.**




**The collapsing, spinning nebula begins to flatten into a rotating pancake**

**Condensation of Proto sun and Proto planets As the nebula collapse further, instabilities in the collapsing, rotating cloud cause local regions to begin to contract gravitationally. These local regions of condensation will become the Sun and the planets, as well as their moons and other debris in the Solar System.**

## MODERN THEORIES

### Origin of the universe

The Big Bang Theory, also called as expand universe hypothesis.
Edwin Hubble in 1920 provided the evidence that the universe is expanding. The galaxies move farther as the time passes.

### Laboratory The Expanding Balloon

In The Expanding Universe, Charles Jenkins tells us that galaxies are moving away from each other. The universe appears to be growing larger.

We can use a balloon to help us understand what is going on in the cosmos. In this activity, the balloon represents the universe. Bits of tape on the surface of the balloon represent some of the galaxies located throughout the universe.

### Tools & Materials

Create your own expanding universe with these simple materials

- round balloon
- masking tape
- tape measure
- pen or pencil

clothespin (optional)

### The Experiment

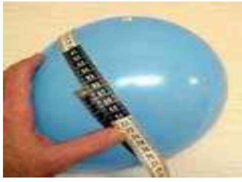
Here's what to do:

1. Blow up the balloon part way. The partially-inflated balloon represents the universe. Imagine that there are many galaxies both inside the balloon universe and on its surface. Have someone hold the mouth of the balloon closed so that it doesn't deflate, or use a clothespin to clamp the rolled-up mouth closed.

2. Tear off three small bits of masking tape, each about the size of your little fingernail. Draw a round dot in the middle of each bit of tape to represent a galaxy. Label each galaxy as A, B, or C.

3. Place the three bits of tape on the balloon so that the distances between them are all different. These represent three of the many galaxies in the universe.

4. Use your tape measure to find the distance from each masking tape galaxy to each of the others. Also measure the circumference of the balloon at its widest part. This gives you an indication of the size of your balloon universe at this time. Record these measurements for Round 1. (See chart below.)



5. Blow the balloon up a bit more, to represent the expanding of the universe. Measure and record the balloon circumference and the distances between the masking tape galaxies for your next round.

Repeat Step 5 a few more times until the balloon is about as big as it can get without popping. (Try to avoid a Big Bang!

Use a chart like the one below to record your results.

| | Changes in Distances between Galaxies as the Universe Expands | | | |
|---|---|---|---|---|
| Balloon | Circumference | From A to B | From B to C | From C to A |
| Round 1 | | | | |
| Round 2 | | | | |
| Round 3 | | | | |
| Round 4 | | | | |

Observe how the distances between the galaxies changed as the balloon universe expanded. Do you see any pattern or trend?

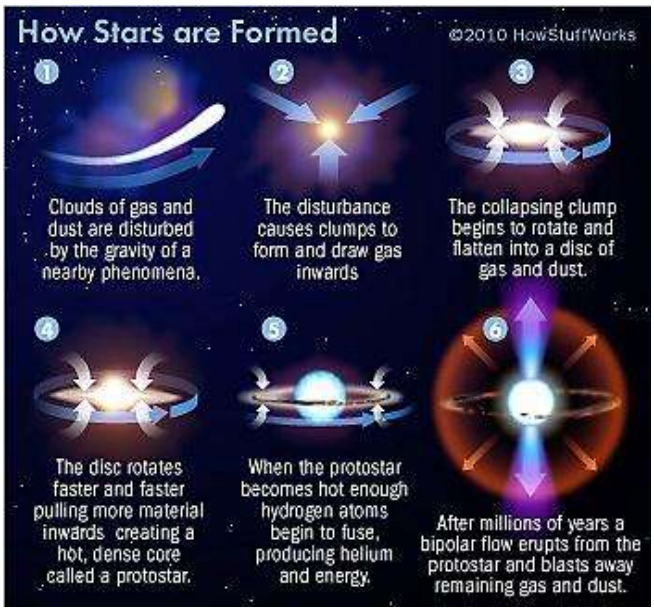
### Stages of Big Bang theory

*(i) In the beginning, all matter was in the form of tiny ball( singular atom) with unimaginable small volume , infinite temperature and infinite density*
*(ii) About 13.7 billion years ago the tiny ball exploded violently. The expansion continues even today.*
*(iii) As a result some energy was converted into matter*
*(iv) Within fraction of second there was rapid expansion*
*(v) The expansion slowdown after three minutes and first atom formed*
*(vi) After 300000 years the temperature dropped down to 4,500 K and gave rise to atomic matter.*
*(vii) The universe became transparent.*

## *Steady State Theory*

*The Big Bang Theory is the standard model of cosmology; however, there have been several other models for the universe. One such model, which gained a large following in the 1950 and 60 (before becoming obsolete in the early 70), is the Steady State Model. This model asserts that the general character of the universe is not changing over time (hence, a steady state).*

*Steady State theory propones the idea that the universe looks the same no matter the viewpoint and that the universe has always looked like this; essentially,the theory states that the universe is uniform throughout both time and space. The advantage of Steady State theory over some other theories is its simple and aesthetic explanations of certain troublesome topics. For example, since the universe is unchanging throughout time, the universe needs no convoluted explanation of its beginning. In addition, to account for the decrease in density that would result from expansion, steady state theory claims new matter constantly must be created in order to maintain a constant density (and therefore a static appearance).*




## *The Demise of Steady State*


*The Steady State theory offered simple solutions to the way the universe worked, but as observatories looked farther back into the early eras of the universe, astronomers started to see contradictions to the theory. Astronomers found that the universe actually evolves over time. For example, cosmologists discovered different types of stars are more common during different ages of the universe. The final demise of the Steady State theory came in the late 1960's with the discovery of the Cosmic Microwave Background. Steady State Theory could offer no convincing explanation for the CMB and as such, most contemporary cosmologists feel this theory is wrong*

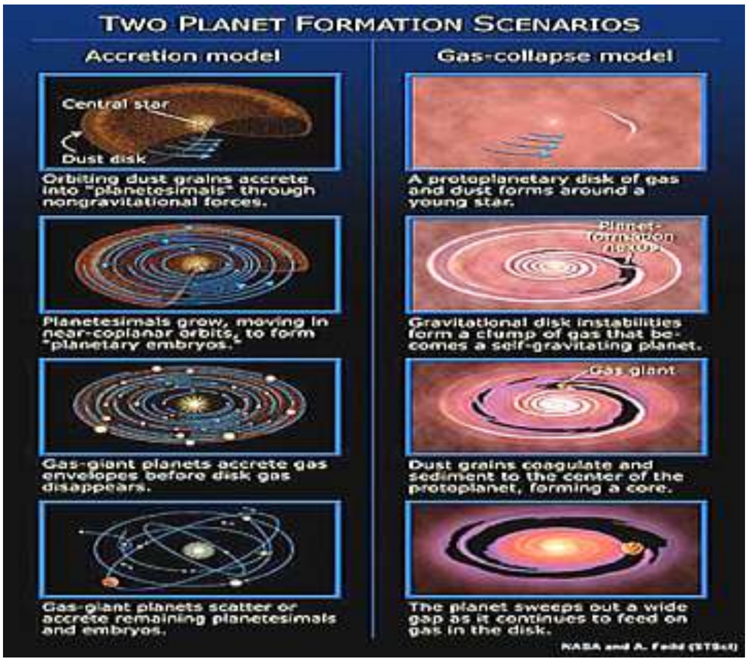
## *The star formation*

1. *The distribution of matter and energy was uneven in the universe.*
2. *The density difference gave rise to differences in gravitational forces*
3. *It caused the matter to get drawn together.*
4. *This is the base for the formation of galaxies*
5. *Galaxy contains large number of stars*
6. *The distance between the start is measured with light years.*
7. *One light year is equal to the distance covered by the light in one year when it travels at the speed of 3 lakh km/hour*
8. *The average diameter of the stars is 80,000 km to 1,50,000 light years*
9. *It starts forming by accumulation of hydrogen gas in the form of cloud*
10. *The denser gases were condensed into stars.*
11. *The formation of star was about 5-6 b y a.*
12. *One light year is 9.461 x$10^{12}$km*
13. *The mean distance from the Sun to the earth is 8.311 minutes*

## *Formation of planets -**Stages in the development of planets***

(i) *The stars are localized lump of gases found in nebula*
(ii) *The gravitational force led to the formation of the core*
(iii) *The huge rotating gas disc and dust develops around the gas core*

(iv) in the next stage the gas cloud starts getting condensed and the matter around the core develops into small rounded objects.

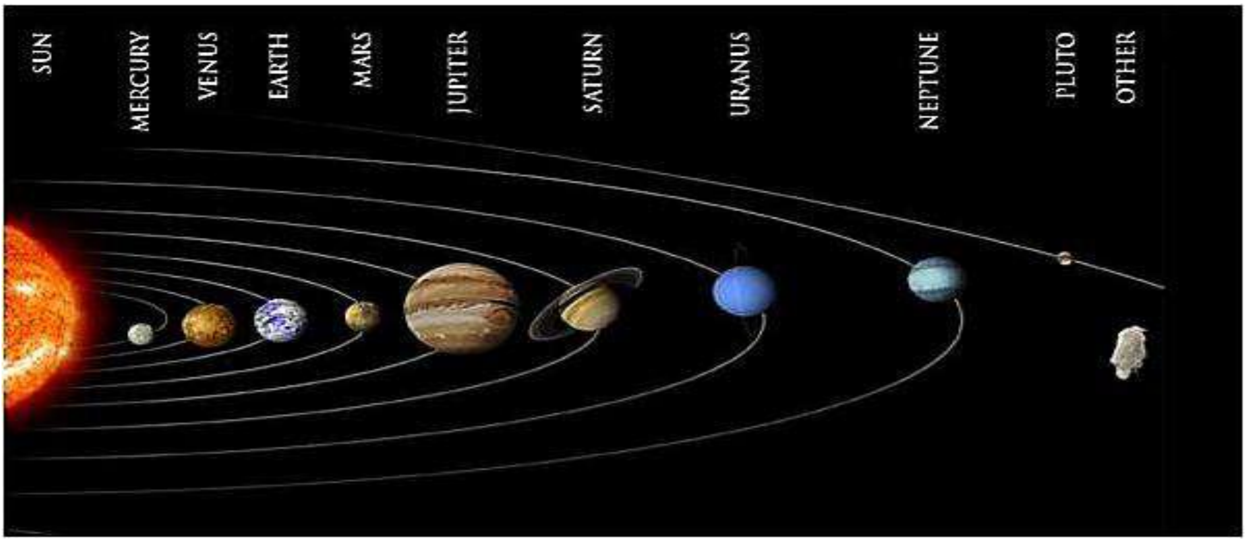



(v)The small rounded objects developed into planetesimals due to the process of cohesion.

(vi)Larger bodies started forming due to collision and attraction.

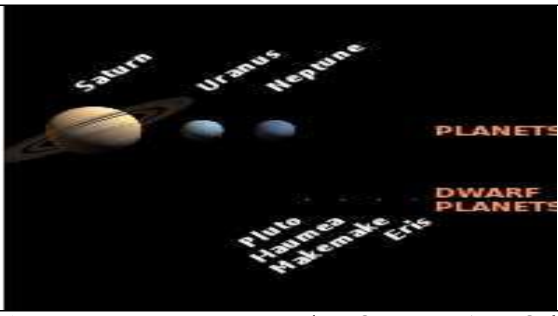
(vii)At the final stage, the small planetesimals accrete to form large bodies in the form of planets.

Our Solar system



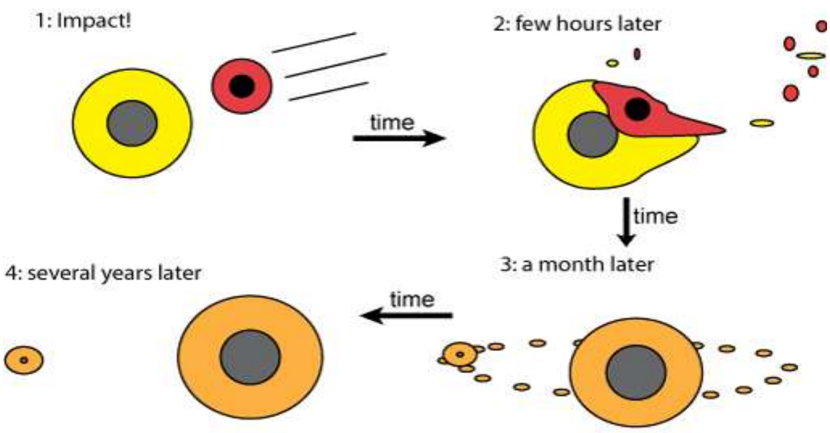

1. Our solar system consists of eight planets
2. The nebula of our solar system started collapsing around 5-5.6 b. y. a
3. The planets were formed about 4.6 b. y .a
4. Our solar system consists of 8 planets, 63 moons, millions of asteroids comets ,huge quantity of gas and dust.
5. There are two types of planets inner planets and outer planets.

## THE DIFFERENCE BETWEEN INNER PLANETS AND OUTER PLANETS

| INNER PLANETS | OUTERPLANETS |
|---|---|
|   |   |
| *1. Mercury ,Venus, Earth & Mars Are Called Inner Planets* | *1. Jupiter Saturn Uranus Neptune& Pluto Are Called Outer Planets* |
| *2. They Are Found Between Belt Of Asteroids And The Sun* | *2. They Are Found After The Belt Of Asteroids* |
| *3. They Are Also Called Terrestrial Planets* | *3. They Are Called Jovian Planets* |
| *4. Smaller In Size* | *4. Larger In Size* |
| *5. High Density* | *5 Low Density* |
| *6. Solid Rocky State* | *6. Gaseous State* |
| *7. They Are Warm* | *7. They Are Cold* |
| | |

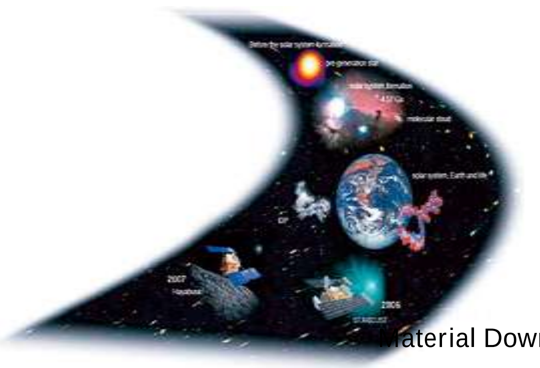
## THE MOON : THE EARLIER EXPLANATION

In 1838, Sir George Darwin suggested that initially the earth and the moon formed a single rapidly rotating body. The whole mass became a dumb-bell shaped body and eventually it broke. The material separated from the earth was formed as Moon and the place became the pacific ocean. It is not accepted now. the present theory is the giant impact theory./big splat theory. A large size body of Mars collided with the earth and that portion was separated from the earth. The same portion became as a moon which revolves around the earth. The Moon was formed about 4.4 b y a.




A long time ago in a planet system close to home...
A giant impact made the Moon. The Moon is mantle material from the Earth and impactor. Earth today is mantle+core from early Earth + impactor.

## EVOLUTION OF THE EARTH



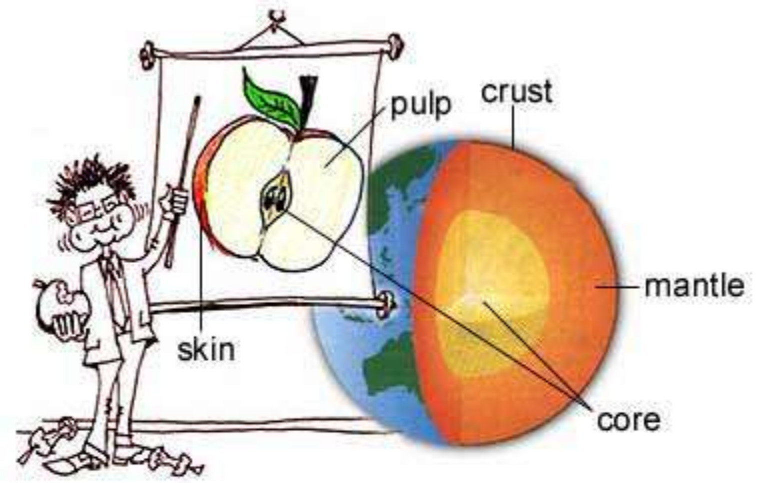
1. The earth was initially barren rocky and hot Object
2. Hydrogen and helium were present
3. It was formed about 4.6 b y a the earth was Layered structure
4. Lighter layer is formed at the outer surface
5. Density increase to wards inside the core

## EVOLUTION OF LITHOSPHERE

1. There was volatile state during its primordial stage 2. Due to high density temperature increased 3. The material started separating depending on their density Light material came out side and heavy material went inside the earth 4. It cooled and condensed into solid which is called lithosphere 5. At the time of formation of the moon the earth again became hot 6. Due to differentiation different layers formed

11. **EVOLUTION OF THE EARTH**



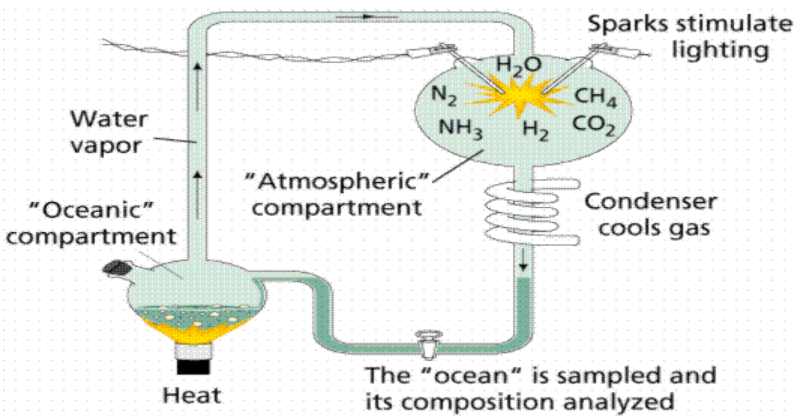

## EVOLUTION OF ATMOSPHERE AND HYDROSPHERE

**THERE ARE THREE STAGES OF THE FORMATION OF THE ATMOSPHERE**

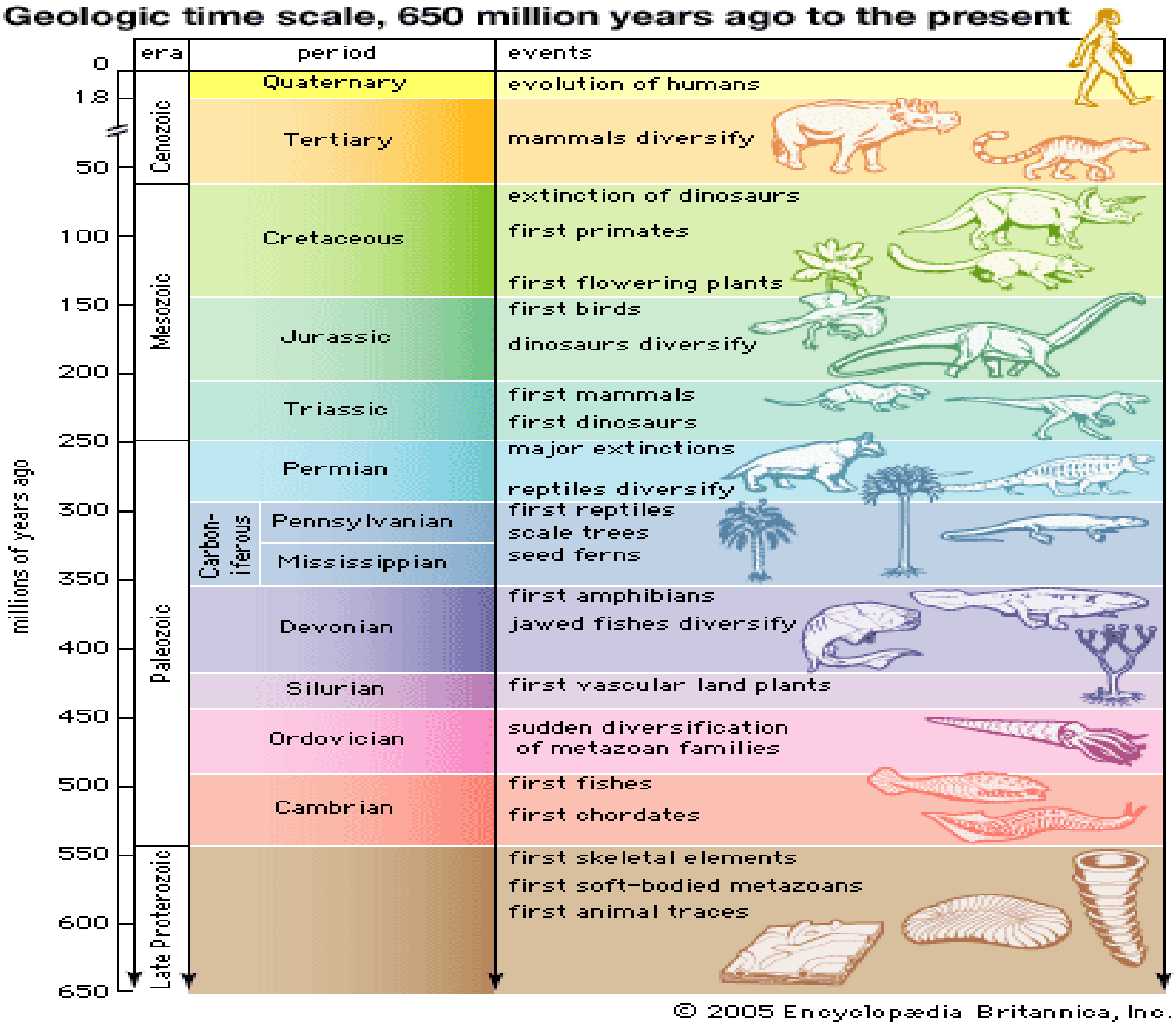
I .IN THE FIRST STAGE : the early atmosphere consist of hydrogen and helium .loss of primordial atmosphere due to solar winds

II. IN THE SECOND STAGE: Gases were released from the earth's interior such as Water vapor and other gases. There were water vapor, nitrogen, carbon dioxide methane, ammonia and little free oxygen. The process of outpouring the gases from the interior of the earth is called degassing. Volcanic eruptions contributed the water vapor and $CO_2$. The $CO_2$. Disolved in the rain water and converted into acid rain. Rain water collected into the depressions called oceans. The oceans were formed about 4000 m y a. The life began to evolve about 3.8 b y a. The photosynthesis evolved about 2500 to 3000 m y a oceans began to contribute oxygen to the atmosphere. oceans were saturated with oxygen and flooded into the atmosphere.

III IN THIRD STAGE: Living organisms changed the composition of the atmosphere due to photosynthesis




The last phase of the earth relates to the origin and evolution of life. It is clear that initially the earth or even the atmosphere of the earth was not conducive for the development of life. Modern scientist believes that origin of life is one kind of chemical reaction, took place in the oceans. Due to lightning, the complex organic molecules were combined into a certain form which can duplicate themselves. They are called first single cell animals. They are able to convert inanimate things into animate things. The earliest form of life existed about 3000 m y a . The life began on the earth about 3800 m y a.



# CHAPTER -3 INTERIOR OF THE EARTH

This chapter deals with

1. Sources of information of about the earth interior 2. direct sources 3. Indirect sources 4. earth quake 5. Earth quake waves 6. Propagation of earthquake waves 7. emergence of shadow zone 8. types of earthquakes 9. effects of earthquakes 10. structure of the earth 11. the crust 12. The mantle 13. the core 14. volcanoes and volcanic landforms 15. types of volcanoes 16. shield volcano 17. composite volcanoes 18. caldera 19. flood basalt provinces 20. mid ocean ridge volcanoes 21. volcanic landforms intrusive forms, plutonic rocks ,batholiths, laccoliths, lapolith, phacolith ,sills & dykes

## Sources of Information about the Earth's Interior

- There are two sources for information about interior of the earth – a) Direct Sources and b) Indirect Sources:
- Direct Sources: Mining, drilling and volcanic eruption are examples of direct sources. During the process of mining and drilling rocks and minerals are extracted which gives information that there are layer system in the crust. Crust is made of many kinds of rocks and minerals. Volcanic eruption suggests that there is some zone inside the earth which is very hot and in liquid condition. Direct sources are not very reliable because mining and drilling can be done only up to some depth only.
- Indirect Sources: Seismic waves, gravitational field, magnetic field, falling meteors etc are example of indirect sources. They are very important for know about earth's interior. Movement of seismic wave suggests that there are three layers in the earth and each layer has different density. Density increases toward the center of the earth.

Movement of seismic wave suggests two things: a) There are three layers in the earth and b) Each layer has different density which increases toward the center of the earth.

EARTH QUAKE

It is the shaking of the earth, natural event. It is caused due to release of energy which generates waves that travel to all directions.

WHY DOES EARTH SHAKE?

The release of energy occurs along the fault line

Rocks along the fault tend to move in opposite directions as the overlying strata press them the friction locks them together.

However, the tendency of movement overcome the friction

As a result, blocks get deformed

They slide over another: as a result energy releases.

Energy waves travel in all directions.

The point where energy releases is called focus/hypocenter

Above the focus point on the surface it is called epicenter

EARTH QUAKE WAVES

All earth quakes take place in the lithosphere ( 200 km depth)

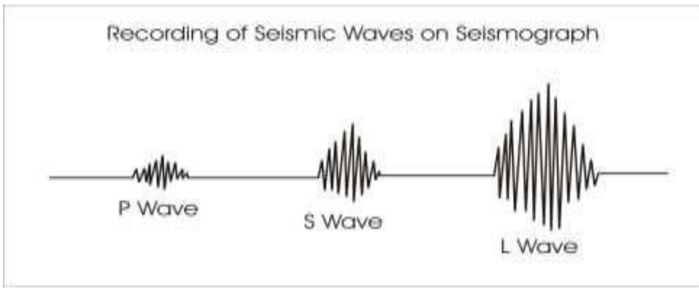
An instrument called *Seismograph* records the waves.

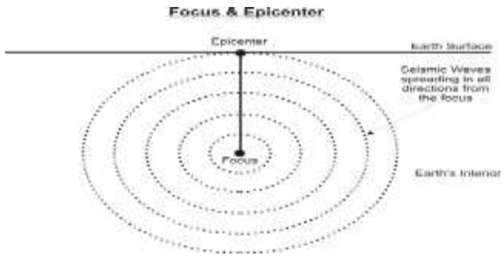
## Earthquake and Seismic Waves

Meaning of Earthquake: Sudden movement or vibration on the earth surface is called earthquake. In other words, sudden release of energy due to tectonic activity is called earthquake. An earthquake may be produced due to: a) movement of plates, b) rising of magma, c) folding and faulting, d) violent volcanic eruption etc. When earthquake occurs, three types of wave are produced called as seismic waves. These are: a) P or Primary Wave, b) S or Secondary Wave, and c) L or Long or Surface Wave.

- P and S waves are combinely called as 'Body Wave' as they move inside the body of the earth.

- P wave is the fastest wave. It is also called as longitudinal wave. These waves move forth and back. In other words, P waves move parallel to the direction of wave. These waves can move in both solid and liquid.
- S wave is slower than P wave. It is also called as transverse wave. It moves perpendicular to the direction of the wave. These waves move only in solid and disappear in liquid.
- L wave is the slowest wave. It moves on the earth surface. It causes maximum destruction on the earth surface.




- Focus: It is point inside the earth surface from where an earthquake starts. It is always hidden inside the earth. Focus of an earthquake may be found at the depth of 100-200 km.
- Epicenter: It is a point on the earth surface which records the seismic waves for the first time. Maximum destruction from an earthquake is caused on the epicenter. Epicenter is located just perpendicular to the focus.
- P and S waves are called as Body Wave.
- P wave can pass through both solid and liquid. But S wave can pass only through solid.
- Seismograph: It is an instrument which record seismic waves on a paper.
- Richter Scale: It is an scale which measures the magnitude of an earthquake. In other words, energy released by an earthquake is measured on Richter Scale. Generally, it is from 0 to 10. An earthquake measuring 6 on Richter Scale is 10 times more stronger than 5 and 100 times more stronger than 4.
- Crust and upper part of the mantle is called 'lithosphere'.
- The opening through with magma comes out from a volcano is called as 'mouth' or 'crater'. When crater is collapsed due to a violent explosion it is called as 'caldera'.
- Mid-Oceanic Ridge: When plates move away from each other under the water of the ocean and magma rises up, it form a long hill like landform called as mid-oceanic ridge. Mid-oceanic ridge of Atlantic Ocean is the best example.
- Mercalli Scale: It was developed by an Italian seismologist. It measures the destruction caused by an earthquake. It ranges from 1 to 12.

## Effects of Earthquake

a) Ground shaking
b) Destruction to houses and buildings
c) Land slide and tsunami
d) Soil liquefaction [solid soil becomes liquid]
e) Damage to dams and reservoirs
f) Fire accidents
g) Destruction to transport and communication lines.

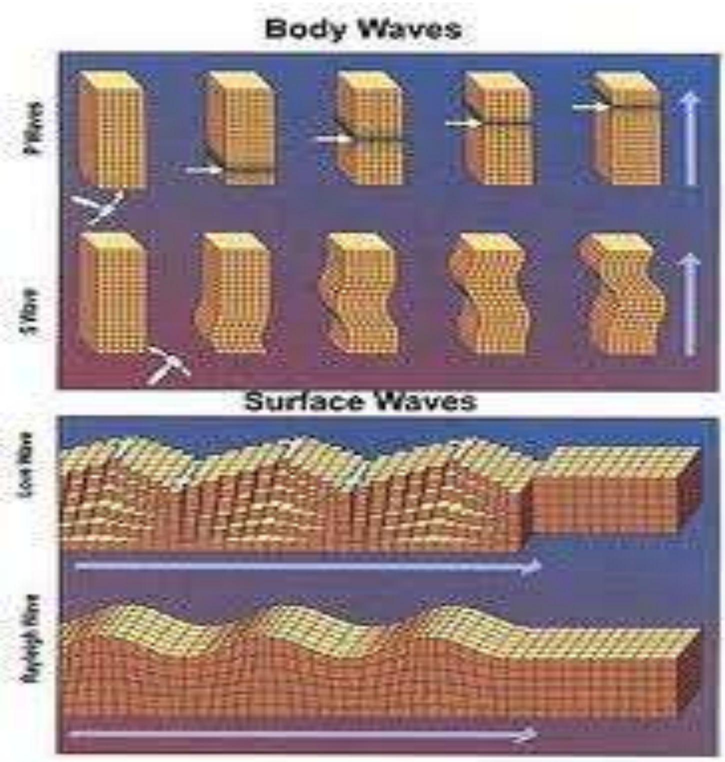
## Shadow Zones and Their Formation

Meaning of Shadow Zone: When earthquake takes place, all the places on the earth surface do not record the seismic waves. There are some zones where seismic waves [P and S waves] do not reach during an earthquake. It is called as shadow zone. Shadow zones are formed due to two reasons:

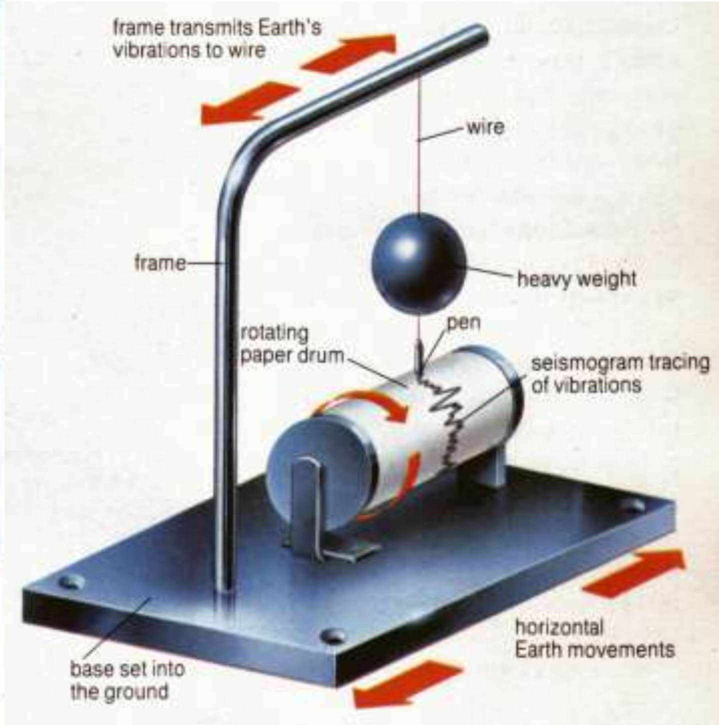
a) Three layers in the earth
b) Varying density of each layer
c) Liquid condition of the mantle

- P Wave Shadow Zone: Ideally seismic waves should move in straight line but due to varying density of layer P wave moves in a curved path. Due to this an area around the earth does not record P wave. This zone is from $105^0$ to $145^0$ from the focus.

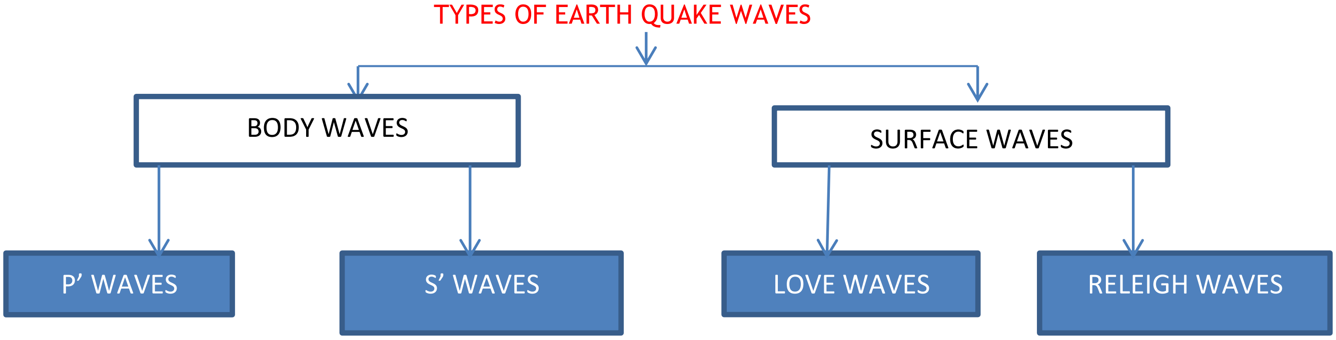
- S Wave Shadow Zone: It is larger zone than P wave shadow zone. It developed because S wave does not pass through liquid mantle of the earth. Therefore, the zone from $105^0$ all around the earth from the focus is called as S wave shadow zone.




SEISMOGRAPH




TYPES OF EARTH QUAKE WAVES



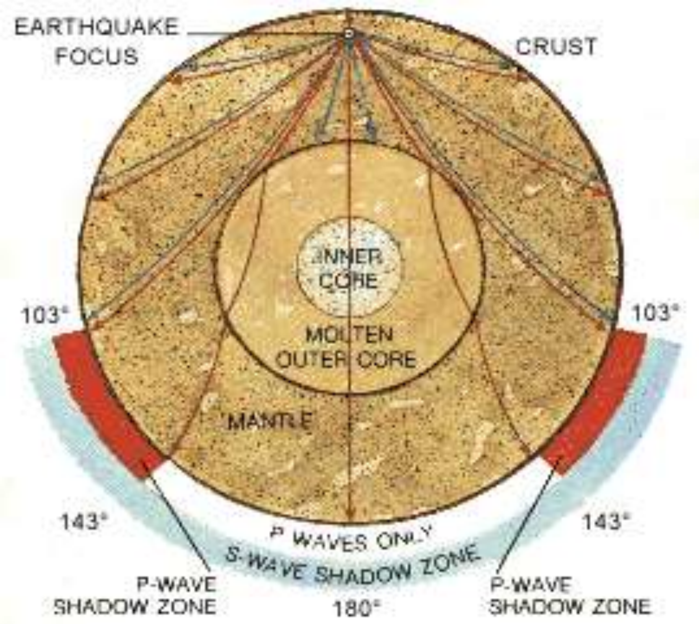

BODY WAVES GENERATED DUE TO ENERGY GENERATED IN THE EARTH'S INTERIOR
They interact with the surface rocks and generate other waves called surface waves
The velocity of the waves changes along with the density of material, denser the material higher the velocity
Their direction also changes according to the density of the material

**PROPAGATION OF EARTHQUAKE WAVES**
When they travel in the body they vibrate the bodies of the rocks
P waves vibrate parallel to their direction of the movement

It led to the density difference in the material due to stretching and squeezing
Other three waves vibrate perpendicular to their direction

They create troughs and crests over the surface

## EMERGENCE OF SHADOW ZONE




Where earthquake waves are not reported, such zones are called earthquake shadow zones.
It is observed that seismographs located beyond 103° from the epicenter do not record the earthquakes.

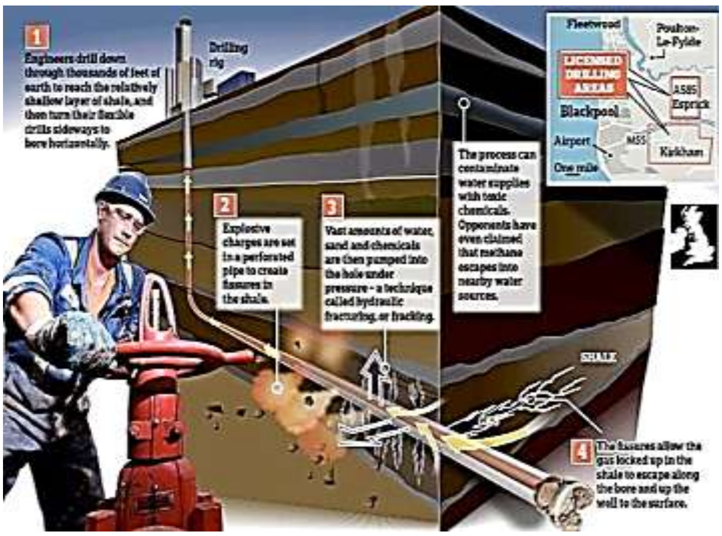
Seismographs located beyond 142° again record ‘p’ waves only .
The entire zone beyond 142° do not receive ‘s’ waves

The shadow zone of ‘s’ waves is much larger than the ‘p’ waves it is equal to 40% of the earth surface

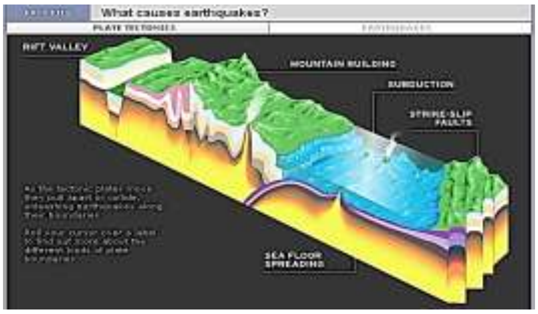
## TYPES OF EARTHQUAKES

INDONE


MINING EARTH QUAKE - SOUTH AFRI



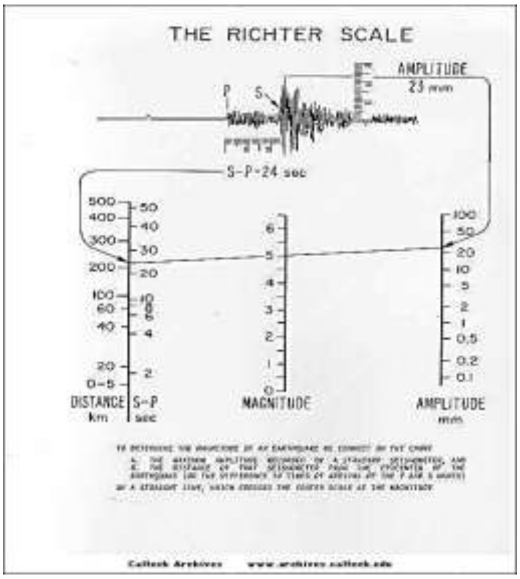
TECTONIC EARTH QUAKE GUJARAT

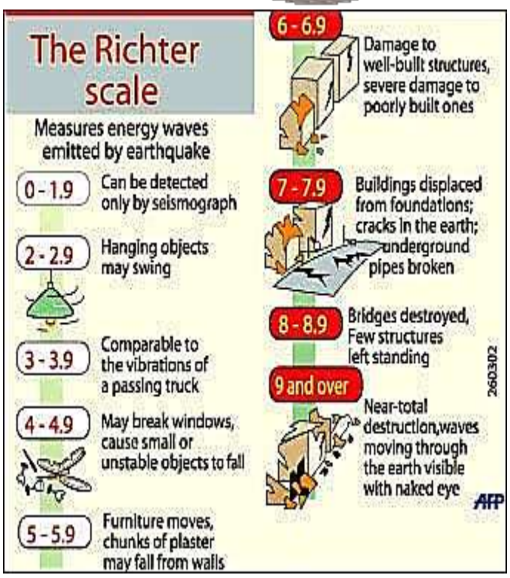



NUCLEAR EXPLOSION EARTH QUAKE JAPAN

RESERVOIR IMPOUND EARTHQUAKE TEHRI DAM

**HOW IS EARTH QUAKE MEASURED-RICHTER SCALE**



The magnitude of most earthquakes is measured on the **Richter scale,** invented by Charles F. Richter in 1934. The Richter magnitude is calculated from the amplitude of the largest seismic wave recorded for the earthquake, no matter what type of wave was the strongest.

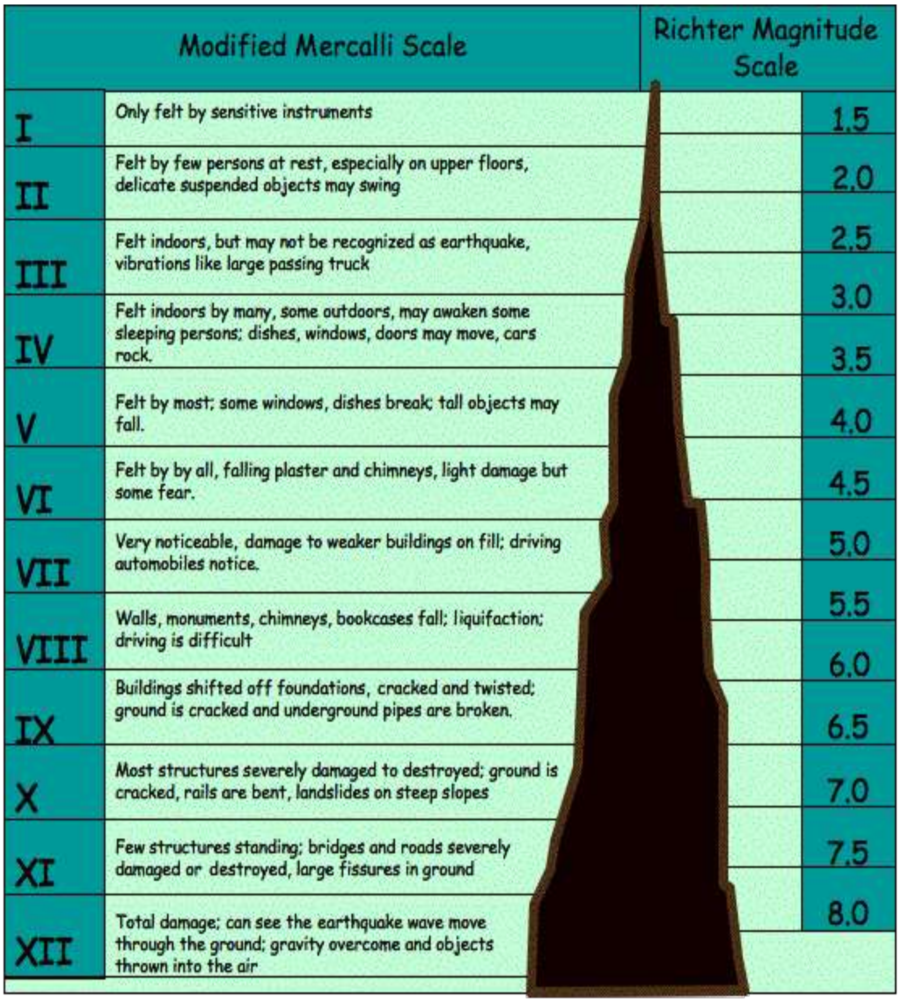
The Richter magnitudes are based on a logarithmic scale (base 10). What this means is that for each whole number you go up on the Richter scale, the amplitude of the ground motion recorded by a seismograph goes up ten times. Using this scale, a magnitude 5 earthquake would result in ten times the level of ground shaking as a magnitude 4 earthquake (and 32 times as much energy would be released). To give you an idea how these numbers can add up, think of it in terms of the energy released by explosives: a magnitude 1 seismic wave releases as much energy as blowing up 6 ounces of TNT. A magnitude 8 earthquake releases as much energy as detonating **6 million tons of TNT**. Pretty impressive, huh? Fortunately, most of the earthquakes that occur each year are magnitude 2.5 or less, too small to be felt by most people.

The Richter magnitude scale can be used to describe earthquakes so small that they are expressed in negative numbers. The scale also has no upper limit, so it can describe earthquakes of unimaginable and (so far) inexperienced intensity, such as magnitude 10.0 and beyond.

Although Richter originally proposed this way of measuring an earthquake's "size," he only used a certain type of seismograph and measured shallow earthquakes in Southern California. Scientists have now made other "magnitude" scales, all calibrated to Richter's original method, to use a variety of seismographs and measure the depths of earthquakes of all sizes.

### The Mercalli Scale

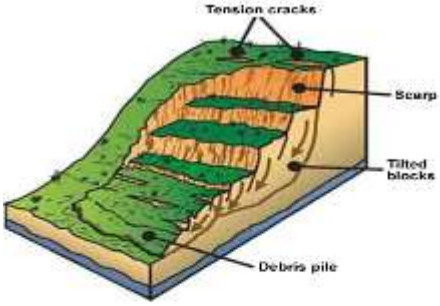
Here's a table describing the magnitudes of earthquakes, their effects, and the estimated number of those earthquakes that occur each year.



## EFFECTS OF EARTH QUAKE

GROUND SHAKING

LAND &MUD SLIDES




AVALANCHES

GROUND LURCHING

SOIL LIQUEFACTION

GROUND DISPLACEMENT

FLOODS FROM DAM

FIRES

STRUCTURAL COLLAPSE

TSUNAMI

First six  listed above have some hearings upon landforms while others may be considered the effects causing immediate concern to the life and properties of people in the region.

Tsunami occurs when the epicenter is below the ocean floor with sufficient magnitude. Tsunamis are waves generated by the termers not by the earthquake. The magnitude should be more than 5 in Richter scale.

The earthquakes of magnitude   8+ are rare occurs once in 1-2 years .tiny types occur every minute.

**The structure of the Earth**

Imagine a Scotch egg......

1. The outer shell of the Earth is called the **CRUST**    (breadcrumbs)
2. The next layer is called the **MANTLE**    (sausage meat)
3. The next layer is the liquid **OUTER CORE**    (egg white)
4. The middle bit is called the solid **INNER CORE**    (egg yolk)

The deepest  anyone has drilled into the earth is around 12 kilometers, we've only scratched the surface. How do we know what's going on **deep** underground?

**There are lots of clues:**

- 1.The overall density of the Earth is much higher than the density of the rocks we find in the crust. This tells us that the inside must be made of something much denser than rock.
- 2. Meteorites (created at the same time as the Earth, 4.6 billion years ago) have been analyzed. The commonest type is called a contrite and they contain iron, silicon, magnesium and oxygen (Others contain iron and nickel). A meteorite has roughly the same density as the whole earth. A meteorite minus its iron has a density roughly the same as Mantle rock (e.g. the mineral called olivine).
- 3. Iron and Nickel are both dense and magnetic.
- 4. Scientists can follow the path of seismic waves from earthquakes as they travel through the Earth. The inner core of the Earth appears to be solid whilst the outer core is liquid (s waves do not travel through liquids). The mantle is mainly solid as it is under extreme pressure (see below). We know that the mantle rocks are under extreme pressure, diamond is made from carbon deposits and is created in rocks that come from depths of 150-300 kilometers that have been squeezed under massive pressures.

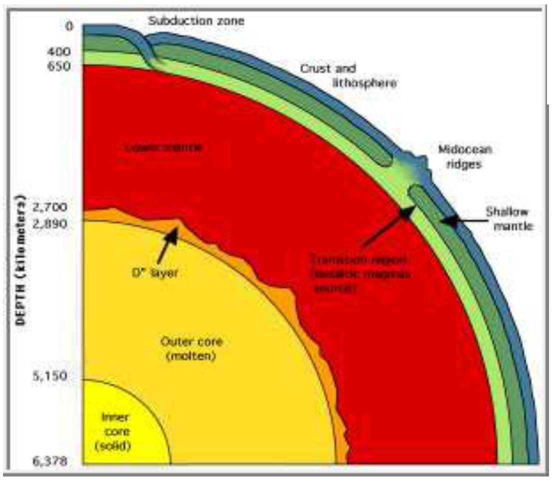
5. The Earth is sphere (as is the scotch egg!) with a diameter of about 12,700 Kilometers. As we go deeper and deeper into the earth the temperature and pressure rises. The core temperature is believed to be an incredible 5000-6000°c.

6. The crust is very thin (average 20Km). This does not sound very thin but if you were to imagine the Earth as a football, the crust would be about ½ millimeter thick. The thinnest parts are under the oceans (OCEANIC CRUST) and go to a depth of roughly 10 kilometers. The thickest parts are the continents (CONTINENTAL CRUST) which extend down to 35 kilometers on average. The continental crust in the Himalayas is some 75 kilometers deep.

7. The mantle is the layer beneath the crust which extends about half way to the centre. It's made of solid rock and behaves like an extremely viscous liquid - (This is the tricky bit... the mantle is a solid which flows????) The convection of heat from the center of the Earth is what ultimately drives the movement of the tectonic plates and cause mountains to rise. Click here for more details

The outer core is the layer beneath the mantle. It is made of **liquid** iron and nickel. Complex convection currents give rise to a dynamo effect which is responsible for the Earth's magnetic field.

8. The inner core is the bit in the middle!. It is made of **solid** iron and nickel. Temperatures in the core are thought to be in the region of 5000- 6000° c and it's solid due to the massive pressure.




## EARTH STRUCTURE

### The crust - the Outer most solid part

1. Brittle in nature
2. Thickness is 5 km. thin under the oceans and thick under the continents
3. 30 km under oceans and 70 km under mountains

Density in the ocean floor is 3g/$cm^3$( basalt) mean density is

2.7g/$cm^3$

### The mantle

1. Second layer from the top of the earth
2. 2. it extends from Moho-discontinuity to a depth of 2900 km.
3. 3.the upper portion of the mantle is called ASTHENOSPHERE ( Astheno= weak it extends up to 400 km)
4. 4. it is the source of magma
5. average density is 3.4g/$cm^3$
6. 6. crust and upper most part of the mantle is called Lithosphere. Its thickness is 10 -200km
7. 7. Lower mantle is in solid state

### The core

1. It extends from 2900 km to 6300 km depth
2. 2. Outer core is liquid while inner core is solid
3. 3. outer core density is 5 g/$cm^3$ inner core is 13 g/$cm^3$
4. made of heavy metals such as Nickel and Iron
5. it is also called as **Nife**

## VOLCANOES AND VOLCANIC LANDFORMS

**A volcano is place where gases, ashes and or molten rock material lava escape to the ground.**

Active volcano Mount Pinatubo, Philippines in 1991.

**Lava from Mt. Kilauea pouring into the ocean during the sunset**

### The Differences between Active, Dormant and Extinct volcanoes

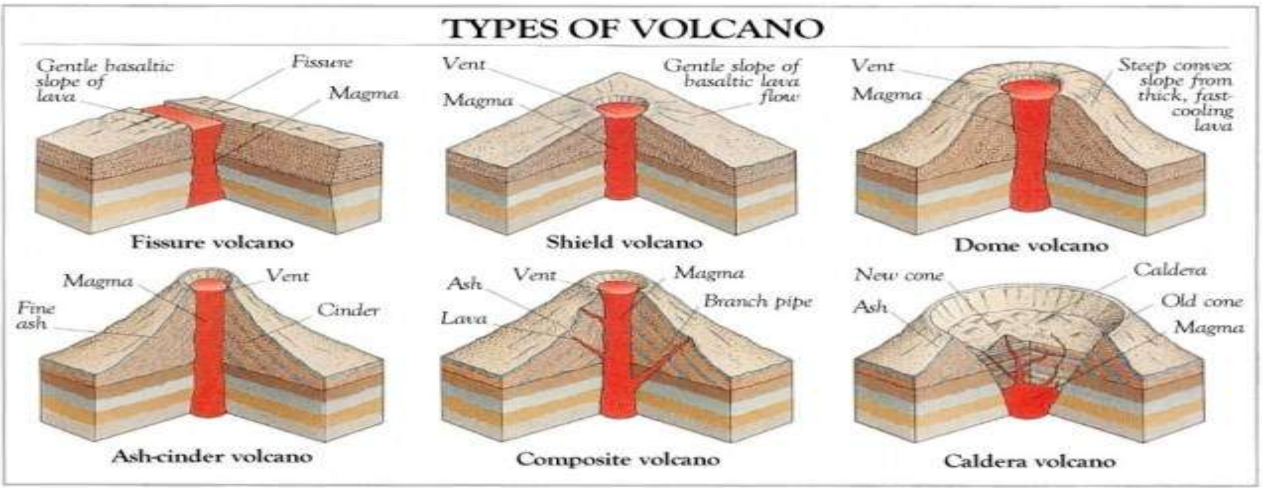
**Active Volcano:** Is a volcano that is currently erupting or shows signs of unrest activities, like earthquake activity or significant amounts of gas discharged. It is a volcano that is not presently erupting, but has erupted in the past is considered likely to do erupt in the future again.

**One of the dormant volcanoes in the Cascades in the "Three Sister Area."**


**Dormant:** These volcanoes are also called "Sleeping" volcanoes because it is presently inactive, but could erupt again. For example, the majority of the Cascade volcanoes arebelieved to be dormant rather than extinct.

**This is an Aerial view of Crater Lake in Oregon.**

**Extinct:** Is a volcano that is presently not erupting, that is unlikely to do so for a very long time in the future.




Classification of volcanoes based on nature of eruption and land forms developed on the surface.

SHIELD VOLCANO

1. Largest of volcanoes
2. Hawaiian islands are best examples
3. Basalt lava flow
4. Lava is very fluid
5. They are not steep
6. They become explosive when water is held in tovent
7. Develops in to cinder cone

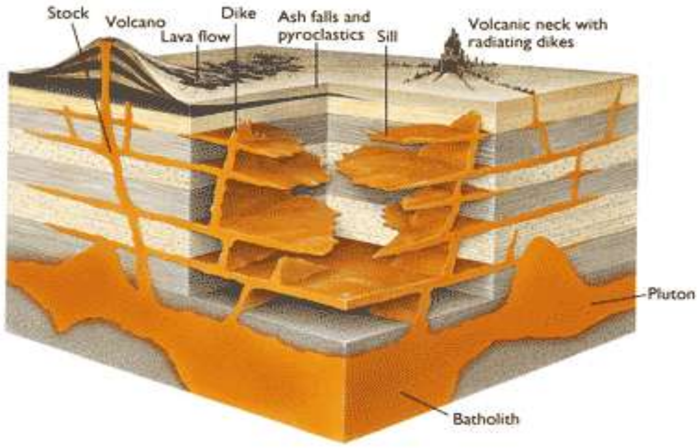
COMPOSITE VOLCANOES

1Cool and more viscous lava
2.Explosive eruptions
3.They erupt pyroclasitc and ashes along with lava
4.Layers are formed

CALDERA

1.These are the most explosive type of volcanoes

2.They collapse themselves and form into lakes
3.The magma chamber is huge and found nearby




FLOOD BASALT PROVINCES

1. Consists of highly fluid lava
2. Some parts of the world are covered by thousands of sq.km of basalt
3. there can be series of flows
4. Average thickness is more than 50 km
5. Individual flow is 100 of sq.k.m
6. Ex. Deccan plateau

MID OCEANIC RIDGES VOLCANOES

1. Found in oceanic surfaces
2. More than 70,000 km length
3. Frequent volcanic eruptions
4. Ex. Mid Atlantic ridge

INTRUSIVE VOLCANIC LANDFORMS

1.when volcanic eruption takes place some lava comes out and some settle down in the lithosphere.
2.when lava comes out forms volcanic rocks, some part cools down in the lower portion forms plutonic rocks

INTRUSIVE FORMS OCCUR INSIDE THE CRUST.

BATHOLITH:
A large part of the magma material that cools in the deeper depthof the crust. They are dome shaped, cover large areas,
They come out when erosion takes place.they are granite bodies.
LACOLITHS: large dome shaped intrusive bodies. Consists of level bodies
Connected through pipe like conduit from below it resembles composite volcanoes found deeper depthsthey are localised source of lava
Ex. Karnataka plateau
LAPOLITHS:concave shaped lava formation phacoliths: wave typed lava formation
SILL: horizontal sheet of lava
DYKES: vertical lava formation

GIST OF THE LESSON: CONTINENTAL DRIFT, EVIDENCES TO SUPPORT CONTINENTAL DRIFT, FORCES OF DRIFTING, POST DRIFT STUDIES, OCEAN FLOOR CONFIGURATION, DISTRIBUTION OF VOLCANOES AND EARTHQUAKES, CONCEPT OF SEA FLOOR SPREADING, PLATE TECTONICS, MAJOR AND MINOR PLATES, TYPES OF PATE BOUNDARIES RATES OF PLATE MOVEMENT, FORCES OF PLATE MOVEMENT& MOVEMENT OF THE INDIAN PLATE.

CONTINENTAL DRIFT: ABRAHAM ORTELIUS a Duchy map maker 1596 first proposed the possibility of joining the continents such as America with Europe and Africa
ANTONIO PELLEGRINI drew the map showing the three continents together.
ALFRED WEGENER a German meteorologist put forth THE CONTINENTAL DRIFT THEORY.
According to him,
All continents formed a single continental mass called PANGAEA
All oceans formed a single universal ocean called PANTHALASSA
AROUND 200 mya THE PANGAEA BEGAN TO SPLIT INTO TWO LARGE MASSES CALLED LAURASIA and GONDWANA LAND
By further splitting Laurasia formed northern continents and Gondwana land formed southern continents.

EVIDENCES TO SUPPORT THE CONTINENTAL DRIFT

1. The matching of continents (jig-saw fit)

A. the shorelines of S. America and Africa have remarkable match

B. a map was produced by Bullard in 1964 to show the jigsaw fit of these two continents.

C. it was fit around 1000 fathom line of the shoreline

2. ROCKS OF SAME AGE ACROSS THE OCEANS

A.the belt of ancient rocks of 2000 my from Brazil coast matches with those of Western Africa
B. Marine deposits of South America and Africa belong to Jurassic age.

3.TILLITE

A. sedimentary rock formed out of glacial deposits
B. sediments from India have similar counter parts at different continents of south.
C.tillile indicates prolonged glaciations
D.The same glaciations is found in Africa, Falklands, Madagascar, Antarctica and Australia
E. the glacial tillite indicates that unambiguous evidence of palaeo climates and drifting of continents.

4.PLACER DEPOSITS
a. Formation of placer deposits of gold in Ghana coast has no source rock.
a. The gold bearing veins of rocks are found in Brazil

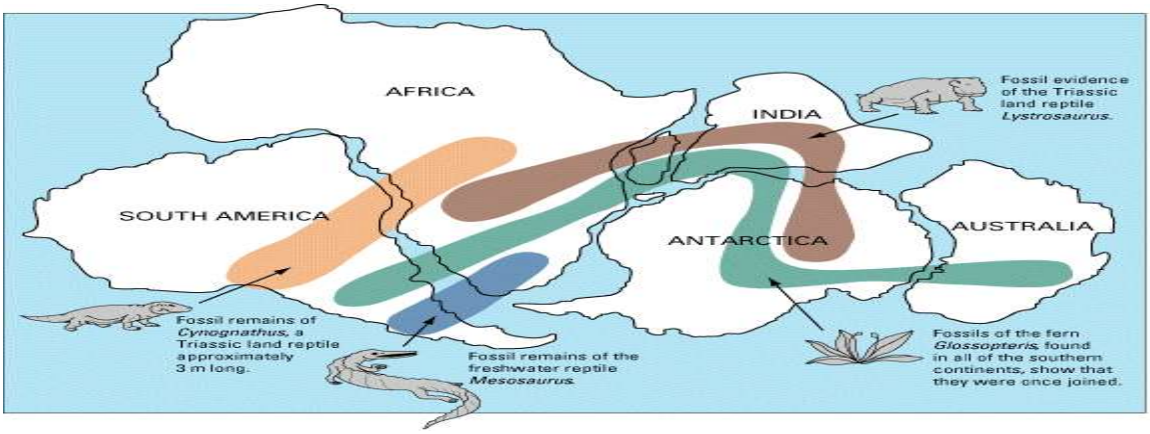
5.DISTRIBUTION OF FOSSILS

- Identical species of animals and plants are found along the coastal regions of the different continents.
    - lemurs occurs in India , Madagascar and Africa.
    - The contiguous land mass was called LEMURIA
    - the fossils of mesosaurus were found in only South Africa and Brazil.

LEMURIA

MESOSAURUS

DISTRIBUTION OF FOSSILS



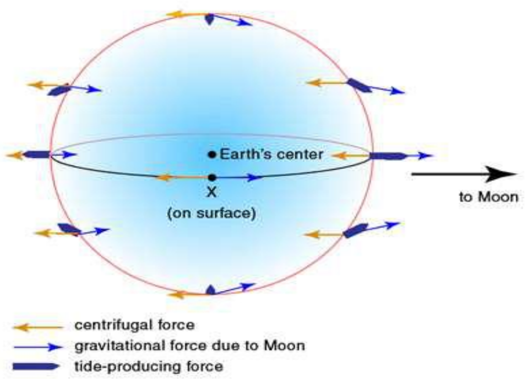

FORCES FOR DRIFTING THE CONTINENTS

1. **Wegner suggested that the movement responsible for the drifting of the continents was caused by**

A. POLAR FLEEING FORCE  B. TIDAL FORCE

**Possible driving forces for plate tectonics:**

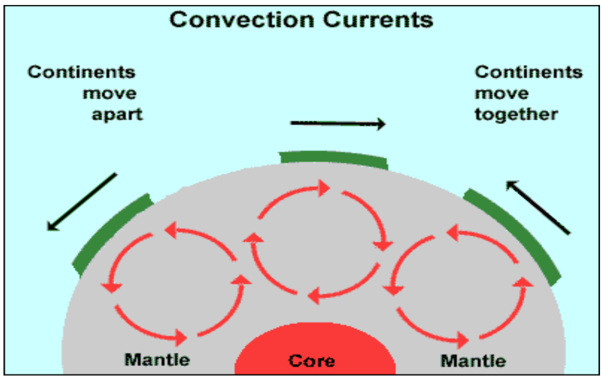
2. bottom lithosphere tractions by convection currents.
3. trench pull (covered earlier).
4. ridge push (sliding off a high, crust in compression).
5. trench suck (rollback).
6. global expanding or contracting forces.
7. membrane forces on spinning ellipsoid (e.g. variants of polar fleeing forces).




TIDAL FORCE

**Wegener suggested that these two forces are responsible for the movement of plates.**

**Most of the scholars consider that these forces are not sufficient to move the plates.**

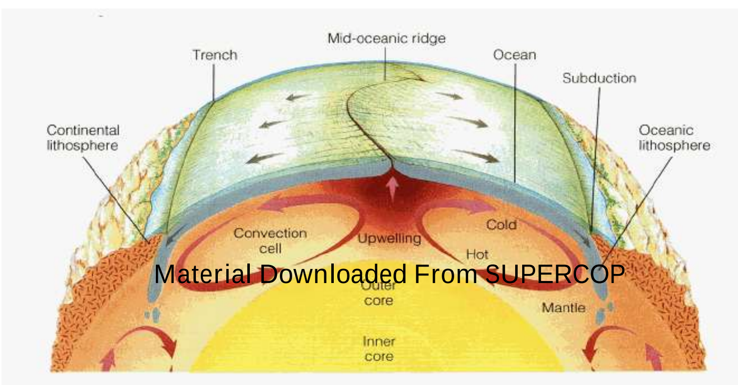



POST DRIFT STUDIES

Information collected from the ocean mapping is more useful to study the continental drift

Convectional current theory

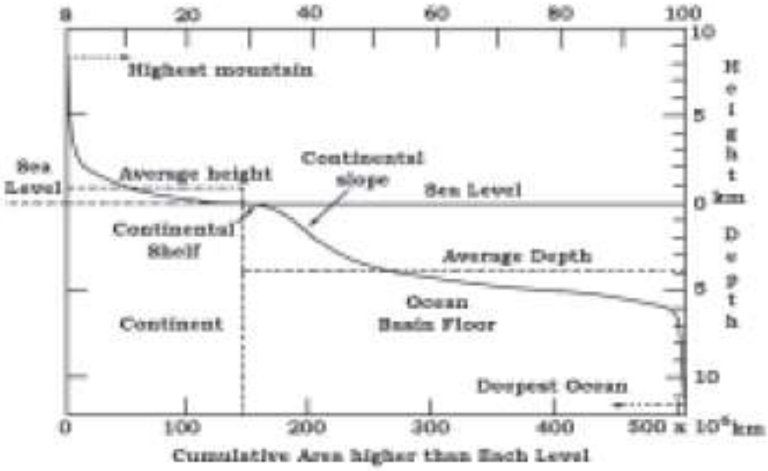
**It was proposed by ARTHUR HOLMES IN 1930**
**Due to difference in the temperature currents are formed due to disintegration of radioactive materials inside the earth.**
**These currents are found entire mantle portion**



## MAPPING OCEAN FLOOR

1. Existence of ridges and deep trenches nearby continental margins
2. Mid oceanic ridge is the most active for volcanic eruptions
3. The ocean floor is much younger than the continents
4. Rocks of equal distance of the ridge have similar chemical composition and age

## OCEAN FLOOR CONFIGURATION




## OCEAN FLOOR CONFIGURATION

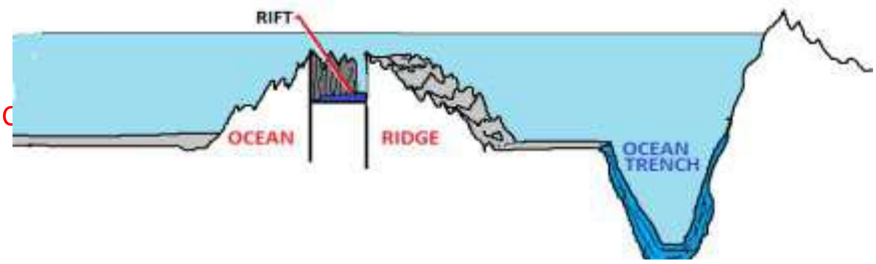
The ocean floor is segmented into three major divisions
Based on depth and configuration

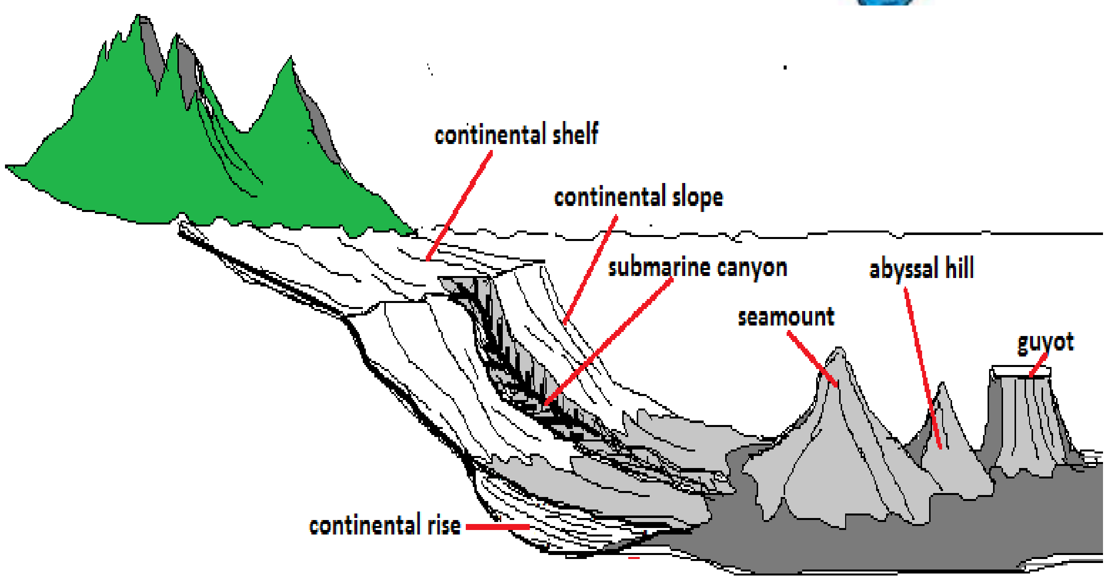
1. **Continental margins**
   **a.Form transitional zone between continental shore and deep sea basins**
   **b.They include continental slope , shelf, continental rise and deep oceanic trenches**

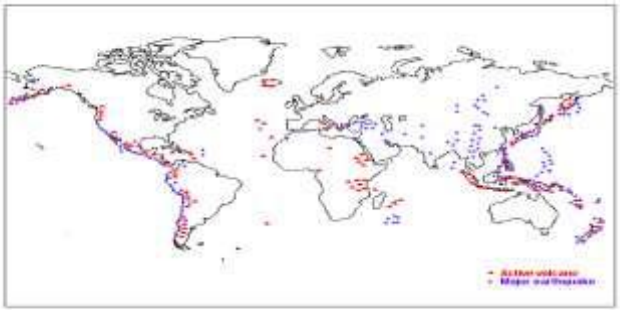
ABYSSAL PLAINS

1. EXTENSIVE PLAINS
2. FOUND BETWEEN CONTINENTAL MARIGN AND MID OCEANIC RIDGE
3. CONTINENTAL SEDIMENTS GET DEPOSITED

MID OCEANIC





DISTRIBUTION OF VOLCANOES AND EARTHQUAKES

1.all volcanoes and earthquakes are paralle  to the coast
2.this line also coinsides with mid- atalantic ridge
3.alpine hymalayan system
4.around the pacific ocean it is called **ring of fire**
Mid oceanic ridges

1. Interconnected mountain system within the ocean
2. Longest mountain chain  in the ocean floor
3. Consist of central rift system at the crust
4. Intense volcanic activity is found

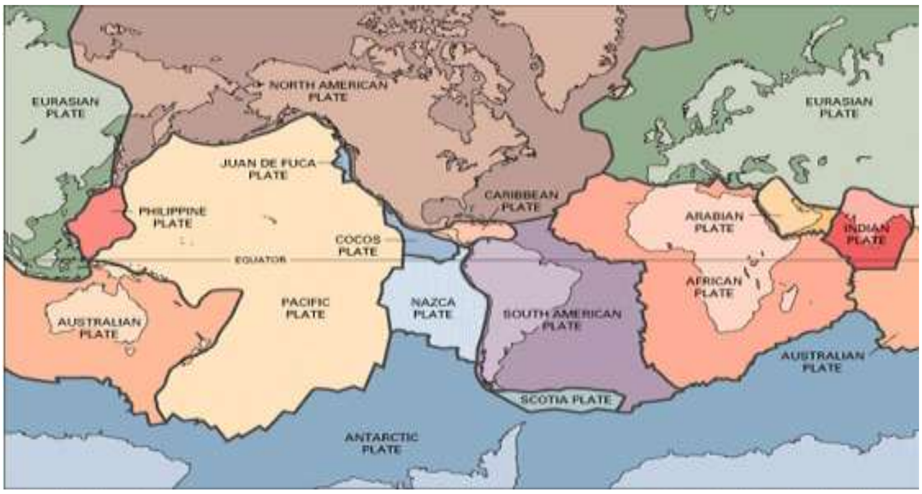
CONCEPT OF SEA FLOOR SPREADING

1.it was proposed by Hess in 1961
2.he believed that new lava pushes out the plates from the mid oceanic ridge
3.palaeo magnetic studies of the ocean floor reveals that
A.along the mid oceanic ridge there is intense volcanic eruption
B.huge amount of lava comes out along the mid atlanticn ridges
C.the equidistant rock formations  have similar  age and chemical compositions & magnetic properties
7.rocks closer to the mid oceanic  ridges are young and normal polarity
8. The age of rocks increases  as the distance increases from the mid oceanic  ridge
9. Oceanic crust is much younger( 200my) than continental crust (3200my)
10. The sediments of ocean floor is very thisn
11.earth quakes are common along the deep sea trenches
Positions of continents through geological past

**PLATE TECTONICS**

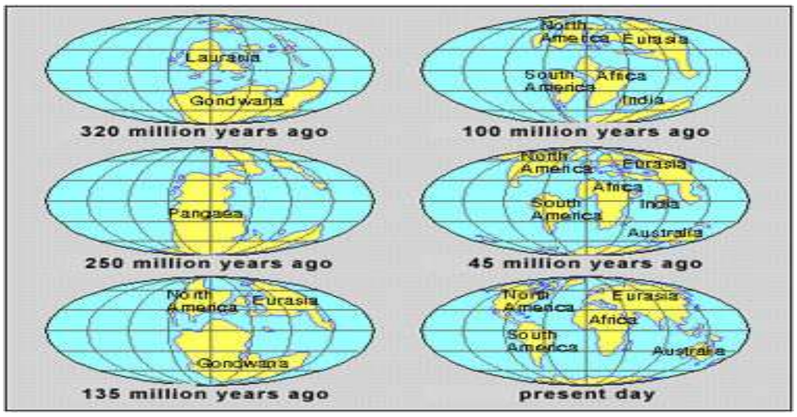
1. **The theory of plate tectonics was introduced by** McKenzie, parker and Morgan in 1967
2. **A tectonic plate is also called as lithosphere plate**
3. **It is a massive irregularly shaped  slab of solid  rock**
4. **Consists of oceanic and continental sphere**
5. **Plates move horizontally over the Asthenosphere**
6. **Average thickness is 100 km of oceanic part and 200 km continental part**
7. **It may be oceanic or continental**
8. **Pacific plate is largest oceanic plate where as Eurasian plate is the largest continental plate**

**MAJOR PLATES OF THE EARTH CRUST**

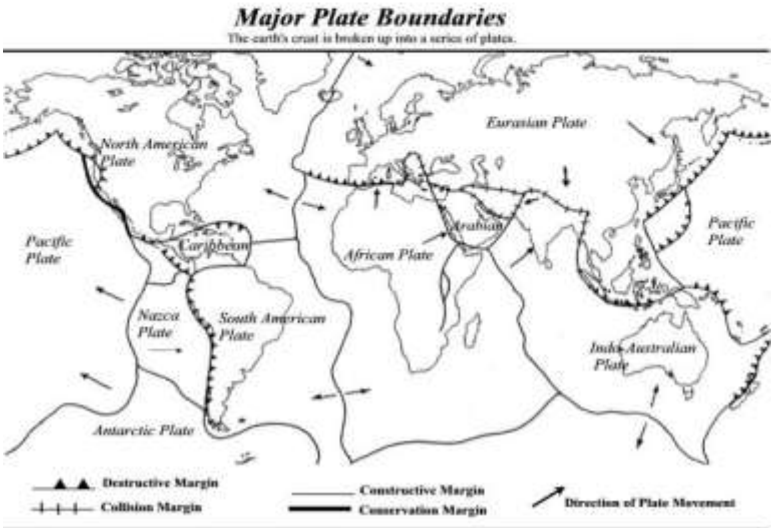



**MAJOR PLATES**

## MAJOR PLATES




1.Antarctica And Surrounding Oceanic Plate 2. North American Plate
3. South American Plate Pacific Plate
India-Australia-New Zealand PLATE
6.African Plate Eurasian Plate




## MINOR PLATES

1. Cocos Plate 2. Nazca Plate 3. Arabian Plate 4. Philippine Plate 5. Caroline Plate 6 .Fuji Plate

These plates are moving constantly throughout geological time not the continent believed by Wegener
Pangaea was the convergent of all the plates
Position of Indian subcontinent is traced with the help of rocks analyzed from Nagpur area

## TYPES OF PLATE BOUNDARIES

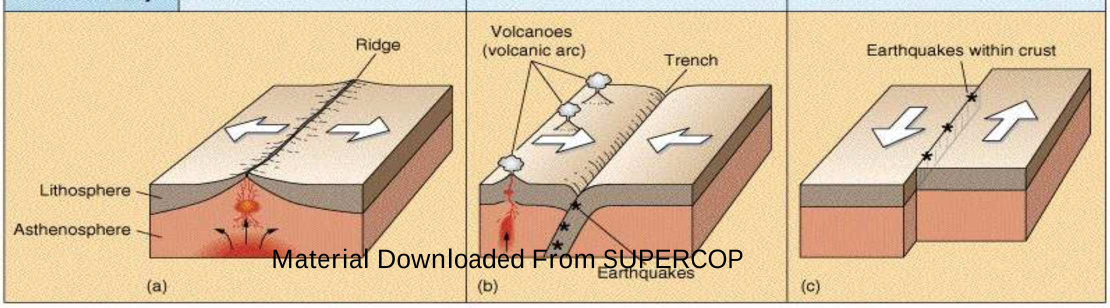
### I. DIVERGENT BOUNDARIES

1. New crust is generated 2. plates move away from each other
2. These are called spreading sites 3. Ex. Mid Atlantic ridge

### II.CONVERGENT BOUNDARY

1. Crust is destroyed 2. sinking of plate is called 'subduction zone'
3. There are three ways in which subduction occurs
i. Ocean and continent ii. Ocean and ocean iii. continent and continent plates

| Type of Margin | Divergent | Convergent | Transform |
|---|---|---|---|
| Motion | Spreading | Subduction | Lateral sliding |
| Effect | Constructive (oceanic lithosphere created) | Destructive (oceanic lithosphere destroyed) | Conservative (lithosphere neither created or destroyed) |
| Topography | Ridge/Rift | Trench | No major effect |
| Volcanic activity? | Yes | Yes | No |



## III TRANSFORM BOUNDARIES

1. Crust is neither produced nor destroyed
2. Plates slide horizontally
3. Perpendicular to the mid oceanic ridges
4. Differential movement of a plate at the same time
5. Rotation of the earth has its effect on this movement

## RATES OF PLATE MOVEMENT

1. The strips of normal and reverse magnetic field helped the scientists to study the rate of plate movement
2. Arctic ridge has the slowest rate less than 2.5 cm /year east pacific rise has more than
3. 15 cm/year

## FORCES OF THE PLATE MOVEMENT

1. Surface of the earth is dynamic
2. Interior is always mobile
3. Beneath the lithosphere there is always movement of magma horizontally
4. Heated material rises to the top and cooled material sinks down
5. This cycle is repeated over the time and form convection cells

## SOURCES OF HEAT

A. Residual heat b. Radioactive decay
6. It was first considered by Arthur Holmes in 1930
7. Later it also influenced Harry Hess

## MOVEMENT OF INDIAN PLATE

1. Indian plate includes India and Australia
2. Northern boundary is along the Himalayas
3. It is the place of continental convergence
4. In the east it extends up to Rakinyoma mountains of Myanmar
5. Eastern margin is spreading site
6. Western margin extends along Kirthar mountains, Makran coast red sea rift .
7. The boundary between India and Antarctica is called divergent boundary
8. Till 225 m y a India was separated by Tethys sea
9. About 200 m y a India started its journey towards north
10. India collided with Asia about 40-50 m y a and caused the upliftment of Himalayas
11. About 140 m y a the position of Indian plate is at 50˚s latitude
12. During the movement of Indian plate two events occurred in India
13. A. out pouring of lava and formation of Deccan plateau
    B. Subsidence of west coast
    14. The Himalayas started rising about 40 m y a


STAGES OF MOVEMENT OF INDIAN PLATE TO WARDS ASIAN PLATE AT DIFFERENT AGES

UNIT III LAND FORMS

# CHAPTER-5 MINERALS AND ROCKS

This unit deals with

Minerals, elem ents, characteristics of minerals such as crystal form cleavage, fracture,lustre, colour,streak, transparency ,structure, hardness specific grvity, important minerals such as feldspar,quartz,pyroxene,amphibole,mica,olivine and their characteristics classificationof minerals, rocks,igneous,sedimentary ,metamorphic rocks rock cycle

**Minerals found in the crust are in solid form where as in intrior they are in liquid form98% of the crust consist of eight elements**

**1.oxygen 2. Silicon 3. Aluminium 4. Iron. 5. Calcium 6. Sodium 7. Potassium 8. Magnes**

**the rest is constituted by titanium, hydrogen, phosphorous, manganese, sulphur carbon, nickel & other elements**

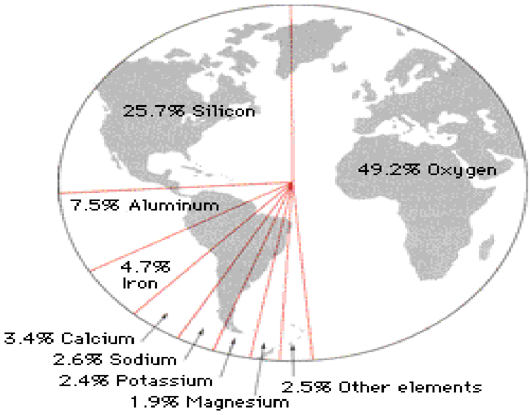



**Table 5.1 : The Major Elements of the Earth's Crust**

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

Many elements found in combination with other elements. These substances are called minerals

Mineral: naturally occuring inorganic substance having an orderly atomic structure and a definite chemical composition and physical properties.

It is composed of two or three minerals /single element ex. S,Cu, Ag,Au, Graphite.

There are at least 2000 minerals in the crust. There are at least six mineral groups which form rocks in the crust.

The basic source of all minerals is the hot magma in the interior of the earth. Coal, petroleum and natural gas are organic minerals

## PHYSICAL CHARACTERISTICS OF MINERALS

(I) EXTERNAL CRYSTAL FORM:Internal arrangement of molecules-cube, octahedrons,hexagonal, prisms.

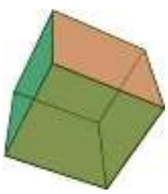


Figure 8 CUBE

Figure 9 HEXAGONAL

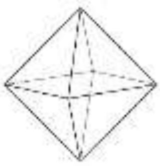


Figure OCTAHEDRONS

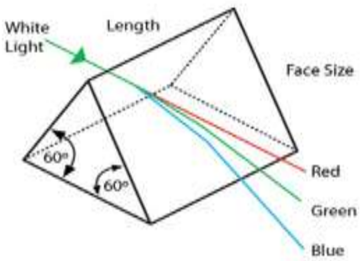



Figure 7 PRISM

(II) CLEAVAGE:


Tendency to break in  given direcations producing relatively plane surfaces, it may any direction

**FRACTURE: Conchoidal fracture**

Obsidian

**Conchoidal fracture** is a curved breakage that resembles the concentric ripples of a mussel shell. It often occurs in amorphous or fine-grained minerals such as flint, opal or obsidian, but may also occur in crystalline minerals such as quartz. **Sub conchoidal fracture** is similar to conchoidal fracture, but not as curved. (Note that obsidian is an igneous rock, not a mineral, but it does illustrate conchoidal fracture well.)

**Earthy fracture**

Limonite

**Earthy fracture** is reminiscent of freshly broken soil. It is frequently seen in relatively soft, loosely bound minerals, such as limonite, kaolinite and aluminite.

**Hackly fracture**

Native copper

**Hackly fracture** (also known as **jagged fracture**) is jagged, sharp and uneven. It occurs when metals are torn, and so is often encountered in native metals such as copper and silver.

**Splintery fracture**

Chrysotile

**Splintery fracture** comprises sharp elongated points. It is particularly seen in fibrous minerals such as chrysotile, but may also occur in non-fibrous minerals such as kyanite.

**Uneven fracture**

Magnetite

**Uneven fracture** is self descriptive. It occurs in a wide range of minerals including arsenopyrite, pyrite and magnetite.The crystal breaks inan irregular manner not along the planes

**LUSTURE : Adamantine lustre**

Cut diamonds

**Adamantine** minerals possess a superlative lustre, which is most notably seen in diamond.[1] Such minerals are transparent or translucent, and have a high refractive index (of 1.9 or more).[2] Minerals with a true adamantine lustre are uncommon, with examples being cerussite and zircon.[2]

Minerals with a lesser (but still relatively high) degree of luster are referred to as **subadamantine**, with some examples being garnet and corundum

**Dull lustre**

Kaolinite

**Dull** (or **earthy**) minerals exhibit little to no luster, due to coarse granulations which scatter light in all directions, approximating a Lambertian reflector. An example is kaolinite.[3] A distinction is sometimes drawn between dull minerals and earthy minerals,[4] with the latter being coarser, and having even less lustre.

**Greasy lustre**

Moss opal

**Greasy** minerals resemble fat or grease. A greasy lustre often occurs in minerals containing a great abundance of microscopic inclusions, with examples including opal and cordierite.[2] Many minerals with a greasy lustre also feel greasy to the touch.[5]

**Metallic lustre**

Pyrite

**Metallic** (or **splendant**) minerals have the lustre of polished metal, and with ideal surfaces will work as a reflective surface. Examples include galena,[6]pyrite[7] and magnetite.[8]

**Pearly lustre**

Muscovite

**Pearly** minerals consist of thin transparent co-planar sheets. Light reflecting from these layers give them a lustre reminiscent of pearls.[9] Such minerals possess perfect cleavage, with examples including muscovite and stilbite.[2]

**Resinous lustre**

Amber

**Resinous** minerals have the appearance of resin, chewing gum or (smooth surfaced) plastic. A principal example is amber, which is a form of fossilized resin.[10]

**Silky lustre**

Satin spar variety of gypsum

**Silky** minerals have a parallel arrangement of extremely fine fibres,[2] giving them a lustre reminiscent of silk. Examples include asbestos, ulexite and the satin spar variety of gypsum. A **fibrous** lustre is similar, but has a coarser texture.

**Submetallic lustre**

Sphalerite

**Submetallic** minerals have similar lustre to metal, but are duller and less reflective. A submetallic lustre often occurs in near-opaque minerals with very high refractive indices,[2] such as sphalerite, cinnabar and cuprite.

**Vitreous lustre**

Quartz

**Vitreous** minerals have the lustre of glass. (The term is derived from the Latin for glass, *vitrum*.) This type of lustre is one of the most commonly seen,[9] and occurs in transparent or translucent minerals with relatively low refractive indices.[2] Common examples include calcite, quartz, topaz, beryl, tourmaline and fluorite, among others.

### Waxy lustre

Jade

**Waxy** minerals have a lustre resembling wax. Examples include jade[11] and chalcedony.[12]

### Optical phenomena

### Asterism

Sapphire cabochon

**Asterism** is the display of a star-shaped luminous area. It is seen in some sapphires and rubies, where it is caused by impurities of rutile.[12][13] It can also occur in garnet, diopside and spinel.

### Aventurescence

Aventurine **Aventurescence** (or **aventurization**) is a reflectance effect like that of glitter. It arises from minute, preferentially oriented mineral platelets within the material. These platelets are so numerous that they also influence the material's body colour. In aventurine quartz, chrome-bearing fuchsite makes for a green stone and various iron oxides make for a red stone.[12]

### Chatoyancy

Tiger's eye

**Chatoyant** minerals display luminous bands, which appear to move as the specimen is rotated. Such minerals are composed of parallel fibers (or contain fibrous voids or inclusions), which reflect light into a direction perpendicular to their orientation, thus forming narrow bands of light. The most famous examples are tiger's eye and cymophane, but the effect may also occur in other minerals such as aquamarine, moonstone and tourmaline.

**Colour change**

Alexandrite

**Color change** is most commonly found in Alexandrite, a variety of chrysoberyl gemstones. Other gems also occur in color-change varieties, including (but not limited to) sapphire, garnet, spinel. Alexandrite displays a color change dependent upon light, along with strong pleochroism. The gem results from small scale replacement of aluminum by chromium oxide, which is responsible for alexandrite's characteristic green to red color change. Alexandrite from the Ural Mountains in Russia is green by daylight and red by incandescent light. Other varieties of alexandrite may be yellowish or pink in daylight and a columbine or raspberry red by incandescent light. The optimum or "ideal" color change would be fine emerald green to fine purplish red, but this is exceedingly rare.

**Schiller**Labradorite

**Schiller**, from German for "twinkle", is a term used to describe the metallic iridescence originating from below the surface of a stone, that occurs when light is reflected between layers of minerals. It is seen in moonstone and labradorite and is very similar to adularescence and aventurescence.[14]

appearance of material without regard to clolour-metallic silky glossy

COLOUR :some colours determined by molecular structure ex.malachite, azurite, chalcopyrite some because of impurities found the crystal.

STREAK : colour of the ground powder of any mineral Ex. Malachit -green, fluorite -purple/white

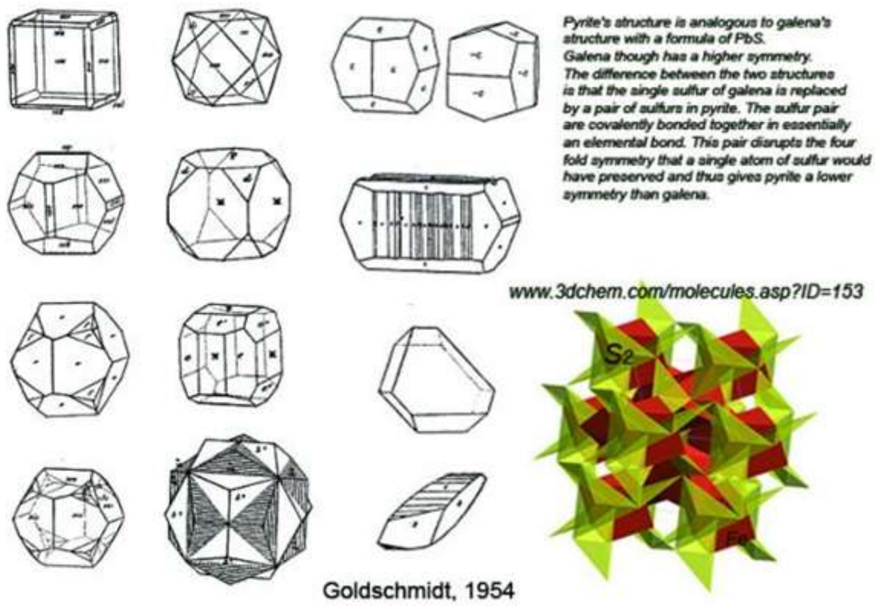
TRANSPARENCY: Transparency **Definition:** Transparency refers to the degree to which light can pass through a mineral.

**Terminology:** *Opaque* - no light can pass through the mineral;

*Translucent* - light can pass through the mineral but is diffused so that images cannot be seen clearly;

*Transparent*– light can pass through the mineral and images can be seen clearly.

1. Transparency -light rays pass through 2.translucent-light pass through but diffused 3.opaque-light doesnot pass through.




Magnetite

(III) STRUCTURE :particular arrangement of the individual crystals – fine medium,or coarse, coarse grained fibrous, separable divergent rdiating

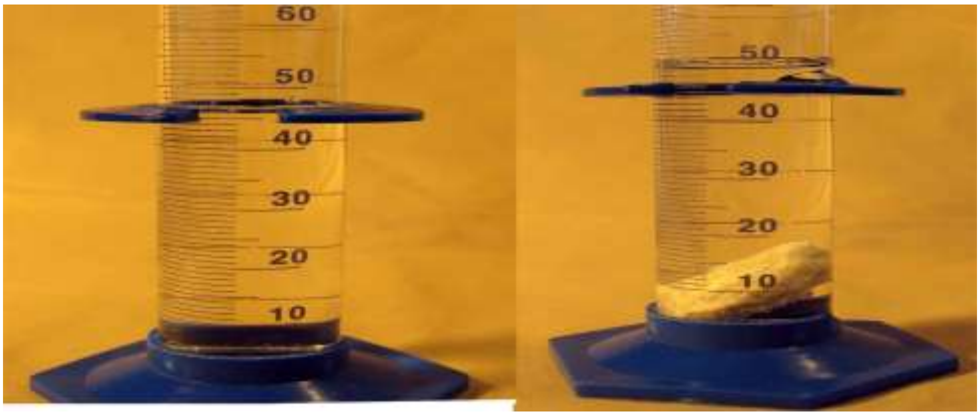
HARDNESS: as corundum. The table below shows comparison with absolute hardness measured by a sclerometer, with pictorial examples.[7][8]

| Mohs hardness | Mineral | Chemical formula | Absolute hardness | Image |
|---|---|---|---|---|
| 1 | Talc | $Mg_3Si_4O_{10}(OH)_2$ | 1 |  |
| 2 | Gypsum | $CaSO_4·2H_2O$ | 3 |  |
| 3 | Calcite | $CaCO_3$ | 9 |  |
| 4 | Fluorite | $CaF_2$ | 21 |  |
| 5 | Apatite | $Ca_5(PO_4)_3(OH^-,Cl^-,F^-)$ | 48 |  |

| Mohs hardness | Mineral | Chemical formula | Absolute hardness | Image |
|---|---|---|---|---|
| **6** | Orthoclase Feldspar | $KAlSi_3O_8$ | 72 |  |
| **7** | Quartz | $SiO_2$ | 100 |  |
| **8** | Topaz | $Al_2SiO_4(OH^-,F^-)_2$ | 200 |  |
| **9** | Corundum | $Al_2O_3$ | 400 |  |
| **10** | Diamond | C | 1600 |  |

(IV) Relative resistence being scratched ten minerals are selected to measure the degree of hardness from 1to 10

1. Talc 2.gypsum 3.calcite 4.fluorite 5.apatite 6.feldspar 7.quartz 8.topaz 9.corundum 10.diamond. ex.fingre nail has 2.5 hardness knife has 5.5 hardness




(V) SPECIFIC GRAVITY :The ratio between the weight of a given object and the weight of an equal volume of water ; object weighed in air and then weighed in water and divide weight in an airby the difference of th etwo weights.

IMPORTANT MINERALS OF THE EARTH CRUST

FELDSPAR: Silicon & Oxygen Are Common Elements ,Sodium, Potassium Calcium Aluminium Are Found In Specific Variety. ½ The Earth  Crust Consists Of  Feldspar.Light Cream To Salmon Pink Colour Used In Ceramics And Glass Making.

QUARTZ:important component of sand granite.consists of silica, hard mineral, insoluble in water it is white ore colorless used INRADO OR RADOR

YROXENE   :consists of calcium aluminum magnesium iron silica, it forms 10% of earth crust, found in meteorites,green or black in colour

OLIVINE:Magnesium,Iron,  Silica are major elements,used in jewellary, greenish crystal, found inbasaltic rocdk

**AMPHIBOLE:**
**major elements.**
**, used in asbestos**

**aluminium, calcium silica, iron magnesium are**
**They form 7% of earth crust, green or black colour**
**industry, hornblende is a;nother formof amphibole**

MICA:consists of potassium, aluminium, magnesium iron silica . Form 4%

Of the earth crust. Found in basaltic rock

IGNEOUS ROCKS; 1. They are primary rocks  2.formed due to cooling of lava 3. They are two types intrusive & extrusive rocks

Extrusive rocks have small grains because of sudden cooling  intrusive rocks have bigger grains due to slow cooling4.they are hard   5. Do not contain fossils   6. Do not allow water to percolate through them 7. No layers

SEDIMENTARY ROCKS:1. Formed Due To Sedimentation  2. Consists Of Layers  3. Contain Fossils 4.The Process Of  Sedimentary Rock Formation Is Called Lithification  5. They Are Three Types . A. Mechanically Formed  B.Chemically Formed  3. Organically Formed.

METAMORPHIC ROCKS: 1.Formed Due To Recrystalization  2.Formed Due To Pressure And Temperature 3. Very Smooth

4. Consists of layers  sime times very preceious stones

**Type of rock**

Igneous rock      Sedimentary rockMetamorphic rock

Granite Sandstone Slate

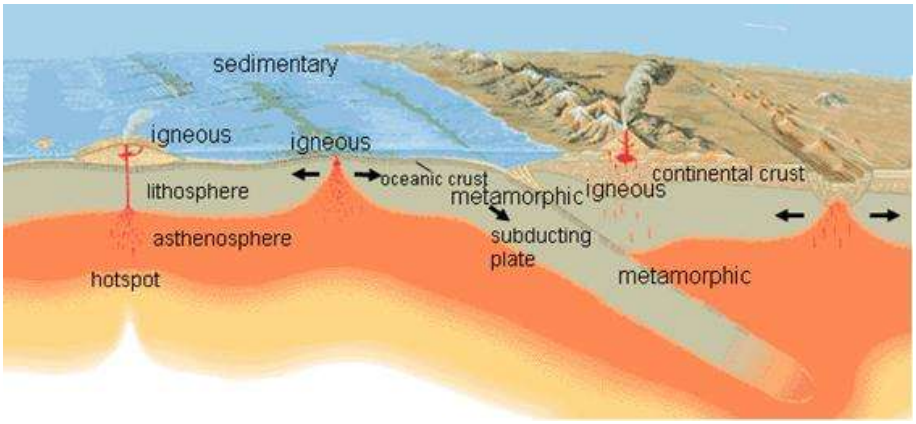
CLASSIFICATIONOF MINERALS

METALLIC MINERALS — NON METALLIC MINERALS

| METALLIC MINERALS | | | NON METALLIC MINERALS | |
|---|---|---|---|---|
| FERROUS | NON FERROUS | PRECIOUS | ORGANIC | INORGANIC |
| IRON | COPPER | GOLD | COAL | SULPHAR ROCKS |

Rocks are aggregate of one or more minerals,they may be hard or soft in varied colours, they do not have definite chemical composition.

Petrology is the science of rocks. Petrologist who studies the scientific methods of rocks.




ROCK CYCLE


A diagram of the rock cycle. Legend: 1 = magma; 2 = crystallization (freezing of rock); 3 = igneous rocks; 4 = erosion; 5 = sedimentation; 6 = sediments&sedimentary rocks; 7 = tectonic burial and metamorphism; 8 = metamorphic rocks; 9 = melting.

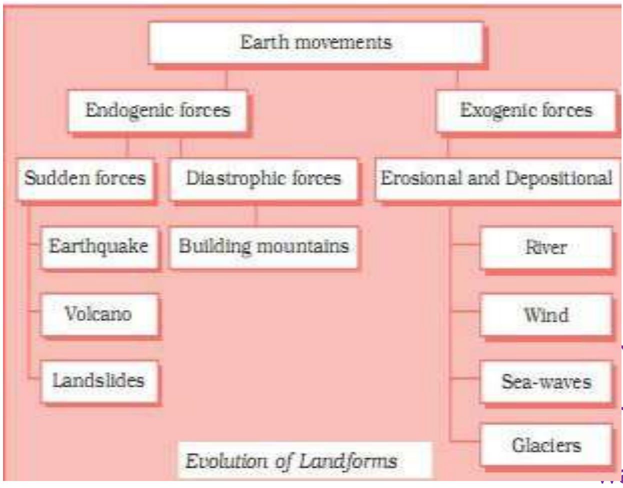
Rock cycle is a continuous process through which old rocks are converted into new rocks. Igneous rocks are changed into metamorphicor sedimentary rocks. Metamorphic rocks afurther change into magma

# CHAPTER -6 GEOMORPHIC PROCESSES

This chapter deals with Geomorphic process,exogenic,endogenic processes,diastrophism,volcanism,weathering,types of weathering mechnical(unloading ,expansion,temperature change expansion freezing thawing frost wedging salt weathering ), chemical (solution, carnonation,hydration oxidation and reduction),biological (plants, animals man).biological activity and weathering, special effects of weathering, significance of weathering, mass movement,slow movement, rapid movementland slide, erosion , deposition, soilformtion, process of soil formation soil forming factors, parent material, topography, climate, biological activity, time.

1. Why earth is uneven?

Due to internal and external forces earth is changing its surface conditions.
The earth crust is always dynamic
It moves vertically and horizontally
The differences in the internal forces making the surface uneven Wearing down of relief features is called gradation.
The endogenic forces always elevate parrts of the earth's surface and hence the exogenic processes fail to even out the relief variations of the surface of the earth.
Variations remain as long as there is difference between endogenic and exogenic forces.
The surface of the earth is sensitive. Human being is using the surface intensively and extensively.
GEOMORPHIC PROCESSES
The endogenic and exogenic forces cause physical stress and chemical actions on the earth material and bring the changes in the configuration of the earth surface is called GEOMORPHIC PROCESSES
**Diastrophism and volcanism are endogenic processes**




**Weathering, Masswasting,Erosion & Deposition Are Exogenic Processes**
**Any Exogenic Element Of Nature Capable Of Acquiring And Transporting Earth Materials Can Be Called A Geomorphic Agent.**
**They Become Mobile When There Is Gradient**
**The Erosional Agents Are**
**1.Running Water ,2. Moving Ice, 3.Wind, 4.Underground Water ,5.Waves**
**A process is a force applied on earth materials affecting the same**
**agent is a mobile medium which removes transports and deposits earth materials.**
**avity also causes directional forces activating downslope movements of matter**
**aves and tides are inderect movements of the earth caused by gravitation**
**With out gravity and gradient there is no mobility for erosional agents as a result there is no erosion transportation, and deposition on the earth surface.**
**All the movements on/in the earth are due to gravitation and gradient.from higher level to lower level and high pressure to low pressure areas**
**ENDOGENIC PROCESS: the energy generating from with in the earth is the main force behind the endogenic geomorphic processes.**

**The energy genarated due to**
**1. Radioactivity 2.Rotational Force 3.Tidal Friction 4.Primordial Heat From The Origin Of The Earth.**
**Diastrophism And Volvanism Are Due To Geothermal Grdients And Heat Flow From Within The Earth.**
**Crustal Thickness,Strength, Action Of Endogenic Forces Are Due To Variations In Geothermal Gradients And Heat Flow Are Uneven.**
**DIASTROPHISM : All process that move elevate or duild up portions of the erth's crust come under DIASTROPHISM**
**THEY ARE TWO TYPES**

1.OROGENIC PROCESSES : mountain building through folding
2.EPEROGENIC PROCESS: uplifting large part of earth crust
3.EARTH QUAKES
4.PLATE TECTONICS: involve horizontal movements

DIFFERENCE BETWEEN OROGENY AND EPEROGENY

| OROGENY | EPEROGENY |
|---|---|
| Crust is severely damaged<br>Mountain building process<br>Folding and faulting<br>Cause tension and comprssion | simple deformation<br>continental formation<br>upliftment of landmass<br>vertical force |

VOLCANISM: Movement of molten rock towards the earth's surface and also formation of many intrusive and extrusive volcanic forms.
Volcanism: it is the process in which volcanoes takes place
Volcanoes are the land forms formed due to volcanic process
EXOGENIC PROCESSES: They derive their energy from atmosphere determined by the prime source The sun and also gradients created by the tectonic factors.
Gravitational force create gradient towards down slope direction.
Force applied per unit area is called
STRESS. Stress can be produced in a sold body pushing or pulling
This includes deformation. Forces acting along the faces of earth materials are shear stresses .(seperating forces). It is this stress that breaks rocks and other earth materials.the shear stress result in angular displacement/slippage. Besides gravitational stress there is molecular stress which is caused by temperature change, crustallisation and melting .chemical processes normally lead to loosening of bonds between grains , dissolving of soluble minerals or cementing materials.
The basic reason for weathering, mass movement erosion and deposition is the development of stress in the earth materials.
Since there are different climatic regions there is variation in the exogenic process from region to region. Temperature and precipitation are the two major elements that control various processes.
All the exogenic process are covered under general term DENUDATION.
The word denude means uncover. Weathering , masswasting erosion and transportation are included in denudation.

DENUDATIONAL PROCESSES AND THEIR Driving Forces

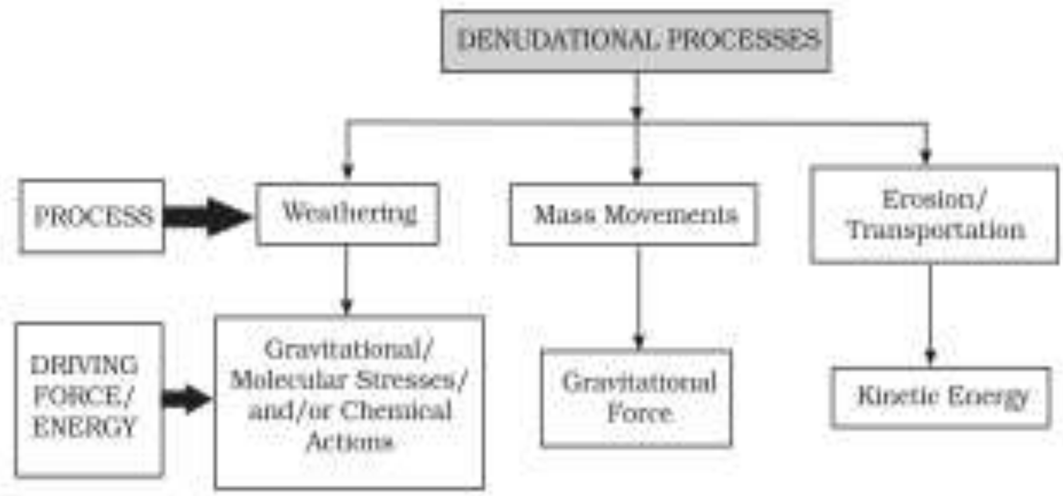



**Figure 6.1 : Denudational processes and their driving forces**

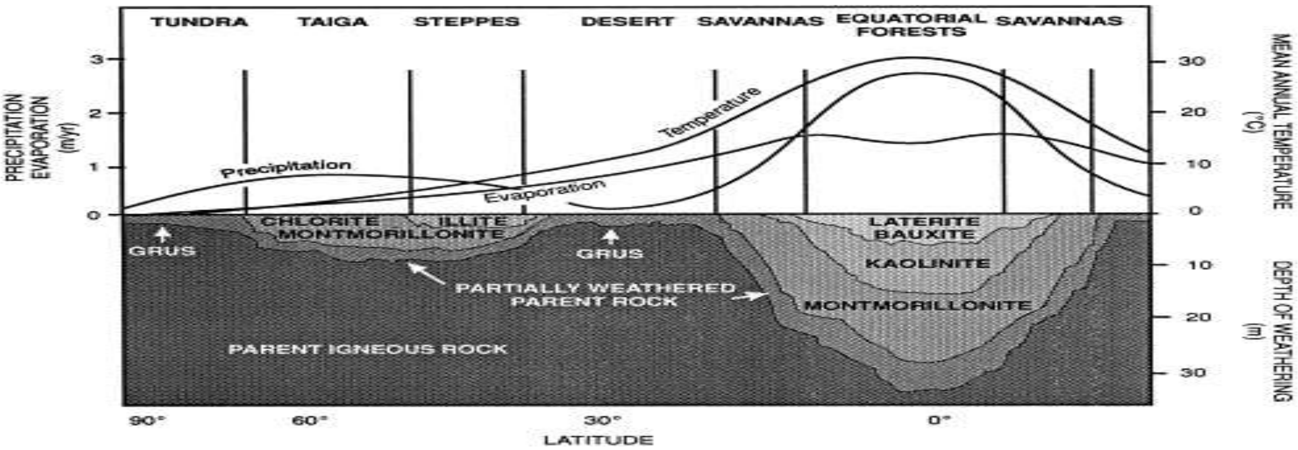
In

This Chart We Observe That For Each Process There Is Driving Force Called Energy On The Earth Surface Thermal Gradient Is Caused By
1. Latitude 2.Seasons 3.Land And Water Distribution 4. Angle Of Earh's Inclination
The Densityof Natural Vegetation Is Greatly Influenced By The Temperature And Precipitation Helps Indirectly The Exogenic Processes.
THE OTHER FACTORS OF CLIMATIC VARIATIONS ARE1.Altitude 2. Angle Of Slope 3. Ocean Currents 4.Amount Of Insolation Received By The Region 5. Wind Velocity And Direction 6. Direcion Of The Slope 7. Amount And Kind Of Precipitation 8.Relation Between Precipitaion And Evaportion 9. Daily Rang Of Temperature 10.Freezing And Thawing Frequency 11. Depth Of Frost Penetration
The Sole Driving Force Behind All The Exogenic Process Is The Sun

When Climatic Factors Are Common The Intensity Of Action Depend On Type And Structure Of Rocks
STRUCTURE INCLUDES folds,faults, orientation inclination of beds, presence or absence of joints ,bedding planes hareness, softness of constituent minerals, chemical susceptibility of mineral constituents , the permeability or impermeability.
Different types of rocks offer varying resistances to various geomorphic processes .
Particular rock may be resistant to one process and non resistant to other process
As a result there is varied relief over the earth surface
The effects of exogenic forces may be small and slow but inlong run they have greater effects
Finally the surface of the earth is operated by different geomorphic processes and at varying rates
WEATHERING: it is the acion of elements of weather on earth materials

Weathering is defined as mechanical disintegration and chemical deconposition of rocks through the actions of various element so fweather and climate
In weathering there is no motion of materials takes place so it si in-situ or on site process
FACTORS INFLUENCING THE WEATHERING& DEPTH OF WEATHERING

1.GEOLOGICAL STRUCTURE 2.CLIMATE 3.TOPOGRAPHY 4. NATURAL VEGETATION




(I) CHEMICAL (II) PHYSICAL/MECHANICAL (III)BIOLOGICAL WEATHERING

CHEMICAL WEATHERING PROCESSES
Agroup of weathering processes viz; solution , carnonation, hydration , oxidation and reduction asc on the roks to decompose, dissolve orreduce them to a fine clastic state through chemical reactions by oxygen ,surface /soil water and other acids. Water and air along with heat must be present to speed up all chemical reactions.
Over and above the carbon dioxide present in the air, decomposition of plants and animals increases the quanitity of carbon dioxide underground . these chemical reactions on various minerals are very much reactions on various minerals are very much similar to the chemical reactions in a laboratory.

**SOLUTION**: the water /acid with dissolved content is called solution. This process involves removal of solids in solution and depends upon solubility of amineral in water or weak acids.when water reacts with any solid many solids may become solution. Ex. Sulphates, nitrates, potassium .
When rain comes these solids dissolve into solution with out leaving any residue.

Calcium carbonate , magnesium bicorbanate present in the lime stone are dissolved in and form carbonic acid,$CO^2$ produced by decaying organic matter along with soil water greatly aids inthis reaction . Common salt is also suceptible to this process.

**CARBONATION:** It is the reaction of carbonate and bicarbonate with minerals such as feldspar, & carboinate minerals $CO^2$ from atmosphere and soil air is absorbed by water to form carbonic acid.Ca$CO^3$& Mg$CO^3$are dissolved in carbonic acid and washed away to form the caves in lime stone region.
Clay minerals are easily eroded due to the presence of minerals which can exchange the ions with the water .
**HYDRATION:** it is the chemical addition of water . minerals take up water and expand . this expansion increases the volume of material.ex. calcium sulphate takes water and convert into gypsum.it is unstabel than calcium sulphate.it is reversible reaction and when this process continuous for longer time the materials diintegrates.
Many clayminerals swell and contract during wetting and drying and a repetition of this process results in cracking of overlying materials.salts inpore spaces undergo rapid and repeated hydration and help in physical weathering through exfoliation and granular disintegration
**OXIDATION AND REDUCTION**
Oxidation means combination of minerals with oxygen to form oxides and hydroxides.
Oxidation occurs when there is sufficient water and atmosphere. EX. Iron, manganes, sulphur, In the process of oxidation breakdown occurs due the addition of oxygen.red colour of iron becomes into yellow colour.when oxidised minerals re kept in the places where there is no oxygen reduction takes place.ex. such conditions occurs below water table waterlogged areas. Red colour of iron becomes greenish or bluish grey.

**PHYSICAL WEATHERING PROCESSES**
Factors Influencing The Physical Weathering
1.Gravitational Force Overburden Pressure, Load And Shearing Stress
2. Expansion Forces Due To Temperature Changes, Crystal Growth Or Animal Activity
3.Water Pressures Controlled By Wetting And Drying Cycles.
They are mostly due to thermal expansion, and pressure release. The repeated action of these processes cause damage to the rocks
**UNLOADING AND EXPANSION:** Removal of overlying rock load because of continued erosion causes vertical pressure release with the result that the upper layers of the rock expand producing disintegration of rock masses.fractures will develop parallel to the ground surface. In areas of curved ground surface aarched fracaatures tend to produce massivce sheets or exfoliation slabs of rock.exfoliation sheets resultinf from expansion due to unloadinf and pressure release my measure hundreds or even thousands of metres in horizontal extent.large smooth rounded domes called exfoliation domes result due to this process

**TEMPERATURE CHANGES AND EXPANSION**: Various minerals found in the rocks expand at different rates when temperature increases. Each one pushes others. When temperature falls contraction takes place.because of diurnal changes in temperature the effects is mostly on superficial layers of the rocks.the effects of this process is significant in hot deserts and cold deserts.though it is small the continuous process for longer time and larger area the effect is greater. The effect is greater at the depth of the rocks.fractures occurs parallel to the surface.due continuous expansion and contraction the rock layers become lose and exfoliation takes place.a large dome shaped structures are formed due to this process. Tores which are large boulders also form due this process.exfoliated domes are big insize where as exfoliated tores are varied sizes.

**FREEZING THAWING AND FROST WEDGING:**due to repeated freezing and melting frost weathering occurs in the pores and cracks of rocks.it is most effective in higher elevations of the midlatitudes.

**Glacial areas are suhjected to frost wedging daily . In this process the rate of freezing is more important. Rapid freezing causes sudden expansion an dhigh pressure. Finally this process makes the rock to break into pieces**

**SALT WEATHERING; salts in the rocks expand due to thermal action hydration and crystallisation.ex. Calcium sodium magnesium potassium and barium .high temperature between 30℃ to 50℃ of surface temperature indesertrs favour such salt expansion.**

**Salt crystals in near surface porescause splitting of individual grains within rocks,.which eventually fall off. This process of falling off of individual grains may result in granualr disingetrationor granular foliation.**

**Salt crystallisationis most effective of all salt weathering processes, in areas with alternating wetting and drying conditions salt crystal growth is favoured and the neighbouring grains are pushed aside.sodium chloride and gypsum crystals in desert areas heave up overlying layers of materials and with the result polygonal cracks develop all over the heaved surface. With swalt crystal growth, chalk breaks down most readily followed byLimstone ,Sandstone ,Chalk ,Gneiss And Granite .**

**BIOLOGICAL WEATHERING: Removal or contribution of ions to the environment due to biological activity is called biological weathering.burrowing and wedging by organism like earthworks tremites, rodents help in exposing the new surfaces to chemical attack and assists in the pentration of moinsture and air..**

**SOME SPECIAL EFFECTS OF WEATHERING: Exfoliation is a is a result but not a process . Removal of layers from curved surfaces result into rounded surfaces.it occurs due to expansion and contraction dnduced by temperature changes.exfoliation domes occur due to unloading where as tors occurs due to thermal expansion .**

**SIGNIFICANCE OF WEATHERING:**Responsible for the formation of soils and erosion and deposition. biodiversity is basically depending on depth of weathering .erosion may not be significant when there is no weathering.weathering aids mass wasting , erosion and reduction of relief and changes in landforms .weathering of rocks and depostion helps in the enrichment and concentrations of certain valuable ores of iron manganaese , aluminium copper.it is an important process of soil formation.

ENRICHMENT:when rocks undergo weathering some materials are removed through chemical or physical leaching by ground water and thereby the concentrationof remaining materials increases. Without such a weathering taking place , the concentration of the same valuable material may not be sufficient and economically viable to exploit , process and refine, this is what is called enrichment.

MASS MOVEMENT: these movements transfer the mass of rock debris down the slopes under the direct influence of gravity.air water ice donot carry debris ,but debris carry them.the movements of mass may range from slow to rapid.

TYPES OF MASS MOVEMENTS:creep,flow , slide and fall. mass movements are active over weathered slopes than unwethered slopes. mass movements are aided by gravity not any erosional agent. mass movements do not come under erosion though there is shift of material.

When force is greater than resistance mass movement occurs. Ex. Weak unconsolidated material, thinly bedded rocks, faults, steeply diffing beds, vertical cliffs ,steep slopes , abundant prefipitation and torrential rains and scarcity of vegetation.

Activating causes precede mass movements:
(i) removal of support from below to materials above through natural or artificial means

(ii)increase in gradient and height of slpes

(iii)overloading through additionof materials naturally or by artificial filling

(iv) overloading due to heavy rainfall saturation and lubrication of slope materials

(v)removel of material or load from over the original slope surfaces.

(vi) occurrence of earthquakes, explosions or macunery

(vii)excessive natural seepage

(viii)heavy draw down of water from lakes, reservoirs and rivers

(ix)indiscriminate removal of natural vegetation

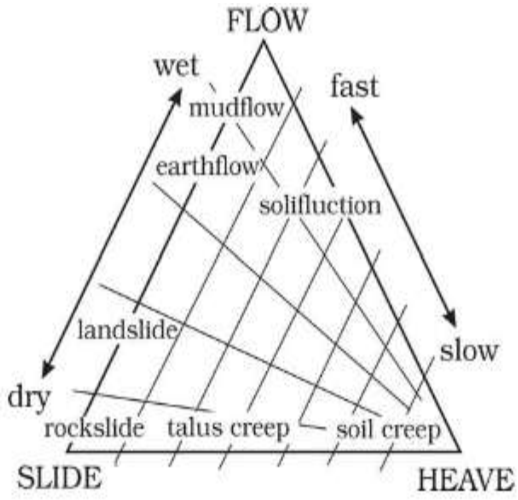
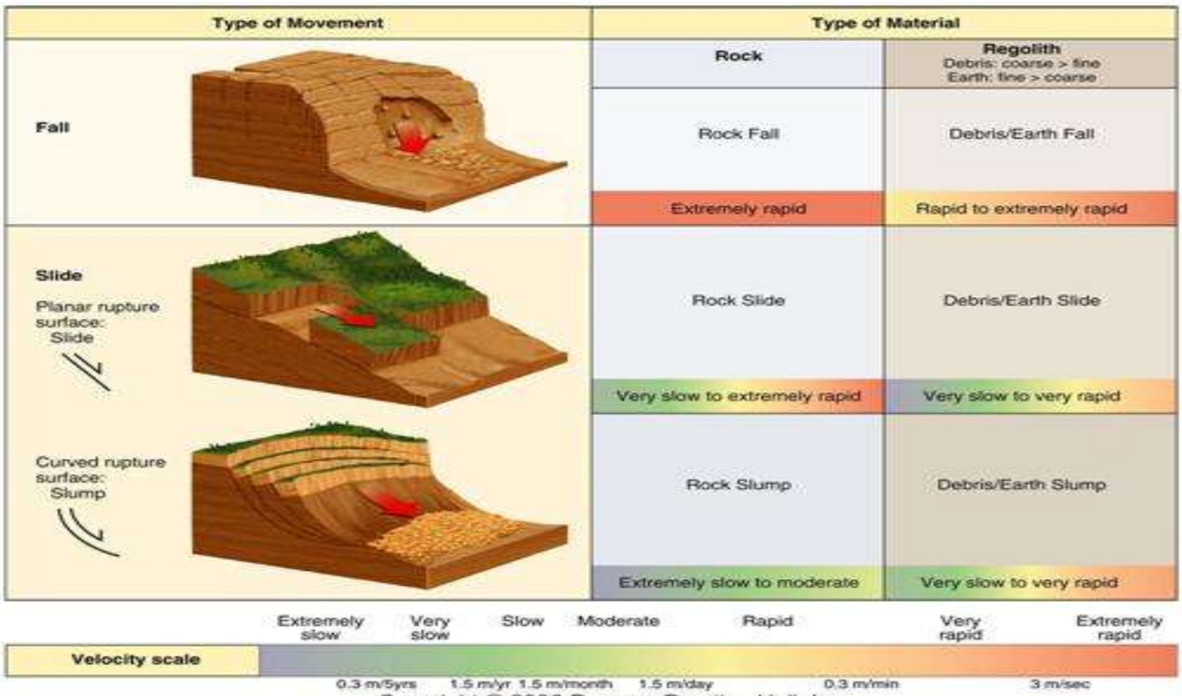



**Figure 6.5 : Relationships among different types of mass movements, their relative rates of movement and moisture limits (after Whitehead, 2001)**

CLASSIFICATION OF MASS MOVEMENTS



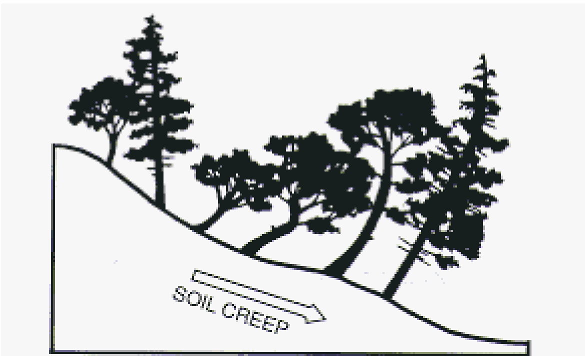


Heave ,flow and slide are the three forms of movements the relationship is shown in the figure no.

The mass movements can be grouped into three types

1.slow movements 2. Rapid movements 3. Land slide

**SLOW MOVEMENTS**



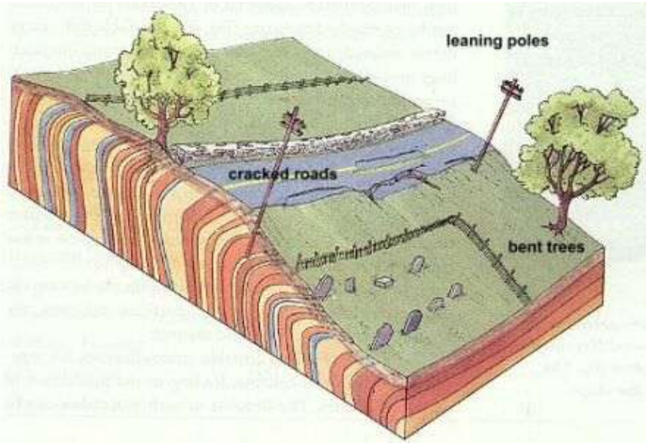

Soil creep causes districtive curved form of tree trunks over time.

*Illustration 5:* **Indications of Soil Creep**

CREEP: It generally occurs on moderately steep, soil covered slopes.

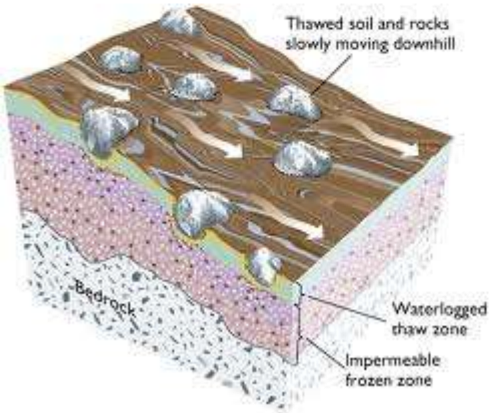
Movement of material is extremely slow. Material may be rockdebris or soil

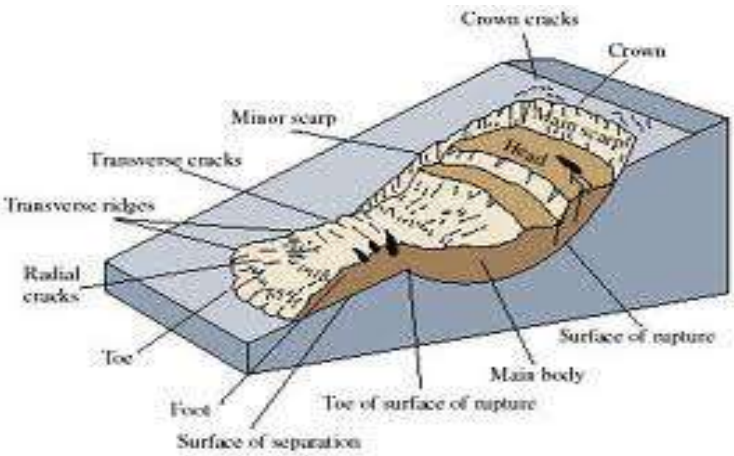
Ex. Bending of telephone pole,and fence poles.




Types of creep : soil creep, talus creep rock creep rock glacier creep

Solifluction:slow down slope flowing soil mass or fine grained rock debris saturated or lubricated with water. It is common in moist temperate areas where surface melting of deeply frozen ground and long continued rain respectively occur frequently.




MUD FLOW

RAPID MOVEMENTS

CONDITIONS: 1.humid climatic regions 2.gentle to steep slopes 3. Heavy rain 4. Loose soils

EARTH FLOW: movements of water saturated clayey or silty erth materials down low angle terraces or hillsides .

EARTHFLOW

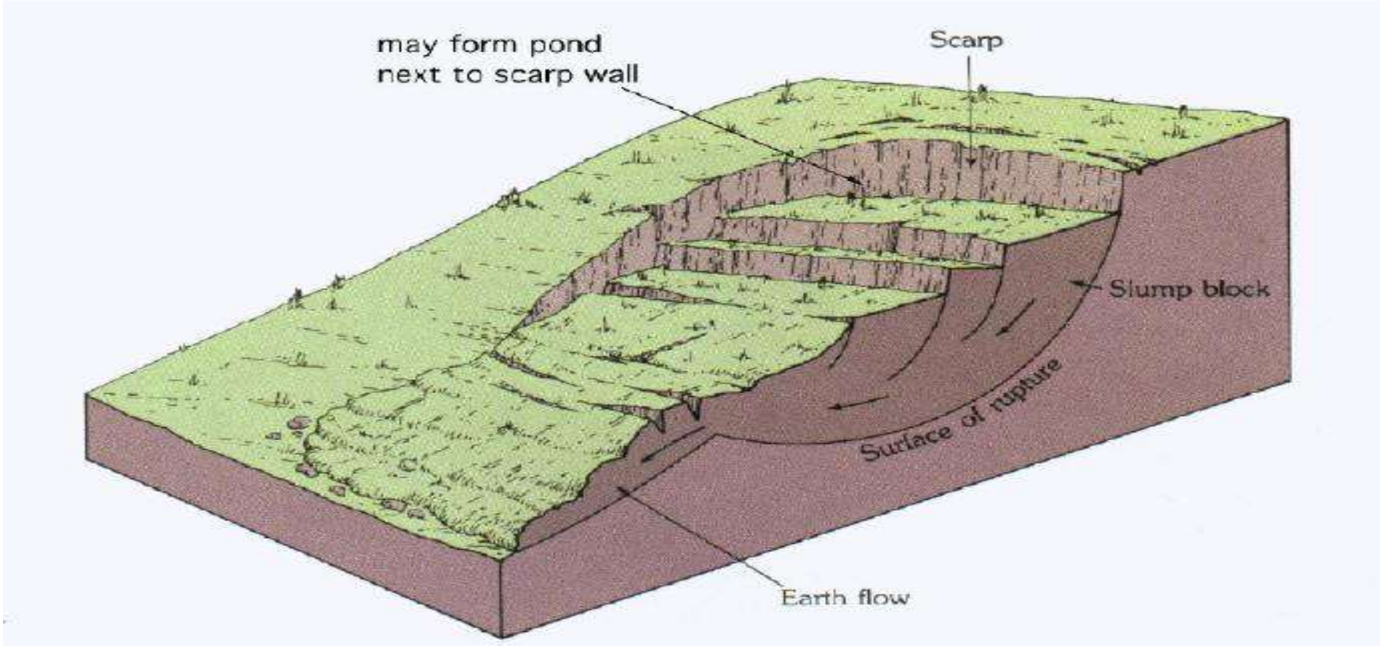
In the absence of vegetation cover and with heavy rainfall,thick layers of weathered materials get saturated with water and either slowly or rapidly flow down along definite channels.it looks like a channels of mud.when they overflow the channels they engulf the roads and rail bridges.

They generally occur due to volcanic eruptions. Volcanic ash dust and other fragments turn intomud due to heavy rains and flow down as tougues or streams ofmud causing great destruction to the human settlements.


DEBRIS AVALANCHES: Found in humid regions with or without vegetationin narrow tracks of steep slopes. It is much faster than mud flow, it is similar to snow avalanches.

LANDSLIDES: these are rapid and perceptible movements.dry materials are found .the size and shape of the materaials are depending on the nature of the rock,degree of weathering,steepness of slope.

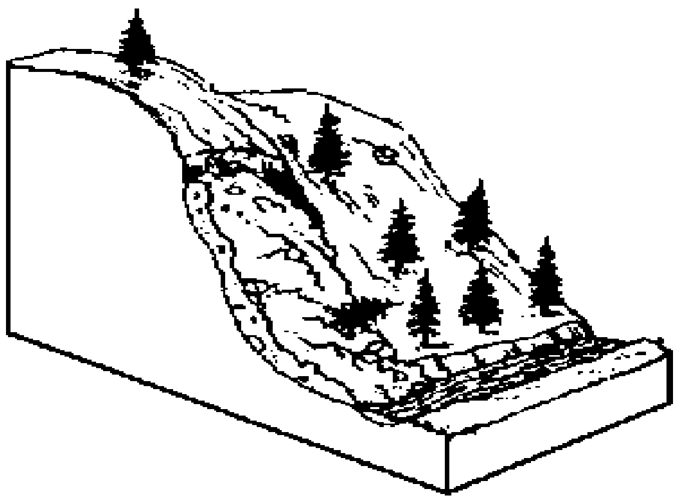
SLUMP:



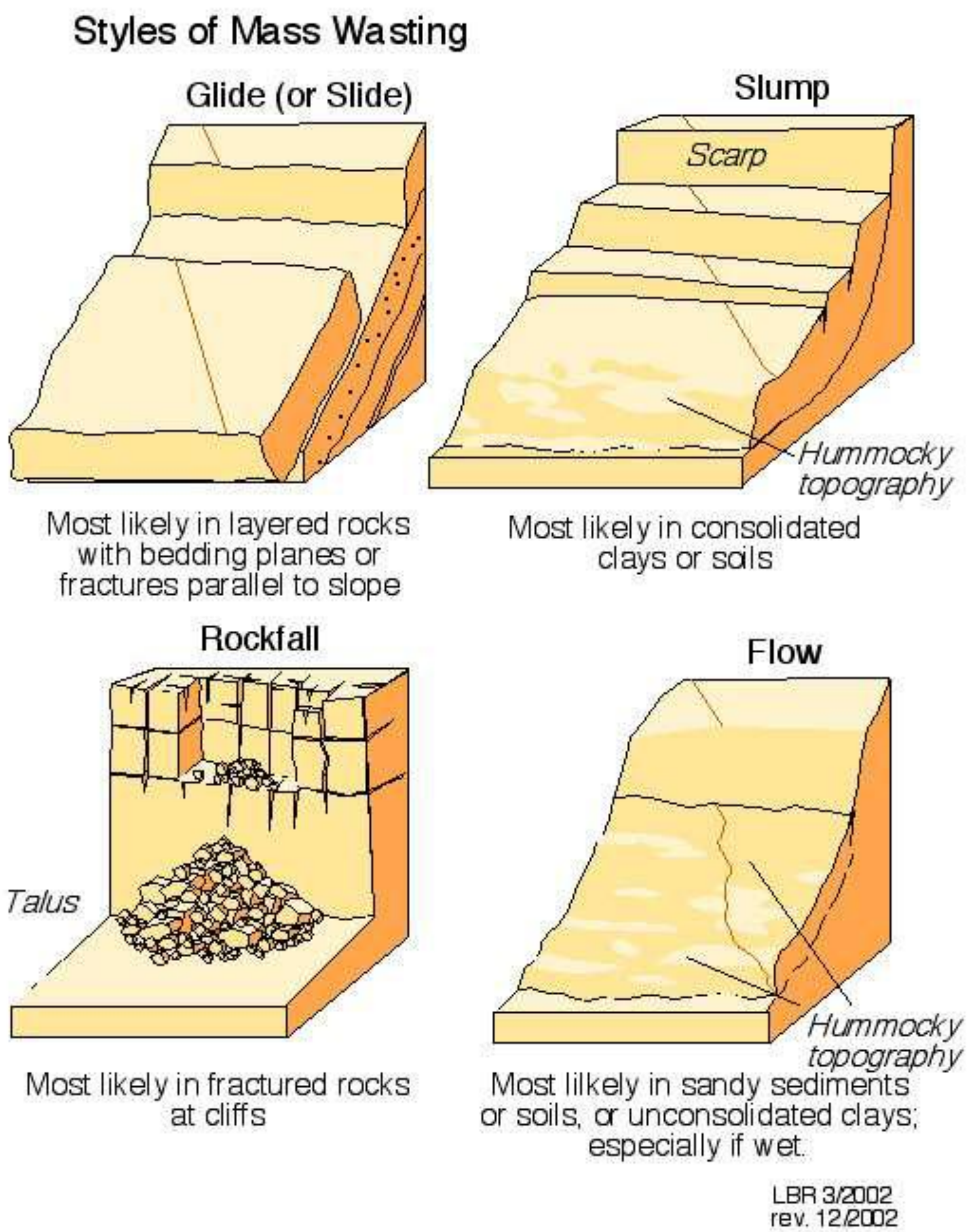

slipping of one or several units of rock debris with a backward rotationwith respect to the slope over which the movement takes place

DEBRIS SLIDE:rapid rolling or sliding of earth debris without backward rotation of mass is known as debris slide.

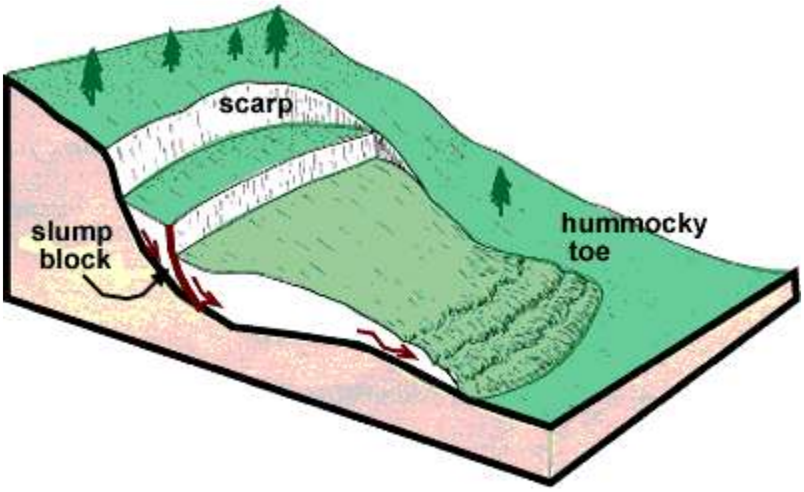
Debris slide



ROCK FALL




Rockslide sliding of individual rock masses down bedding  joint or fault surfaces . it generally occurs at the steep slopes. Superficial layers of the rock  gnerally fall.



mass movement

Reasons for land slides along the Himalayas

1. Tectonically active
2. Made of sedimentary rocks
3. Steep slopes
4. Heavy rains
5. Unconsolidated material is found

EROSION AND DEPOSITION

Erosion involves acquisition and transportation of rock debris

Abration by rock debris carried by geomorphic agents also aids erosion

By erosion relief degrades . the landscape is work down. Weatherin may not be pre condition for erosion.

Weathering , mass wasting, and erosion are degradational processes. It is the erosion largly responsible for continuous changes that the earth surface is undergoing.

Erosion and transportation are controlled by kinetic energy.wind running water and glaciers are controlled by climate.

Comparison of wind runing water and glacier

| wind | Running water | glacier |
|---|---|---|
| Predominent in hot deserts | Found most parts of the earth | Found only in high latitude and altitude |
| Sand dunes are common features | Valleys and deltas are common features | U shaped valleys and morians are common |
| Ex. Sahara, atacama kalahari | Amazon.Nile, Bramhaputra | Greenland, Antarctica |
| Air is gas | Water is liquid | Glacier is solid |
| Limited land forms | Extensive land forms | Limited land forms |
| High speed | Normal speed | Very slow movement |

EROSION:"application of kinetic energy associated with the agent to the surface of the land along which it moves". It is computed as KE =½ $mv^2$

M=mass v= velocity KE= kinetic energy

SOIL FORMATION: Soil is the collection natural bodies on the earth's surface containing living matter and supporting or cpable or suporting plants.

Soil is a dynamic mateial in which many chemical , bioligical , and physical activities go on constantly. It is the result of decay, it is also a medium of growth. It is changing and developing body. Characteristics are changing from season to season.

Too cold ,too hot , and dry areas biological activity stops.organic matter increases when leaves fall and decompose.

PROCESS OF SOIL FORMATION: weathering is basic process for soil formation. The weathered material is transported and decomposed due to bacteria lichens and moss. The dead remains increases the humus of the soil.minor grasses and ferns can grow. Bushes , trees also grow .plants roots and burrowing animals help the soil formation.

PEDOLOGY:is Sceince of soil formation

PEDOLOGIST:is the scientist of soil formation

SOIL FORMING FACTORS:1. Parent material 2. Topography 3. Climate 4. Biological activity. 5.time

PARENT MATERIAL:passive control factor ,it is insitu, onsite, or transported.it depends on texture, structure, chemical compositon of the soil. Nature and depth of weathering is an important factor.chemical composition ,texture are the characteristics derived from patent material

TOPOGRAPHY:passive control factor,amount of exposer to the sun light,drainage system,steep slopes have less deposition,gentle slopes have thick soils. Plains have thick and dark coloured soils . In mid latitude southern slopes expose to the sun light and get decomposed more .

CLIMATE:it is an active factor in soil formation. Climatic elements are (i) moisture( interms of its intensity, frequency and durationof precipitation –evaporation and humidity

(II) Temperature in terms of seasonal and diurnal variation.

Precipitation increases the biological activity.

Excess of water helps to transport the dissolved particles to downward (eluviation)

Deposition of these particles is called 'Illuviation'

Heavy rainfall removes the calcium , magnesium, sodium ,potasium along with silica.

Removal of silica is called desilication

In dry areas excess of evaporation leads to deposition of salts on the surface of the soil

These salt layers are called 'hard pans' in the hot deserts

In tropical climates, under moderate rainfall conditions calcium carbonate nodules are formed.

Biological activity :plants and animals add organic matter to the soil.also helps in moisture retention. Dead plants add humus to the soil In humid areas, the bacterial activity is higher than cold areas

As a result undecomposed material is found in cold areas

In hot areas bacteria fix the nitrogen in the soil which is used by the plants

Rhizobium is the bacteria fix the nitrogen in the soil and live in the roots of legumenace plantsants, temites,rodents, earthworms change the chemical composition of th soil.

Time: Important controlling factor of soil formatioon.Longer the time,thicker the soil layers. No time limit for the formation of the soil layers.

# CHAPTER-7 LANDFORMS AND THEIR EVOLUTION

After weathering, geomorphic agents operate the landforms to change.
Land form:small to medium rracts or parcels of the earth,s surface are called landorms.
Several landforms together are called landscape
Each landform has its own shape ,size and materials
Geomorphological processes are slow but significant in longrun
Every landform has a beginning , they change their shape and composition in course of time.
Due to changes in climate and vertical and horizontal movements landforms change their shape.
Each landform undergo three stages called youth , mature and old stages
Geomorphology is the science of landforms
Various geomorphic agents bring the changes to the landforms such as running water, moving ice, wind glaciers, underground water, waves by erosion and deposition.
Each geomorphological agent produces its own assemblage of landforms.
Most of the geomorphological processes are imperceptible.
The study of the landforms reveals that the stage structure and process of land forms
They produce erosional and depositional features.

Factors influencing erosion:

1. Rock structures such as fold , fault, joints, fractures, hardness, softness permeability, and impermeability
2. Stability of sea level
3. Tectonic stability of landmass
4. Climate

RUNNING WATER

1.In humid regions rainfall is heavy so running water is dominant agent
2.there are two components of running wrter

A. OVERLAND FLOW -SHEET EROSION B. LINEAR FLOW -STREAM EROSION

Most of the erosional featuresa are formed in upper course/youth ful stage of the river
Depositional features are formed in the lower course /old stage of the river
Steep the slo[e more the erosion/gentle the slope mor ethe depostion
Vertical erosion is more in the upper course lateral erosion is more in the lower course

OVERLAND FLOW: it is also called as sheet erosion
Depending on the irregularities of the surface the sheet erosion concentrate in to channels
Due to sheer friction of the water narrow channels are formed
They are called rills. Rills develop into gullies, gullies further deepen and converted into valleys
In the erly stages downward cutting makes waterfalls,cascades in the middle stages streams cut their beds slower and lateral erosion of valley sides becomes severe.
Later stages, the flat valley is formed with *monodknocks*. This type of plain is called *peneplain*.

## Stages of the river

YOUTH

1.Less Streams 2. Less Integration 3. 'V'shaped Valleys Are Common 4.Stream Divides Are Swampy Marshy Areas 5. Water Falls And Rapids Are Common

MATURE

1.More Streams 2. More Integration Of Streams 3.Deep 'V'shaped Valleys4.Wider Flood Plains 5.Meanders Are Present 6.Rapids And Water Falls Disappear

OLD

1.Smaller Tributaries 2.Few In Number 3. Flood Plains Are Common 4. Natural Leeves And Oxbow Lakes Are Also Present 5. Most Of The Landscape Is Just Above Sea Level.

EROSIONAL LANDFORMS

’V SHAPED VALLEY


GORGE

CANYON

DIFFERENCE BETWEEN GORGE AND CANYON

| GORGE | CANYON |
|---|---|
| 1.steep sides | 1. Step like sides |
| 2.equalwidth of top and bottom | 2.wider at the top and narrow at thebottom |
| 3.small inlength | 3. Longer inlength |
| 4.they are found in semi arid lands | 4. Found in dry areas ex. Grand |
| grand canyon bramhaputra gorge | |

POT HOLES:

1.They are circular depressions 2.formed by abrasion 3.pebbles and boulders get collected in these holes and rotated and make depression wider and deep 4. They keep valley deepened 5.at the foot of the water falls they become plunge pools

PLUNGE POOLS

- Found Foot Of The Water Falls
- Formed Due To Soft Rocks
- They Are Below The Level Of  River Bed

MEANDERS

1. Lateral erosion is common in the lower course of the rivers
2. Due to low kinetic energy water is changing its  course
3. Generally found  in the flood plains
4. When meanders are found in deep and hard rocky areas they are called incised  or entrenched meanders
5. Same meanders develop loops  which later on converted into oxbow lakes

6.Some times they deepen the rocks and converted into  canyons

RIVER TERRACES

Marking old valley floor
They represent flood plainlevels
Theymay consist of stream deposits
They are formed due to verticl erosion
There  may be  number  of  formal  flood plains
If they are at the same level they are called paired terraces
If  they  are  found  at  different  levels   they  are   called   nonpaired terraces
Unpaired terraces are found in the areas of slow upliftment areas

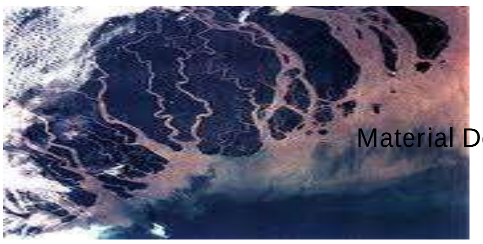
Reasons for the formation  of river terraces
1.receding water after  a peak flow
2.change in hydrological regime due to climatic change
3.tectonic uplift of land
4.sea level changes  incase of rivers closer to the sea    alluvial fans.

1. Found  near the foot of the hills
2. The river break into number of channels
3. Low gradient
4. Coarse  load is deposited
5. Low gradient
6. Cone  shaped deposit
7. Channels shif their position  in the plain
8. They are called distributaries
9. Cones are gentle slope inhumid areas and dry lands they have steep slope

ALLUVIALPLAIN

Formed along the river banks
1. Made of alluvial soils
2. They are divided into two types khadar and bangar
3. Khadar soils are found near the river and bangar soils are found away from the river
4. They are very fertile

DELTAS 1.Found near by the mouth of the river  2. Made of fine alluvial soils



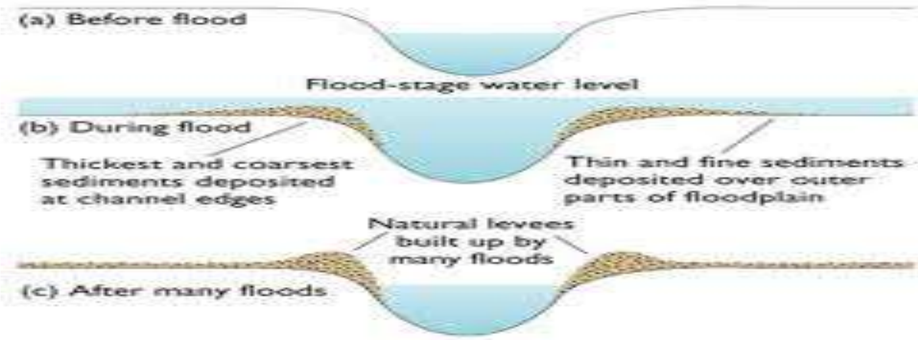
1. They are in triangular shape 5. Similar to Greek letter Delta 6. Divided by distributaries 7. Deposited material is

stratified on the basis of size. Coarse material is deposited first and then fine material

GANGA DELTA FLOOD PLAINS

2. Major landorms in the river deposition 2.big boulders are deposited first and then fine material is carried to the longer distance. The active flood plain is found in the river bank where as inactive flood plain is found above the level of river bank. The flood plains in deltas are called delta plains.

NATURAL LEEVES : t

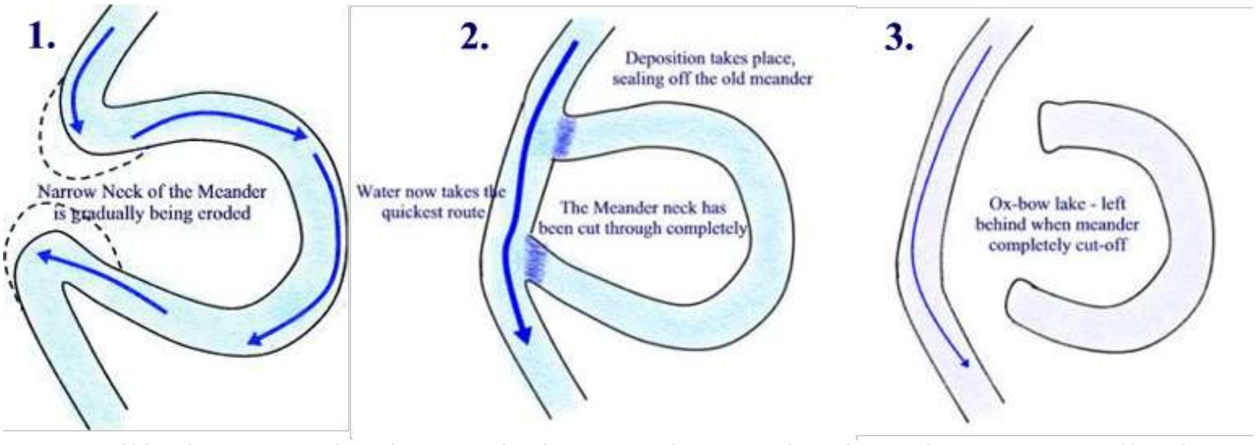



They are assoiated with flood plains.found along the flood plains of large rivers.they are low linear , parallel ridges made of coarse material found along the river bank. When river shift laterlya series of natural levees can form

POINT BARS :they are also called as meander bars. 2.found along the convex side of meanders of large rivers. They are uniform in profile.if there are more then one ridge narrow and elongated depressions are found in between the point bars.MEANDERS: loop like channels are called meanders.it is not a landform it is a type of river channel. Reasons for the formation of meanders

1.gentle gradient 2.unconsolidated material make irregularities 3.coriolis force 4. Slight irregularities along the river banks.

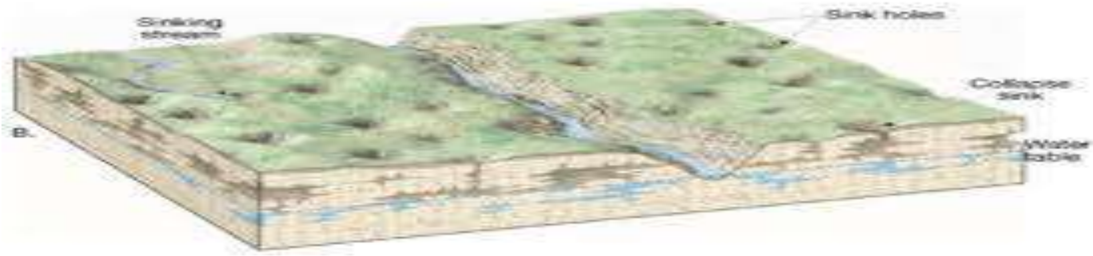
Formation of OXBOW LAKES:Found along the river bank on the convex side of the meander. Convex side is deposited and concave side is eroded. Concane bank is eroded and also it is called




cutoff bank convex side is long gentle slope . as they grow long loops the curve is cutoff and formed into Oxbow lakes.

BRAIDED CHANNEL
When rivers carry coarse material, there can be selective deposition of coarser materials causing formation of a central bar, which diverts the flow towards the banks; and this flow increases lateral erosion on the banks. As the valley widens, the water column is reduced and more and more materials are deposited as islands and lateral bars developing a number of separate channels of water flow.

KARST TOPOGRAPHY. Any limestone or dolomitic region showing typical landforms produced by the action of groundwater through the processes of solution and deposition is called ***Karsttopography*** after the typical topography developed in limestone rocks of Karst region in the Balkans adjacent to Adriatic Sea.




**Pools, Sinkholes, Lapis and Limestone Pavements**
Small to medium sized round to sub-rounded shallow depressions called ***swallow holes*** form on the surface of lime stones through solution.

Sinkholes are very common in limestone/karst areas. ***A sinkhole*** is an opening more or less circular at the top and funnel-shaped towards the bottom with sizes varying in area from a few sq. m to a hectare and with depth from a less than half a metre to thirty metres or more.
. The term ***doline*** is sometimes used to refer the collapse sinks. Solution sinks are more common than collapse sinks. Quite often the surface run-off simply goes down swallow and sink holes and flow as underground streams and re-emerge at a

distance downstream through a cave opening. When sinkholes and dolines join because of slumping of materials along their margins or due to roof collapse of caves, long, narrow to wide trenches called ***valleysinks*** or ***Uvalas*** form.

Gradually, most of the surface of the limestone is eaten away by these pits and Trenches, leaving it extremely irregular with a maze of points, grooves and ***ridges*** or ***lapies***.

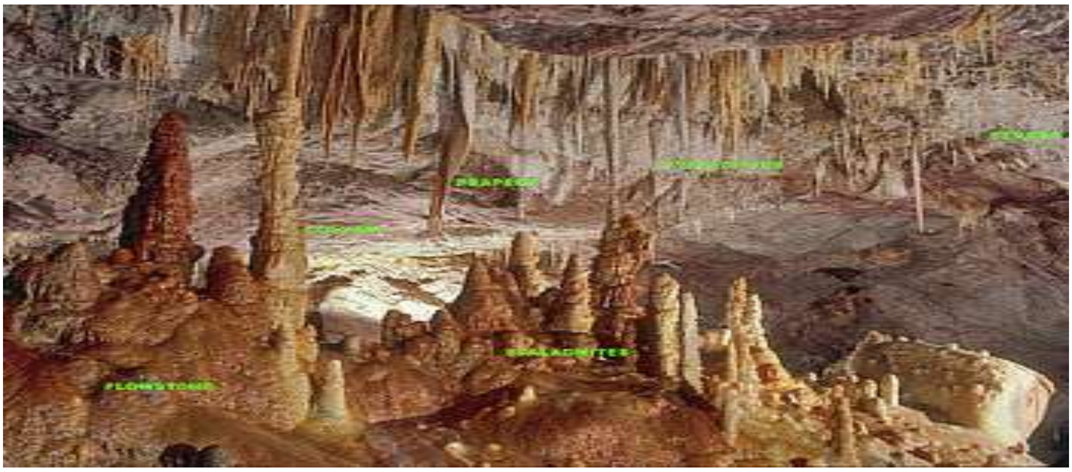
Especially, these ridges or lapies form due to differential solution activity along parallel to sub-parallel joints. The lapie field may eventually turn into somewhat smooth ***limestone pavements***.

**Caves**

In areas where there are alternating beds of rocks with limestone or dolomites in between or in areas where, limestone are dense, massive and occurring as thick beds, cave formation is prominent. Water percolates down either through the materials or through cracks and joints and moves horizontally along bedding planes. It is along these bedding planes that the limestone dissolves and long and narrow to wide gaps called ***caves***

**Depositional Landforms**

Many depositional forms develop within the limestone caves. The chief chemical in lime stone is calcium carbonate, which is easily soluble in carbonated water (carbon dioxide absorbed rainwater). This calcium carbonate is deposited when the water carrying it in solution evaporates or loses its carbon dioxide as it trickles over rough rock surfaces. **Stalactites, Stalagmites and Pillars** ***Stalactites*** hang as icicles of different diameters. Normally they are broad at their bases and taper towards the free ends showing up in a variety of forms. ***Stalagmites*** rise up from the floor of the caves. In fact, stalagmites form due to dripping water from the surface or through the thin pipe, of the stalactite, immediately below it,. Stalagmites may take the shape of a column, a disc, with either a smooth, rounded bulging end or a miniature crater like depression. The stalagmite and stalactites eventually fuse to give rise to ***columns and pillars*** of different diameters



Difference between stalagmites and stalactites

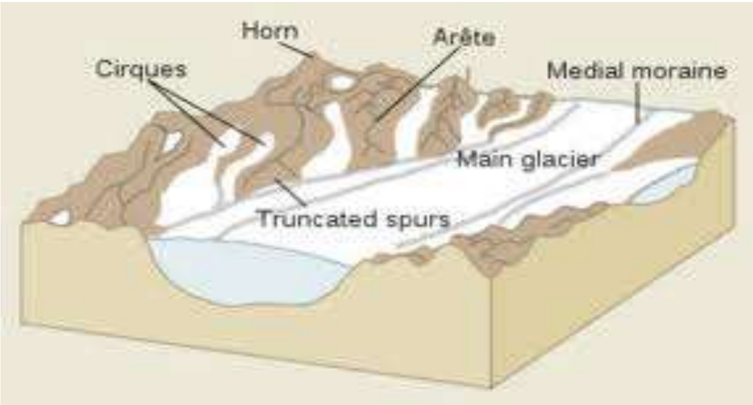
| STALAGMITES | STALACTITES |
|---|---|
| Grow from the floor<br>Broad base<br>Formed due to evaporation  of water<br>Broad edge<br>They are pillar shape | Grow from the roof<br>Narrow base<br>Formed due to condensation<br>Sharp edge<br>They are conical shape |

## GLACIERS

Masses of ice moving as sheets over the land (continental glacier or piedmont glacier if a vast sheet of ice is spread over the plains at the foot of mountains) or as linear flows down the slopes of mountains in broad trough-like valleys (mountain and valley glaciers) are called ***glaciers***.

## Cirque

Cirques are the most common of landforms in glaciated mountains.  The cirques quite often are found at the heads of glacial valleys. The accumulated ice cuts these cirques while moving down the mountain tops. They are deep, long and wide troughs or basins with very steep concave to vertically dropping high walls at its head as well as sides. A lake of water can is seen quite often within the cirques after the glacier disappears. Such lakes are called ***cirque or tarn lakes***. There can be two or more cirques one leading into another down below in a stepped sequence.



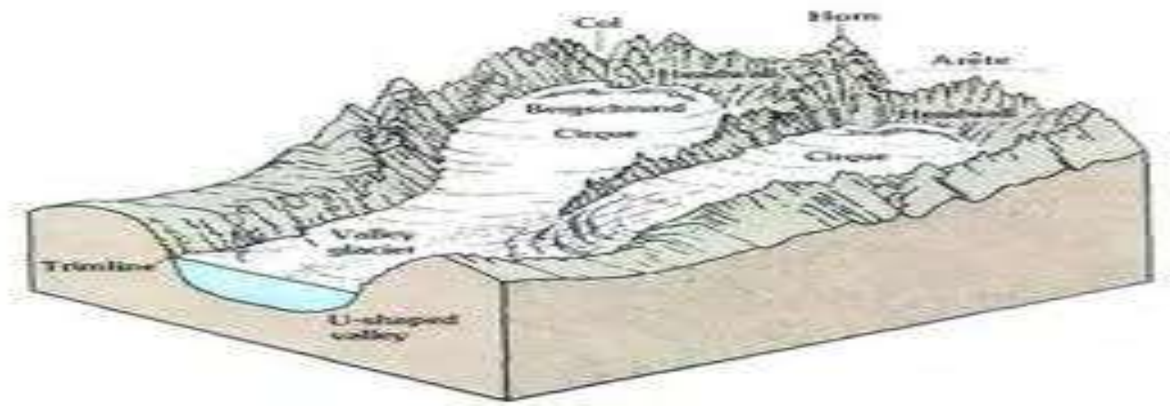

**Horns and Serrated Ridges**

Horns form through head ward erosion of the cirque walls. If three or more radiating glaciers cut head ward until their cirques meet, high, sharp pointed and steep sided peaks called ***horns*** form. The divides between cirque sidewalls or head walls get narrow because of progressive erosion and turn into serrated or saw-toothed ridges sometimes referred to as arêtes with very sharp crest and a zig-zag
Outline.

MORAINS

**Glacial Valleys/Troughs**

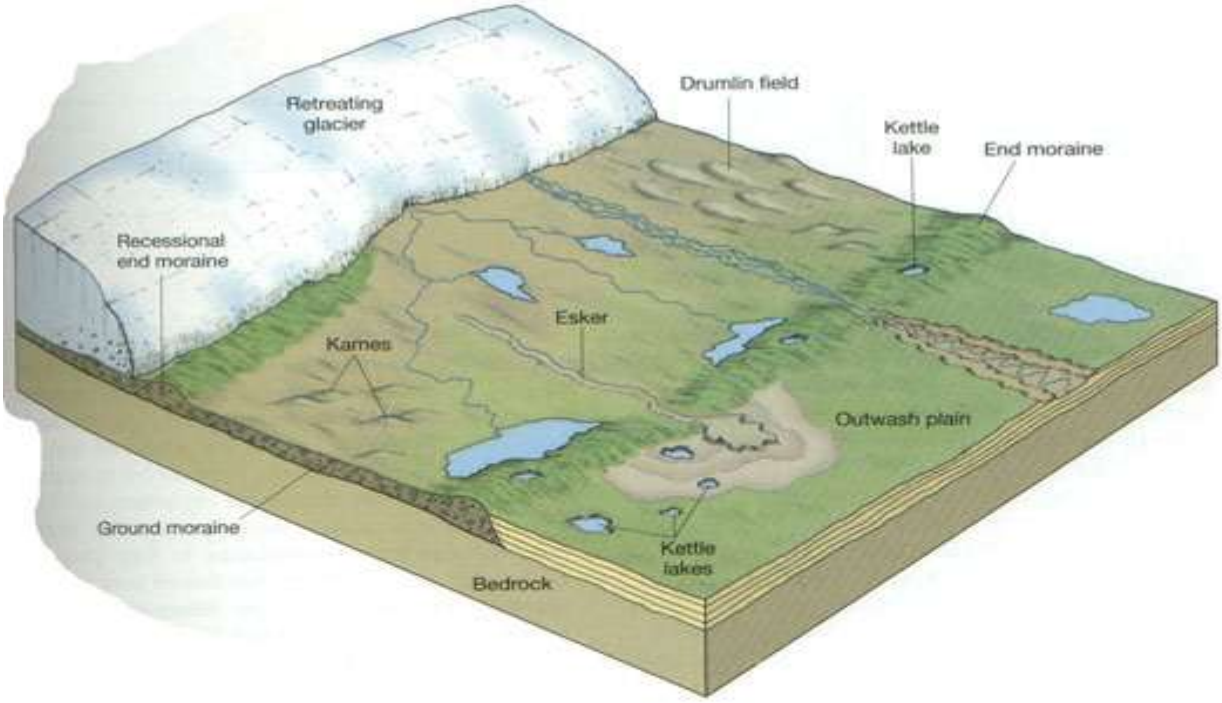
Glaciated valleys are trough-like and ***U-shaped*** with broad floors and relatively smooth, and steep sides. The valleys may contain littered debris or debris shaped as ***moraines*** with swampy appearance. There may be lakes gouged out of rocky floor or formed by debris within the valleys. There can be hanging valleys




at an elevation on one or both sides of the main glacial valley. The faces of divides or spurs of such hanging valleys opening into main glacial valleys are quite often truncated to give them an appearance like triangular facets. Very deep glacial troughs filled with sea water and making off shore lines (in high latitudes) are called ***fjords/fiords***. fiords at the Norway coast

**Depositional Landforms**

The un assorted coarse and fine debris dropped by the melting glaciers is called ***glacial till***. Most of the rock fragments in till are angular to sub angular
in form. Streams form by melting ice at the bottom, sides or lower ends of glaciers.
Some amount of rock debris small enough to be carried by such melt-water streams is washed down and deposited. Such glacio-fluvial deposits are called ***outwash deposits***.
Unlike till deposits, the outwash deposits are roughly stratified and assorted. The rock fragments in outwash deposits are somewhat rounded at their edges. Figure 7.14 shows a few depositional landforms commonly found In glaciated areas.




TYPES OF MORAINS
They are long ridges of deposits of **glacial till**. Terminal moraines are long ridges of debris deposited at the end of the glaciers. ***Lateral moraines*** form along the sides parallel to the glacial valleys. The lateral moraines may join a terminal moraine forming a horse-shoe shaped ridge .There can be many lateral moraines on either side in a glacial valley. These moraines partly or fully owe their origin to glacio fluvial waters pushing up materials to the sides of glaciers. Many valley glaciers retreating rapidly leave an irregular sheet of till over their valley floors. Such deposits varying greatly in thickness and in surface topography are called ***ground moraines***. The moraine in the center of the glacial valley flanked by lateral moraines is called ***medial moraine***. They are imperfectly formed as compared to lateral moraines. Sometimes medial moraines are indistinguishable
from ground moraines.

**Eskers**
When glaciers melt in summer, the water flows on the surface of the ice or seeps down along the margins or even moves through holes in the ice. These waters accumulate beneath the glacier and flow like streams in a channel beneath the ice. Such streams flow over the ground (not in a valley cut in the ground) with ice forming its banks. Very coarse materials like boulders and blocks along with some minor fractions of rock debris carried into this stream settle in the valley of ice beneath the glacier and after the ice melts can be found as a sinuous ridge called ***esker***.
**Outwash Plains**
The plains at the foot of the glacial mountains or beyond the limits of continental ice sheets are covered with glacio-fluvial deposits in the form of broad flat alluvial fans which may join to form outwash plains of gravel, silt, sand and clay. Distinguish between river alluvial plains and glacial outwash plains.
**Drumlins**
Drumlins are smooth oval shaped ridge-like features composed mainly of glacial till with some masses of gravel and sand. The long axes of drumlins are parallel to the direction of ice movement. They may measure up to 1 km in length and 30 m or so in height. One end of the drumlins facing the

glacier called the ***stoss*end** is blunter and steeper than the other end called ***tail***. The drumlins form due to dumping of rock debris beneath heavily loaded ice through fissures in the glacier. The **stoss** end gets blunted due to pushing by moving ice. Drumlins give an indication of direction of glacier movement.

## COASTAL LAND FORMS

Other than the action of waves, the coastal landforms depend upon (i) the configuration of land and sea floor;
(ii) whether the coast is advancing (emerging) seaward or retreating (submerging) landward.
Assuming sea level to be constant, two types of coasts are considered to explain the concept of evolution of coastal landforms:
(i) high, rocky coasts (submerged coasts);
(ii) low, smooth and gently sloping sedimentary coasts (emerged coasts

### HIGH ROCKY COASTS

Along the high rocky coasts, the rivers appear to have been drowned with highly irregular coastline. The coastline appears highly indented with extension of water into the land where glacial valleys ***(fjords)*** are present.
Along high rocky coasts, waves break with great force against the land shaping the hill sides into cliffs. With constant pounding by waves, the cliffs recede leaving a ***wave-cut platform*** in front of the sea cliff..
Bars are submerged features and when bars show up above water, they are called ***barrier bars***.
Barrier bar which get keyed up to the headland of a bay is called a ***spit***.
When barrier bars and spits form at the mouth of a bay and block it, a ***lagoon*** forms.
The lagoons would gradually get filled up by sediments from the land giving rise to a **coastal plain.**

### LOW SEDIMENTARY COASTS

Along low sedimentary coasts the rivers appear to extend their length by building coastal plains and deltas. The coastline appears smooth with occasional incursions of water in the form of ***lagoons and tidal creeks***.
The land slopes gently into the water. Marshes and swamps may abound along the coasts. Depositional features dominate. When waves break over a gently sloping sedimentary coast, the bottom sediments get churned and move readily building ***bars***, ***barrier bars***, ***spits and lagoons***.
Lagoons would eventually turn into a swamp which would subsequently turn into a coastal plain.
The west coast of our country is a high rocky retreating coast. Erosional forms dominate in the west coast. The east coast of India is a low sedimentary coast. Depositional forms dominate in the east coast.

### EROSIONAL LANDFORMS

**Cliffs, Terraces, Caves and Stacks**

Wave-cut cliffs and terraces are two forms usually found where erosion is the dominant shore process. Almost all sea cliffs are steep and may range from a few m to 30 m or even more. At the foot of such cliffs there may be a flat or gently sloping platform covered by rock debris derived from the sea cliff behind. Such platforms occurring at elevations above the average height of waves is called a ***wave-cut terrace***.

### EROSIONAL FEATURES OF WAVES


The lashing of waves against the base of the cliff and the rock debris that gets smashed against the cliff along with lashing waves create hollows and these hollows get widened and deepened to form ***sea caves***.

The roofs of caves collapse and the sea cliffs recede further inland. Retreat of the cliff may leave some remnants of rock standing isolated as small islands just off the shore. Such resistant masses of rock, originally parts of a cliff or hill are called ***sea stacks***.
Like all other features, sea stacks are also temporary and eventually coastal hills and cliffs will disappear because of wave erosion giving rise to narrow coastal plains, and with onrush of deposits from over the land behind may get covered up by alluvium or may get covered up by shingle or sand to form a wide beach.

## DEPOSITIONAL LANDFORMS

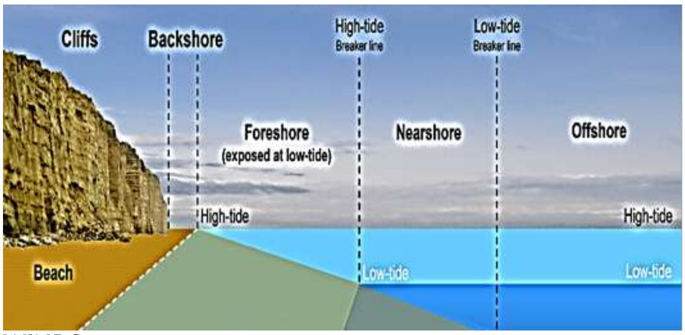
**Beaches and Dunes**

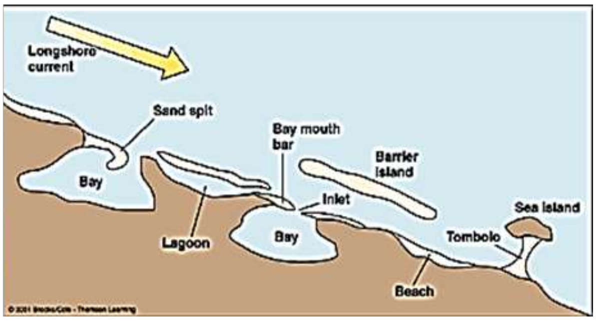
Beaches are characteristic of shorelines that are dominated by deposition, but may occur as patches along even the rugged shores. Most of the sediment making up the beaches comes from land carried by the streams and rivers or from wave erosion. Beaches are temporary features. The sandy beach which appears so permanent may be reduced to a very narrow strip of coarse pebbles in some other season. Most of the beaches are made up of sand sized materials. Beaches called shingle beaches contain excessively small pebbles and even cobbles.

**Bars, Barriers and Spits**

A ridge of sand and shingle formed in the sea in the off-shore zone (from the position of low tide waterline to seaward) lying approximately parallel to the coast is called an ***off-shore bar***.
An off-shore bar which is exposed due to further addition of sand is termed a ***barrier bar***.
The off-shore bars and barriers commonly form across the mouth of a river or at the entrance of a bay. Sometimes such barrier bars get keyed up to one end of the bay when they are called ***spits*** (Figure 7.15).Spits may also develop attached to headlands/hills.
The barriers, bars and spits at the mouth of the bay gradually extend leaving only a small opening of the bay into the sea and the bay will eventually develop into a lagoon.
The lagoons get filled up gradually by sediment coming from the land or from the beach itself (aided by wind) and a broad and wide coastal plain may develop replacing a lagoon.

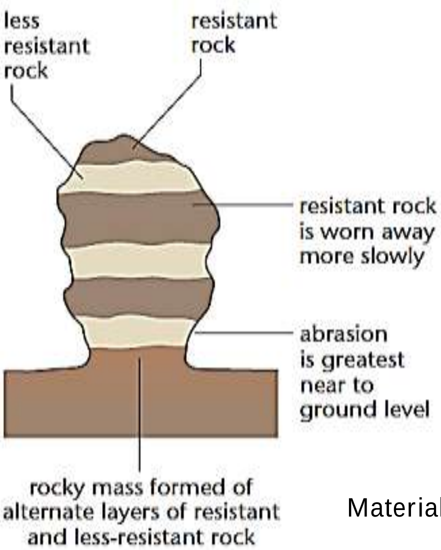
Depositional features of the sea waves




## WINDS

Wind is one of the two dominant agents in hot deserts.
Winds cause deflation, abrasion and impact.
Deflation includes lifting and removal of dust and smaller particles from the surface of rocks.
In the transportation, process sand and silt act as effective tools to abrade the land surface.
The impact is simply sheer force of momentum, which occurs when sand is blown into or against a rock surface

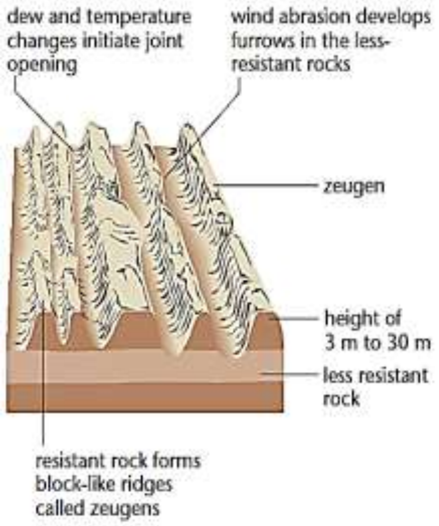



## EROSIONAL LANDFORMS

**Pediments and Pedi plains**

Landscape evolution in deserts is primarily concerned with the formation and extension of pediments. Gently inclined rocky floors close to the mountains at their foot with or without a thin cover of debris, are called ***pediments***.
Such rocky floors form through the erosion of mountain front through a combination of lateral erosion by streams and sheet flooding.
Erosion starts along the steep margins of the landmass or the steep sides of the
tectonically controlled steep incision features over the landmass.
Once, pediments are formed with a steep wash slope followed by

cliff or free face above it, the steep wash slope and free face retreat backwards. This method of erosion is termed as parallel retreat of slopes through back wasting.
So, through parallel retreat of slopes, the pediments extend backwards at the
expense of mountain front, and gradually, the mountain gets reduced leaving an ***inselberg*** which is a remnant of the mountain.
That's how the high relief in desert areas is reduced to low featureless plains called ***Pedi plains***.

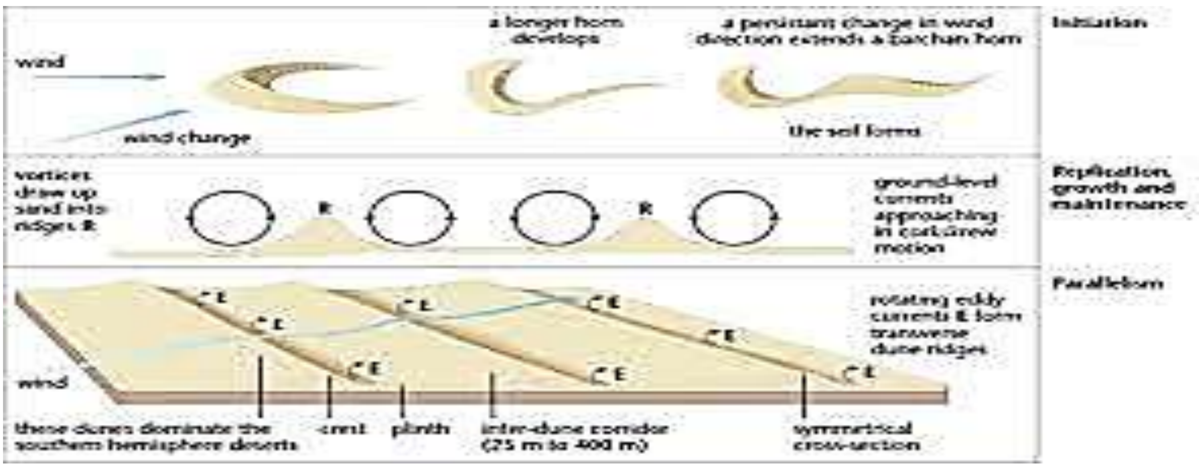



**Playas** Plains are by far the most prominent landforms in the deserts. In basins with mountains and hills around and along, the drainage is towards the center of the basin and due to gradual deposition of sediment from basin margins, a nearly level plain forms at the center of the basin. In times of sufficient water, this plain is covered up by a shallow water body. Such types of shallow lakes are called as ***playas*** where water is retained only for short duration due to evaporation and quite often the playas contain good deposition of salts. The playa plain covered up by salts is called ***alkali flats***.

**Deflation Hollows and Caves**
Weathered mantle from over the rocks or bare soil, gets blown out by persistent movement of wind currents in one direction. This process may create shallow depressions called ***deflation hollows***.
Deflation also creates numerous small pits or cavities over rock surfaces. The rock faces suffer impact and abrasion of wind-borne sand and first shallow depressions called blow outs are created, and some of the ***blow outs*** become deeper and wider fit to be called ***caves***.

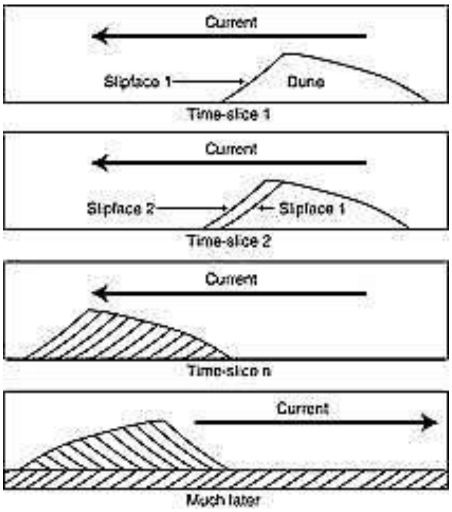
**Mushroom, Table and Pedestal Rocks** Many rock-outcrops in the deserts easily
susceptible to wind deflation and abrasion are worn out quickly leaving some remnants of resistant rocks polished beautifully in the shape of mushroom with a slender stalk and a broad and rounded pear shaped cap above. Sometimes, the top surface is broad like a table top and quite often, the remnants stand out like pedestals.
Wind is a good sorting agent. Depending upon the velocity of wind, different sizes of grains are moved along the floors by rolling or saltation and carried in suspension and in this process of transportation itself, the materials get sorted. When the wind slows or begins to die down, depending upon sizes of grains and their critical velocities, the grains will begin to settle .So, in depositional landforms made by wind, good sorting of grains can be found. Since wind is there everywhere and wherever there is good source of sand and with constant wind directions, depositional features in arid regions can develop anywhere.

**Sand Dunes**

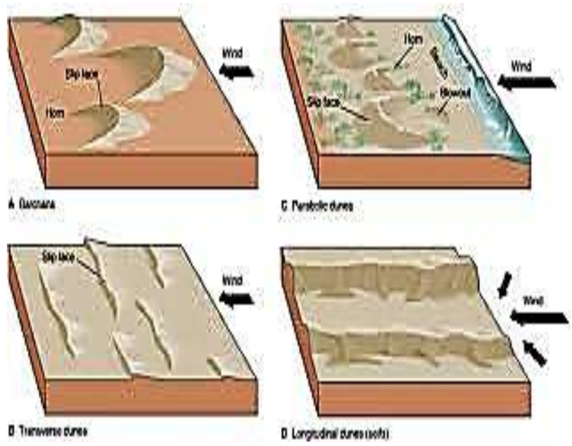



Dry hot deserts are good places for sand dune formation. Obstacles to initiate dune formation are equally important. There can be a great variety of dune forms Crescent shaped dunes called ***barchans***
with the points or wings directed away from wind direction i.e., downwind, form where the wind direction is constant and moderate and where the original surface over which sand is moving is almost uniform.

***Parabolic dunes*** form when sandy surfaces are partially covered with vegetation. That means parabolic dunes are reversed barchans with wind direction being the same.




***Seif*** is similar to barchan with a small difference. Seif has only one wing or point. This happens when there is shift in wind conditions. The lone wings of seifs can grow very long and high. Longitudinal dunes form when supply of sand is poor and wind direction is constant. They appear as long ridges of considerable length but low in height.




***Transverse dunes*** are aligned perpendicular to wind direction. These dunes form when the wind direction is constant and the source of sand is an elongated feature at right angles to the wind direction. They may be very long and low in height. When sand is plenty, quite often, the regular shaped dunes coalesce and lose their individual characteristics. Most of the dunes in the deserts shift and a few of them will get stabilized especially near human habitations.

## CHAPTER-8 COMPOSITION AND STRUCTURE OF ATMOSPHERE

***This unit deals with***
***• Atmosphere — compositions and structure; elements of weather and climate***
***• Insolation — angle of incidence and distribution; heat budget of the earth — heating and cooling of atmosphere (conduction, convection, terrestrial radiation, advection); temperature — factors controlling temperature; distribution of temperature — horizontal and vertical; inversion of temperature• Pressure — pressure belts; winds-planetary seasonal and local, air masses and fronts; tropical and extra tropical cyclones***
***• Precipitation — evaporation; condensation — dew, frost, fog, mist and cloud; rainfall — types and world distribution***
***• World climates — classification (Koeppen), greenhouse effect, global warming and climatic changes***

### CHAPTER EIGHT

**What is the importance of atmosphere?**

Air is essential to the survival of all organisms. Some organisms like humans may survive for some time without food and water but can't survive even a few minutes without breathing air. That shows the reason why we should understand the atmosphere in greater detail.

**Define The Atmosphere**

Atmosphere is a mixture of different gases and it envelopes the earth all round. It contains life-giving gases like oxygen for humans and animals and carbon dioxide for plants.

**What is the average height of the Atmosphere?**

The air is an integral part of the earth's mass and 99 per cent of the total mass of the atmosphere is confined to the height of 32 km from the earth's surface. The air is colourless and odourless and can be felt only when it blows as wind.

**Can you imagine what will happen to us in the absence of ozone in the atmosphere?**

**In the absence of Ozone life is not possible on the earth surface.**

**COMPOSITION OF THE ATMOSPHERE**

The atmosphere is composed of gases, water vapour and dust particles. The proportion of gases changes in the higher layers of the atmosphere in such a way that oxygen will be almost in negligible quantity at the height of 120 km. Similarly, carbon dioxide and water vapour are found only up to 90 km from the surface of the earth.

**COMPOSITION AND STRUCTURE OF ATMOSPHERE**

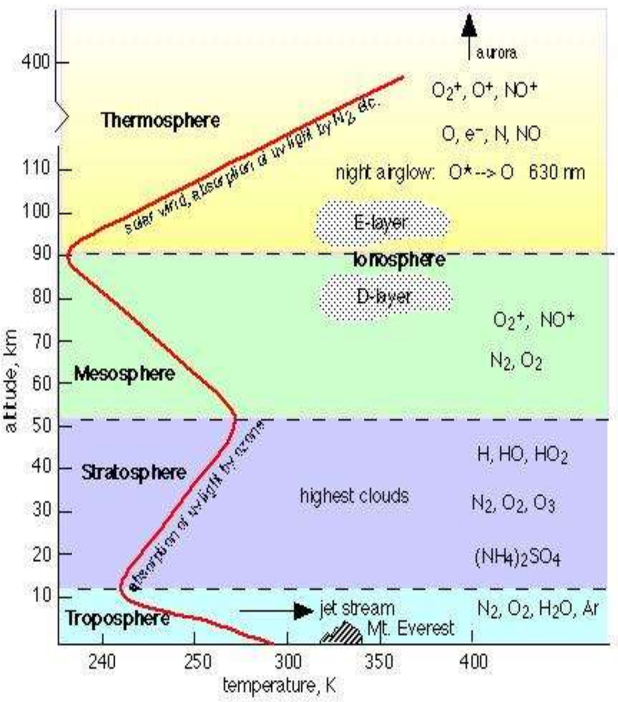



**Table 8.1 : Permanent Gases of the Atmosphere**

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

**Study the above table showing the composition of the atmosphere and answer the following questions.**
**1. Which gas constitutes the highest % of atmosphere?**
**2. Name the gas which constitutes least % of atmosphere**

Gases

**Carbon dioxide** is meteorologically a very important gas as it is transparent to the Incoming solar radiation but opaque to the outgoing terrestrial radiation. It absorbs a part of terrestrial radiation and reflects back some part of it towards the earth's surface. It is largely responsible for the ***green house effect***.

The volume of carbon dioxide has been rising in the past few decades mainly because of the burning of fossil fuels. This has also increased the temperature of the air.

**Ozone is** another important component of the atmosphere found between 10 and 50 km above the earth's surface and acts as a filter and absorbs the ***ultra-violet rays*** radiating from the sun and prevents them from reaching the surface of the earth.

**Water Vapour**

Water vapour is also a variable gas in the atmosphere, which decreases with altitude. In the warm and wet tropics, it may account for four per cent of the air by volume, while in the dry and cold areas of desert and polar regions, it may be less than one per cent of the air. Water vapour also decreases from the equator towards the poles. It also absorbs parts of the insolation from the sun and preserves the earth's radiated heat. It thus, acts like a blanket allowing the earth neither to become too cold nor too hot. Water vapour also contributes to the stability and instability in the air.

**Dust Particles**

Atmosphere has a sufficient capacity to keep small solid particles, which may originate from different sources and include sea salts, fine soil, smoke-soot, ash, pollen, dust and disintegrated particles of meteors. Dust particles are generally concentrated in the lower layers of the atmosphere; yet, convectional air currents may transport them to great heights. The higher concentration of dust particles is found in subtropical and temperate regions due to dry winds in comparison to equatorial and polar regions. Dust and salt particles act as hygroscopic nuclei around which water vapour condenses to produce clouds.

**STRUCTURE OF THE ATMOSPHERE**

1.The atmosphere consists of different layers with varying density and temperature. 2. Density is highest near the surface of the earth and decreases with increasing altitude.

3.The column of atmosphere is divided into five different layers depending upon the temperature condition.

**Name the layers of atmosphere**

They are: troposphere, stratosphere, mesosphere, thermosphere and exosphere.

***The troposphere***

***1.It*** is the lowermost layer of the atmosphere.

2. Its average height is 13 km
3. extends roughly to a height of 8 km near the poles and about 18 km at the equator.
4. Thickness of the troposphere is greatest at the equator because heat is transported to great heights by strong convectional currents.
5. This layer contains dust particles and water vapour.
6. All changes in climate and weather take place in this layer.
7. The temperature in this layer decreases at the rate of 1 °C for every 165 m of height.
8. This is the most important layer for all biological activity.
9. The zone separating the troposphere from stratosphere is known as the ***tropopause***.

The air temperature at the tropopause is about minus 800 °C over the equator and about minus 45° C over the poles.

The temperature here is nearly constant, and hence, it is called the tropopause.

***The stratosphere***

1. It is found above the tropopause and extends up to a height of 50 km.
2. One important feature of the stratosphere is that it contains the ***ozone layer***.
3. This layer absorbs ultra-violet radiation and shields life on the earth from intense, harmful form of energy.

***The mesosphere***

**1. It** lies above the stratosphere,

2. which extends up to a height of 80 km.
3. In this layer, once again, temperature starts decreasing with the increase in altitude and Up to minus 100°C at the height of 80 km.

4. The upper limit of mesosphere is known as the ***mesopause.***

***The ionosphere***

**1 .It** is located between 80 and 400 km above the mesopause.
2. It contains electrically charged particles known
as ions, and hence, it is known as ionosphere.
3. Radio waves transmitted from the earth are reflected back to the earth by this layer.
4. Temperature here starts increasing with height.
5. The uppermost layer of the atmosphere above reaches up to minus 100

**Exosphere**

1. the thermosphere is known as the ***exosphere***.
2. This is the highest layer but very little is known
about it.
3. Whatever contents are there, these are extremely rarefied in this layer, and it gradually merges with the outer space.

**Elements of Weather and Climate**

The main elements of atmosphere which are subject to change and which influence human life on earth are
1. temperature,
2. pressure,
3. winds,
4. humidity,
5. clouds
6. precipitation.

# CHAPTER -9 SOLAR RADIATION, HEAT BALANCE AND TEMPERATURE

**This chapter deals with**

**Solar radiation, variability of insolation at the surface of the earth heating and cooling of atmosphere, terrestrial radiation ,heat budget of the planet earth, latitudinal variation in net radiation balance, temperature, factors influencing the temperature (such as the latitude, altitude, distance from the sea air mass ocean currents) distribution of temperature, isotherm.**

**Define insolation.**

The earth's surface receives most of its energy in short wavelengths. The energy received by the earth is known as incoming solar radiation which in short is termed as ***insolation***.

**Which factor is responsible for the varied distribution of energy?**

As the earth is a Geoid resembling a sphere, the sun's rays fall obliquely at the top of the atmosphere and the earth intercepts a very small portion of the sun's energy.

**What is the average amount of energy received by the earth?**

On an average the earth receives 1.94 calories per sq. cm per minute at the top of its atmosphere.

Give the reasons why it is summer when earth is far away from the sun and winter when it is nearest to the Sun.

The solar output received at the top of the atmosphere varies slightly in a year due to the variations in the distance between the earth and the sun. During its revolution around the sun, the earth is farthest from the sun (152 million km) on 4th July. This position of the earth is called ***aphelion***. On 3rd January, the earth is the nearest to the sun (147 million km). This position is called ***perihelion***. Therefore, the annual insolation received by the earth on 3$^{rd}$ January is slightly more than the amount received on 4th July. However, the effect of this variation in the solar output is masked by other factors like the distribution of land and sea and the atmospheric circulation. Hence, this variation in the solar output does not have
great effect on daily weather changes on the surface of the earth.

**Variability of Insolation at the Surface of the Earth**

The amount and the intensity of insolation vary during a day, in a season and in a year. The factors that cause these variations in insolation are

(i) the rotation of earth on its axis;
(ii) the angle of inclination of the sun's rays;
(iii) the length of the day;
(iv) the transparency of the atmosphere;
(v) the configuration of land in terms of its aspect.

The last two however, have less influence. The fact that the earth's axis makes an angle of 66_ with the plane of its orbit round the sun has a greater influence on the amount of insolation received at different latitudes.

Note: The variations in the duration of the day at different latitudes on solstices are given in the Table below.

**Table 9.1 : Length of the Day in Hours and Minutes on Winter and Summer Solstices in the Northern Hemisphere**

| Latitude | 0° | 20° | 40° | 60° | 90° |
|---|---|---|---|---|---|
| December 22 | 12h 00m | 10h 48m | 9h 8m | 5h 33m | 0 |
| June 21 | 12 h | 13h 12m | 14h 52m | 18h 27m | 6 months |

The second factor that determines the amount of insolation received is the angle of
inclination of the rays. This depends on the latitude of a place. The higher the latitude the less is the angle they make with the surface of the earth resulting in slant sunrays. The area covered by vertical rays is always less than that covered by the slant rays. If more area is covered, the energy gets distributed and the net energy received
per unit area decreases. Moreover, the slant rays are required to pass through greater depth of the atmosphere resulting in more absorption, scattering and diffusion.

The **incoming radiation is not fully reached to the earth surface. Why ?**

1. The atmosphere is largely transparent to short wave solar radiation. The incoming solar radiation passes through the atmosphere before striking the earth's surface.
2. Within the troposphere water vapor, ozone and other gases absorb much of the near infrared radiation.
3. Very small-suspended particles in the troposphere scatter visible spectrum both to the space and towards the earth surface.

4. This process adds colour to the sky.
5. The red colour of the rising and the setting sun and the blue colour of the sky are the result of scattering of light within the atmosphere.

**What is the average distribution of insolation on the surface ?Give the reasons for such variation.**

***Spatial Distribution of Insolation on the Earth's Surface***

The insolation received at the surface varies
from about 320 Watt/m in the tropics to about 70 Watt/min the poles. Maximum insolation is received over the subtropical deserts, where the cloudiness is the least. Equator receives comparatively less insolation than the tropics. Generally, at the same latitude the insolation is more over the continent than over the oceans. In winter, the middle and higher latitudes receive less radiation than in summer.

**HEATING AND COOLING OF ATMOSPHERE**

**Name the ways of heating the atmosphere.**

1. **Radiation 2. Conduction 3. Advection 4. convection**

1. Horizontal movement of the air is relatively more important than the vertical movement.
2. In middle latitudes, most of diurnal (day and night) variation in daily weather are caused by advection alone.
3. In tropical regions particularly in northern India during summer season local winds called 'loo' is the outcome of advection process.

**Terrestrial Radiation**

1. The insolation received by the earth is in shortwaves forms and heats up its surface.
2. The earth after being heated itself becomes a radiating body and it radiates energy to the atmosphere in long wave form.
3. This energy heats up the atmosphere from below.
4. This process is known as terrestrial radiation.
5. The long wave radiation is absorbed by the atmospheric gases particularly by carbon dioxide and the other green house gases. Thus, the atmosphere is indirectly heated by the earth's radiation.

The atmosphere in turn radiates and transmits heat to the space. Finally the amount of heat received from the sun is returned to space, thereby maintaining constant temperature at the earth's surface and in the atmosphere.

**With the help of a diagram explain the Heat Budget of the Planet Earth.**

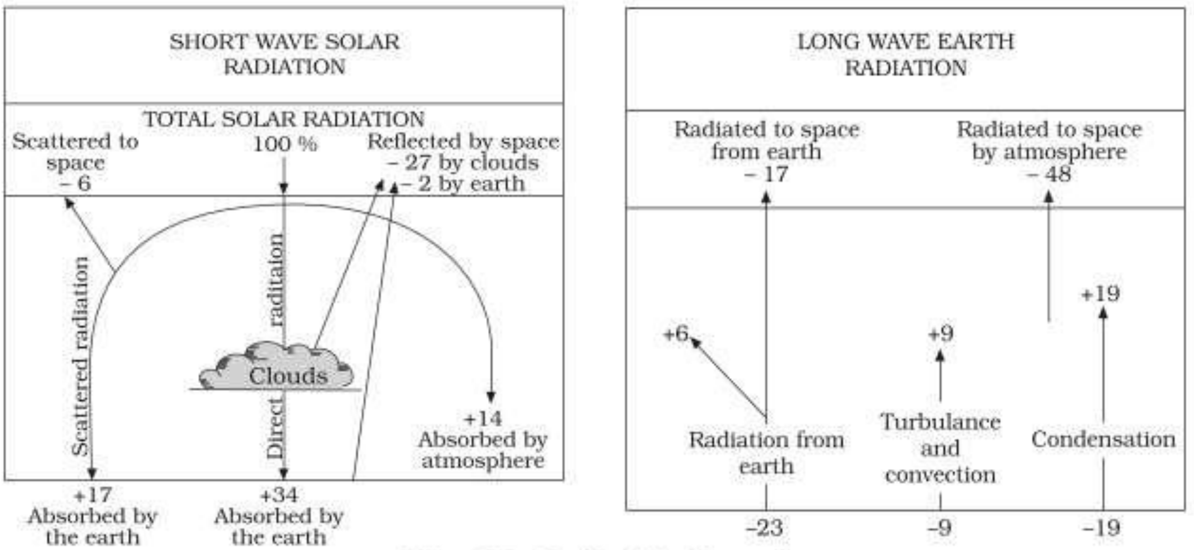



**Figure 9.2 : Heat budget of the earth**

**INCOMING SOLAR RDIATION**

1. Figure 9.2 depicts the heat budget of the planet earth. The earth as a whole does Not accumulate or loose heat. It maintains its temperature.
2. This can happen only if the amount of heat received in the form of insolation equals the amount lost by the earth through terrestrial radiation.
3. Consider that the insolation received at the top of the atmosphere is 100 percent.
4. While passing through the atmosphere some amount of energy is reflected, scattered and absorbed.
5. Only the remaining part reaches the earth surface.
6. Roughly 35 units are reflected back to space even before reaching the earth's surface.
7. Of these, 27 units are reflected back from the top of the clouds

8. Only 2 units from the snow and ice-covered areas of the earth.
9. The remaining 65 units are absorbed,
10. 14 units within the atmosphere and 51 units by the earth's surface.

## TERRESTRIAL RADIATION

1. The earth radiates back 51 units in the form of terrestrial radiation.
2. 17 units are radiated to space directly
3. the remaining 34 units are absorbed by the atmosphere
4.6 units absorbed directly by the atmosphere,
5.9 units through convection and turbulence
6. 19 units through latent heat of condensation
7.48 units absorbed by the atmosphere(14 units from insolation +34 units from terrestrial radiation) are also radiated back into space.

Thus, the total radiation returning from the earth and the atmosphere respectively is 17+48=65 units which balance the total of 65 units received from the sun. This is termed the heat budget or heat balance of the earth.
This explains, why the earth neither warms up nor cools down despite the huge transfer of heat that takes place.

## What do you mean by 'Albedo'?

The reflected amount of radiation is called the ***albedo of the earth***.

***Variation in the Net Heat Budget at the Earth's Surface***

As explained earlier, there are variations in the amount of radiation received at the earth's surface. Some part of the earth has surplus radiation balance while the other part has deficit.

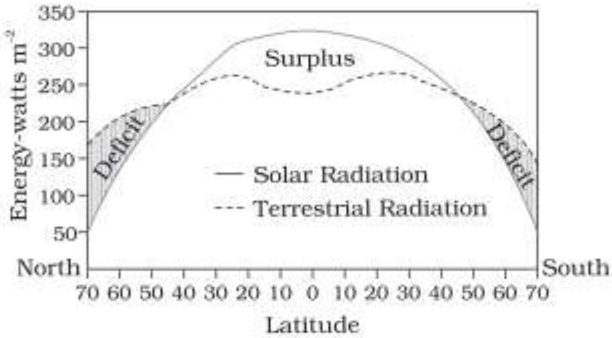



**Figure 9.3 : Latitudinal variation in net radiation balance**

Figure 9.3 depicts the latitudinal variation in the net radiation balance of the earth the atmosphere system.
The figure shows that there is a surplus of net radiation balance between 40 degrees north and south and the regions near the poles have a deficit.
The surplus heat energy from the tropics is redistributed pole wards and as a result the tropics do not get progressively heated up due to the accumulation of excess heat or the high latitudes get permanently frozen due to excess deficit.

## WHAT IS THE DIFFERENCE BETWEEN HEAT AND TEMPERATURE

## Temperature

The interaction of insolation with the atmosphere and the earth's surface creates heat which is measured in terms of temperature.
While heat represents the molecular movement of particles comprising a substance, the temperature is the measurement in degrees of how hot (or cold) a thing (or a place) is.

***Factors Controlling Temperature Distribution***

The temperature of air at any place is influenced by
(i) the latitude of the place;
(ii) the altitude of the place;
(iii) distance from the sea, the air mass circulation;
(IV) the presence of warm and cold ocean currents; (v) local aspects.

***1.The latitude*** **:** The temperature of a place depends on the insolation received. It has been explained earlier that the insolation varies according to the latitude hence the temperature also varies accordingly.

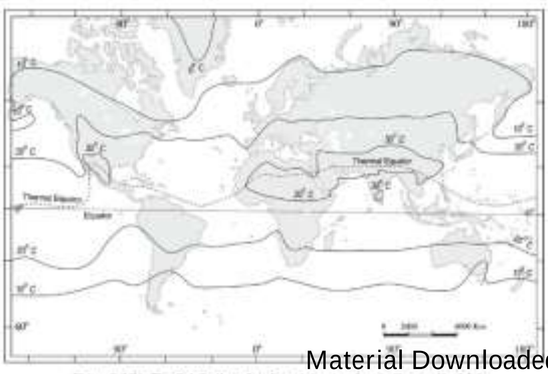


Figure 9.4 (b) : The distribution of surface air temperature in the month of July

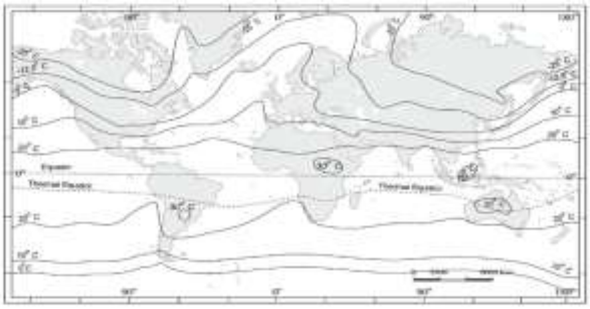
***2.The altitude*** **:** The atmosphere is indirectly heated by terrestrial radiation from below. Therefore, the places near the sea-level record higher temperature than the places situated at higher elevations. In other words, the temperature generally decreases with increasing height. The rate of decrease of temperature with height is termed as the normal lapse rate. It is 6.5˚C per 1,000 m.

***Distance from the sea***: Another factor that influences the temperature is the location of a place with respect to the sea. Compared to land, the sea gets heated slowly and loses heat slowly. Land heats up and cools down quickly. Therefore, the variation in temperature over the sea is less compared to land. The places situated near the sea come under the moderating influence of the sea and land breezes which moderate the temperature.

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

***Ocean currents***

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



***Isotherms*** are lines joining places having equal temperature.

Fig no. 9.4 (a) distribution of surface temperature in the month of january

Figure 9.4 (a) and (b) show the distribution of surface air temperature in the month of January and July.

1. In general the effect of the latitude on temperature is well pronounced on the map,
2. the isotherms are generally parallel to the latitude.
3. The deviation from this general trend is more pronounced in January than in July, especially in the northern hemisphere.
4. In the northern hemisphere the land surface area is much larger than in the southern hemisphere.
5 .Hence, the effects of land mass and the ocean currents are well pronounced.

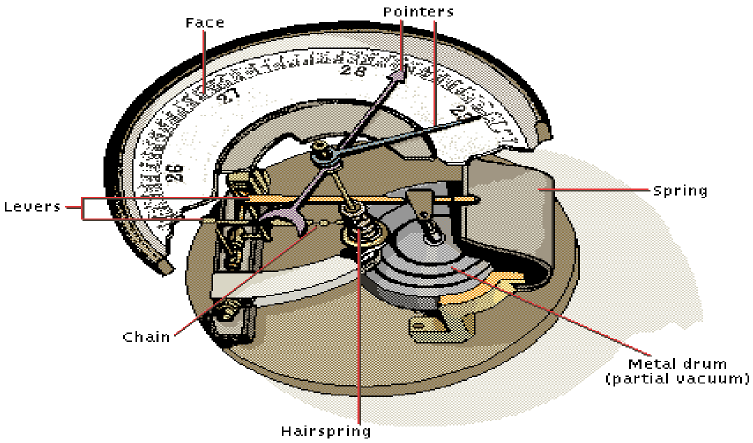
In January the isotherms deviate to the north over the ocean and to the south over the continent. This can be seen on the North Atlantic Ocean.

## INVERSION OF TEMPERATURE

Normally, temperature decreases with increase in elevation. It is called normal lapse rate. At times, the situations is reversed and the normal lapse rate is inverted. It is called Inversion of temperature. Inversion is usually of short duration but quite common nonetheless. A long winter night with clear skies and still air is ideal situation for inversion. The heat of the day is radiated off during the night, and by early morning hours, the earth is cooler than the air above.

# CHAPTER-10 ATMOSPHERIC CIRCULATION AND WEATHER SYSTEM

**This chapter deals with**
**Atmospheric pressure, vertical variation pressure, horizontal distribution of pressure, world distribution of sea level pressure, factors affecting the velocity and direction of wind( pressure gradient force, frictional force, carioles force, pressure and wind, ) general circulation of the atmosphere, ENSO seasonal wind, local winds land and sea breezes mountain and valley winds, air masses , fronts, exratropical cyclone tropical cyclones, thunderstorms, tornadoes.**




The weight of a column of air contained in a unit area from the mean sea level to the top of the atmosphere is called the ***atmospheric pressure***. The atmospheric pressure is expressed in units of milibar. At sea level the average atmospheric pressure is 1,013.2 milibar. Due to gravity the air at the surface is denser and hence has higher pressure. Air pressure is measured with the help of a mercury barometer or the aneroid barometer.

The pressure decreases with height. At any elevation it varies from place to place and its variation is the primary cause of air motion, i.e. wind which moves from high pressure areas to low pressure areas.

## Vertical Variation of Pressure

In the lower atmosphere the pressure decreases rapidly with height. The decrease amounts to about 1 mb for each 10 m increase in elevation. It does not always decrease at the same rate. Table 10.1 gives the average pressure and temperature at selected levels of elevation for a standard atmosphere.

**Table 10.1 : Standard Pressure and Temperature at Selected Levels**

**Table 10.1 : Standard Pressure and Temperature at Selected Levels**

| Level | Pressure in mb | Temperature °C |
|---|---|---|
| Sea Level | 1,013.25 | 15.2 |
| 1 km | 898.76 | 8.7 |
| 5 km | 540.48 | -17. 3 |
| 10 km | 265.00 | -49.7 |

The vertical pressure gradient force is much larger than that of the horizontal pressure gradient.
But, it is generally balanced by a nearly equal but opposite gravitational force. Hence, we do not experience strong upward winds.

## Horizontal Distribution of Pressure

Small differences in pressure are highly significant in terms of the wind direction and velocity.
Horizontal distribution of pressure is studied by drawing isobars at constant levels. Isobars are lines connecting places having equal pressure. In order to eliminate the effect of altitude on pressure, it is measured at any station after being reduced to sea level for purposes of comparison.

## World Distribution of Sea Level Pressure

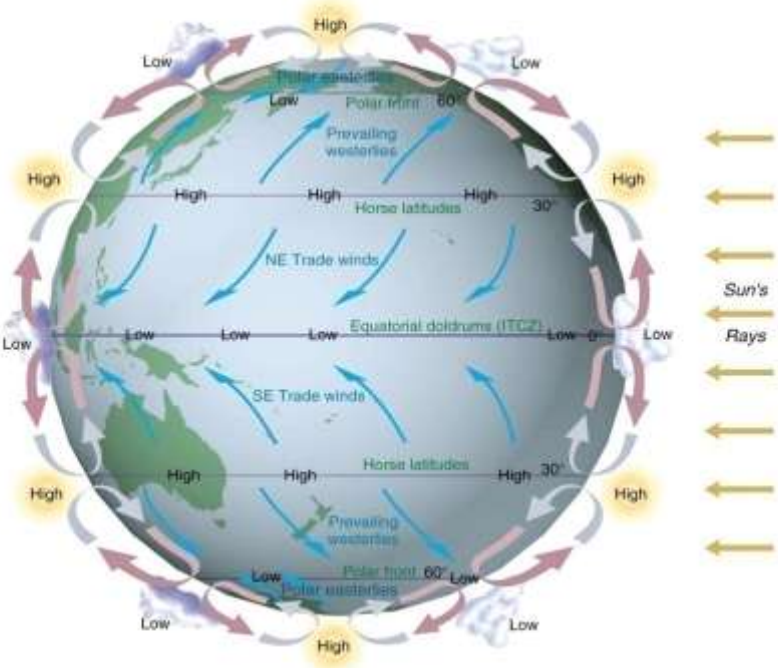
The world distribution of sea level pressure in January and July has been shown in Figures 10.2 and 10.3. Near the equator the sea level pressure is low and the area is known as ***equatorial low***.
Along 30° N and 30 °S found the high-pressure areas known as the **subtropical highs**.
Further pole wards along 60°N and 60°S, the low-pressure belts are termed as the **sub polar lows**.
Near the poles the pressure is high and it is known as the ***polar high***.
These pressure belts are not permanent in nature. They oscillate with the apparent movement of the sun. In the northern hemisphere in winter they move southwards and in the summer northwards.

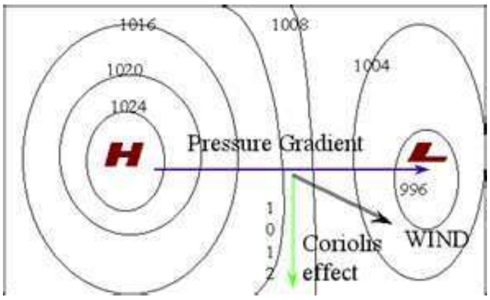
 

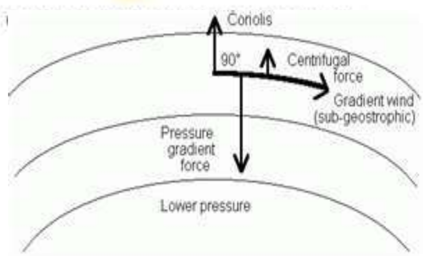
## Forces Affecting the Velocity and Direction of Wind

You already know that the air is set in motion due to the differences in atmospheric pressure. The air in motion is called wind. The wind blows from high pressure to low pressure. addition, rotation of the earth also affects the wind movement. The force exerted by the rotation of the earth is known as the Coriolis force.

**The horizontal winds near the earth surface respond to the combined effect of three forces – the pressure gradient force, the frictional force and the Carioles' force. In addition, the gravitational force acts downward.**



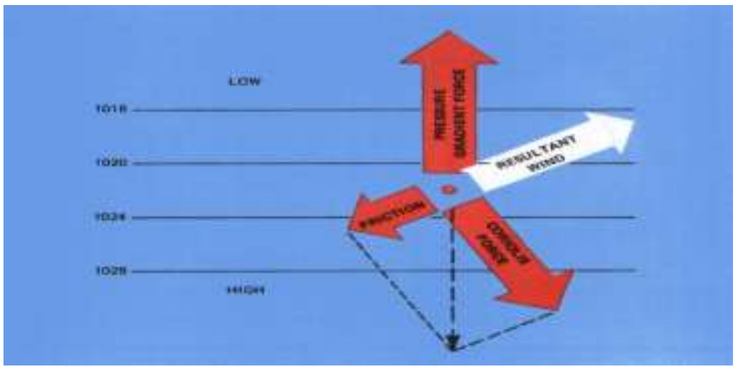




### *Pressure Gradient Force*

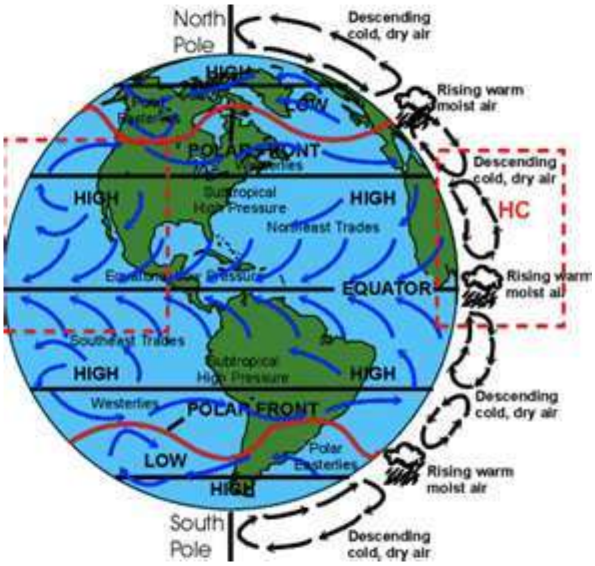
The differences in atmospheric pressure produces a force. The rate of change of pressure with respect to distance is the pressure gradient. The pressure gradient is strong where the isobars are close to each other and is weak where the isobars are apart.


- It affects the speed of the wind. It is greatest at the surface and its influence generally extends up to an elevation of 1 - 3 km. Over the sea surface the friction is minimal.

### *Coriolis Force*

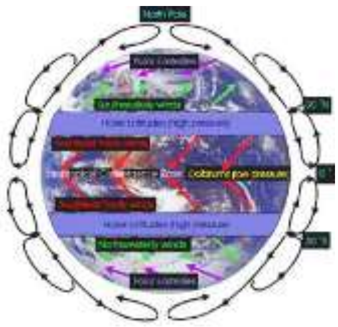



The rotation of the earth about its axis affects the direction of the wind. This force is called the Coriolis force after the French physicist who described it in 1844. It deflects the wind to the right direction in the northern hemisphere and to the left in the southern hemisphere. The deflection is more when the wind velocity is high. The Coriolis force is directly proportional to the angle of latitude. It is maximum at the poles and is absent at the equator. The Coriolis force acts perpendicular to the




pressure gradient force. The pressure gradient force is perpendicular to an isobar. The higher the pressure gradient force, the more is the velocity of the wind and the larger is the deflection in the direction of wind. As a result of these two forces operating perpendicular to each other, in the low-pressure areas the wind blows around it. At the equator, the Coriolis force is zero and the wind blows perpendicular to the isobars. The low pressure gets filled instead of getting intensified. That is the reason why tropical cyclones are not formed near the equator.

***Pressure and Wind***

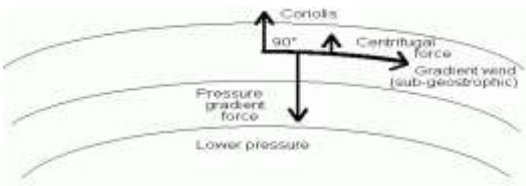



The velocity and direction of the wind forces. The winds in surface, are free controlled mainly by When isobars are

balanced by the parallel to the isobar.

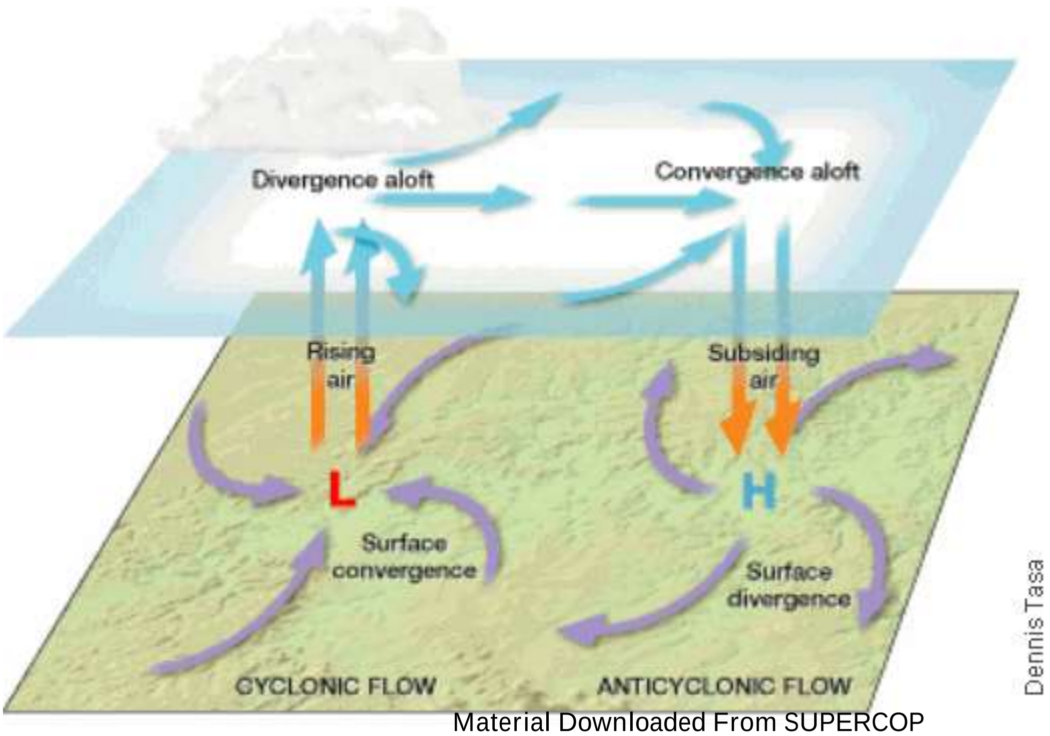
are the net result of the wind generating the upper atmosphere, 2 - 3 km above the from frictional effect of the surface and are the pressure gradient and the Coriolis force. straight and when there is no
friction, the pressure gradient force is Coriolis force and the resultant wind blows This wind is known as the geostrophic wind .

- **Figure 10.4 : Geostrophic Wind**



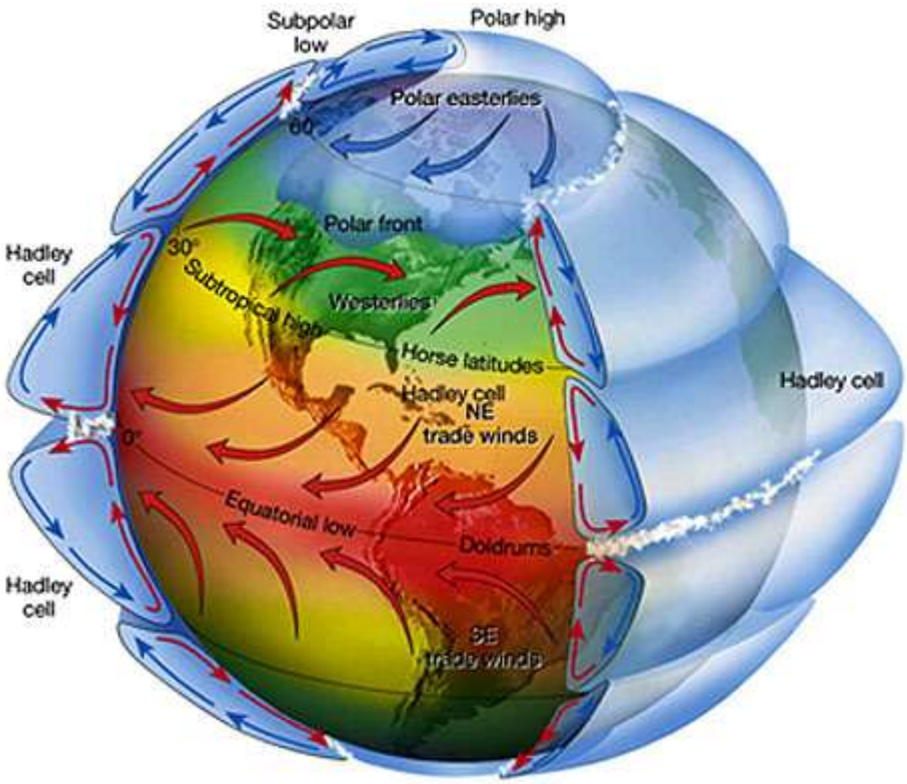

The wind circulation around a low is called ***cyclonic circulation***. Around a high it is called ***anti cyclonic circulation***.

The direction of winds around such systems changes according to their location in




different hemispheres (Table 10.2).The wind circulation at the earth's surface
closely related to the wind circulation at higher level. Generally, over low pressure area the air will converge and rise. Over high pressure area the air will subside from above and diverge at the surface (part from convergence, some eddies, convection currents, orographic uplift and uplift along fronts cause the rising of air, which is essential for the formation of clouds and precipitation.

**General circulation of the atmosphere**




The pattern of planetary winds largely depends on : (i) latitudinal variation of atmospheric heating;
(ii) emergence of pressure belts;
(iii)the migration of belts following apparent path of the sun;
(iv) the distribution of continents and oceans;
(v) the rotation of earth.
The pattern of the movement of the planetary winds is called the general circulation of the atmosphere. The general circulation of the atmosphere also sets in motion the ocean water circulation which influences the earth's climate. A schematic description of the general circulation is shown in Figure 10.6. The air at the Inter Tropical Convergence Zone (ITCZ) rises because of convection caused by high insolation and a low pressure is created.
The winds from the tropics converge at this low pressure zone.
The converged air rises along with the convective cell.
It reaches the top of the troposphere up to an altitude of 14 km. and moves towards the poles. This causes accumulation of air at about 30 N and S.
Part of the accumulated air sinks to the ground and forms a subtropical high. Another reason for sinking is the cooling of air when it reaches 30 N and S latitudes.
Down below near the land surface the air flows towards the equator as the easterlies.
The easterlies from either side of the equator converge in the Inter Tropical Convergence Zone (ITCZ).
Such circulations from the surface upwards and ***vice-versa*** are called cells.
Such a cell in the tropics is called ***Hadley Cell***.
In the middle latitudes the circulation is that of sinking cold air that comes from the poles and the rising warm air that blows from the subtropical high. At the surface these winds are called westerlies and the cell is known as the ***Ferrel cell***. At polar latitudes the cold dense air subsides near the poles and blows towards middle latitudes as the polar easterlies. This cell is called the **polar cell.**

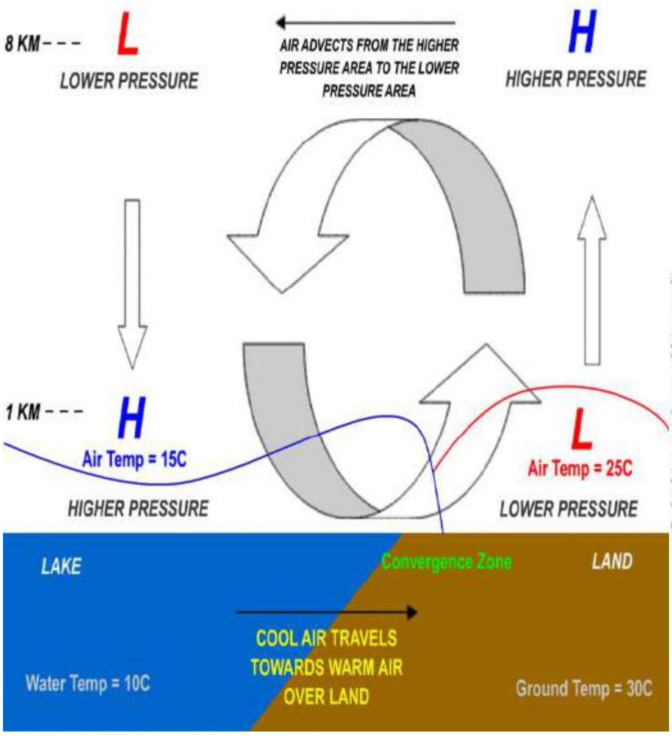
## General Atmospheric Circulation and its Effects on Oceans

Warming and cooling of the Pacific Ocean is most important in terms of general atmospheric circulation. The warm water of the central Pacific Ocean slowly drifts towards South American coast and replaces the cool Peruvian current. Such appearance of warm water off the coast of Peru is known as the El Nino. The El Nino event is closely associated with the pressure changes in the Central Pacific and Australia. This change in pressure condition over Pacific is known as the southern oscillation. The combined phenomenon of southern oscillation and El Nino is known as ENSO. In the years when the ENSO is strong, large-scale variations in weather occur over the world. The arid west coast of South America receives heavy rainfall, drought occurs in Australia and sometimes in India and floods in China. This phenomenon is closely monitored and is used for long range forecasting in major parts of the world.

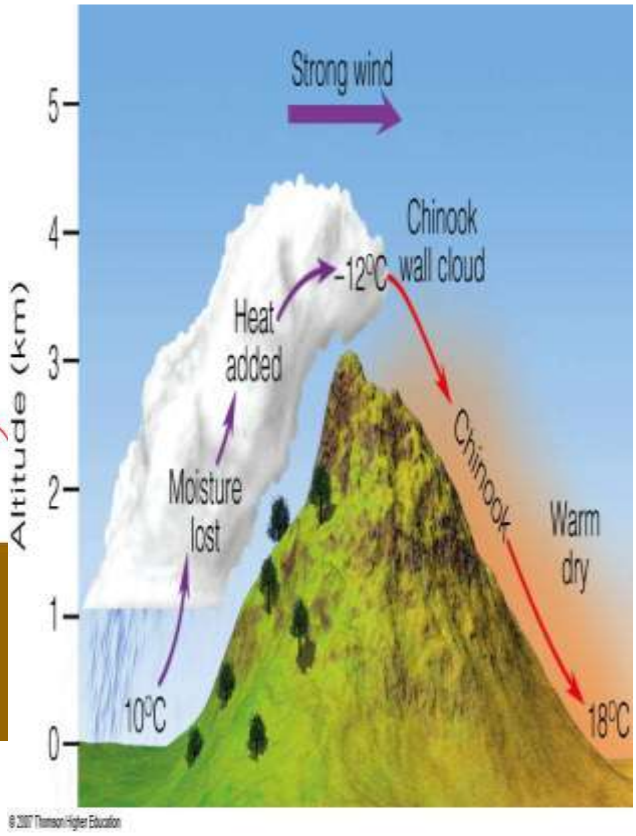
- ***Seasonal Wind***

The pattern of wind circulation is modified indifferent seasons due to the shifting of regions of maximum heating, pressure and wind belts. The most pronounced effect of such a shift is noticed in the monsoons, especially over southeast Asia.

SEASONAL WIND



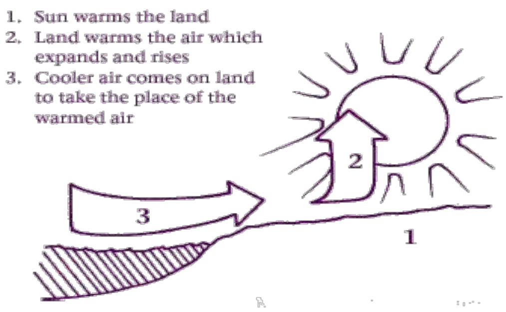

LOCAL WIND




The other local deviations from the general circulation system are as follows.

- ***Local Winds***

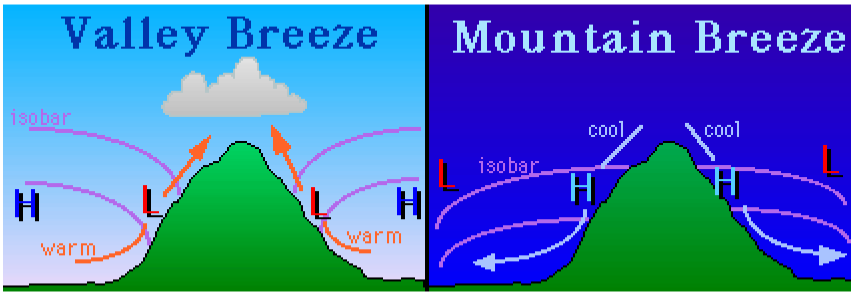
Differences in the heating and cooling of earth surfaces and the cycles those develop daily or annually can create several common, local or regional winds.




***Land and Sea Breezes***

As explained earlier, the land and sea absorb and transfer heat differently. During the day the land heats up faster and becomes warmer than the sea. Therefore, over the land the air rises giving rise to a low pressure area, whereas the sea is relatively cool and the pressure over sea is relatively high. Thus, pressure gradient from sea to land is created and the wind blows from the sea to the land as the sea breeze. In the night the reversal of condition takes place. The land loses heat faster and is cooler than the sea. The pressure gradient is from the land to the sea and hence land breeze results (Figure 10.7).

Figure 10.7 : Land and sea breezes

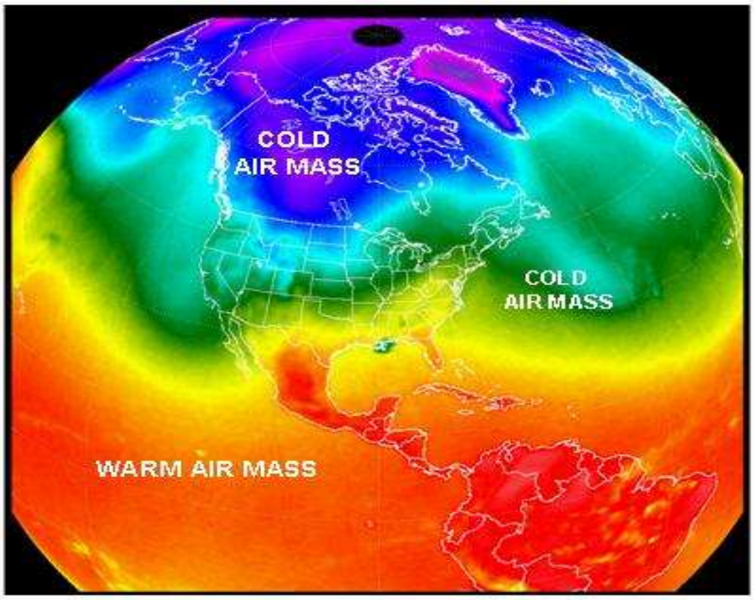



***Mountain and Valley Winds***

In mountainous regions, during the day the slopes get heated up and air moves upslope and to fill the resulting gap the air from the valley blows up the valley. This wind is known as the valley breeze. During the night the slopes get cooled and the dense air descends into the valley as the mountain wind. The cool air, of the high plateaus and ice fields draining into the valley is called katabatic wind. Another

type of warm wind occurs on the leeward side of the mountain ranges. The moisture in these winds, while crossing the mountain ranges condense and precipitate. When it descends down the leeward side of the slope the dry air gets warmed up by adiabatic process. This dry air may melt the snow in a short time.

***Air mass***



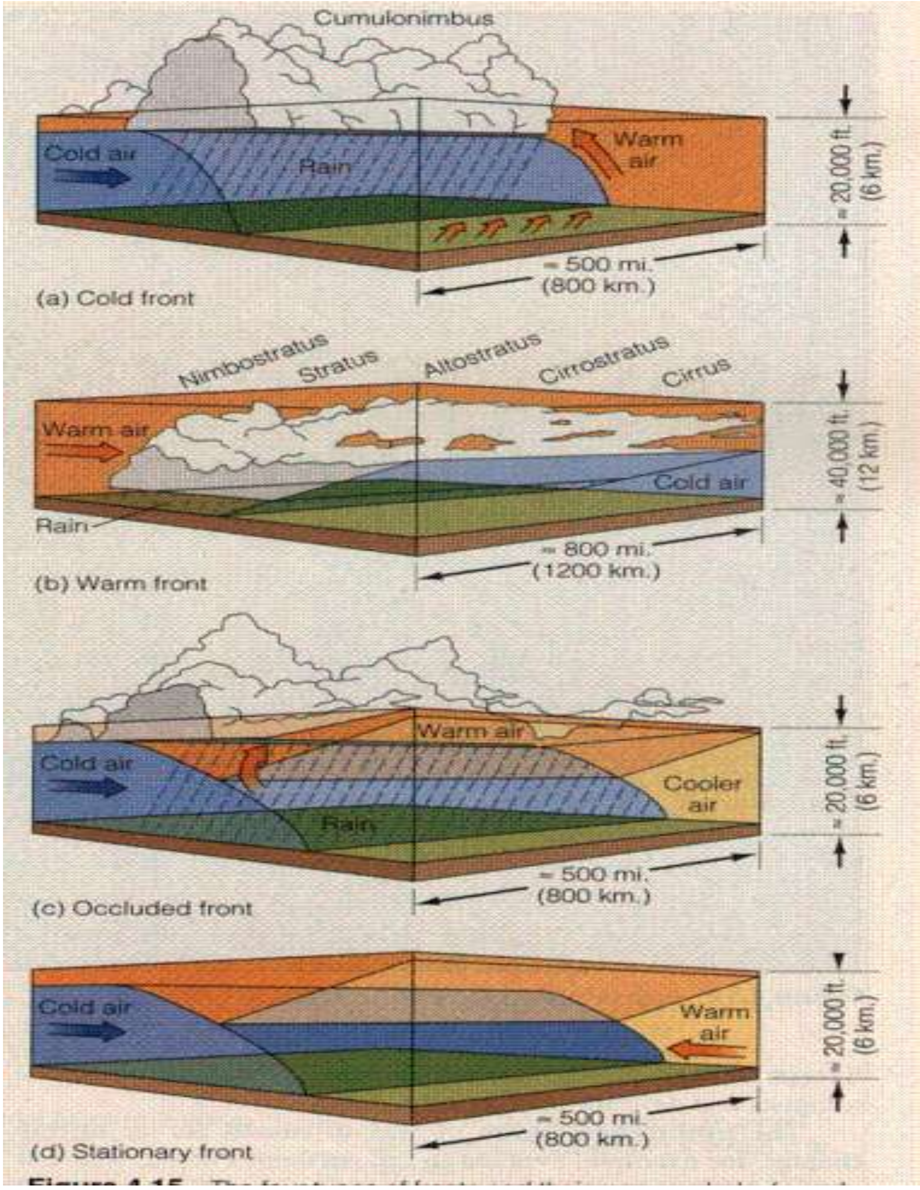

When the air remains over a homogenous area for a sufficiently longer time, it acquires the characteristics of the area. The homogenous regions can be the vast ocean surface or vast plains. The air with distinctive characteristics in terms of temperature and humidity is called an **air mass**.

It is defined as a large body of air having little horizontal variation in temperature and moisture. The homogenous surfaces, over which air masses form, are called the source regions.

The air masses are classified according to the source regions. There are five major source regions. These are:

(i) Warm tropical and subtropical oceans;
(ii) The subtropical hot deserts;
(iii) The relatively cold high latitude oceans;
(iv) The very cold snow covered continents in high latitudes;
(v) Permanently ice covered continents in the Arctic and Antarctica. Accordingly, following types of air masses are recognised:

(i) Maritime tropical (mT);
(ii) Continental tropical (cT);
Maritime polar (mP);
(iv) Continental polar (cP);
(iv) Continental arctic (cA).
(v) Tropical air masses are warm and polar air masses are cold.




***Fronts***

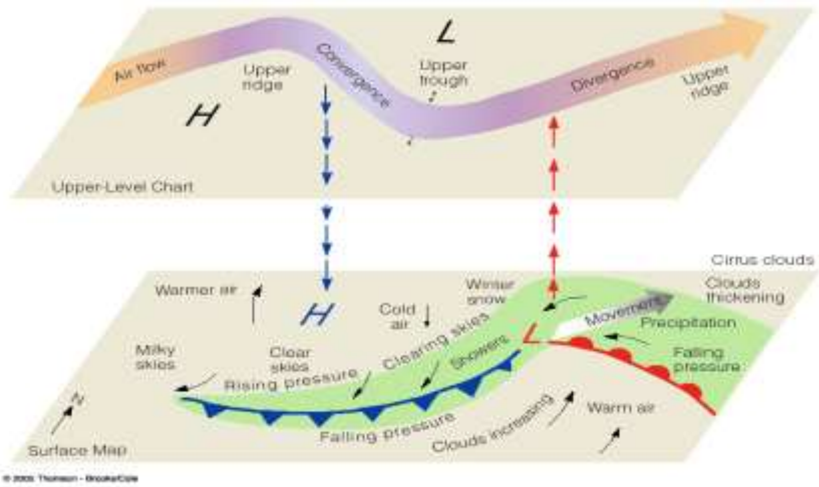
When two different air masses meet, the boundary zone between them is called a ***front***.

The process of formation of the fronts is known as ***frontogenesis***. There are four types of fronts:

(a) Cold; (b) Warm;
(c) Stationary; (d) Occluded.

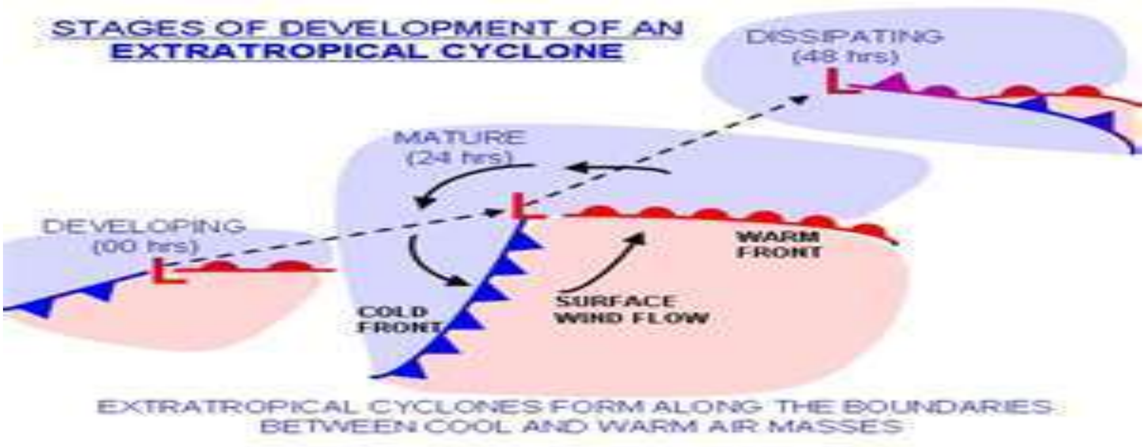
When the front remains stationary, it is called a ***stationary front***.

When the cold air moves towards the warm air mass, its contact zone is called the ***cold front***, whereas if the warm air mass moves towards the cold air mass, the contact zone is a warm front. If an air mass is fully lifted above the land surface, it is called the ***occluded front***.



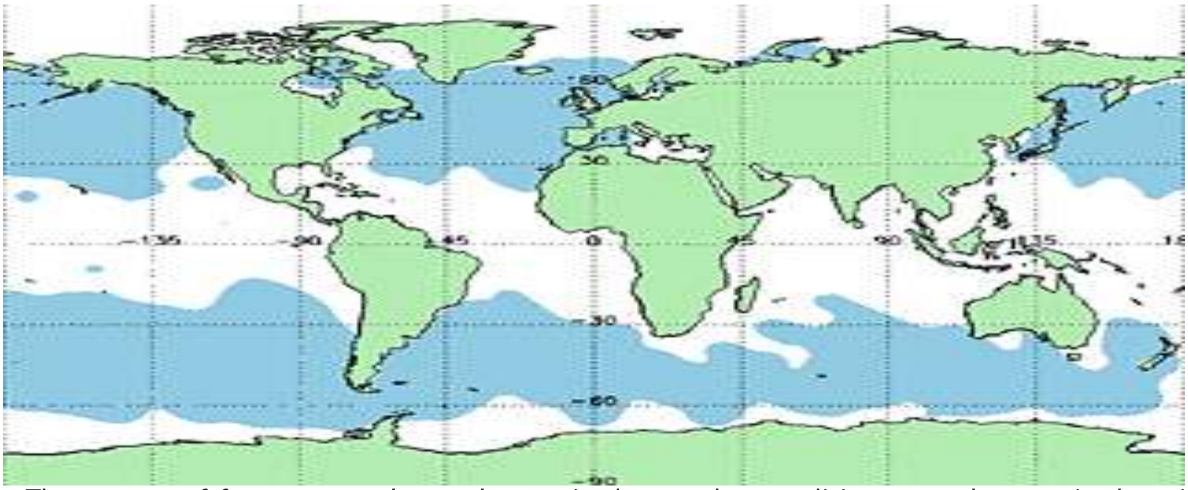

The fronts occur in middle latitudes and are characterized by steep gradient in temperature and pressure. They bring abrupt changes in temperature and cause the air to rise to form clouds and cause precipitation.

***Extra Tropical Cyclones***




The systems developing in the mid and high latitude, beyond the tropics are called the ***middle latitude or extra tropical cyclones***.

- location of temperate cyclones



The passage of front causes abrupt changes in the weather conditions over the area in the middle and high latitudes. Extra tropical cyclones form along the polar front.
Initially, the front is stationary. In the northern hemisphere, warm air blows from the south and cold air from the north of the front.
When the pressure drops along the front, the warm air moves northwards and the cold air move towards, south setting in motion an anticlockwise cyclonic circulation.
The cyclonic circulation leads to a well developed extra tropical cyclone, with a warm front and a cold front.

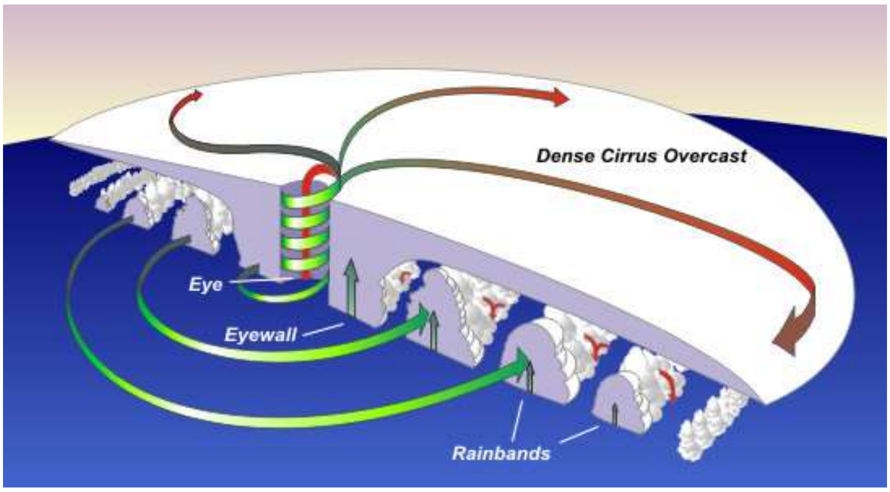
***Tropical Cyclones***

Tropical cyclones are violent storms that originate over oceans in tropical areas and
large scale destruction caused by violent winds, very heavy rainfall and storm surges. This is one of the most devastating natural calamities. They are known as ***Cyclones*** in the Indian Ocean, ***Hurricanes*** in the Atlantic, ***Typhoons*** in the Western Pacific and South China Sea, and ***Willy-willies*** in the Western Australia.
Tropical cyclones originate and intensify over warm tropical oceans.

**The conditions favourable for the formation and intensification of tropical storms are:**

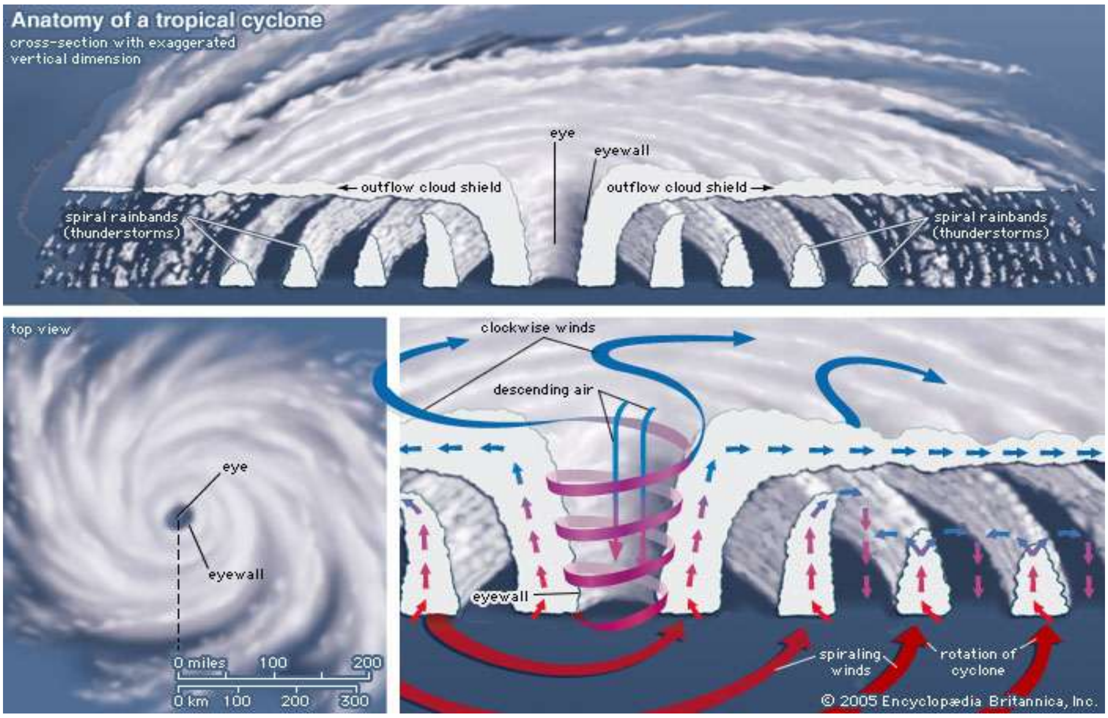
(i) Large sea surface with temperature higher than 27° C;
(ii) (ii) Presence of the Coriolis force;
(iii) Small variations in the vertical wind speed;
(iv) A pre-existing weak low-pressure area or low-level-cyclonic circulation;
(v) Upper divergence above the sea level system.

The energy that intensifies the storm, comes from the condensation process in the towering cumulonimbus clouds, surrounding the centre of the storm. With continuous supply of moisture from the sea, the storm is further strengthened. On reaching the land the moisture supply is cut off and the storm dissipates. The place where a tropical cyclone crosses the coast is called the landfall of the cyclone. The cyclones, which cross 20 N latitude generally, reserve and they are more destructive. A schematic representation of the vertical structure of a mature tropical cyclonic storm is shown in Figure given below




**Physical Structure of Tropical Cyclone**

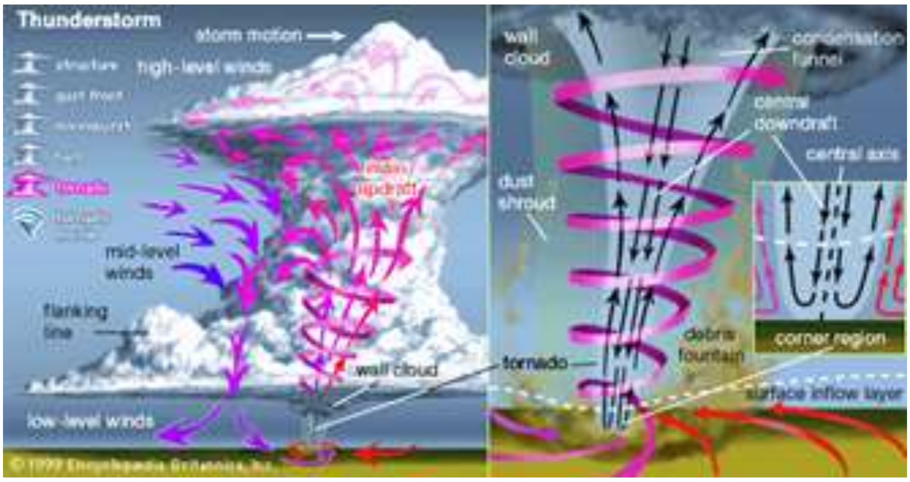
*To best understand the structure of tropical cyclones, you may find useful to briefly review the concept of thermal wind and vorticity*




Structure of a tropical cyclone. (Source: Britannica)

A mature tropical cyclone is characterized by the strong spirally circulating wind around the centre, called the eye. The diameter of the circulating system can vary between 150 and 250 km.
The eye is a region of calm with subsiding air. Around the eye is the eye wall, where there is a strong spiraling ascent of air to greater height reaching the tropopause. The wind reaches maximum velocity in this region, reaching as high as 250 km per hour. Torrential rain occurs here. From the eye wall rain bands may radiate and trains of cumulus and cumulonimbus clouds may drift into the outer region. The diameter of the storm over the Bay of Bengal, Arabian sea and Indian ocean is between 600 - 1200 km. The system moves slowly about 300 - 500 km per day.
The cyclone creates storm surges and they inundate the coastal low lands. The storm peters out on the land.

## • *Thunderstorms and Tornadoes*




Other severe local storms are **thunderstorms and tornadoes.** They are of short duration, occurring over a small area but are violent. ***Thunderstorms*** are caused by intense convection on moist hot days.

From severe thunderstorms sometimes spiralling wind descends like a trunk of an elephant with great force, with very low pressure at the centre, causing massive destruction on its way. Such a phenomenon is called a ***tornado***. Tornadoes generally occur in middle latitudes. The tornado over the sea is called ***water sprouts***.

These violent storms are the manifestation of the atmosphere's adjustments to varying energy distribution. The potential and heat energies are converted into kinetic energy in these storms and the restless atmosphere again returns to its stable state.

# CHAPTER -11 WATER IN THE ATMOSPHERE

This chapter deals with Humidity, types of humidity, relative humidity, absolute humidity, specific humidity, dew point, condensation, saturated air, types of precipitation -dew, frost, fog, mist, clouds cirrus, cumulus, stratus, nimbus, precipitation, types-(rainfall, sleet, snowfall, hailstones,)rainfall types convectional type, orographic rainfall, cyclonic rainfall, world distribution of rainfall.

Air contains water vapour. It varies from zero to four per cent by volume of the atmosphere and plays an important role in the weather phenomena. Water is present in the atmosphere in three forms namely – gaseous, liquid and solid.
The moisture in the atmosphere is derived from water bodies through evaporation and from plants through transpiration. Thus, there is a continuous exchange of water between the atmosphere, the oceans and the continents through the processes of evaporation, transpiration, condensation and precipitation.

Water vapour present in the air is known as humidity. It is expressed quantitatively in different ways.
The actual amount of the water vapour present in the atmosphere is known as the ***absolute humidity***.
It is the weight of water vapour per unit volume of air and is expressed in terms of grams per cubic metre.
The ability of the air to hold water vapour depends entirely on its temperature. The absolute humidity differs from place to place on the surface of the earth.
The percentage of moisture present in the atmosphere as compared to its full capacityat a given temperature is known as the ***relative humidity***.
The air containing moisture to its full capacity at a given temperature is said to be ***saturated***.
The temperature at which saturation occurs in a given sample of air is known as ***dew point***.

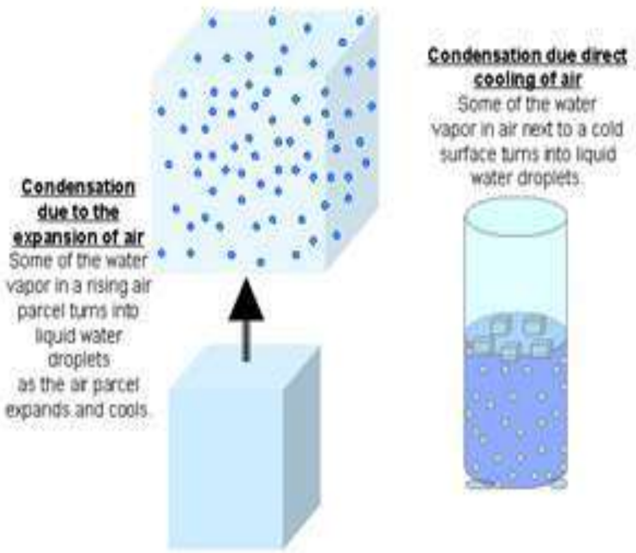
## WATER IN THE ATMOSPHERE EVAPORATION AND CONDENSATION

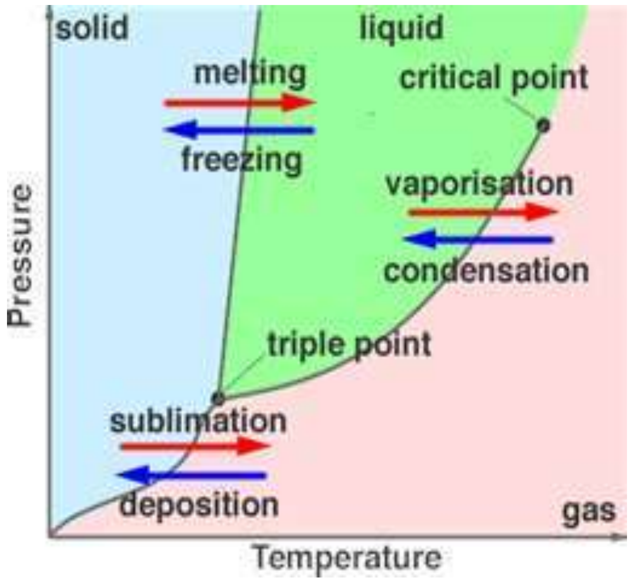
The amount of water vapour in the atmosphere is added or withdrawn due to evaporation and condensation respectively.
Evaporation is a process by which water is transformed from liquid to gaseous state. Heat is the main cause for evaporation.
The temperature at which the water starts evaporating is referred to as the ***latent heat of vaporization***.
Hence, the greater the movement of air, the greater is the evaporation.
The transformation of water vapour into water is called ***condensation***. Condensation is caused by the loss of heat. When moist air is cooled, it may reach a level when its capacity to hold water vapour ceases. Then, the excess water vapour condenses into liquid form. If it directly condenses into solid form, it is known as ***sublimation***.
In free air, condensation results from cooling around very small particles termed as hygroscopic condensation nuclei. Particles of dust, smoke and salt from the ocean are particularly good nuclei because they absorb water.
Condensation also takes place when the moist air comes in contact with some colder object and it may also take place when the temperature is close to the dew point.
Condensation, therefore, depends upon the amount of cooling and the relative humidity of the air. Condensation is influenced by the volume of air, temperature, pressure and humidity. Condensation takes place:

(i) When the temperature of the air is reduced to dew point with its volume remaining constant;
(ii)when both the volume and the temperature are reduced;
(iii) when moisture is added to the air through evaporation. However, the most favourable condition for condensation is the decrease in air temperature.

After condensation the water vapour or the moisture in the atmosphere takes one of the following forms — dew, frost, fog and clouds.
Forms of condensation can be classified on the basis of temperature and location.

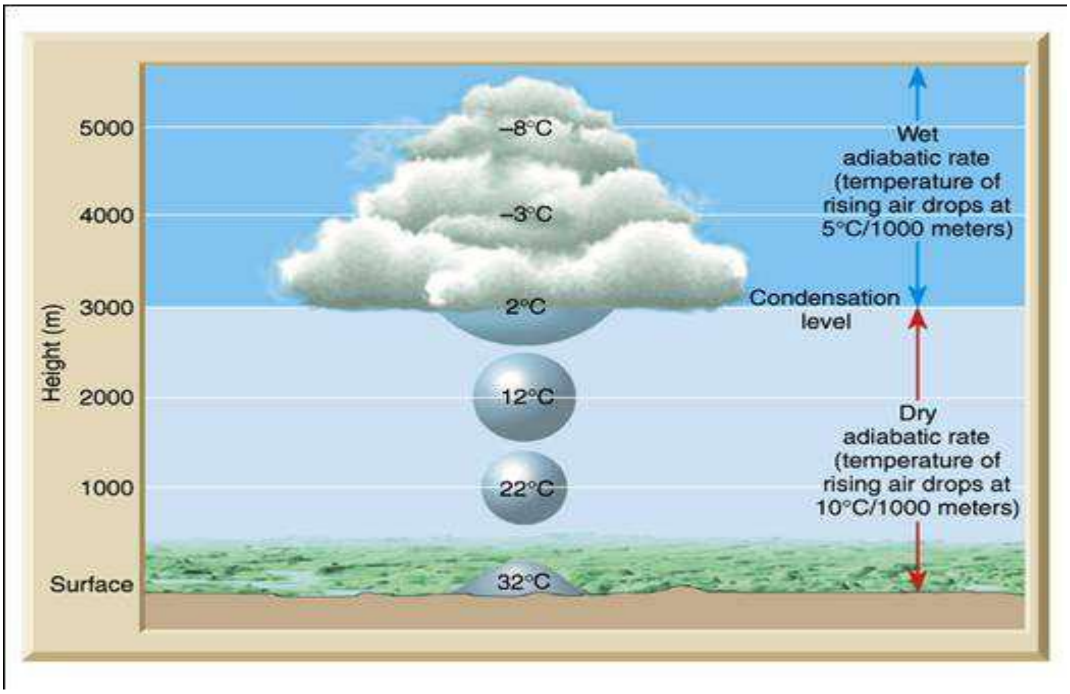
Condensation takes place when the dew point is lower than the freezing point as well as higher than the freezing point.




**Dew**

- When the moisture is deposited in the form of water droplets on cooler surfaces of solid objects (rather than nuclei in air above the surface) such as stones, grass blades and plant leaves, it is known as ***dew***.




The ideal conditions for its formation are 1. clear sky, 2. calm air, 3. high relative humidity, 4. cold and long nights.
For the formation of dew, it is necessary that the dew point is above the freezing point.
**Frost**
Frost forms on cold surfaces when condensation takes place below freezing point (0C), i.e. the dew point is at or below the freezing point. The excess moisture is deposited in the form of minute ice

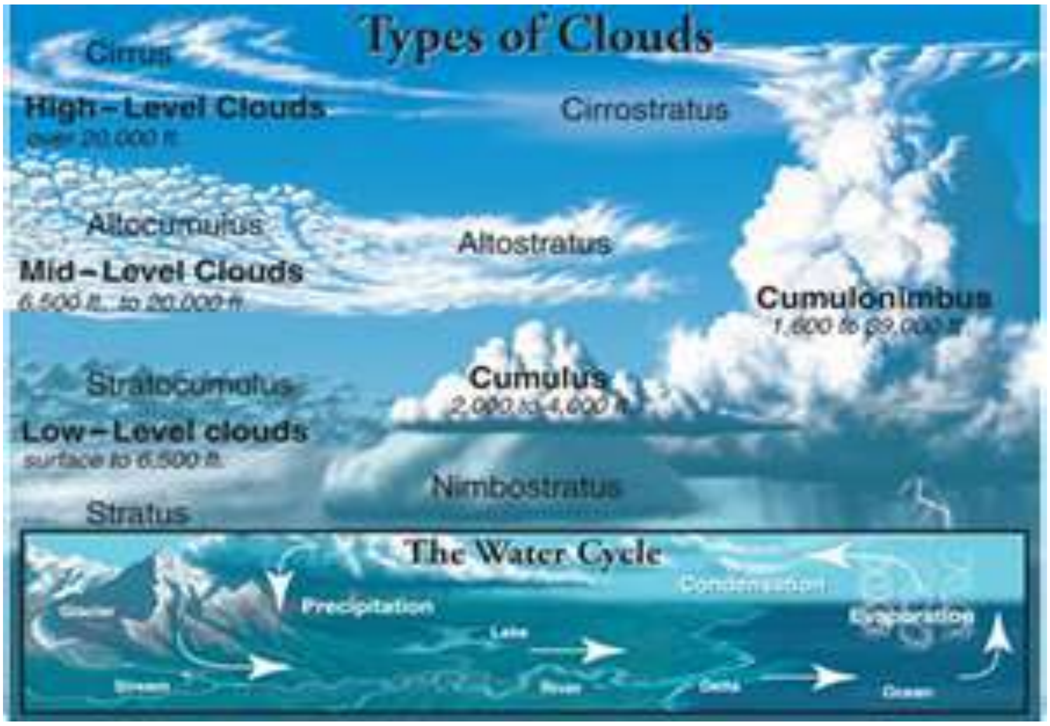
crystals instead of water droplets. The ideal conditions for the formation of white frost are the same as those for the formation of dew, except that the air temperature must be at or below the freezing point. 0

### Fog and Mist

When the temperature of an air mass containing a large quantity of water vapour falls all of a sudden, condensation takes place within itself on fine dust particles. So, the ***fog*** is a cloud with its base at or very near to the ground. Because of the fog and mist, the visibility becomes poor to zero. In urban and industrial centres smoke provides plenty of nuclei which help the formation of fog and mist. Such a condition when fog is mixed with smoke, is described as ***smog***.
The only difference between the mist and fog is that mist contains more moisture than the fog. In mist each nuclei contains a thicker layer of moisture. Mists are frequent over mountains as the rising warm air up the slopes meets a cold surface. Fogs are drier than mist and they are prevalent where warm currents of air come in contact with cold currents. Fogs are mini clouds in which condensation takes place around nuclei provided by the dust, smoke, and the salt particles.

### Clouds

Cloud is a mass of




minute water droplets or tiny crystals of ice formed by the condensation of the water vapour in free air at considerable elevations. As the clouds are formed at some height over the surface of the earth, they take
various shapes. According to their height, expanse, density and transparency or
opaqueness clouds are grouped under four types :
(i) cirrus; (ii) cumulus; (iii) stratus; (iv) nimbus.

### *Cirrus*

Cirrus clouds are formed at high altitudes(8,000 - 12, 000 m). They are thin and detached clouds having a feathery appearance. They are always white in colour.

### *Cumulus*

Cumulus clouds look like cotton wool. They are generally formed at a height of 4,000 -7,000 m. They exist in patches and can be seen scattered here and there. They have a flat base.

### *Stratus*

As their name implies, these are layered clouds covering large portions of the sky. These clouds are generally formed either due to loss of heat or the mixing of air masses with different temperatures.

### *Nimbus*

Nimbus clouds are black or dark gray. They form at middle levels or very near to the surface of the earth. These are extremely dense and opaque to the rays of the sun. Sometimes, the clouds are so low that they seem to touch the ground. Nimbus clouds are shapeless masses of thick vapour.
A combination of these four basic types can give rise to the following types of clouds: ***high clouds*** – cirrus, cirrostratus, cirrocumulus;
***middle clouds*** – altostratus and altocumulus;

*low clouds*– stratocumulus and nimbostratus
and ***clouds with extensive vertical development*** – cumulus and cumulonimbus.

**Precipitation**

The process of continuous condensation in free air helps the condensed particles to grow in size. When the resistance of the air fails to hold them against the force of gravity, they fall on to the earth's surface. So after the condensation of water vapour, the release of moisture is known as ***precipitation***. This may take place in liquid or solid form.
The precipitation in the form of water is called ***rainfall***, when the temperature is lower than the 0 C, precipitation takes place in the form of fine flakes of snow and is called ***snowfall***.
Moisture is released in the form of hexagonal crystals. These crystals form flakes of snow. Besides rain and snow, other forms of precipitation are ***sleet*** and ***hail***, though the latter are limited in occurrence and are sporadic in both time and space.
***Sleet*** is frozen raindrops and refrozen melted snow-water. When a layer of air with the temperature above freezing point overlies a subfreezing layer near the ground, precipitation takes place in the form of sleet. Raindrops, which leave the warmer air, encounter the colder air below. As a result, they solidify and reach the ground as small pellets of ice not bigger than the raindrops from which they are formed.
Sometimes, drops of rain after being released by the clouds become solidified in to small rounded solid pieces of ice and which reach the surface of the earth are called ***hailstones***.
These are formed by the rainwater passing through the colder layers. Hailstones have several concentric layers of ice one over the other.

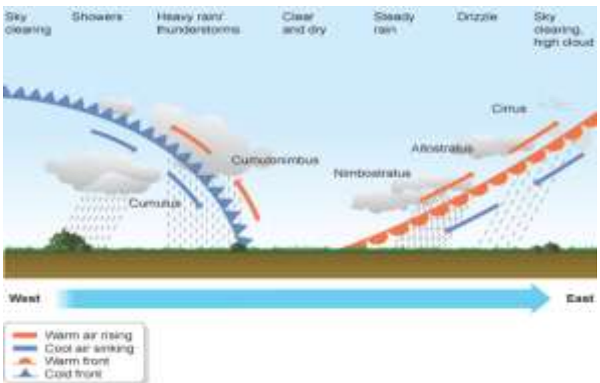
**Types of Rainfall**

On the basis of origin, rainfall may be classified into three main types –
**1. the convectional, 2. orographic or relief and 3. the cyclonic or frontal**.

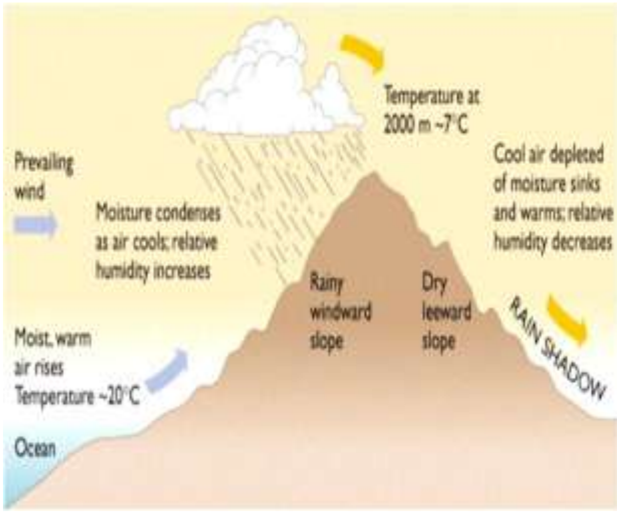
***Convectional Rain***

The, air on being heated, becomes light and rises up in convection currents. As it rises, it expands and loses heat and consequently, condensation takes place and cumulous clouds are formed. With thunder and lightening, heavy rainfall takes place but this does not last long. Such rain is common in the summer or
in the hotter part of the day. It is very common in the equatorial regions and interior parts of the continents, particularly in the northern hemisphere.

***cyclonic Rainfall***

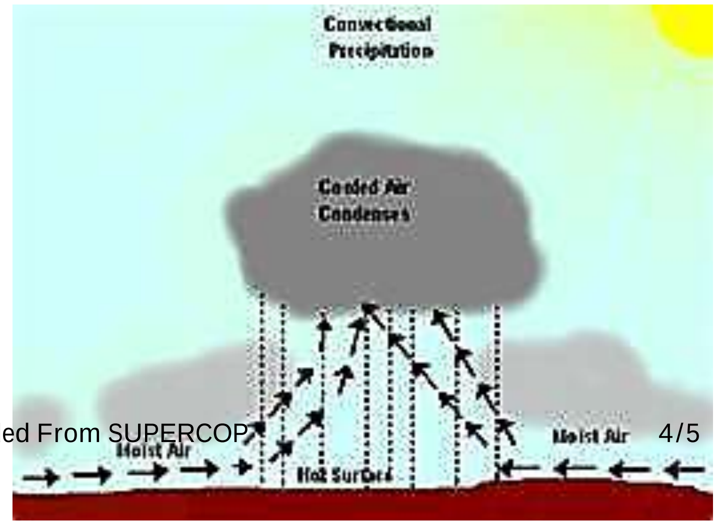



***Orographic rainfall***



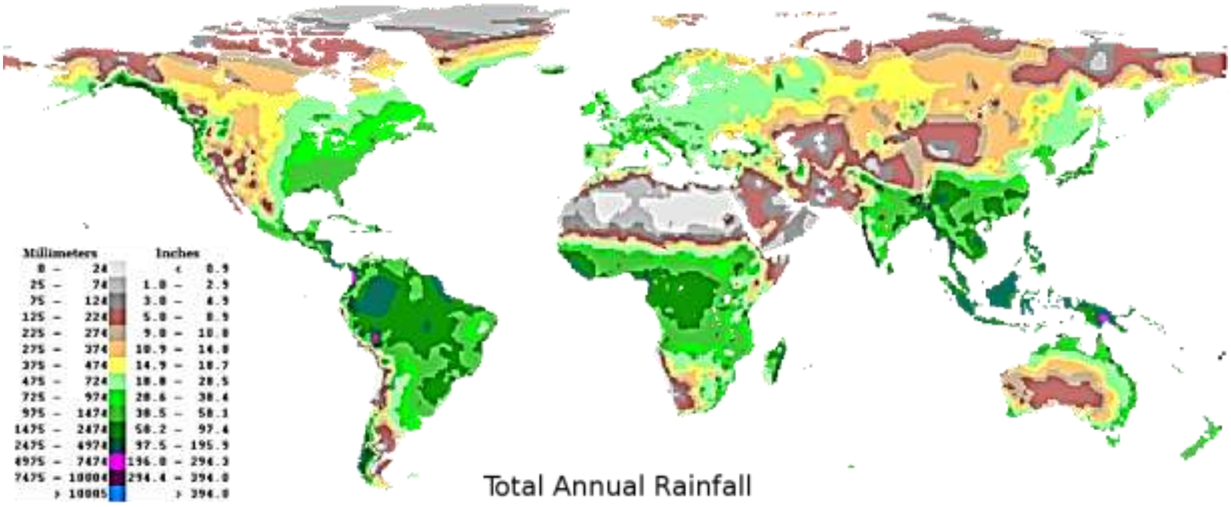

CONVECTIONAL RAIN FALL

When the saturated air mass comes across a mountain, it is forced to ascend and as it rises ,it expands; the temperature falls, and the moisture is condensed. The chief characteristic of this sort of rain is that the windward slopes receive greater rainfall. After giving rain on the windward side, when these winds reach the other slope, they



descend, and their temperature rises. Then their capacity to take in moisture increases and hence, these leeward slopes remain rainless and dry. The area situated on the leeward side, which gets less rainfall is known as the ***rain-shadow area***. It is also known as the ***relief rain***. ***Cyclonic Rain***

**World Distribution of Rainfall**




Different places on the earth's surface receive different amounts of rainfall in a year and that too in different seasons.

1. In general, as we proceed from the equator towards the poles, rainfall goes on decreasing steadily.
2. The coastal areas of the world receive greater amounts of rainfall than the interior of the continents.
3. The rainfall is more over the oceans than on the landmasses of the world because of being great sources of water.
4. Between the latitudes 35 and 40 N and S of the equator,
5. the rain is heavier on the eastern coasts and goes on decreasing towards the west.
6. But, between 45 and 65 N and S of equator, due to the westerlies, the rainfall is first received on the western margins of the continents and it goes on decreasing towards the east.
7. Wherever mountains run parallel to the coast, the rain is greater on the coastal plain, on the windward side and it decreases towards the leeward side.

**ON THE BASIS OF THE TOTAL AMOUNT OF ANNUALPRECIPITATION, MAJOR PRECIPITATION REGIMES OF THEWORLD ARE IDENTIFIED AS FOLLOWS.**

1. The equatorial belt, the windward slopes of the mountains along the western coasts in the cool temperate zone and the coastal areas of the monsoon land receive heavy rainfall of over 200 cm per annum.
2. Interior continental areas receive moderate rainfall varying from 100 - 200 cm per annum.
3. The coastal areas of the continents receive moderate amount of rainfall.
4. The central parts of the tropical land and the eastern and interior parts of the temperate lands receive rainfall varying between 50 - 100 cm per annum.
5. Areas lying in the rain shadow zone of the interior of the continents and high latitudes receive very low rainfall-less than 50 cm per annum.
6. Seasonal distribution of rainfall provides an important aspect to judge its effectiveness.
7. In some regions rainfall is distributed evenly throughout the year such as in the equatorial belt and in the western parts of cool temperate regions.

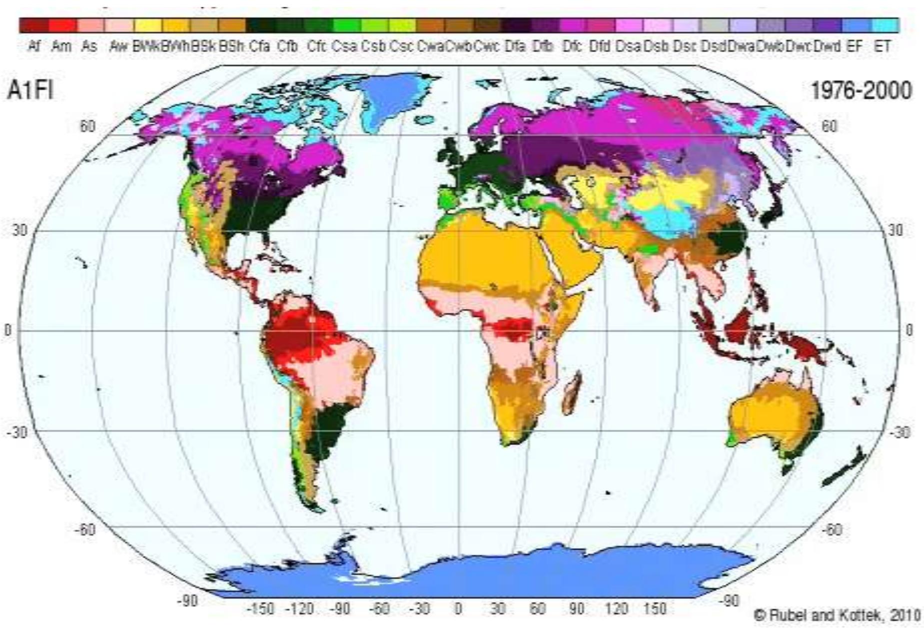
# CHAPTER-12 WORLD CLIMATE AND CLIMATE CHANGE

## This chapter deals with

The world climate can be studied by organizing information and data on climate and synthesizing them in smaller units for easy understanding, description and analysis. Three broad approaches have been adopted for classifying climate. They are empirical, genetic and applied. Empirical classification is based on observed data, particularly on temperature and precipitation. Genetic classification attempts to organize climates according to their causes. Applied classification is for specific purpose.

**KOEPPEN' S SCHEME OF CLASSIFICATION OF CLIMATE**

**Koeppen**




The most widely used classification of climate is the empirical climate classification scheme developed by V. Koeppen. Koeppen identified a close relationship between the distribution of vegetation and climate. He selected certain values of **temperature and precipitation** and related them to the distribution of vegetation and used these values for classifying the climates.

It is an empirical classification based on mean annual and mean monthly temperature and precipitation data. He introduced the use of capital and small letters to designate climatic groups and types. Although developed in 1918 and modified over a period of time, Koeppen's scheme is still popular and in use.

Koeppen recognized five major climatic groups, four of them are based on temperature and one on precipitation. Table 12.1 lists the climatic groups and their characteristics according to Koeppen.

The capital letters : A,C, D and E delineate humid climates and B dry climates.

The climatic groups are subdivided into types, designated by small letters, based on seasonality of precipitation and temperature characteristics.

The seasons of dryness are indicated by the small letters : f, m, w and s, where f corresponds to no dry season,

**Table 12.1 : Climatic Groups According to Koeppen**

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

m - monsoon climate, w- winter dry season and s - summer dry season.
The small letters a, b,c and d refer to the degree of severity of temperature.
The B- Dry Climates are subdivided using the capital letters S for steppe or semi-arid and W for deserts.

**Table 12.2 : Climatic Types According to Koeppen**

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

## Group A : Tropical Humid Climates

1. Tropical humid climates exist between Tropic of Cancer and Tropic of Capricorn. 2. The sunbeing overhead throughout the year and the presence of Inter Tropical Convergence Zone(ITCZ) make the climate hot and humid.
3. Annual range of temperature is very low and annual rainfall is high.
4. The tropical group is divided into three types, namely
(i) Af- Tropical wet climate;
(ii) Am - Tropical monsoon climate;
(iii) Aw- Tropical wet and dry climate.

***Tropical Wet Climate (Af)***

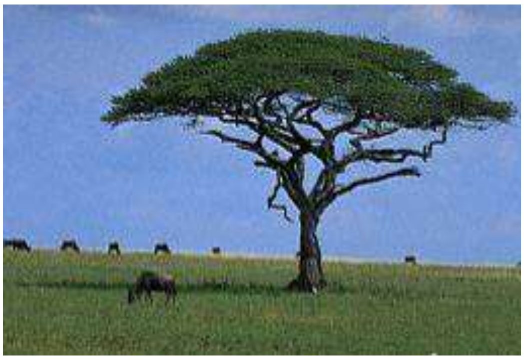
1. Tropical wet climate is found near the equator.
2. The major areas are the Amazon Basin in South America, western equatorial Africa and the islands of East Indies.
3. Significant amount of rainfall occurs in every month of the year as thunder showers in the afternoon.
4. The temperature is uniformly high and the annual range of temperature is negligible.
5. The maximum temperature on any day is around 30°C while the minimum temperature is around 20°C.
6. Tropical evergreen forests with dense canopy cover and large biodiversity are found in this climate

***Tropical Monsoon Climate (Am)***

Tropical monsoon climate (Am) is found over the Indian sub-continent, North Eastern part of South America and Northern Australia. Heavy rainfall occurs mostly in summer. Winter is dry.

***Tropical Wet and Dry Climate (Aw)***

Tropical wet and dry climate occurs north and south of Af type climate regions. It borders with dry climate on the western part of the continent and Cf or Cw on the eastern part.



Extensive Aw climate is found to the north and south of the Amazon forest in Brazil and adjoining parts of Bolivia and Paraguay in South America, Sudan and south of Central Africa. The annual rainfall in this climate is considerably less than that in Af and Am climate types and is variable also.

The wet season is shorter and the dry season is longer with the drought being more severe.

Temperature is high throughout the year and diurnal ranges of temperature are the
greatest in the dry season. Deciduous forest and tree-
shredded grasslands occur in this climate.

**Dry Climates : B**

Dry climates are characterized by very low rainfall that is not adequate for the growth of plants. These climates cover a very large areaof the planet extending over large latitudes from 15° - 60° north and south of the equator.

At low latitudes, from 15° - 30°, they occur in the area of subtropical high where subsidence and inversion of temperature do not produce rainfall.

On the western margin of the continents, adjoining the cold current, particularly over the west coast of South\ America, they extend more equator wards and occur on the coast land.

In middle latitudes, from 35° - 60° north and south of equator, they are confined to the interior of continents where maritime-humid winds do not reach and to areas often surrounded by mountains.

Dry climates are divided into steppe or semi-arid climate (BS) and desert climate (BW).

They are further subdivided as subtropical steppe (BSh) and subtropical desert (BWh) at latitudes from 15° - 35° and mid-latitude steppe (BSk) and mid-latitude desert (BWk) at latitudes between 35° - 60°.

***Subtropical Steppe (BSh) and Subtropical Desert (BWh) Climates***Subtropical steppe (BSh) and subtropical desert (BWh) have common precipitation and temperature characteristics.

Located in the transition zone between humid and dry climates, subtropical steppe receives slightly more rainfall than the desert, adequate enough for the growth of sparse grasslands.
The rainfall in both the climates is highly variable.
The variability in the rainfall affects the life in the steppe much more than in the desert, more often causing famine.
Rain occurs in short intense thundershowers in deserts and is ineffective in building soil moisture.
***Fog*** is common in coastal deserts bordering cold currents.
Maximum temperature in the summer is very high.
The highest shade temperature of 58° C was recorded at ***Al Aziziyah***, Libya on
13 September 1922. The annual and diurnal ranges of temperature are also high.

***Warm Temperate (Mid-Latitude) Climates-C***

Warm temperate (mid-latitude) climates extend from 30° - 50° of latitude mainly on the eastern and western margins of continents.
These climates generally have warm summers with mild winters.
They are grouped into four types:

(i) Humid subtropical, i.e. dry in winter and hot in summer (Cwa);
(ii) Mediterranean (Cs);
(iii) Humid subtropical, i.e. no dry season and mild winter (Cfa);
(iv) Marine west coast climate(Cfb).

***Humid Subtropical Climate (Cwa)***

Humid subtropical climate occurs pole ward of Tropic of Cancer and Capricorn, mainly in North Indian plains and South China interior plains.
The climate is similar to Aw climate except that the temperature in winter is warm.

***Mediterranean Climate (Cs)***

As the name suggests, Mediterranean climate occurs around Mediterranean sea, along the west coast of continents in subtropical latitudes between 30° - 40° latitudes e.g. — Central California, Central Chile, along the coast in south eastern and south western Australia.
These areas come under the influence of sub tropical high in summer and westerly wind in winter. Hence, the climate is characterised by hot, dry summer and mild, rainy winter.
Monthly average temperature in summer is around 25° C and in winter below 10°C. The annual precipitation ranges between 35 - 90 cm.

***Humid Subtropical (Cfa) Climate***

Humid subtropical climate lies on the eastern parts of the continent in subtropical latitudes.
In this region the air masses are generally unstable and cause rainfall throughout the year.
They occur in eastern United States of America, southern and eastern China, southern Japan, northeastern Argentina, coastal south Africa and eastern coast of Australia.
The annual averages of precipitation vary from 75-150 cm. Thunderstorms in summer and frontal precipitation in winter are common.
Mean monthly temperature in summer is around 27°C, and in winter it varies

from 5°-12° C. The daily range of temperature is small.

***Marine West Coast Climate (Cfb)***

Marine west coast climate is located poleward from the Mediterranean climate on the west coast of the continents.
The main areas are:
Northwestern Europe, west coast of North America, north of California, southern Chile, southeastern Australia and New Zealand.
Due to marine influence, the temperature is moderate and in winter, it is warmer its latitude.
The mean temperature in summer months ranges from 15°-20°C and in winter
4°-10°C. The annual and daily ranges of temperature are small. Precipitation occurs throughout the year.
Precipitation varies greatly from 50-250cm.

**Cold Snow Forest Climates (D)**

Cold snow forest climates occur in the large continental area in the northern hemisphere between 40°-70° north latitudes in Europe, Asia and North America. Cold snow forest climates are divided into two types:

(i) Df- cold climate with humid winter;
(ii) (ii) Dw- cold climate with dry winter.
(iii) The severity of winter is more pronounced in higher latitudes.

***Cold Climate with Humid Winters (Df)***

Cold climate with humid winter occurs pole ward of marine west coast climate and mid latitude steppe.
The winters are cold and snowy.
The frost free season is short.
The annual ranges of temperature are large.
The weather changes are abrupt and short.Poleward, the winters are more severe.

***Cold Climate with Dry Winters (Dew)***

Cold climate with dry winter occurs mainlyover North eastern Asia. The development of pronounced winter anticyclone and its weakening in summer sets in monsoon like reversal of wind in this region.

Pole ward summer temperatures are lower and winter temperatures are extremely low with many locations experiencing below freezing point temperatures for up to seven months in a year. Precipitation occurs in summer. The annual precipitation is low from 12-15 cm.

**polar Climates (E)**

Polar climates exist poleward beyond 70°latitude.
Polar climates consist of two types:
(i) Tundra (ET); (ii) Ice Cap (EF).

***Tundra Climate (ET)***

The tundra climate (ET) is so called after the types of vegetation, like low growing mosses, lichens and flowering plants.
This is the region of permafrost where the sub soil is permanently frozen. The short growing season and waterlogging support only low growing plants.
During summer, the tundra regions have very long duration of day light.

*Ice Cap Climate (EF)*

The ice cap climate (EF) occurs over interior Greenland and Antarctica. Even in summer, the temperature is below freezing point.
This area receives very little precipitation.
The snow and ice get accumulated and the mounting pressure causes the deformation of the ice sheets and they break.
They move as icebergs that float in the Arctic and Antarctic waters.
Plateau Station Antarctica ,79°S, portray this climate. HIGH LATITUDE CLIMATE
ICE CAP CLIMATE

**Highland Climates (H)**
Highland climates are governed by topography. In high mountains, large changes in mean temperature occur over short distances.
Precipitation types and intensity also vary spatially across high lands. There is vertical zonation of layering of climatic types with elevation in the mountain environment.

**CLIMATE CHANGE**

The type of climate we experience now might be prevailing over the last 10,000 years with minor and occasionally wide fluctuations.
India also witnessed alternate wet and dry periods.
Archaeological findings show that the Rajasthan desert experienced wet and cool climate around 8,000 B.C.
The period 3,0001,700 B.C. had higher rainfall. From about 2,000-1,700 B.C.,
this region was the centre of the Harappan civilization.
Dry conditions since then.
In the geological past, the earth was warm some 500-300 million years ago, through the Cambrian, Ordovician and Silurian periods.
During the Pleistocene epoch, glacial and inter-glacial periods occurred, the last major peak glacial period ago.
The present inter-glacial period started 10,000 years ago.

**Climate in the recent past**

Variability in climate occurs all the time. The 1990s recordedthe warmest temperature of the century andsome of the worst floods around the world.
The worst devastating drought in the Sahel region, south of the Sahara desert, from 1967-1977is one such variability.

During the 1930s, severe drought occurred in southwestern Great Plains of the United States, described as the ***dust bowl***.
Historical records of crop yield or crop failures, of floods and migration of people tell about the effects of changing climate.
A number of times Europe witnessed warm, wet, cold and dry periods, the significant episodes were the warm and dry conditions in the tenth and eleventh centuries,
when the Vikings settled in Greenland. Europe witnessed "Little Ice Age" from 1550 to about 1850.
From about 1885-1940 world temperature showed an upward trend. After 1940, the rate of increase in temperature slowed down.

## Causes of Climate Change

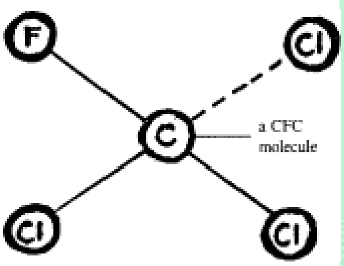
The causes for climate change are many.
They can be grouped into Astronomical 2.Terrestrial causes.
The astronomical causes area.
A. the changes in solar output associated with sunspot activities. Sunspots are dark and cooler patches on the sun which increase and decrease in a cyclical manner. B. According to some meteorologists, when the number of sunspots increase, cooler and wetter weather and greater storminess occur.
C. decrease in sunspot numbers is associated with warm and drier conditions. Yet, these findings are not statistically significant.
D. An another astronomical theory is Millankovitch oscillations, which infer cycles in the variations in the earth's orbital characteristics around the sun, the wobbling of the earth and the changes in the earth's axial tilt.
E. All these alter the amount of insolation received from the sun, which in turn, might have a bearing on the climate.
F. Volcanism is considered as another cause for climate change. Volcanic eruption throws up lots of aerosols into the atmosphere. These aerosols remain in the atmosphere for a considerable period of time reducing the sun's radiation reaching the Earth's surface.
After the recent Pinatoba and El Cion volcanic eruptions, the average temperature of the earth fell to some extent for some years.
The most important anthropogenic effect on the climate is the increasing trend in concentration of greenhouse gases in the atmosphere which is likely to cause global warming.

## Global Warming

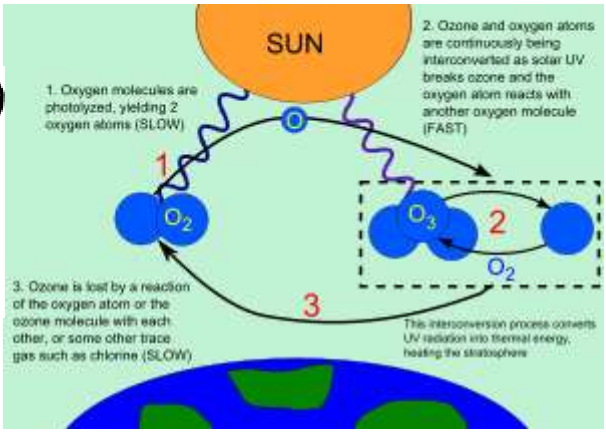
Due to the presence of greenhouse gases, the atmosphere is behaving like a ***greenhouse***. The atmosphere also transmits the incoming solar radiation but absorbs the vast majority of long wave radiation emitted upwards by the earth's surface. The gases that absorb long wave radiation are called greenhouse gases. The processes that warm the atmosphere are often collectively referred to as the ***greenhouse effect***.

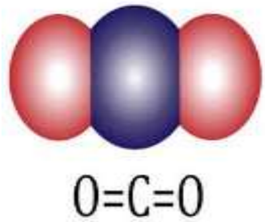
The term ***greenhouse*** is derived from the analogy to a greenhouse used in cold areas for preserving heat. ***A greenhouse*** is made up of glass. The glass which is transparent to incoming short wave solar radiation is opaque to outgoing long wave radiation. The glass, therefore, allows in more radiation and prevents the long wave radiation going outside the glass house, causing the temperature inside the glasshouse structure warmer than outside.

***Greenhouse Gases (GHGs)***
The primary GHGs of concern today are carbondioxide ($CO_2$),

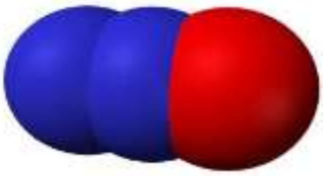


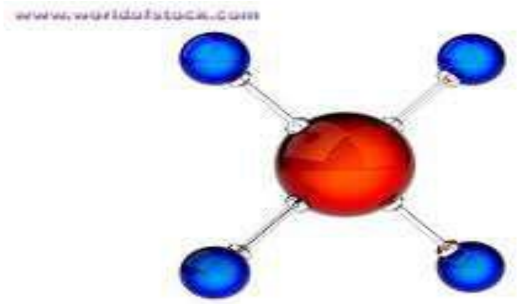

Chlorofluorocarbons



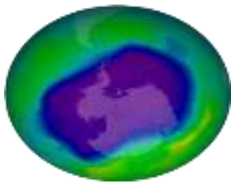
NITROUS OXIDE METHANE






(NO2) CH4

and ozone(O3). Some other gases such as nitric oxide (NO)and carbon monoxide (CO) easily react with GHGs and affect their concentration in the atmosphere.
The effectiveness of any given GHG will depend on the magnitude of the Increase in its concentration, its life time in the atmosphere and the wavelength of radiation that it absorbs. The chlorofluorocarbons(CFCs) are highly effective. ***Ozone*** which absorbs ultra violet radiation in the stratosphere is very effective in absorbing terrestrial radiation when it is present in the lower troposphere. Another important point to be noted is that the more time the GHG molecule remains in the atmosphere, the longer it will take for earth's atmospheric system to recover from any change brought about by the latter.
The ***largest concentration*** of GHGs in the atmosphere is ***carbon dioxide***.
1. The emission of CO2 comes mainly from fossil fuel combustion (oil, gas and coal). 2. Forests and oceans are the sinks for the carbon dioxide.
3. Forests use CO 2 in their growth.
4. So, deforestation
5. due to changes in land use, also increases the concentration of Co 2
The time taken for atmospheric CO2 to adjust to changes in sources to sinks is 20-50 years. It is rising at about 0.5 per cent annually.
Doubling of concentration of $co_2$ over pre-industrial levelis used as an index for estimating the changes in climate in climatic models.
Chlorofluorocarbons (CFCs) are products of human activity. ***Ozone*** occurs in the stratosphere where ultra-violet rays convert oxygen into ozone. Thus, ultra violet rays do not reach the earth's surface. The CFCs which drift into the stratosphere destroy the ozone .Large depletion of ozone occurs over Antarctica. ***The*** depletion ***of ozone concentration in the*** stratosphere is called the ***ozone hole***.



This allows the ultra violet rays to pass through the troposphere.
International efforts have been initiated for reducing the emission of GHGs into the atmosphere. The most important one is the ***Kyoto protocol*** proclaimed in 1997.
This protocol went into effect in 2005, ratified by 141 nations.
Kyoto protocol bounds the 35 industrialized countries to reduce their emissions by the year 2012 to 5 per cent less than the levels prevalent in the year 1990.
The increasing trend in the concentration of GHGs in the atmosphere may, in the long run, warm up the earth.
Once the global warming sets in, it will be difficult to reverse it. The effect of global warming may not be uniform everywhere.
Nevertheless, the adverse effect due to global warming will adversely affect the life supporting system.
Rise in the sea level due to melting of glaciers and ice-caps and thermal expansion of the sea may inundate large parts of the coastal area and islands, leading to social problems.
This is another cause for serious concern for the world community. Efforts have already been initiated to control the emission of GHGs and to arrest the trend towards global warming.
One of the major concerns of the world today is global warming.

.The annual average near-surface air temperature of the world is approximately 14°C. The greatest warming of the 20th century was during the two periods, 1901-44 and 1977-99.
Over each of these two periods, global temperatures rose by about 0.4°C. In between, there was a slight cooling, which was more marked in the Northern Hemisphere.
The globally averaged annual mean temperature at the end of the 20th century was about 0.6°C above that recorded at the end of the 19th century.
The seven warmest years during the 1856-2000 were recorded in the last decade.
The year 1998 was the warmest year, probably not only for the 20th century but also for the whole millennium.

## Kyoto declaration

(a) Implement and/or further elaborate policies and measures in accordance with its national circumstances, such as:

(i) Enhancement of energy efficiency in relevant sectors of the national economy;

(ii) Protection and enhancement of sinks and reservoirs of greenhouse gases not controlled by the Montreal Protocol, taking into account its commitments under relevant international environmental agreements; promotion of sustainable forest management practices, afforestation and reforestation;

(iii) Promotion of sustainable forms of agriculture in light of climate change considerations;

(iv) Research on, and promotion, development and increased use of, new and renewable forms of energy, of carbon dioxide sequestration technologies and of advanced and innovative environmentally sound technologies;

(v) Progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors that run counter to the objective of the Convention and application of market instruments;

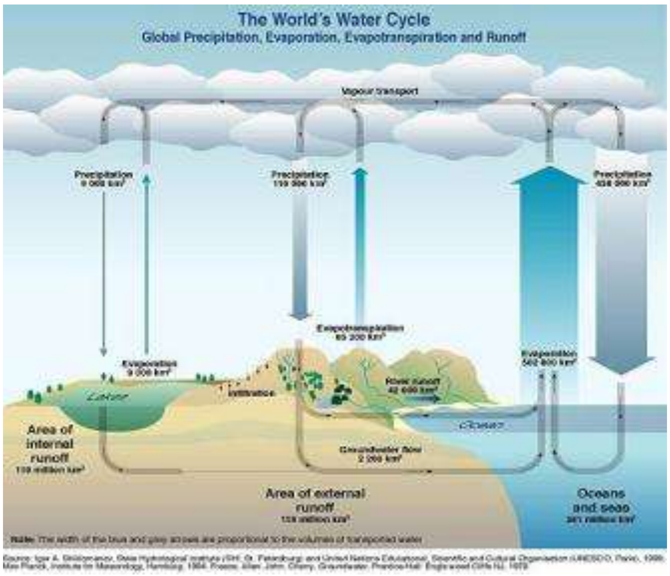
(vi) Encouragement of appropriate reforms in relevant sectors aimed at promoting policies and measures which limit or reduce emissions of greenhouse gases not controlled by the Montreal Protocol;

(vii) Measures to limit and/or reduce emissions of greenhouse gases not controlled by the Montreal Protocol in the transport sector;

(viii) Limitation and/or reduction of methane emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy;

## UNIT V CHAPTER -13 *WATER (OCEANS)*

*This unit deals with• Hydrological Cycle*
*• Oceans — submarine relief; distribution of temperature and salinity; movements of ocean water-waves, tides and currents*




The earth, fortunately has an abundant supply of water on its surface. Hence, our planet is called the ***'Blue Planet'***.

### HYDROLOGICAL CYCLE

The ***hydrological cycle***, is the circulation of water within the earth's hydrosphere in different forms i.e. the liquid, solid and the gaseous phases. It also refers to the continuous exchange of water between the oceans,

**STUDY THE GIVEN TABLE SHOWING THE WATER COMPOSITION ON THE EARTH SURFACE AND ANSWER THE FOLLOWING QUESTIONS**

**1. What is the % of water in the oceans?**
**2. Which component of the earth consists of least percentage of water content?**
**3. what is the main use of soil moisture?**

**Table 13.1 : Water on the Earth's surface**

| *Reservoir* | *Volume (Million Cubic km )* | *Percentage of the Total* |
|---|---|---|
| Oceans | 1,370 | 97.25 |
| Ice Caps and Glaciers | 29 | 2.05 |
| Groundwater | 9.5 | 0.68 |
| Lakes | 0.125 | 0.01 |
| Soil Moisture | 0.065 | 0.005 |
| Atmosphere | 0.013 | 0.001 |
| Streams and Rivers | 0.0017 | 0.0001 |
| Biosphere | 0.0006 | 0.00004 |

**Table 13.2 : Components and Processes of the Water Cycle**

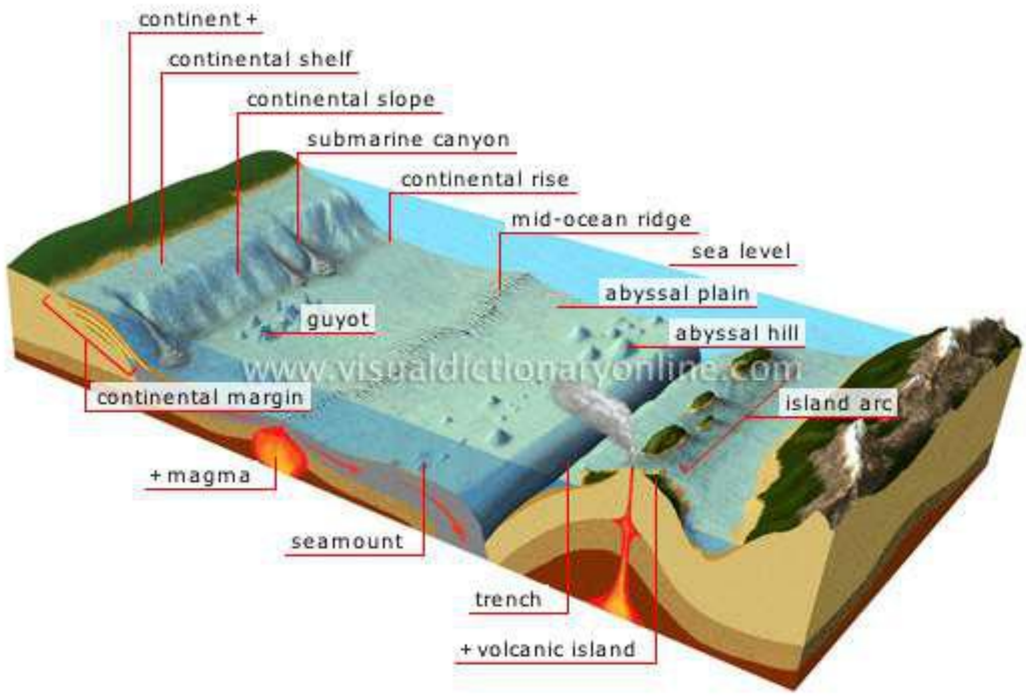
| Components | Processes |
|---|---|
| Water storage in oceans | Evaporation Evapotranspiration Sublimation |
| Water in the atmosphere | Condensation Precipitation |
| Water storage in ice and snow | Snowmelt runoff to streams |
| Surface runoff | Stream flow freshwater storage infiltration |
| Groundwater storage | Groundwater discharge springs |

**Study above table and answer the questions that fallow**

1. **What do you mean by evapotranspiration?**
2. **What are the different forms of water in the atmosphere?**

The above table shows the distribution of water on the surface of the earth. About 71 per cent of the planetary water is found in the oceans. The remaining is held as freshwater in glaciers and icecaps, groundwater sources, lakes, soil moisture, atmosphere, streams and within life. Nearly 59 per cent of the water that falls on land returns to the atmosphere through evaporation from over the oceans as well as from other places. The remainder runs-off on the surface, infiltrates into the ground or a part of it becomes glacier. It is to be noted that the renewable water on the earth is constant while the demand is increasing tremendously. This leads to water crisis in different parts of the world — spatially and temporally. The pollution of river waters has further aggravated the crisis. How can you intervene in improving the water quality and augmenting the available quantity of water?

**RELIEF OF THE OCEAN FLOOR**




**Divisions of the Ocean Floors**

The ocean floors can be divided into four major divisions:

1) The Continental Shelf;
2) The Continental Slope;
3) The Deep Sea Plain;
4) The Oceanic Deeps.

Besides, these divisions

There are also major and minor relief features in the ocean floors like ridges, hills, sea mounts, guyots, trenches, canyons, etc.

***Continental Shelf***

1. The continental shelf is the extended margin of each continent occupied by relatively shallow seas and gulfs.
2. It is the shallowest part of the ocean showing an average gradient of 1° or even less.
3. The shelf typically ends at a very steep slope, called the shelf break.
4. The width of the continental shelves vary from one ocean to another.
5. The average width of continental shelves is about 80 km.
6. The shelves are almost absent or very narrow along some of the margins like the coasts of Chile, the west coast of Sumatra, etc.
7. On the contrary, the Siberian shelf in the Arctic Ocean, the largest in the world, stretches to 1,500 km in width.
8. The depth of the shelves also varies. It may be as shallow as 30 m in some areas while in some areas it is as deep as 600 m.
9. The continental shelves are covered with variable thicknesses of sediments brought down by rivers, glaciers, wind, from the land and distributed by waves and currents. 10.Massive sedimentary deposits received over a long time by the continental shelves, become the source of fossil fuels.

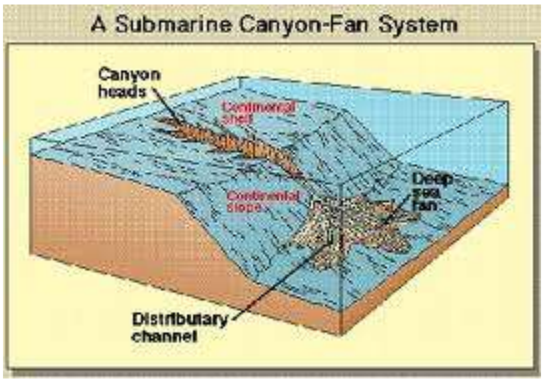
***Continental Slope***

1. The continental slope connects the continental shelf and the ocean basins.
2. It begins where the bottom of the continental shelf sharply drops off into a steep slope.
3. The gradient of the slope region varies between 2-5°.

4. The depth of the slope region varies between 200 and 3,000 m.

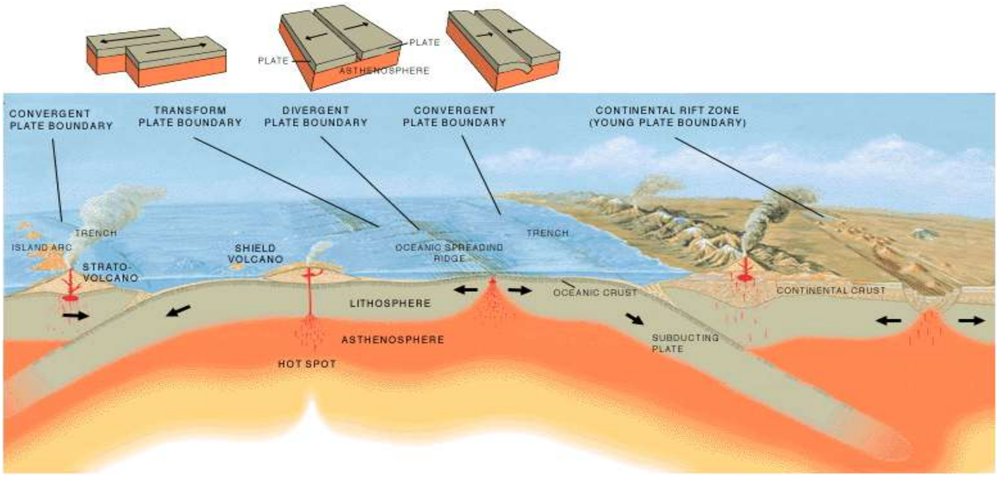
**Deep Sea Plain**

1. Deep sea plains are gently sloping areas of the ocean basins.
2. These are the flattest and smoothest regions of the world.
3. The depths vary between 3,000 and 6,000 m.
4. These plains are covered with fine-grained sediments like clay and silt.




**Oceanic Deeps or Trenches**

1. These areas are the deepest parts of the oceans.
2. The trenches are relatively steep sided, narrow basins.
3. They are some 3-5 km deeper than the surrounding ocean floor.
4. They occur at the bases of continental slopes and along island arcs and are associated with active volcanoes and strong earthquakes.
5. That is why they are very significant in the study of plate movements.
6. As many as 57 deeps have been explored so far; of which 32 are in the Pacific Ocean; 19 in the Atlantic Ocean and 6 in the Indian Ocean.




**Mid-Oceanic Ridges**

1. A mid-oceanic ridge is composed of two chains of mountains separated by a large depression.
2. The mountain ranges can have peaks as high as 2,500 m and some even reach above the ocean's surface.
3. Iceland, a part of the mid Atlantic Ridge, is an example.


***Seamount***

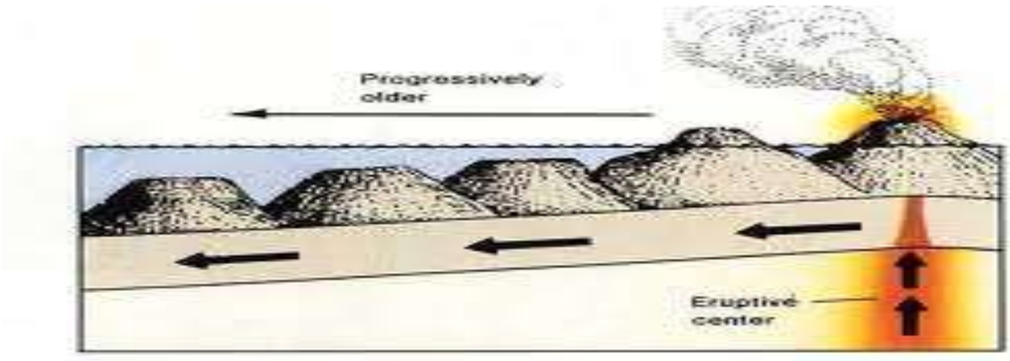
It is a mountain with pointed summits, rising from the seafloor that does not reach the surface of the ocean. Seamounts are volcanic in origin. These can be 3,000-4,500 m tall. The Emperor seamount, an extension of the Hawaiian Islands in the Pacific Ocean, is a good example.

***Submarine Canyons***

These are deep valleys, some comparable to the Grand Canyon of the Colorado river. They are sometimes found cutting across the continental shelves and slopes, often extending from the mouths of large rivers. The Hudson Canyon is the best known submarine canyon in the world.

***Guyots***

It is a flat topped seamount. They show evidences of gradual subsidence through stages to become flat topped submerged mountains. It is estimated that more than 10,000 seamounts and guyots exist in the Pacific Ocean alone.



Sea Floor Moving Over a Mantle Plume

***Atoll***

These are low islands found in the tropical oceans consisting of coral reefs surrounding a central depression. It may be a part of the sea (lagoon), or sometimes form enclosing a body of fresh, brackish, or highly saline water.

**TEMPERATURE OF OCEAN WATERS**

Ocean waters get heated up by the solar energy just as land. The process of heating and cooling of the oceanic water is slower than land.

**Factors Affecting Temperature Distribution ON THE OCEANS**

The factors which affect the distribution of temperature of ocean water are :

(i) ***Latitude***: the temperature of surface water decreases from the equator towards the poles because the amount of insolation decreases pole ward.

(ii) ***Unequal distribution of land and water*** : the oceans in the northern hemisphere receive more heat due to their contact with larger extent of land than the oceans in the southern hemisphere.

(iii) ***Prevailing wind*** : the winds blowing from the land towards the oceans drive warm surface water away form the coast resulting in the upwelling of cold water from below. It results into the longitudinal variation in the temperature. Contrary to this, the onshore winds pile up warm water near the coast and this raises the temperature.

***(iv) Ocean currents*** : warm ocean currents raise the temperature in cold areas while the cold currents decrease the temperature in warm ocean areas. Gulf stream (warm current) raises the temperature near the eastern coast of North America and the West Coast of Europe while the Labrador current (cold current) lowers the temperature near the north-east coast of North America.

**(v) Horizontal and Vertical Distribution of Temperature**

The temperature-depth profile for the ocean water shows how the temperature decreases with the increasing depth. The profile shows a boundary region between the surface waters of the ocean and the deeper layers. The boundary usually begins around 100 - 400 m below the sea surface and extends several hundred of metres downward .This boundary region, from where there is a rapid decrease of temperature, is called the ***thermocline***.

About 90 per cent of the total volume of water is found below the thermocline in the deep ocean. In this zone, temperatures approach 0° C. The temperature structure of oceans over middle and low latitudes can be described as a three-layer system from surface to the bottom.

The ***first layer*** represents the top layer of warm oceanic water and it is about 500m thick with temperatures ranging between 20° and 25° C. This layer, within the tropical region, is present throughout the year but in mid -latitudes it develops only during summer.

The ***second layer*** called the thermocline layer lies below the first layer and is characterized by rapid decrease in temperature with increasing depth. The thermocline is 500 -1,000 m thick.

The ***third layer*** is very cold and extends up to the deep ocean floor.

In the Arctic and Antarctic circles, the surface water temperatures are close to 0° C and so the temperature change with the depth is very slight. Here, only one layer of cold water exists, which extends from surface to deep ocean floor.

**SALINITY OF OCEAN WATERS**

Salinity is the term used to define the total content of dissolved salts in sea water It is calculated as the amount of salt (in gm) dissolved in 1,000 gm (1 kg) of seawater. It is usually expressed as parts per thousand (o/) or ppt. Salinity is an important property of sea water. Salinity of 24.7° /oo has been considered as the upper limit to demarcate 'brackish water'.

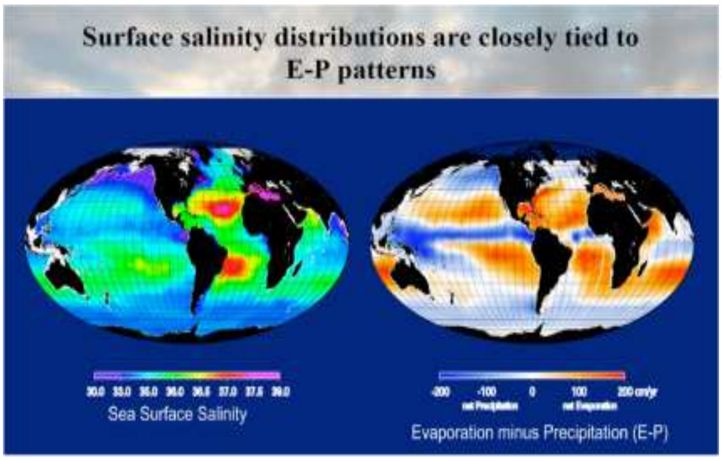
Factors affecting ocean salinity are mentioned below:

(i) The salinity of water in the surface layer of oceans depend mainly on evaporation and precipitation.
(ii) Surface salinity is greatly influenced in coastal regions by the fresh water flow from rivers, and in polar regions by the processes of freezing and thawing of ice.
(iii) Wind, also influences salinity of an area by transferring water to other areas.
(iv) The ocean currents contribute to the salinity variations. Salinity, temperature and density of water are interrelated. Hence, any change in the temperature or density influences the salinity of water in an area.

> Highest salinity in water bodies
> Lake Van in Turkey (330 °/$_{oo}$).
> Dead Sea (238 °/$_{oo}$).
> Great Salt Lake (220 °/$_{oo}$)

**Table 13.4 : Dissolved Salts in Sea Water (gm of Salt per kg of Water)**

| | |
|---|---|
| Chlorine | 18.97 |
| Sodium | 10.47 |
| Sulphate | 2.65 |
| Magnesium | 1.28 |
| Calcium | 0.41 |
| Potassium | 0.38 |
| Bicarbonate | 0.14 |
| Bromine | 0.06 |
| Borate | 0.02 |
| Strontium | 0.01 |




## HORIZONTAL DISTRIBUTION OF SALINITY

The salinity for normal open ocean ranges between 33 o/ oo. and 37 o/oo. In the land locked Red Sea, it is as high as 41 o/00 while in the estuaries and the Arctic, the salinity fluctuates from 0 - 35 o/oo, seasonally. In hot and dry regions, where evaporation is high, the salinity sometimes reaches to 70 o/

The salinity variation in the Pacific Ocean is mainly due to its shape and larger areal extent. Salinity decreases from 35 o/oo on the western parts of the northern hemisphere because of the influx of melted water from the Arctic region. In the same way, after 15° - 20° south, it decreases to 33 - 31 o/oo The average salinity of the Atlantic Ocean is around 36 0/00 The highest salinity is recorded between 15° and 20° latitudes.

Maximum salinity (37 o/oo.) is observed between 20° N and 30° N and 20° W - 60° W. It gradually decreases towards the north. The North Sea, in spite of its location in higher latitudes, records higher salinity due to more saline water brought by the North Atlantic Drift. Baltic Sea records low salinity due to influx of river waters in large quantity. The Mediterranean records higher salinity due to high evaporation.

## Vertical Distribution of Salinity

1. Salinity changes with depth, but the way it changes depends upon the location of the sea.
2 .Salinity at the surface increases by the loss of water to ice or evaporation, or decreased by the input of fresh waters, such as from the rivers.
3. Salinity at depth is very much fixed, because there is no way that water is 'lost', or the salt is 'added.'
4. There is a marked difference in the salinity between the surface zones and the deep zones of the oceans.
5. The lower salinity water rests above the higher salinity dense water.
6. Salinity, generally, increases with depth and there is a distinct zone called the ***halocline,*** where salinity increases sharply. Other factors being constant, increasing salinity of sea water causes its density to increase. High salinity sea water, generally, sinks below the lower salinity water. This leads to stratification by salinity

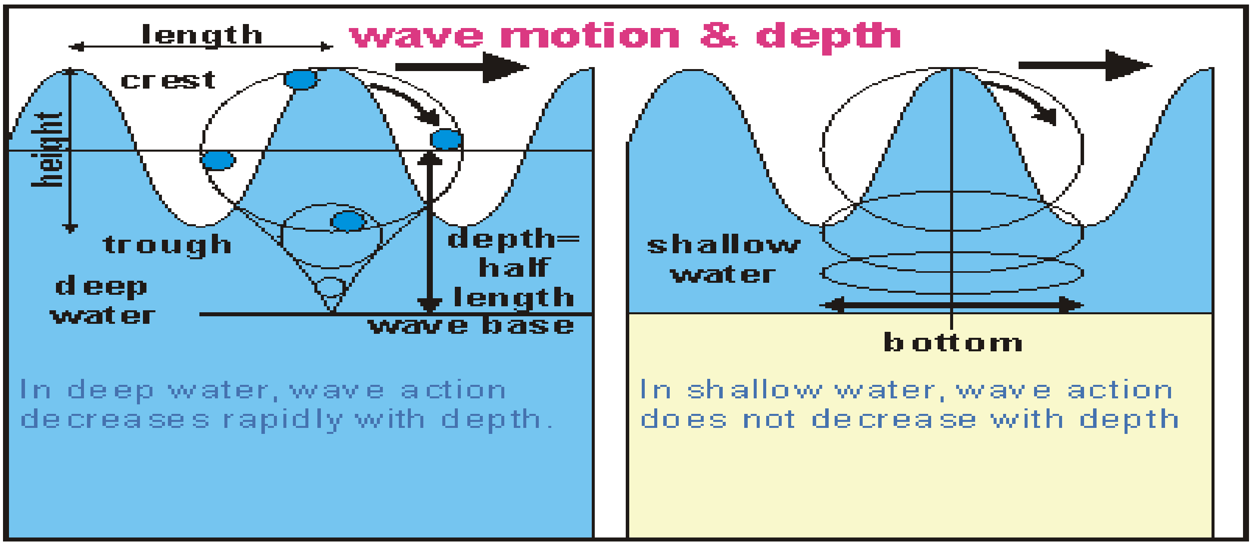
# CHAPTER 14 MOVEMENTS OF OCEAN WATER

This chapter deals with

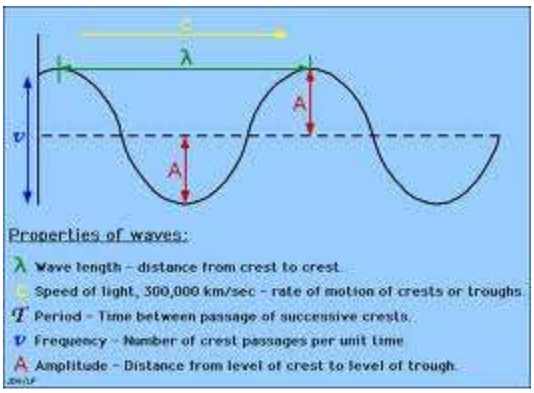
- Waves
- Characteristics Of Waves Tides Factors Influencing Waves And Tides
- Types Of Tides Semidiurnal , Diurnal Tide, Mixed , Spring, Neap Tides
- Importance Of Tides
- Ocean Currents
- Types Of Ocean Currents
- Major Ocean Currents
- Effects Of Ocean Currents

The ocean water is dynamic. Its physical characteristics like temperature, salinity, density and the external forces like of the sun, moon and the winds influence the movement of ocean water.
The horizontal and vertical motions are common in ocean water bodies.
The horizontal motion refers to the ocean currents and waves.
The vertical motion refers to tides.
Ocean currents are the continuous flow of huge amount of water in a definite direction while the waves are the horizontal motion of water.
Water moves ahead from one place to another through ocean currents while the water in the waves does not move, but the wave trains move ahead.
The vertical motion refers to the rise and fall of water in the oceans and seas.
Due to attraction of the sun and the moon, the ocean water is raised up and falls down twice a day.
The upwelling of cold water from subsurface and the sinking of surface water are also forms of vertical motion of ocean water.

## WAVES




Waves are actually the energy, not the water as such, which moves across the ocean surface.
Water particles only travel in a small circle as a wave passes. Wind provides energy to the waves.
Wind causes waves to travel in the ocean and the energy is released on shorelines.




### Characteristics of Waves

***Wave crest and trough*** : The highest and lowest points of a wave are called the crest and trough respectively.
***Wave height***: It is the vertical distance from the bottom of a trough to the top of a crest of a wave.
***Wave amplitude*** : It is one-half of the wave height.
***Wave period*** : It is merely the time interval between two successive wave crests or troughs as they pass a fixed point.

***Wavelength***: It is the horizontal distance between two successive crests.
***Wave speed*** : It is the rate at which the wave moves through the water, and is measured in knots.
***Wave frequency***: It is the number of waves passing a given point during a one second time interval.

## TIDES

The periodical rise and fall of the sea level, once or twice a day, mainly due to the attraction of the sun and the moon, is called a ***tide***.

**Movement of water caused by meteorological effects (winds and atmospheric pressure changes) are called *surges*.**
Surges are not regular like tides.

The 'tide-generating' force is the difference between these two forces; i.e. the gravitational attraction of the moon and the centrifugal force.

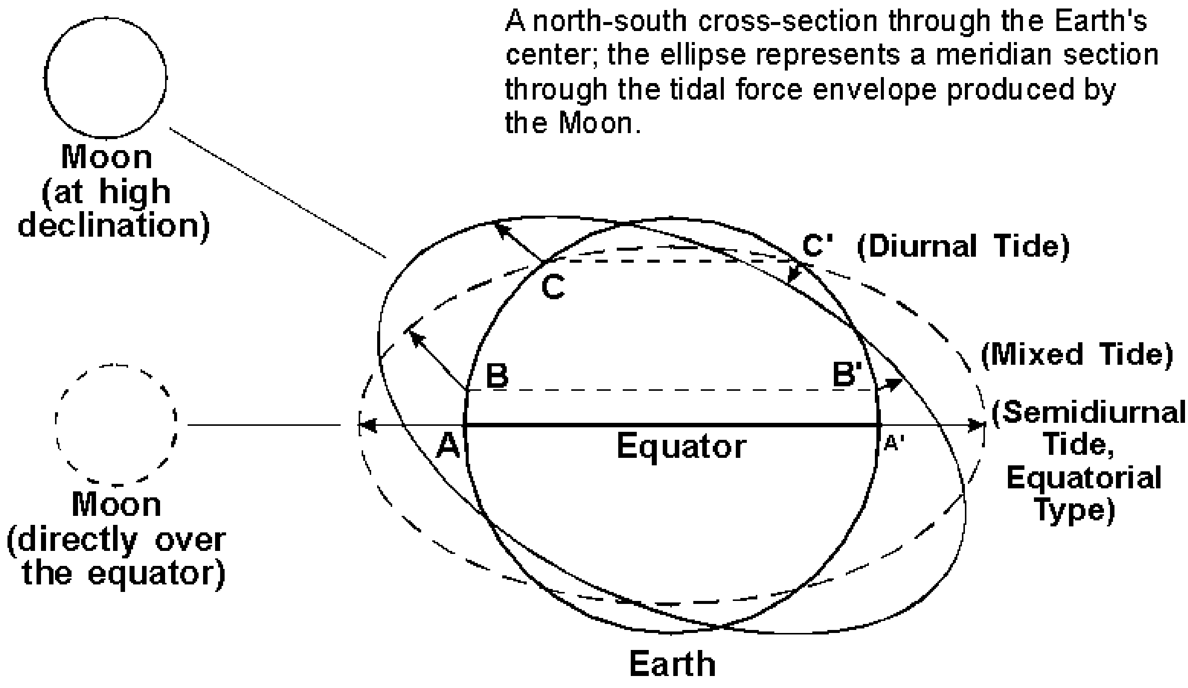
On the surface of the earth, the horizontal tide generating forces are more important than the vertical forces in generating the tidal bulges.

The tidal bulges on wide continental shelves, have greater height. When tidal bulges hit the mid-oceanic islands they become low.
The shape of bays and estuaries along a coastline can also magnify the intensity of tides.
Funnel-shaped bays greatly change tidal magnitudes. When the tide is channeled between islands or into bays and estuaries they are called ***tidal currents***.

### Tides of Bay of Fundy, Canada


The highest tides in the world occur in the Bay of Fundy in Nova Scotia, Canada. The tidal bulge is 15 - 16 m. Because there are two high tides and two low tides every day (roughly a 24 hour period); then a tide must come in within about a six hour period. As a rough estimate, the tide rises about 240 cm an hour (1,440 cm divided by 6 hours). If you have walked down a beach with a steep cliff alongside (which is common there), make sure you watch the tides. If you walk for about an hour and then notice that the tide is coming in, the water will be over your head before you get back to where you started!

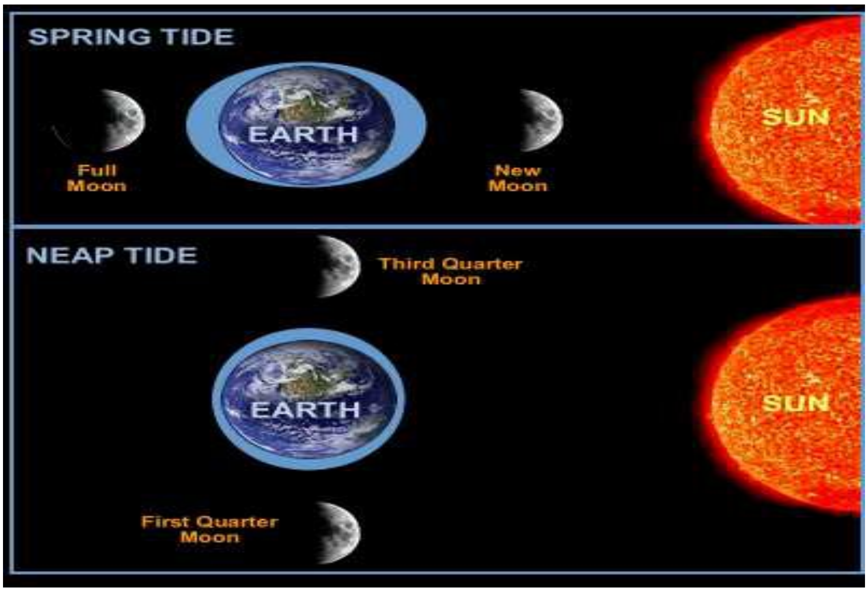
**Types of Tides**
Tides vary in their frequency, direction and movement from place to place and also from time to time. Tides may be grouped into various types based on their frequency of occurrence in one day or 24 hours or based on their height.
***Tides based on Frequency***
***Semi-diurnal tide :***The most common tidal pattern, featuring two high tides and two low tides each day. The successive high or low tides are approximately of the same height.
***Diurnal tide :*** There is only one high tide and one low tide during each day. The successive high and low tides are approximately of the same height.




***Mixed tide :*** Tides having variations in height are known as mixed tides. These tides generally occur along the west coast of North America and on many islands of the Pacific Ocean.

***Tides based on the Sun, Moon and the Earth Positions The height of rising water (high tide) varies appreciably depending upon the position of sun and moon with respect to the earth. Spring tides and neap tides come under this category.***

***Spring tides*** : The position of both the sun and the moon in relation to the earth has direct bearing on tide height. When the sun, the moon and the earth are in a straight line, the height of the tide will be higher. These are called spring tides and they occur twice a month, one on full moon period and another during new moon
period.



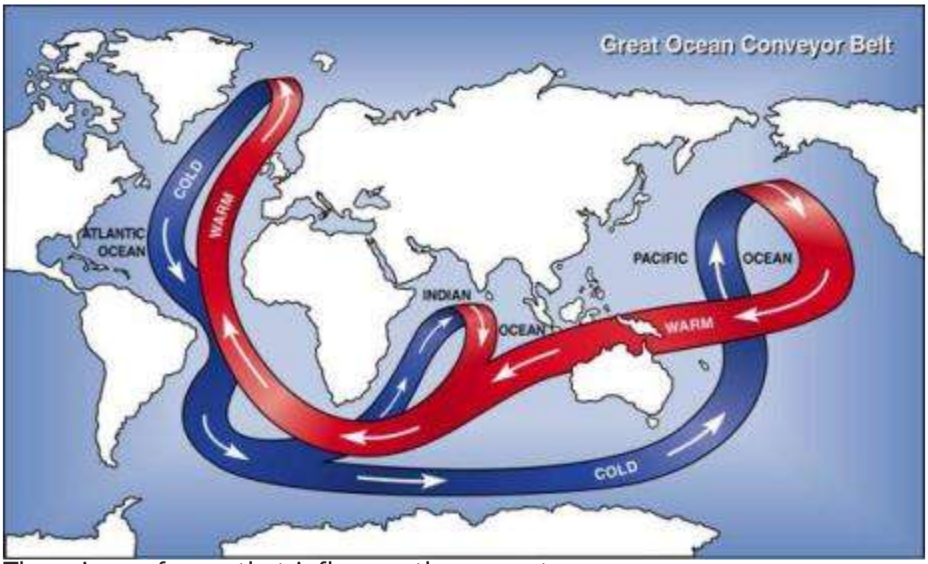

***Neap tides*** :Normally, there is a seven day interval between the spring tides and neap tides. At this time the sun and moon are at right angles to each other and the forces of the sun and moon tend to counteract one another. The Moon's attraction, though more than twice as strong as the sun's, is diminished by the counteracting force of the sun's gravitational pull.
Once in a month, when the moon's orbit is closest to the earth ***(perigee)***, unusually high and low tides occur. During this time the tidal range is greater than normal. Two weeks later, when the moon is farthest from earth ***(apogee)***, the moon's gravitational force is limited and the tidal ranges are less than their average heights. When the earth is closest to the sun***(perihelion)***, around 3rd January each year, tidal ranges are also much greater, with unusually high and unusually low tides. When the earth is farthest from the sun ***(aphelion)***,around 4th July each year, tidal ranges are much less than average. The time between

the high tide and low tide, when the water level is falling, is called the ***ebb***. The time between the low tide and high tide, when the tide is rising, is called the ***flow*** or ***flood***.

## Importance of Tides

Since tides are caused by the earth-moon-sun positions which are known accurately, the tides can be predicted well in advance. This helps the navigators and fishermen plan their activities. Tidal flows are of great importance in navigation. Tidal heights are very important, especially harbors near rivers and within estuaries having shallow 'bars' at the entrance, which prevent ships and boats from entering into the harbour. Tides are also helpful in desilting the sediments and in removing polluted water from river estuaries. Tides are used to generate electrical power (in Canada, France, Russia, and China). A 3 MW tidal power project at Durgaduani in Sunderbans of West Bengal is under way.

## OCEAN CURRENTS




Ocean currents are like river flow in oceans. They represent a regular volume of water in a definite path and direction. Ocean currents are influenced by two types of forces namely :

(i) primary forces that initiate the movement of water;

(ii) secondary forces that influence the currents to flow.

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

## Characteristics of Ocean Currents

1. Currents are referred to by their "drift".
2. the currents are strongest near the surface and may attain speeds over five knots.
3. At depths, currents are generally slow with speeds less than 0.5 knots.
4. We refer to the speed of a current as its "drift."
5. Drift is measured in terms of knots.
6. The strength of a current refers to the speed of the current. A fast current is considered strong.
7. A current is usually strongest at the surface and decreases in strength (speed) with depth. 8.Most currents have speeds less than or equal to 5 knots.
9 .Differences in water density affect vertical mobility of ocean currents.
10. Water with high salinity is denser than water with low salinity and in the same way cold water is denser than warm water.
11. Denser water tends to sink, while relatively lighter water tends to rise.
12. Cold-water ocean currents occur when the cold water at the poles sinks and slowly moves towards the equator.
Warm-water currents travel out from the equator along the surface, flowing towards the poles to replace the sinking cold water.

**Types of Ocean Currents**
The ocean currents may be classified based on their depth as surface currents and deep water currents :
(i) ***surface currents*** constitute about 10 per cent of all the water in the ocean, these waters are the upper 400 m of the ocean;
(ii) ***deep water currents*** make up the other 90 per cent of the ocean water. These waters move around the ocean basins due to variations in the density and gravity. Deep waters sink into the deep ocean basins at high latitudes, where the temperatures are cold enough to cause the density to increase.
Ocean currents can also be classified based on temperature :
as cold currents and warm currents:
(i)***cold currents*** bring cold water into warm water areas.
These currents are usually found on the west coast of the continents in the low and middle latitudes (true in both hemispheres) and on the east coast in the higher latitudes in the Northern Hemisphere;
(ii) ***warm currents*** bring warm water into cold water areas and are usually observed on the east coast of continents in the low and middle latitudes (true in both hemispheres). In the northern hemisphere they are found on the west coasts of continents in high latitudes.

***Major Ocean Currents Figure 14.3***


1. Major ocean currents are greatly influenced by the stresses exerted by the prevailing winds and coriolis force.
2. The oceanic circulation pattern roughly corresponds to the earth's atmospheric circulation pattern.
3. The air circulation over the oceans in the middle latitudes is mainly anticyclonic (more pronounced in the southern hemisphere than in the northern hemisphere).
4. The oceanic circulation pattern also corresponds with the same. At higher latitudes, where the wind flow is mostly cyclonic, the oceanic circulation follows this pattern.
5. In regions of pronounced monsoonal flow, the monsoon winds influence the current movements.
6. Due to the coriolis force, the warm currents from low latitudes tend to move to the right in the northern hemisphere and to their left in the southern hemisphere.
7. The oceanic circulation transports heat from one latitude belt to another in a manner similar to the heat transported by the general circulation of the atmosphere. 8. The cold waters of the Arctic and Antarctic circles move towards warmer water in tropical and equatorial regions, while the warm waters of the lower latitudes move pole wards.
9. The major currents in the different oceans are shown in the above figure.
Prepare a list of currents which are found in Pacific, Atlantic and Indian Ocean
How is the movement of currents influenced by prevailing winds? Give some examples from Figure14.3.

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

UNIT VI CHAPTER-15 *LIFE ON THE EARTH*

*This unit deals with*

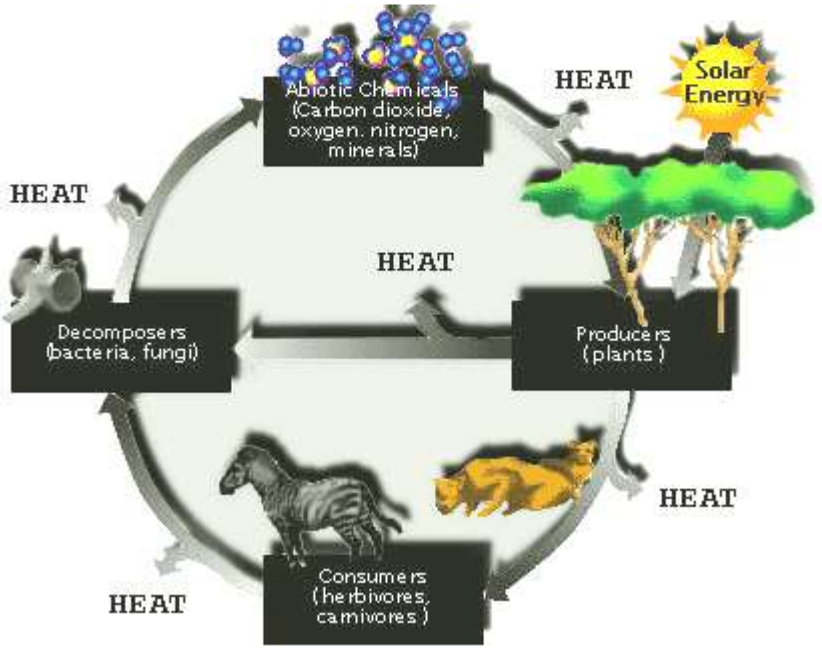
- *Biosphere — Importance Of Plants And Other Organisms;*
- *Ecosystems,*
- *Bio-Geo Chemical Cycle And Ecological Balance;*
- *Biodiversity And Conservation*

## LIFE ON THE EARTH

Living organisms of the earth, constituting the ***biosphere*****,** interact with other environmental realms. The biosphere includes all the living components of the earth. It consists of all plants and animals, including all the micro- organisms that live on the planet earth and their interactions with the surrounding environment.

Organisms exist on the lithosphere, the hydrosphere as well as in the atmosphere.
The biosphere and its components are very significant elements of the environment. These elements interact with other components of the natural landscape such as land, water and soil. They are also influenced by the atmospheric elements such as the temperature, rainfall, moisture and sunlight.

The interactions of biosphere with land, air and water are important to the growth, development and evolution of the organism. The interactions of a particular group of organisms with abiotic factors within a particular habitat resulting in clearly defined energy flows and material cycles on land, water and air, are called ***ecological systems***.



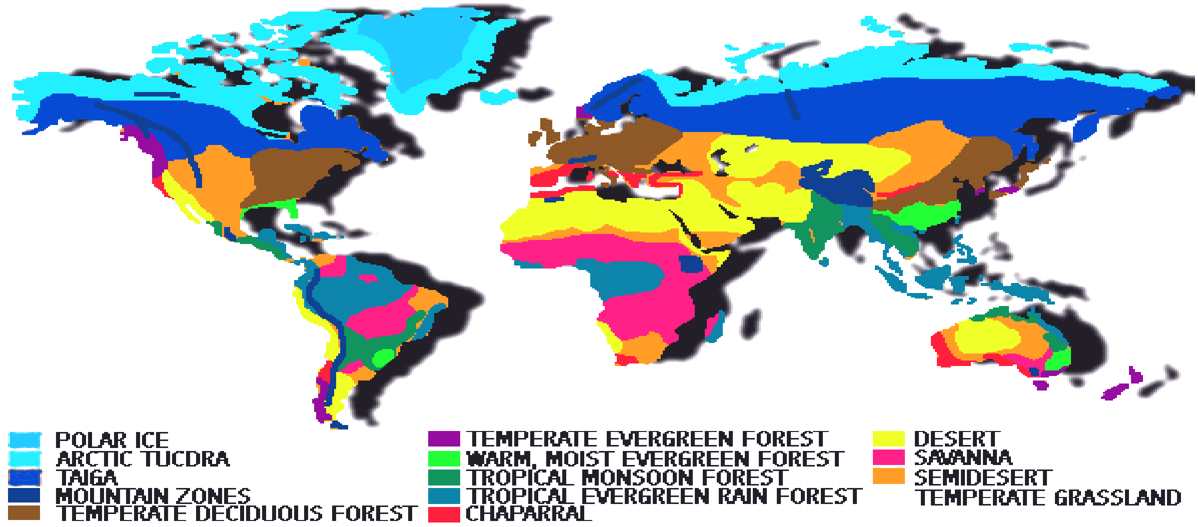

The term ***ecology*** is derived from the Greek word ***'oikos'*** meaning 'house', combined with the word ***'logy'*** meaning the 'science of' or 'the study of '. Literally, ecology is the study of the earth as a 'household', of plants, human beings, animals and micro-organisms. They all live together as interdependent components. A German zoologist ***Ernst Haeckel***, who used the term as '***oekologie***' in 1869, became the first person to use the term 'ecology'. The study of interactions between life forms (biotic) and the physical environment (abiotic) is the science of ecology. Hence, ***ecology can be defined as a scientific study of the interactions of organisms with their physical environment and with each other***.

A ***habitat*** in the ecological sense is the totality of the physical and chemical factors that constitute the general environment.

A system consisting of biotic and abiotic components is known as ecosystem.

Different types of ecosystems exist with varying ranges of environmental conditions where various plants and animal species have got adapted through evolution. This phenomenon is known as ***ecological adaptation***.

## Types of Ecosystems




Ecosystems are of two major types:
***Terrestrial*** and ***aquatic***. Terrestrial ecosystem can be further be classified into ***'biomes'***.
***A biome*** is a plant and animal community that covers a large geographical area.
The boundaries of different biomes on land are determined mainly by climate.
A biome can be defined as the total assemblage of plant and animal species interacting within specific conditions.
These include rainfall, temperature, humidity and soil conditions.
Some of the major biomes of the world are: ***forest, grassland, desert and tundra biomes***.
Aquatic ecosystems can be classed as marine and freshwater ecosystems. Marine ecosystem includes the oceans, estuaries and coral reefs. Freshwater ecosystem includes lakes, ponds, streams, marshes and bogs.

## Structure and Functions of Ecosystems

The structure of an ecosystem involves a description of the available plant and animal species. From a structural point of view, all ecosystems consist of abiotic and biotic factors.
***Abiotic factors*** include rainfall, temperature, sunlight, atmospheric humidity, soil conditions, inorganic substances (carbon dioxide, water, nitrogen, calcium, phosphorus, potassium, etc.).
***Biotic factors*** include the producers, the consumers (primary, secondary, tertiary) and the decomposers.

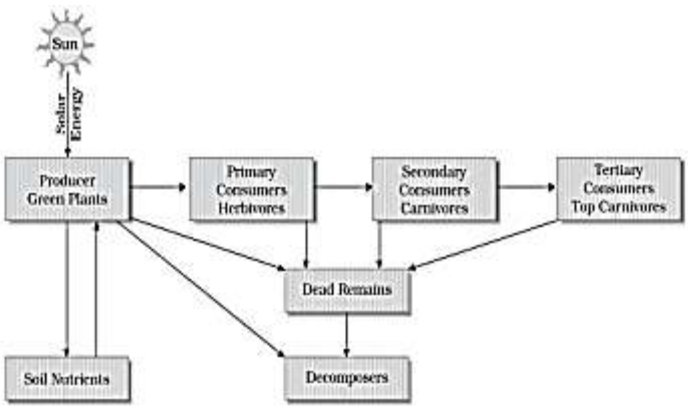



Figure 15.1 : Structure and functions of ecosystems

The ***producers*** include all the green plants, which manufacture their own food through photosynthesis.
The ***primary consumers*** include herbivorous animals like deer, goats, mice and all plant-eating animals.
The ***carnivores*** include all the flesh-eating animals like snakes, tigers and lions. Certain carnivores that feed also on carnivores are known as top carnivores like hawks and mongooses.
***Decomposers*** are those that feed on dead organisms (for example, scavengers like vultures and crows), and further breaking down of the dead matter by other decomposing agents like bacteria and various microorganisms.

The producers are consumed by the primary consumers whereas the primary consumers are, in turn, being eaten by the secondary consumers.

Further, the secondary consumers are consumed by the tertiary consumers.
The decomposers feed on the dead at each and every level. They change them into various substances such as nutrients, organic and inorganic salts essential for soil fertility.
This sequence of eating and being eaten and the resultant transfer of energy from one level to another is known as the ***food-chain***.
Transfer of energy that occurs during the process of a food chain from one level to another is known as ***flow of energy***.
This interconnecting network of species is known as ***food web***.
There are two types of food-chains are recognized:
***grazing food-chain*** and ***detritus food-chain***.
There is a loss of energy at each level which may be through respiration, excretion or decomposition.
The levels involved in a food chain range between three to five and energy is lost at each level.
A detritus food-chain is based on autotrophs energy capture initiated by grazing animals and involves the decomposition or breaking down of organic wastes and dead matter derived from the grazing food-chain.

**Types of Biomes**

There are five major biomes —
1.forest,2. desert,3. grassland,4 aquatic and 5.altitudinal biomes

**Biogeochemical Cycles**

The sun is the basic source of energy on which all life depends. This energy initiates life processes in the biosphere through photosynthesis, the main source of food and energy for green plants. During photosynthesis, carbon dioxide is converted into organic compounds and oxygen. Out of the total solar insolation that reaches the earth's surface, only a very small fraction (0.1 per cent) is fixed in photosynthesis. More than half is used for plant respiration and the remaining part is temporarily stored or is shifted to other portions of the plant.
This balance of the chemical elements is maintained by a cyclic passage through the tissues of plants and animals. The cycle starts by absorbing the chemical elements by the organism and is returned to the air, water and soil through decomposition. These cycles are largely energized by solar insolation. These cyclic movements of chemical elements of the biosphere between the organism and the environment are referred to as ***biogeochemical cycles***.
***Bio*** refers to living organisms and ***geo*** to rocks, soil, air and water of the earth.
There are two types of biogeochemical cycles : the ***gaseous*** and the ***sedimentary*** cycle.
In the gaseous cycle, the main reservoir of nutrients is the atmosphere and the ocean. In the sedimentary cycle, the main reservoir is the soil and the sedimentary and other rocks of the earth's crust.

***The Water Cycle***

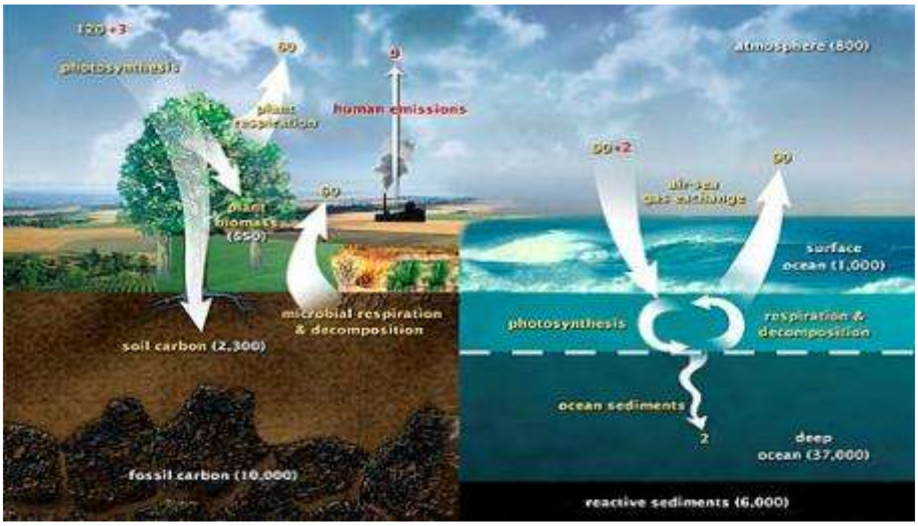
***CLASSIFICATION OF BIOMES***

| ***Biomes*** | ***Subtypes*** | ***Regions*** | ***Climatic Characteristics*** | ***Soil*** | ***Flora and Fauna*** |
|---|---|---|---|---|---|
| Forest | A. Tropical<br>1. Equatorial<br><br>2. Deciduous<br><br>B. Temperate | A1. 10° N-S<br><br>A2. 10° - 25° N-S<br><br>B. Eastern North America, N.E. Asia, Western and Central Europe | A1. Temp. 20-25°C, evenly distributed<br><br>A2. Temp. 25-30°C, Rainfall, ave. ann. 1,000mm, seasonal<br><br>B. Temp. 20-30° | A1. Acidic, poor in nutrients<br><br>A2. Rich in nutrients<br><br>B. Fertile, en-riched with decaying litter | A1. Multi-layered canopy tall and large trees<br>A2. Less dense, trees of medium height;many varieties coexist. Insects,bats, birds and mammals are common species in both<br>B. Moderately dense broad leaved trees. With less diversity of plant species. Oak, Beach, Maple etc. are some common species. |

| | | | | | |
|---|---|---|---|---|---|
| | C. Boreal | C. Broad belt of Eurasia and North America (parts of Siberia, Alaska, Canada and Scandinavia) | C, Rainfall evenly distributed 7501,500mm, Welldefined seasons and distinct winter.<br>C. Short moist moderately warm summers and long cold dry winter; very low temperatures. Precipitation mostly snowfall 400 -1,000 mm | C. Acidic and poor in nutrients, thin soil cover | Squirrels, rabbits, skunks, birds, black bears, mountain lions etc.<br>C. Evergreen conifers like pine, fur and spruce etc. Wood peckers, hawks, bears, wolves, deer, hares and bats are common animals |
| Desert | A. Hot and Dry desert<br>B. Semi arid desert<br>C. Coastal desert<br>D. Cold desert | A. Sahara, Kalahari, Marusthali, Rub-el-Khali<br>B. Marginal areas of hot deserts<br>C. Atacama<br>D. Tundra climatic regions | A. Temp. 20 - 45°C.<br>B. 21 - 38°C.<br>C. 15 - 35°C.<br>D. 2 - 25°C<br>A-D Rainfall is less than 50 mm | Rich in nutrients with little or no organic matter | A-C. Scanty vegetation; few large mammals, insects, reptiles and birds<br>D. Rabbits, rats, Antelopes and ground squirrels |
| Grassland | A. Tropical Savannah<br>B. Temperate Steppe | A. Large areas of Africa, Australia, South America and India<br>B. Parts of Eurasia and North America | A. Warm hot climates, Rainfall 500-1,250 mm<br>B. Hot summers and cold winter. Rainfall 500 900 mm | A. Porous with thin layer of humus.<br>B. Thin flocculated soil, rich in bases | A. Grasses; trees and large shrubs absent; giraffes zebras, buffalos, leopards, hyenas, elephants, mice, moles, snakes and worms etc., are common animals<br>B. Grasses; occasional trees such as cotton-woods, oaks and willows; gazelles, zebras, rhin- oceros, wild horses, lions, varieties of birds, worms, snakes etc., are common |

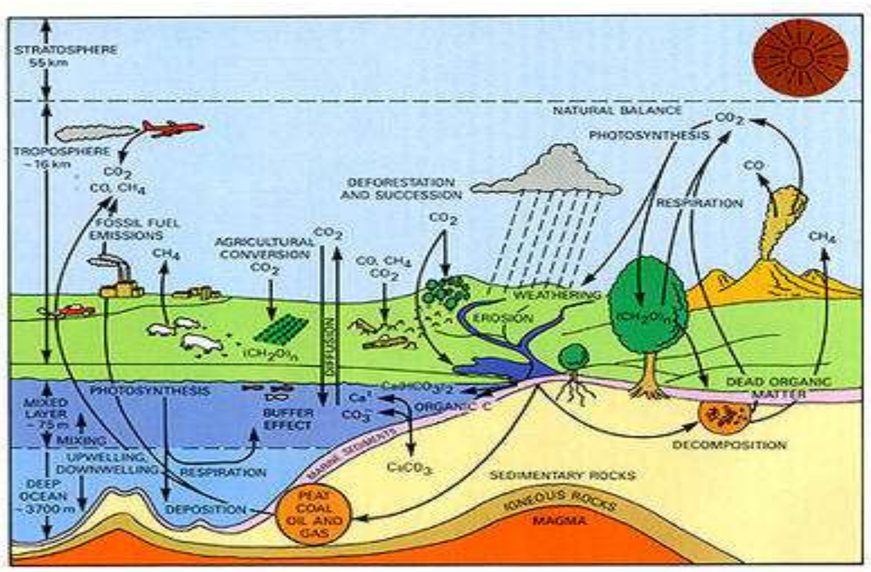
| | | | | | |
|---|---|---|---|---|---|
| | | | | | animals |
| Aquatic | A. Freshwater<br>B. Marine | A. Lakes, streams, rivers and wetlands<br>B. Oceans, coral reefs, lagoons and estuaries | A-B Temperatures vary widely with cooler air temperatures and high humidity | A. Water, swamps and marshes<br>B.Water, tidal swamps and marshes | Algal and other aquatic and marine plant communities with varieties of water dwelling animals |
| Altitudinal | | Slopes of high mountain ranges like the Himalayas, the Andes and the Rockies | Temperature and precipitation vary depending upon latitudinal zone | Regolith over slopes | Deciduous to tundra vegetation varying according to altitude |

***The Carbon Cycle* Figure 15.2 : Carbon Cycle**

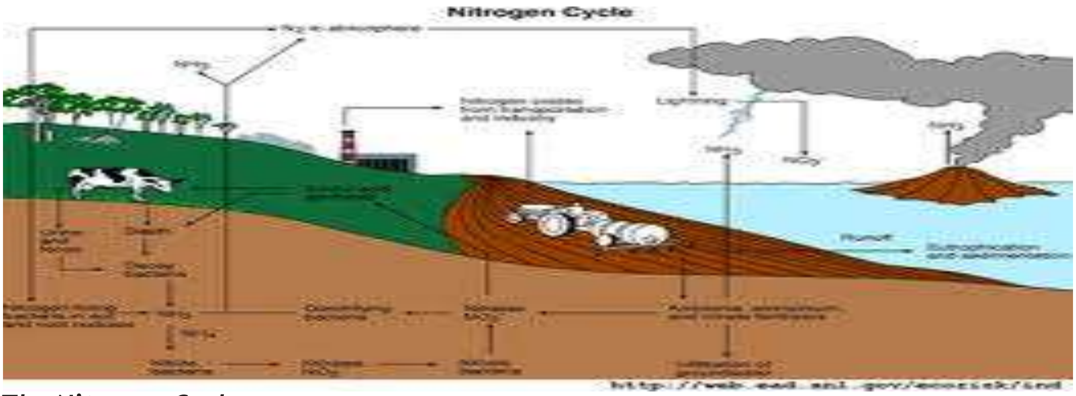



Carbon is one of the basic elements of all living organisms. It forms the basic constituent of all the organic compounds. The biosphere contains over half a million carbon compounds in them. The carbon cycle is mainly the conversion of carbon dioxide. This conversion is initiated by the fixation of carbon dioxide from the atmosphere through ***photosynthesis***.

***The Oxygen Cycle***




Oxygen is the main by-product of photosynthesis. It is involved in the oxidation of carbohydrates with the release of energy, carbon dioxide and water. The cycling of oxygen is a highly complex process. Oxygen occurs in a number of chemical forms and combinations. It combines with nitrogen to form nitrates and with many other minerals and elements to form various oxides such as the iron oxide, aluminum oxide and others. Much of oxygen is produced from the decomposition of water molecules by sunlight during photosynthesis and is released in the atmosphere through transpiration and respiration processes of plants.




***The Nitrogen Cycle***

Nitrogen is a major constituent of the atmosphere comprising about seventy-nine per cent of the atmospheric gases.

It is also an essential constituent of different organic compounds such as the amino acids, nucleic acids, proteins, vitamins and pigments.

Only a few types of organisms like certain species of soil bacteria and blue green algae are capable of utilising it directly in its gaseous form.

Generally, nitrogen is usable only after it is fixed. Ninety per cent of fixed nitrogen is biological.

The principal source of free nitrogen is the action of soil micro-organisms and associated plant roots on atmospheric nitrogen found in pore spaces of the soil. Nitrogen canal so be fixed in the atmosphere by lightning and cosmic radiation. In the oceans, some marine animals can fix it. After atmospheric nitrogen has been fixed into an available form, green plants can assimilate it. Herbivorous animals feeding on plants, in turn, consume some of it. Dead plants and animals, excretion of nitrogenous wastes are converted into nitrites by the action of bacteria present in the soil. Some bacteria can even convert nitrites into nitrates that can be used again by green plants. There are still other types of bacteria capable of converting nitrates into free nitrogen, a process known as ***denitrification***

***Other Mineral Cycles***

1. phosphorus, 2 sulphur, 3. calcium 3. potassium cycles
2. They usually occur as salts dissolved in soil water or lakes, streams and seas.. All living organisms fulfill their mineral requirements from mineral solutions in their environments.
3. Other animals receive their mineral needs from the plants and animals they consume.
4. After the death of living organisms, the minerals are returned to the soil and water through decomposition and flow.

**Ecological Balance**

1. Ecological balance is a state of dynamic equilibrium within a community of organisms in a habitat or ecosystem.

2 .It can happen when the diversity of the living organisms remains relatively stable. 3. Gradual changes do take place but that happens only through natural succession.

4. It can also be explained as a stable balance in the numbers of each species in an ecosystem.

5. This occurs through competition and cooperation between different organisms where population remains stable.

6. This balance is brought about by the fact that certain species compete with one another determined by the environment in which they grow.

7. This balance is also attained by the fact that some species depend on others for their food and sustenance.

8 Such accounts are encountered in vast grasslands where the herbivorous animals (deer, zebras, buffaloes, etc.) are found in plenty.

Ecological balance may be disturbed due to

1. the introduction of new species,
2. natural hazards or human causes.
3. Human pressure on the earth's resources has put a heavy toll on the ecosystem.
4. This has destroyed its originality and has caused adverse effects to the general environment. Ecological imbalances have brought many natural calamities like floods, landslides, diseases, erratic climatic occurrences, etc

# CHAPTER -16 BIODIVERSITY AND CONSERVATION

This chapter deals with

- Ecology
- Types Of Ecosystem
- Structure And Function Of Ecosystem
- Types Of Biomes
- Biogeochemical Cycles
- Water Cycles
- The Carbon Cycle
- Oxygen Cycle
- Nitrogen Cycle
- Ecological Balance

Biodiversity as we have today is the result of 2.5-3.5 billion years of evolution. Before the advent of humans, our earth supported more biodiversity than in any other period. Since, the emergence of humans, however, biodiversity has begun a rapid decline, with one species after another bearing the brunt of extinction due to overuse. The number of species globally vary from 2 million to 100 million, with 10 million being the best estimate. New species are regularly discovered most of which are yet to be classified (an estimate states that about 40 per cent of fresh water fishes from South America are not classified yet). Tropical forests are very rich in bio-diversity Biodiversity is a system in constant evolution, from a view point of species, as well as from view point of an individual organism.
The average half-life of a species is estimated at between one and four million years, and 99 per cent of the species that have ever lived on the earth are today extinct.

Biodiversity is not found evenly on the earth. It is consistently richer in the tropics. As one approaches the polar regions, one finds larger and larger populations of fewer and fewer species.

Biodiversity itself is a combination of towards, ***Bio*** (life) and ***diversity*** (variety). In simple terms, biodiversity is the number and variety of organisms found within a specified geographic region.
It refers to the varieties of plants, animals and micro-organisms, the genes they contain and the ecosystems they form. It relates to the variability among living organisms on the earth, including the variability within and between the species and that within and between the ecosystems.

LEVELS OF BIODIVERSITY
(i)Genetic diversity;
(ii)Species diversity;
(iii)Ecosystem diversity.

**Genetic Diversity**
Genetic biodiversity refers to the variation of genes within species. Groups of individual organisms having certain similarities in their physical characteristics are called ***species***. Human beings genetically belong to the ***homo sapiens*** group and also differ in their characteristics such as height, colour, physical appearance, etc., considerably. This is due to genetic diversity. This genetic diversity is essential for a healthy breeding of population of species.

**Species Diversity**
This refers to the variety of species. It relates to the number of species in a defined area.
The diversity of species can be measured through its richness, abundance and types. Some areas are more rich in species than others. Areas rich in species diversity are called ***hotspots*** of diversity (Figure 16.5).

**Ecosystem Diversity**
The broad differences between ecosystem types and the diversity of habitats and ecological processes occurring within each ecosystem type constitute the ecosystem diversity.
The 'boundaries' of communities (associations of species) and ecosystems are not very rigidly defined. Thus, the demarcation of ecosystem boundaries is difficult and complex.
**Importance of Biodiversity**
1. Biodiversity has contributed in many ways to the development of human culture

In turn, human communities have played a major role in shaping the diversity of nature at the genetic, species and ecological levels.
Biodiversity plays the following roles:

1. ecological, 2. economic 3. scientific.
2. Species of many kinds perform some function or the other in an ecosystem. Nothing in an ecosystem evolves and sustains without any reason.
3. That means, every organism, besides extracting its needs, also contributes something of useful to other organisms.
4. Species capture and store energy, produce and decompose organic materials, help to cycle water and nutrients throughout the ecosystem, fix atmospheric gases and help regulate the climate.

5. These functions are important for ecosystem function and human survival.
6. The more diverse an ecosystem, better are the chances for the species to survive through adversities and attacks, and consequently, is more productive.
7.the more the variety of species in an ecosystem, the more stable the ecosystem is likely to be.

## Economic Role of Biodiversity

1. ‘crop diversity’, which is also called agro-biodiversity.
2. Biodiversity is seen as a reservoir of resources to be drawn upon for the manufacture of food, pharmaceutical, and cosmetic products.
3. This concept of biological resources is responsible for the deterioration of biodiversity.
4. At the same time, it is also the origin of new conflicts dealing with rules of division and appropriation of natural resources.
5. Some of the important economic commodities that biodiversity supplies to humankind are: food crops, livestock, forests, fish, medicinal resources, etc.

## Scientific Role of Biodiversity

1. Biodiversity is important because each species can give us some clue as to how life evolved and will continue to evolve.
2. Biodiversity also helps in understanding how life functions and the role of each species in sustaining ecosystems of which we are also a species.
3. This fact must be drawn upon every one of us so that we live and let other species also live their lives.
4. The level of biodiversity is a good indicator of the state of our relationships with other living species. In fact, the concept of biodiversity is an integral part of many human cultures.

## LOSS OF BIODIVERSITY

Tropical regions which occupy only about one-fourth of the total area of the world, contain about three fourth of the world human population. Over exploitation of resources and deforestation have become rampant to fulfill the needs of large population. Tropical rain forests contain 50 per cent of the species on the earth. Destruction of natural vegetation have proved disastrous for the entire biosphere.
1. Natural calamities such as earthquakes, floods, volcanic eruptions, forest fires, droughts, etc. cause damage to the flora and fauna of the earth, bringing change the biodiversity of respective affected regions.
2. Pesticides and other pollutants such as hydrocarbons and toxic heavy metals destroy the weak and sensitive species.
3. Species which are not the natural inhabitants of the local habitat but are introduced into the system, are called ***exotic species***.
There are many examples when a natural biotic community of the ecosystem suffered extensive damage because of the introduction of exotic species.
During the last few decades, some animals like tigers, elephants, rhinoceros, crocodiles, minks and birds were hunted mercilessly by poachers for their horn, tusks, hides, etc. It has resulted in the rendering of certain types of organisms as endangered category.
The International Union of Conservation of Nature and Natural Resources (IUCN) has classified the threatened species of plants and animals into three categories for the purpose of their conservation.

## Endangered Species

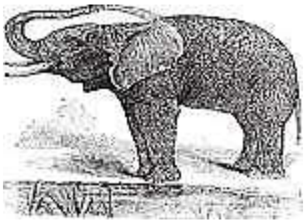

It includes those species which are in danger of extinction. The IUCN publishes information about endangered species world-wide as the ***Red List*** of threatened species.

## Vulnerable Species

Tiger

Lion

African Elephant



Black leopard

This includes the species which are likely to be in danger of extinction in near future if the factors threatening to their extinction continue. Survival of these species is not assured as their population has reduced greatly.

## Rare Species

Study the following pictures of rare species and identify them:

Population of these species is very small in the world; they are confined to limited areas or thinly scattered over a wider area.

**CONSERVATION OF BIODIVERSITY**

Biodiversity is important for human existence.

1. All forms of life are so closely interlinked that disturbance in one gives rise to imbalance in the others.
2. If species of plants and animals become endangered, they cause degradation in the environment, which may threaten human being's own existence.

3. There is an urgent need to educate people to adopt environment-friendly practices and reorient their activities in such a way that our development is harmonious with other life forms and is sustainable.
4. There is an increasing consciousness of the fact that such conservation with sustainable use is possible only with the involvement and cooperation of local communities and individuals.

6. For this, the development of institutional structures at local levels is necessary.

The critical problem is not merely the conservation of species nor the habitat but the continuation of process of conservation. The Government of India along with 155 other nations have signed the Convention of
Biodiversity at the Earth Summit held at Rio de Janeiro, Brazil in June 1992.
The world conservation strategy has suggested the following steps for biodiversity conservation:
(i) Efforts should be made to preserve the species that are endangered.
(ii) Prevention of extinction requires proper planning and management.
(iii) Varieties of food crops, forage plants, timber trees, livestock, animals and their wild relatives should be preserved;
(iv) Each country should identify habitats of wild relatives and ensure their protection.
(v) Habitats where species feed, breed, rest and nurse their young should be safeguarded and protected.
(vi) International trade in wild plants and animals be regulated.
vii To protect, preserve and propagate the variety of species within natural boundaries, the Government of India passed the ***Wild Life (Protection) Act, 1972***, under which national parks and sanctuaries were established and biosphere reserves declared.
There are some countries which are situated in the tropical region; they possess a large number of the world's species diversity. They are called ***mega diversity centres***.
There are 12 such countries, namely
1. Mexico, 2.Columbia,3. Ecuador,4. Peru,5. Brazil, 6.Democratic Republic of Congo, 7.Madagascar,8. China,9. India, 10.Malaysia,11. Indonesia 12. Australia in which these centers are located.


The International Union for the Conservation of Nature and Natural Resources (IUCN) has identified certain areas as biodiversity hotspots Hotspots are defined according to their vegetation. Plants are important because these determine the primary productivity of an ecosystem. Most, but not all,of the hotspots rely on species-rich ecosystems for food, firewood, cropland, and income from timber. In Madagascar, for example, about 85 per cent of the plants and animals are found nowhere else in the world, Other hotspots in wealthy countries are facing different types of pressures. The islands of Hawaii have many unique plants and animals that are threatened by introduced species and land development

# UNIT -1 INTRODUCTION - INDIA

*This unit deals with*

- *Location – space relations and India's place in the world*


Facts of India

| India Facts | |
|---|---|
| Territorial Sea | 12 nm (nautical miles) |
| Contiguous Zone | 24 nm |
| Exclusive economic Zone | 200 nm |
| Continental Shelf | 200 nm or to the edge of the continental margin |
| Longest River | Ganga |
| Largest Lake | Lake Chilka |
| Highest Point | Mt. $K^2$ (8611 m) |
| Highest Point of Himalaya | Kanchan Junga (8,598 m) |
| Lowest Point | Kuttanad (-2.2 m) |
| Northernmost Point | Siachen Glacier near Karakoram |
| Southernmost Point | Indira Point, Great Nicobar, Andaman & Nicobar Islands |
| Southernmost Point of India (Mainland) | Cape Comorin (Kanya Kumari) |
| Westernmost Point | West of Ghuar Mota, Gujarat |
| Easternmost Point | Kibithu, Arunachal Pradesh |
| Highest Altitude | Kanchenjunga, Sikkim |
| Lowest Altitude | Kuttanad (Kerala) |

Mark the southernmost and northern most latitudes and the easternmost and westernmost longitudes.
The mainland of India, extends from Kashmir in the north to Kanyakumari in the south and Arunachal Pradesh in the east to Gujarat in the west. India's territorial limit further extends towards the sea up to 12 nautical miles (about 21.9 km) from the coast.
Our southern boundary extends up to 6°45' N latitude in the Bay of Bengal.
Let us work out implications of having such a vast longitudinal and latitudinal extent-
The latitudinal and longitudinal extent of India are roughly about 30 degrees, whereas the actual distance measured from north to south extremity is 3,214 km, and that from east to west is only 2,933 km.
What is the reason for this difference?
This difference is based on the fact that the distance between two longitudes decreases towards the poles whereas the distance between two latitudes remains the same everywhere.
Find out the distance between two latitudes?

From the values of latitude, it is understood that the southern part of the country lies within the tropics and the northern part lies in the sub-tropical zone or the warm temperate zone. This location is responsible for large variations in land forms, climate, soil types and natural vegetation in the country. Now, let us observe the longitudinal extent and its implications on the Indian people. From the values of longitude, it is quite discernible that there is a variation of nearly 30 degrees, which causes a time difference of nearly two hours between the easternmost and the westernmost parts of our country. You are familiar with the concept of Indian Standard Time (IST). What is the use of the standard meridian? While the sun rises in the northeastern states about two hours earlier as compared to Jaisalmer, the watches in Dibrugarh, Imphal in the east and Jaisalmer, Bhopal or Chennai in the other parts of India show the same time.

Why does this happen?

There is a general understanding among the countries of the world to select the standard meridian in multiples of 7°30' of longitude. That is why 82°30' E has been selected as the 'standard meridian' of India. Indian Standard Time is ahead of Greenwich Mean Time by 5 hours and 30 minutes.

There are some countries where there are more than one standard meridian due to their vast east-to-west extent. For example, the USA has seven time zones.

Name a few places in India through which the standard meridian passes.

1. ALLAHABAD 2. KAKINADA

India with its area of 3.28 million sq. km accounts for 2.4 per cent of the world's land surface area and stands as the seventh largest country in the world. Find out the names of the countries which are larger than India.

**SIZE**

*Total area of India is 32, lakh sq. km 7th largest country with 2.4 % of total land area of the world*

*Indian subcontinent.*

It includes the countries Pakistan, Nepal, Bhutan, Bangladesh and India.

Coastline length is 7516.5 km land frontier area is 15200 km.

**INDIA AND ITS NEIGHBORS**

1. Pakistan 2. China 3. Nepal 4. Bhutan 5. Myanmar 6. Bangladesh 7. Sri Lanka 8 Maldivies..

Sri Lanka is separated from India by the Gulf of Mannar and Palk Strait

***PHYSIOGRAPHY***

- *Structure and Relief; physiographic divisions*
- *Drainage systems: concept of water sheds — the Himalayan and the Peninsular*

**Can you map different phases in the movement of the Indian plate?**


This northward movement of the Indian plate is continuing and it has significant consequences on the physical **environment of the Indian subcontinent.**

**Can you name some important consequences of the northward movement of the Indian plate?**

1.FORMATION OF HIMALAYAS
2.FORMATION OF INDO GANGETIC PLAIN
3.ARABIAN SEA FORMATION 4. EMERGENCE OF DECCAN PLATEAU

It is primarily through the interplay of these endogenic and exogenic forces and lateral movements of the plates that the present geological structure and geomorphologic processes active in the Indian subcontinent came into existence.

Based on the variations in its geological structure and formations, India can be divided into three geological divisions.

**STRUCTUREAND PHYSIOGRAPHY**


Figure 2.2 : India : Physical

(i) The Peninsular Block
(ii) The Himalayas and other Peninuslar Mountains
(iii)Indo-Ganga-Brahmaputra Plain.

**THE PENINSULAR BLOCK**

**Boundaries of the PENINSULAR BLOCK**

1.The northern boundary of the Peninsular Block may be taken as an irregular line

Movement of Indian plate running from Kachch along the western flank of the Aravali Range near Delhi and then roughly parallel to the Yamuna and the Ganga as far as the Rajmahal Hills and the Ganga delta. Apart from these,

2. The Karbi Anglong and the Meghalaya Plateau in the northeast and Rajasthan in the west are also extensions of this block.

3.The northeastern parts are separated by the Malda fault in West Bengal from the Chotanagpur plateau.

4.The Peninsula is formed essentially by a great complex of very ancient gneisses and granites,

5.Since the Cambrian period, the Peninsula has been standing like a rigid block with the exception of some of its western coast which is submerged beneath the sea and some other parts changed due to tectonic activity without affecting the original basement.

6. As a part of the Indo-Australian Plate, it has been subjected to various vertical movements and block faulting. The rift valleys of the Narmada, the Tapi and the Mahanadi and the Satpura block mountains are some examples of it.

The Peninsula mostly consists of relict and residual mountains like the Aravali hills, the Nallamala hills, the Javadi hills, the Veliconda hills, the Palkonda range and the Mahendragiri hills, etc.

**THE HIMALAYAS AND OTHER PENINSULAR MOUNTAINS**

1. The Himalayas along with other Peninsular mountains are young, weak and flexible in their geological structure unlike the rigid and stable Peninsular Block.

2. Consequently, they are still subjected to the interplay of exegetic and endogenic forces, resulting in the development of faults, folds and thrust plains.
3. These mountains are tectonic in origin, dissected by fast-flowing rivers which are in their youthful stage.
4.Various landforms like gorges, V-shaped valleys, rapids, waterfalls, etc. are indicative of this stage.

**INDO-GANGA-BRAHMAPUTRA PLAIN**

The third geological division of India comprises the plains formed by the river Indus, the Ganga and the Brahmaputra.

It was a geo-synclinal depression which attained its maximum development during the third phase of the Himalayan mountain formation approximately about 64 million years ago.

Since then, it has been gradually filled by the sediments brought by the Himalayan and Peninsular rivers.

Average depth of alluvial deposits in these plains ranges from 1,000-2,000 m.

**PHYSIOGRAPHY**

'Physiography' of an area is the outcome of structure, process and the stage of development.

India can be divided into the following physiographic divisions:

(1) The Northern and North-eastern Mountains
(2) The Northern Plain
(3) The Peninsular Plateau
(4) The Indian Desert
(5) The Coastal Plains
(6) The Islands.

**The North and Northeastern Mountains**

1. The North and Northeastern Mountains consist of the Himalayas and the Northeastern hills.
2. The Himalayas consist of a series of parallel mountain ranges.

Some of the important ranges are the Greater Himalayan range, which includes the Great Himalayas and the Trans-Himalayan range, the Middle Himalayas and the Shiwalik.

3. The general orientation of these ranges is from northwest to the southeast direction in the northwestern part of India. Himalayas in the Darjeeling and Sikkim regions lie in an east west direction, while in Arunachal Pradesh they are from southwest to the northwest direction. In Nagaland, Manipur and Mizoram, they are in the north south direction.
4. The approximate length of the Great 2500 km ,width is 160 to 400 km
6. Himalayas are not only the physical barrier, they are also a climatic, drainage and cultural divide.

THE HIMALAYAS CAN BE DIVIDED INTO THE FOLLOWING SUB-DIVISIONS:

(i) Kashmir or Northwestern Himalayas
(ii) Himachal and Uttaranchal Himalayas
(iii) Darjiling and Sikkim Himalayas
(iv) Arunachal Himalayas
(v) Eastern Hills and Mountains.

*Kashmir or Northwestern Himalayas*

1. It comprise a series of ranges such as the KARAKORAM, LADAKH, ZASKAR AND PIR PANJAL.
2 .It is a cold desert, which lies between the Greater Himalayas and the Karakoram ranges.
3. The world famous valley of Kashmir and the famous Dal Lake are found.
4. Important glaciers Baltoro and Siachen are also found in this region.
5. The Kashmir Himalayas are also famous for Karewa formations, which are useful for the cultivation
of *Zafran*, a local variety of saffron.
6. Some of the important passes of the region are ZojiLa on the Great Himalayas, Banihal on the Pir Panjal,Photu La on the Zaskar and Khardung La on the Ladakh range.
7. Some of the important fresh lakes such as Dal and Wular and salt water lakessuch as Pangong Tso and Tso Moriri are also in this region.
8. This region is drained by the river Indus, and its tributaries such as the Jhelum and the Chenab.
9. The landscape of Himalayas is a major source of attraction for adventure tourists. some famous places of pilgrimage such as Vaishno Devi, Amarnath Cave, Charar -e-Sharif.
10. The southernmost part of this region consists of longitudinal valleys known as 'duns'. Jammu dun and Pathankot dun are important examples.

*The Himachal and Uttarakhand Himalayas*

The northernmost part of the Himachal Himalayas is an extension of the Ladakh cold desert, in which

all the three ranges of Himalayas are prominent. These are the Great Himalayan range, the Lesser Himalayas (which is locally known as Dhaoladhar in Himachal Pradesh and Nagtibha in Uttarakhand)and the Shiwalik range from the North to the South 0
2. In this section of Lesser Himalayas, the altitude between 1,000-2,000m
3.The important hill stations such as Dharamshala, Mussoorie, Shimla, Kaosani and the cantonment towns and health resorts such as Shimla, Mussoorie, Kasauli, Almora, Lansdowne and Ranikhet, etc.
4.The two distinguishing features of this region from the point of view of physiography are the 'Shiwalik' and 'Dun formations'. Some important duns located in this region are the the places of pilgrimage such as the Gangotri, Yamunotri, Kedarnath, Badrinathand Hemkund Sahib are also situated in this part.
5. The region is also known to have five famous Prayags (river confluences)

*The Darjeeling and Sikkim Himalayas*

1. They are flanked by Nepal Himalayas in the west and Bhutan Himalayas in the east.
2. It is relatively small but is a most significant part of the Himalayas.
3. Known for its fast-flowing rivers such as Tista,
4. It is a region of high mountain peaks like Kanchenjunga (Kanchengiri), and deep valleys.
5. The higher reaches of this region are inhabited by Lepcha tribes while the southern part, particularly 6. Tea plantation is done
7. Absence of siwaliks
8. Duar formations are important .

*The Arunachal Himalayas*

1. These extend from the east of the Bhutan Himalayas up to the Diphu pass in the east.
2. The general direction of the mountain range is from southwest to northeast.
3. Some of the important mountain peaks of the region are Kangtu and Namcha Barwa.
4. These ranges are dissected by fast-flowing rivers from the north to the south, forming deep gorges. 5. The important river is Brahmaputra flows through a deep gorge after crossing Namcha Barwa. Some of the important rivers are the Kameng, the Subansiri, the Dihang, the Dibang and the Lohit.
6. These are perennial with the high rate off all, thus, having the highest hydro-electric power potential in the country.
7. The important tribes are the Monpa, Daffla, Abor, Mishmi, Nishi and the Nagas. Most of these communities practise *Jhumming*. It is also known as shifting or slash and burn cultivation.

*The Eastern Hills and Mountains*

1. These are part of the Himalayan mountain system having their general alignment from the north to the south direction.
They are known by different local names. In the north, they are known as Patkai Bum, Naga hills, the Manipur hills and in the south as Mizo or Lushai hills.
(i) These are low hills, inhabited by numerous tribal groups practicing Jhum cultivation.
(ii) Most of these ranges are separated from each other by numerous small rivers.
(iii) The Barak is an important river in Manipur and Mizoram.
(iv) The physiography of Manipur is unique by the presence of a large lake known as 'Loktak' lake at the centre, surrounded by mountains from all sides.
(v) Mizoram which is also known as the 'Molassis basin' which is made up of soft unconsolidated

**The Northern Plains**

1.The northern plains are formed by the alluvial deposits brought by the rivers – the Indus, the Ganga and the Brahmaputra.
2.These plains extend approximately 3,200 km from the east to the west.
3. The average width of these plains varies between 150-300 km.
4.The maximum depth of alluvium deposits varies between 1,000-2,000 m. From the north to the south
5.these can be divided into three major zones: the *Bhabar*, the *Tarai* and the alluvial plains.
6.The alluvial plains can be further divided into the *Khadar* and the*Bhangar*.

7. *Bhabar* is a narrow belt ranging between 8-10 km parallel to the Shiwalik foothills at the break-up of the slope.
8.The streams and rivers coming from the mountains deposit heavy materials of rocks and boulders, and at times, disappear in this zone.
9. South of the *Bhabar* is the *Tarai* belt, with an approximate width of 10-20 km where most of the streams and rivers re-emerge without having any properly demarcated channel,
10.Marshy and swampy conditions known as the *Tarai*.

11.This has a luxurious growth of natural vegetation and houses a varied wild life.
12.The south of *Tarai* is a belt consisting of old and new alluvial deposits known as the *Bhangar* and *Khadar* respectively.

**The Peninsular Plateau**

1. Irregular triangle in shape
2. Rising from the height of 150 m above the river plains up to an elevation of 600-900 m
3. Delhi ridge in the northwest, (extension of Aravalis), the Rajmahal hills in the east, Gir range in the west and the Cardamom hills in the south constitute the outer extent of the Peninsular plateau. northeast, Shillong and Karbi-Anglong plateau.
3. The Peninsular India is made up of a series of patland plateaus such as the Hazaribagh plateau, the Palamu plateau, the Ranchi plateau, the Malwa plateau, the Coimbatore plateau and the Karnataka plateau, etc.
4. This is one of the oldest and the most stable landmass of India.
5. The general elevation of the plateau is from the west to the east, .
6. Narmada, tapti ,Mahanadi, Godavari, Krishna, and cauvery are some of the important rivers

7.Some of the important physiographic features of this region are tors, block mountains, rift valleys, spurs, bare rocky structures, series of hummocky hills and wall-like quartzite dykes offering natural sites for water storage.
8.Thewestern and northwestern part of the plateau has an emphatic presence of black soil.
9.The northwestern part of the plateau has a complex relief of ravines and gorges. The ravines of Chambal, Bhind and Morena are some of the well-known examples.

On the basis of the prominent relief features, the Peninsular plateau can be divided into three broad groups:
(i) The Deccan Plateau
(ii) The Central Highlands
(iii) The Northeastern Plateau.

*The Deccan Plateau*

1.This is bordered by the Western Ghats in the west, Eastern Ghats in the east and the Satpura, Maikal range and Mahadeo hills in the north.
2.Western Ghats are locally known by different names such as Sahyadri in Maharashtra, Nilgiri hills in Karnataka and Tamil Nadu and Anaimalai hills and Cardamom hills in Kerala.
3. Western Ghats are comparatively higher in elevation and more continuous than the Eastern Ghats. Their average elevation is about 1,500 m with the height increasing from north to south.
4.'Anaimudi' (2,695 m), the highest peak of Peninsular plateau is located on the Anaimalai hills of the Western Ghats followed by Dodabetta(2,637 m) on the Nilgiri hills.
5.Most of the Peninsular rivers have their origin in the Western Ghats. Eastern Ghats comprising the discontinuous and low hills are highly eroded by the rivers such as the Mahanadi, the Godavari, the Krishna, the Kaveri, etc.
6. Some of the important ranges include the Javadi hills, the Palkonda range, the Nallamala hills, the
Mahendragiri hills, etc.
7. The Eastern and the Western Ghats meet each other at the Nilgiri hills.

*The Central Highlands*

1.They are bounded to the west by the Aravali range.
2. The Satpura range is formed by a series of scarped plateaus on the south, generally at an elevation varying between 600-900 m above the mean sea level.
3. This forms the northernmost boundary of the Deccan plateau.
4.It is a classic example of the relict mountains which are highly denuded and form discontinuous ranges.
5.This region has undergone metamorphic processes in its geological history, which can be corroborated by the presence of metamorphic rocks such as marble, slate, gneiss, etc.
6.The general elevation of the Central Highlands ranges between 700-1,000 m
7.Banas is the only significant tributary of the river Chambal that originates from the Aravalli in the west.
8.An eastern extension of the Central Highland is formed by the Rajmahal hills, to the south of which
lies a large reserve of mineral resources in the Chotanagpur plateau.

*The Northeastern Plateau*

1. It is an extension of the main Peninsular plateau.
2. It is believed that due to the force exerted by the northeastward movement of the Indian plate at the time of the Himalayan origin, a huge fault was created between the Rajmahal hills and the Meghalaya plateau. Later, this depression got filled up by the deposition activity of the numerous rivers.
3. The Meghalaya and Karbi Anglong plateau stand detached from the main Peninsular Block.

The Meghalaya plateau is further sub-divided into three:
(i) The Garo Hills; (ii) The Khasi Hills; (iii) The Jaintia Hills, named after the tribal groups inhabiting this region.

4. An extension of this is also seen in the Karbi Anglong hills of Assam.
5 .Rich in mineral resources like coal, iron ore, sillimanite, limestone and uranium.
6. The Meghalaya plateau has a highly eroded surface.
7. Cherrapunji displays a bare rocky surface devoid of any permanent vegetation cover.

**The Indian Desert**

1. Located at the north west of India
2. It is a land of undulating topography dotted with longitudinal dunes and *barchans*.
3. This region receives low rainfall below 150 mm per year; hence,
4 It has arid climate with low vegetation cover.
5. It is because of these characteristic features that this is also known as *Marusthali*.
7 It is believed that during the Mesozoic era, this region was under the sea.
8. This can be corroborated by the evidence available at wood fossils park at Aakal and marine deposits around Brahmsar, near Jaisalmer (The approximate age of the wood fossils is estimated to be 180 million years).

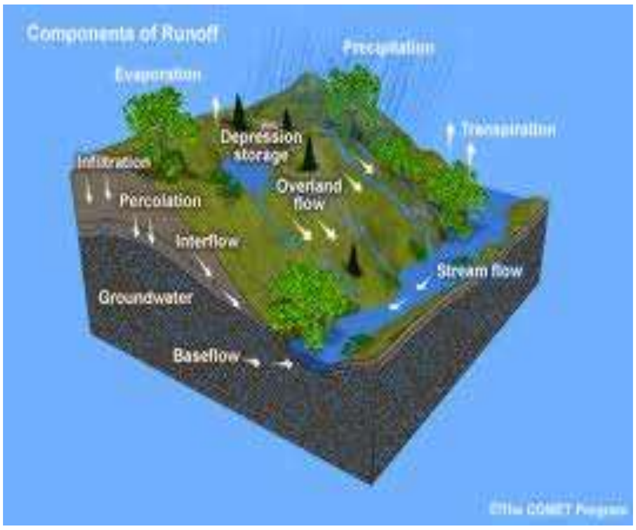
| WEST COAST PLAIN | EAST COAST PLAIN |
|---|---|
| 1. Narrow | Broad |
| 2. Extend form Gujarat to Kerala | Extend from West Bengal to Tmilnadu |
| 3. It is named as Katch and Kathiawad in Gujarat, Konkan in Goa and Maharashtra Malabar in Karnataka and Kerala | It is named as circar in A.P Orissa Coramandal in Tamilnadu |
| 4. Estuaries are common | Deltas are common |
| 5. Back waters are common | Suitable for agriculture |
| 6. Suitable for fisheries | Deposition is prominent |
| 7. Erosion is prominent | |

**DIFFERENCE BETWEEN LAKSHADWEEP AND ANDAMAN NICOBAR ISLANDS**

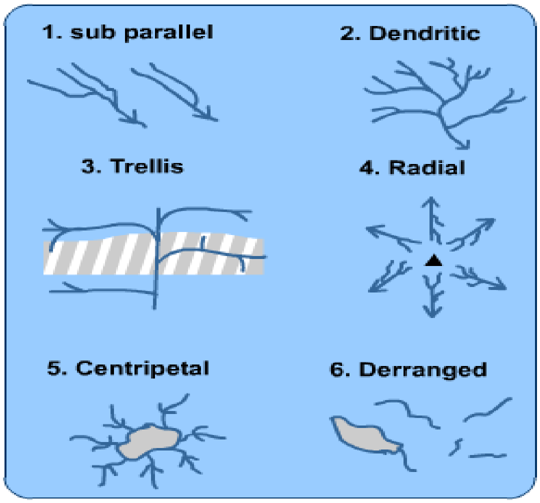
| Lakshadweep islands | Andaman Nicobar islands |
|---|---|
| **1. Found in Arabian sea** **There are 36 islands** | **Found in bay of Bengal** **Total 572 islands are found** |
| **2.** These are scattered between 8°N-12°N and 71°E -74°E longitude | **Located between** 6°N-14°N and 92°E -94°E. |
| **3.** These islands receive convectional rainfall and have an equatorial type of vegetation. | The two principal groups of islets include the Ritchie's archipelago and the Labrynth island. |
| 4. The entire island group is built of coral deposits | |
| **5.** *Minicoy* is the largest island with an area of 453 sq. km. The entire group of islands is broadly divided by the Eleventh degree channel, north of which is the Amini Island and to the south of the Canannore Island. The Islands of this archipelago have storm beaches consisting of unconsolidated pebbles, shingles, cobbles and boulders on the eastern seaboard. | They are separated by a water body which is called the Ten degree channel formed by volcanic eruption. Barren island is the only active volcano in India Some important mountain peaks in Andaman and Nicobar islands are Saddle peak (North Andaman – 738 m), Mount Diavolo (Middle Andaman – 515 m), Mount Koyob (South Andaman – 460 m) and Mount Thuiller (Great Nicobar – 642 m). |

# CHAPTER -3 DRAINAGE SYSTEM

The flow of water through well-defined channels is known as 'drainage'
The network of such channels is called a 'drainage system'.
The drainage pattern of an area is the outcome of the geological time period, nature and structure of rocks, topography, slope, amount of water flowing and the periodicity of the flow.

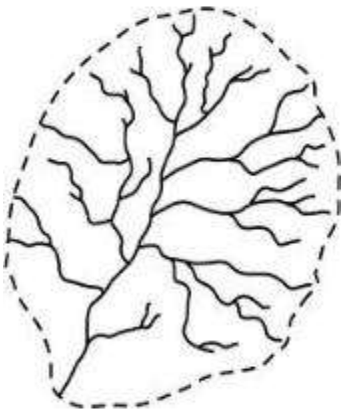



**Drainage system**




**Important Drainage Patterns**

(i) The drainage pattern resembling the branches of a tree is known as "dendritic" the examples of which are the rivers of northern plain.
(ii) When the rivers originate from a hill and flow in all directions, the drainage pattern is Known as 'radial'. The rivers originating from the Amarkantak range present a good example of it.
(iii) When the primary tributaries of rivers flow parallel to each other and secondary tributaries join them at right angles, the pattern is known as 'trellis'.
(iv) When the rivers discharge their waters from all directions in a lake or depression, the pattern is know as 'centripetal'.
The boundary line separating one drainage basin from the other is known as the watershed.
The catchments of large rivers are called river basins while those of small rivulets and rills are often referred to as watersheds.



There is, however, a slight difference between a river basin and a watershed. Watersheds are small in area while the basins cover larger areas.
They are accepted as the most appropriate micro, meso or macro planning regions.
Indian drainage system may be divided on various bases.
On the basis of discharge of water
(orientations to the sea), it may be grouped into:
(i) the Arabian Sea drainage; and
(ii) the Bay of Bengal drainage.
They are separated from eachother through the Delhi ridge, the Aravalis and the Sahyadris (water divide is shown by a line in Figure 3.1). river basin
77 per cent of the drainage area consisting of the Ganga, the Brahmaputra, the Mahanadi, the Krishna, etc. is oriented towards the Bay of Bengal
23 percent comprising the Indus, the Narmada, the Tapi,the Mahi and the Periyar systems discharge their waters in the Arabian Sea.
On the basis of the size of the watershed,
the drainage basins of India are grouped into three categories:
(i) Major river basins with more than 20,000 sq. km of catchment area. It includes 14 drainage basins such as the Ganga, the Brahmaputra, the Krishna, the Tapi, the Narmada, the Mahi, the Pennar, the Sabarmati, the Barak, etc.

(ii) Medium river basins with catchment area between 2,000-20,000 sq. km incorporating 44 river basins such as the Kalindi, the Periyar, the Meghna, etc.
(iii) Minor river basins with catchment area of less than 2,000 sq. km include fairly good number of rivers flowing in the area of low rainfall.
North Indian rivers are originating from Himalayas peninsular rivers are originating from Western ghats
The Narmada and Tapi are two large rivers which are exceptions originating form central highlands.
the Indian drainage may also be classified into the Himalayan drainage and the Peninsular drainage.

## THE HIMALAYAN DRAINAGE

1. The Himalayan drainage system has a long geological history.
2. the important rivers are Ganga, the Indus and the Brahmaputra rivers.
3. Since these are fed both by melting of snow and precipitation, rivers of this system are perennial.
4 .rivers form giant gorges V-shaped valleys, rapids and waterfalls in their mountainous course.
5. While entering the plains, they form depositional features like flat valleys, ox-bow lakes, flood plains,

## EVOLUTION OF THE HIMALAYAN DRAINAGE

1.Geologists believe that a mighty river called Shiwalik or Indo-Brahma traversed the entire longitudinal extent of the Himalaya from Assam to Punjab and onwards to Sind, and finally discharged into the Gulf of Sind near lower Punjab during the Miocene period some 5-24 million years ago
2. The remarkable continuity of the Shiwalik and its lacustrine origin and alluvial deposits consisting of sands, silt, clay, boulders and conglomerates support this viewpoint.
in due course of time Indo– Brahma river was dismembered into three main drainage systems:

(i) the Indus and its five tributaries in the western part;
(ii) the Ganga and its Himalayan tributaries in the central part; and
(iii) the stretch of the Brahmaputra in Assam and its Himalayan tributaries in the eastern part.

The dismemberment was probably due to the Pleistocene upheaval in the western Himalayas, including the uplift of the Potwar Plateau (Delhi Ridge), which acted as the water divide between the Indus and Ganga drainage systems.
Likewise, the down thrusting of the Malda gap area between the Rajmahal hills and the Meghalaya plateau during the mid-pleistocene period, diverted the Ganga and the Brahmaputra systems to flow Towards the Bay of Bengal.

## THE RIVER SYSTEMSOFTHEHIMALAYAN DRAINAGE

### The Indus System

1.It is one of the largest river basins of the world, covering an area of 11,65,000 sq. km (in India it is 321, 289 sq. km and a total length of 2,880 km (in India 1,114 km).
2. The Indus also known as the Sindhu, is the westernmost of the Himalayan rivers in India.
3. It originates from a glacier near Bokhar Chu (31°15' N latitude and 81°40' E longitude) in the Tibetan region at an altitude of 4,164 m in the Kailash Mountain range.
4. In Tibet, it is known as '*Singi Khamban*; or Lion's mouth. After flowing in the northwest direction between the Ladakh and Zaskar ranges, it passes through Ladakh and Baltistan.
5.It cuts across the Ladakh range, forming a spectacular gorge near Gilgit in Jammu and Kashmir.
6. It enters into Pakistan near Chillar in the Dardistan region. Find out the area known as Dardistan.
7. tributaries such as the Shyok, the Gilgit, theZaskar, the Hunza, the Nubra, the Shigar, the Gasting and the Dras.
9. It finally emerges out ofthe hills near Attock where it receives the Kabul river on its right bank.
10.The other important tributaries joining the right bank of the Indus are the Khurram, the Tochi, the Gomal, the Viboa and the Sangar. They all originate in the Sulaiman ranges.
11. The river flows southward and receives 'Panjnad' a little above Mithankot. The Panjnad is the name given to the five rivers of Punjab, namely the Satluj, the Beas, the Ravi, the Chenab and the Jhelum.It finally discharges into the Arabian Sea, east of Karachi. The Indus flows in India only through the Leh district in Jammu and Kashmir.

### The Ganga System

1. The Ganga is the most important river of India both from the point of view of its basin and cultural significance.
2. It rises in the Gangotri glacier near Gaumukh (3,900 m) in the Uttarkashi district of Uttarakhand.

3. Here, it is known as the Bhagirathi.
4. It cuts through the Central and the Lesser Himalayas in narrow gorges. At Devprayag, the Bhagirathi
5. meets the Alaknanda; hereafter, it is known as the Ganga.
6. The Alaknanda has its source in the Satopanth glacier above Badrinath. The Alaknanda consists of the Dhauli and the Vishnu Ganga which meet at Joshimath or Vishnu Prayag.
7. The other tributaries of Alaknanda such as the Pindar joins it at Karna Prayag while Mandakini or Kali Ganga meets it at Rudra Prayag.
8. The Ganga enters the plains at Haridwar. From here, it flows first to the south, then to the south-east and east before splitting into two distributaries, namely the Bhagirathi and the Hugli. The river has a length of 2,525 km. It is shared by Uttarakhand (110 km) and Uttar Pradesh(1,450 km), Bihar (445 km) and West Bengal (520 km).
9. The Ganga basin covers about 8.6 lakh sq. km area in India alone.
10. The Ganga river system is the largest in India having a number of perennial and non-perennial rivers originating in the Himalayas in the north and the Peninsula in the south, respectively.
11. The Son is its major right bank tributary.
12. The important left bank tributaries are the Ramganga, the Gomati, the Ghaghara, the Gandak, the Kosi and the Mahananda.
13. The river finally discharges itself into the Bay of Bengal near the Sagar Island.

## The Brahmaputra System

1.The Brahmaputra, one of the largest riversof the world, has its origin in the Chemayungdung glacier of the Kailash range near the Mansarovar lake.
2.From here, it traverses eastward longitudinally for a distance of nearly 1,200 km in a dry and flat region of southern Tibet, where it is known as the Tsangpo, which means 'the purifier.'
3.The Rango Tsangpo is the major right bank tributary of this river in Tibet.
4. It emerges as a turbulent and dynamic river after carving out a deep gorge in the Central Himalayas near Namcha Barwa (7,755 m).
5.The river emerges from the foothills under the name of Siang or Dihang. It enters India
west of Sadiya town in Arunachal Pradesh.
6. Flowing southwest, it receives its main left bank tributaries, viz., Dibang or Sikang and Lohit; thereafter, it is known as the Brahmaputra.
7. The Brahmaputra receives numerous tributaries in its 750 km long journey through the Assam valley.
8.Its major left bank tributaries are the Burhi Dihing and Dhansari (South) whereas the important right bank tributaries are the Subansiri, Kameng, Manas and Sankosh.
9. The Brahmaputra enters into Bangladesh near Dhubri and flows southward. In Bangladesh, the Tista joins it on its right bank from where the river is known as the Yamuna.
10. It finally merges with the river Padma, which falls in the Bay of Bengal. The Brahmaputra is well-
known for floods, channel shifting and bank erosion.
11.This is due to the fact that most of its tributaries are large, and bring large quantity of sediments owing to heavy rainfall in its catchment area.

## THE PENINSULAR DRAINAGE SYSTEM

1.The Peninsular drainage system is older than the Himalayan one.
2. This is evident from the broad, largely-graded shallow valleys, and the maturity of the rivers.
3.The Western Ghats running close to the western coast act as the water divide between the major Peninsular rivers, discharging their water in the Bay of Bengal and as small rivulets joining the Arabian Sea.
4.Most of the major Peninsular rivers except Narmada and Tapi flow from west to east.
5.The Chambal, the Sind, the Betwa, the Ken, the Son, originating in the northern part of the Peninsula belong to the Ganga river system. The other major river systems of the Peninsular drainage are – the Mahanadi the Godavari, the Krishna and the Kaveri.
6.Peninsular rivers are characterised by fixed course, absence of meanders and non -perennial flow of water.
7.The Narmada and the Tapi which flow through the rift valley are, however, exceptions.

## The Evolution of Peninsular Drainage System

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

(i) Subsidence of the western flank of the Peninsula leading to its submergence below the sea during the early tertiary period. Generally, it has disturbed the symmetrical plan of the river on either side of the original watershed.
(ii) Upheaval of the Himalayas when the northern flank of the Peninsular block was subjected to subsidence and the consequent trough faulting. The Narmada and The Tapi flow in trough faults and fill the original cracks with their detritus materials. Hence, there is a lack of alluvial and deltaic deposits in these rivers.
(iii) Slight tilting of the Peninsular block from northwest to the southeastern direction gave orientation to the entire drainage system towards the Bay of Bengal during the same period.

**Table 3.1 : Comparison between the Himalayan and the Peninsular River**

**Table 3.1 : Comparison between the Himalayan and the Peninsular River**

| Sl. No. | Aspects | Himalayan River | Peninsular River |
|---|---|---|---|
| 1. | Place of origin | Himalayan mountain covered with glaciers | Peninsular plateau and central highland |
| 2. | Nature of flow | Perennial; receive water from glacier and rainfall | Seasonal; dependent on monsoon rainfall |
| 3. | Type of drainage | Antecedent and consequent leading to dendritic pattern in plains | Super imposed, rejuvenated resulting in trellis, radial and rectangular patterns |
| 4. | Nature of river | Long course, flowing through the rugged mountains experiencing headward erosion and river capturing; In plains meandering and shifting of course | Smaller, fixed course with well-adjusted valleys |
| 5. | Catchment area | Very large basins | Relatively smaller basin |
| 6. | Age of the river | Young and youthful, active and deepening in the valleys | Old rivers with graded profile, and have almost reached their base levels |

### *The River Regime*

1.The pattern of flow of water in a river channel over a year is known as its regime.
2. The north Indian rivers originating from the Himalayas are perennial as they are fed by glaciers through snow melt and also receive rainfall water during rainy season.
3.The rivers of South India do not originate from glaciers and their flow pattern witnesses fluctuations. 4. The flow increases considerably during monsoon rains. Thus, the regime of the rivers of South India is controlled by rainfall which also varies from one part of the Peninsular plateau to the other.
5.The discharge is the volume of water flowing in a river measured over time. It is measured either in
cusecs (cubic feet per second) or cumecs (cubic metres per second).
6.The Ganga has its minimum flow during the January-June period. The maximum flow is attained either in August or in September. After September, there is a steady fall in the flow. The river, thus, has a monsoon regime during the rainy season.
7.There are striking differences in the river regimes in the eastern and the western parts of the Ganga Basin.
8.The Ganga maintains a sizeable flow in the early part of summer due to snow melt before the monsoon rains begin. The mean maximum discharge of the Ganga at Farakka is about 55,000 cusecs while the mean minimum is only 1,300 cusecs.
**What are the factors responsible for such a large difference?**

## EXTENT OF USABILITY OF RIVER WATER

**River Water can be used in the following way**

1. Construction of dams
2. Interlinking of rivers
3. Construction of check dams
4. Construction of canals parallel to the river
5. Lift irrigation

## PROBLEMS OF RIVER WATER USABILITY

(i) No availability in sufficient quantity
(ii) River water pollution
(iii) Load of silt in the river water
(iv) Uneven seasonal flow of water
(v) River water disputes between states
(vi) Shrinking of channels due to the extension of settlements towards the thalweg

**Why are the rivers polluted?**
**Have you seen the dirty waters of cities entering into the rivers?**
**Where do the industrial affluent and wastes get disposed of ?**
Most of the cremation grounds are on the banks of rivers and the dead bodies are sometimes thrown in the rivers. On the occasion of some festivals, the flowers and statues are immersed in the rivers. Large scale bathing and washing of clothes also pollute river waters.
**How can the rivers be made pollution free?**
**Have you read about Ganga Action Plan, or about a campaign for cleaning the Yamuna at Delhi? Collect materials on schemes for making rivers pollution free and organise the materials into a write up.**

# UNIT –III CHAPTER 3 *CLIMATE, VEGETATION AND SOIL*

.
*This unit deals with*
- *Weather and climate – spatial and temporal distribution of temperature ,pressure, winds and rainfall; Indian monsoons: mechanism, onset and variability – spatial and temporal; climatic types*
- *Natural vegetation – forest types and distribution; wild life conservation; biosphere reserves*
- *Soils – major types and their distribution, soil degradation and conservation*

## DIFFERENCE BETWEEN WEATHER AND CLIMATE

| WEATHER | CLIMATE |
| --- | --- |
| 1.Weather is the momentary state of the atmosphere<br>2.Weather changes quickly, may be within a day or week | 1.climate refers to the average of the weather conditions over a longer period of time<br>2.climate changes imperceptibly and may be noted after 50 years or even more |

## UNITY AND DIVERSITY INTHE MONSOON CLIMATE

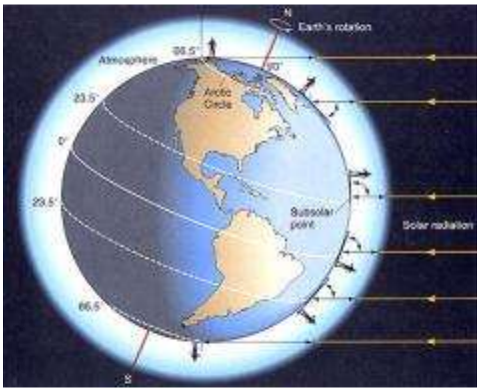
### UNITY OF THE CLIMATE
1.The monsoon regime emphasizes the unity of India with the rest of southeast Asian region.
2.This view of broad unity of the monsoon type of climate should not, however, lead one to ignore its regional variations which differentiate the weather and climate of different regions of India.
3.The climate of Kerala and Tamil Nadu in the south are so different from that of Uttar Pradesh and Bihar in the north, and yet all of these have a monsoon type of climate.

### DIVERSITY OF CLIMATE
The climate of India has many regional variations expressed in the pattern of
1.winds,2.temperature 3. rainfall, 4. rhythm of seasons
5.degree of wetness or dryness.

### TEMPERATURE VARIATION
1.While in the summer the mercury occasionally touches 55°C in the western Rajasthan, it drops down to as low as minus 45°C in winter around Leh.
2.Churu in Rajasthan may record a temperature of 50°C or more on a June day while the mercury hardly touches 19°C in Tawang (Arunachal Pradesh)on the same day.
3.On a December night, temperature in Drass (Jammu and Kashmir) may drop down to minus 45°C while Thiruvananthapuram or Chennai on the same night records 20°C or 22°C.
4.In Kerala and in the Andaman Islands, the difference between day and night temperatures may be hardly seven or eight degree Celsius. But in the Thar desert, if the day temperature is around 50°C, at night, it may drop down considerably up to 15°-20°C.

### THE REGIONAL VARIATIONS IN PRECIPITATION.
1.While snowfall occurs in the Himalayas, it only rains over the rest of the country.
2.While Cherrapunji and Mawsynramin the Khasi Hills of Meghalaya receive rainfall over 1,080 cm in a year, Jaisalmer in Rajasthan rarely gets more than 9 cm of rainfall during the same period.
3.Tura situated in the Garo Hills of Meghalaya may receive an amount of rainfall in a single day which is equal to 10 years of rainfall at Jaisalmer.
4.While the annual precipitation is less than 10 cm in the northwest Himalayas and the western deserts, it exceeds 400 cm in Meghalaya.
5.The Ganga delta and the coastal plains of Orissa are hit by strong rain-bearing storms almost every third or fifth day in July and August while the Coromandal coast, a thousand km to the south, goes generally dry during these months.
6. Most parts of the country get rainfall during June-September, but on the coastal areas of Tamil Nadu, it rains in the beginning of the winter season.

**FACTORS DETERMINING THE CLIMATE OF INDIA**




India's climate is controlled by a number of factors which can be broadly divided into two groups — factors related to location and relief, and factors related to air pressure and winds.

**Factors related to Location and Relief**

*Latitude :*

the Tropic of Cancer passes through the central part of India in east-west direction. Thus, northern part of the India lies in sub-tropical and temperate zone and the part lying south of the Tropic of Cancer falls in the tropical zone.

The tropical zone being nearer to the equator, experiences high temperatures throughout the year with small daily and annual range.

Area north of the Tropic of Cancer being away from the equator, experiences extreme climate with high daily and annual range of temperature.

*The Himalayan Mountains :*

1.Himalayas in the north along with its extensions act as an effective climatic divide.

2.The towering mountain chain provides an invincible shield to protect the subcontinent from the cold northern winds.

3. The Himalayas also trap the monsoon winds, forcing them to shed their moisture within the subcontinent.

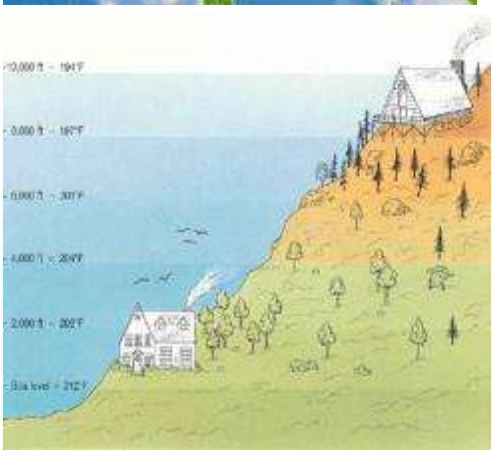
*Distribution of Land and Water :*

As compared to the landmass, water heats up or cools down slowly. This differential heating of land and sea creates different air pressure zones in different seasons in and around the Indian subcontinent. Difference in air pressure causes reversal in the direction of monsoon winds.

*Distance from the Sea* :With a long coastline, large coastal areas have an equable climate.

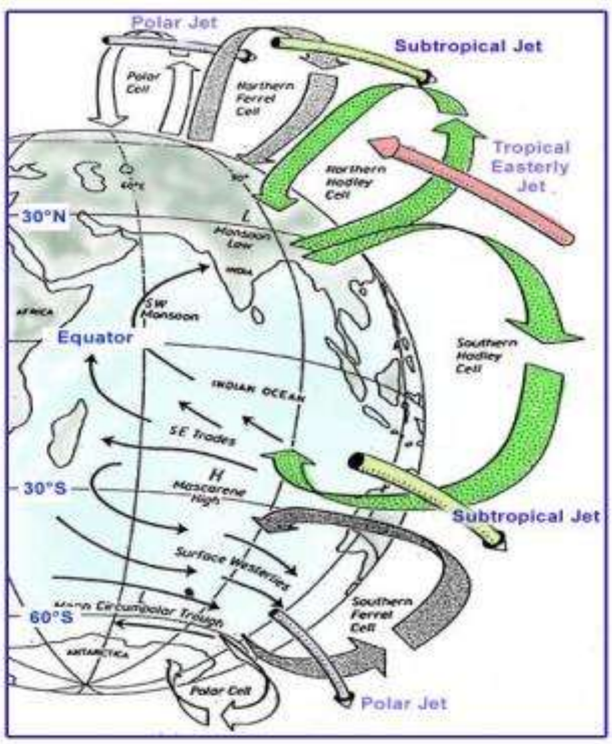
Areas in the interior of India are far away from the moderating influence of the sea. Such areas have extremes of climate. That is why, the people of Mumbai and the Konkan coast have hardly any idea of extremes of temperature and the seasonal rhythm of weather.

*Altitude :As the altitude increases the temperature falls down, that is why Himalayas experience cold climate and north Indian plains plain experience hot climate*



*Relief* :The physiography or relief of India also affects the temperature, air pressure, direction and speed of wind and the amount and distribution of rainfall.

The windward sides of Western Ghats and Assam receive high rainfall during June-September whereas the southern plateau remains dry due to its leeward situation along the Western Ghats.




**Factors Related to Air Pressure and Wind**

To understand the differences in local climates of India, we need to understand the mechanism of the following three factors:

(i) Distribution of air pressure and winds on the surface of the earth.

(ii) Upper air circulation caused by factors controlling global weather and the inflow of different air masses and jet streams.

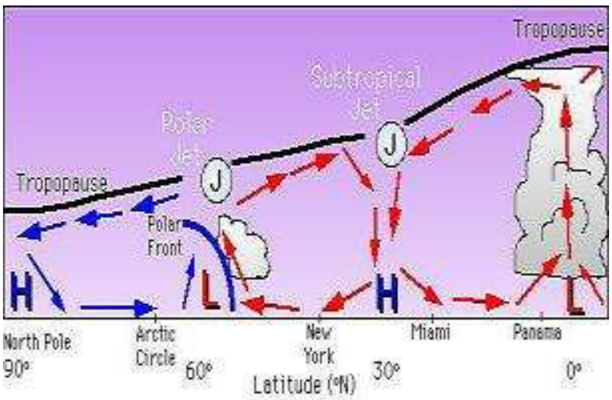
(iii) Inflow of western cyclones generally known as disturbances during the winter season and tropical depressions during the south-west monsoon period into India, creating weather conditions favorable to rainfall. The mechanism of these three factors can be understood with reference to winter and

summer seasons of the year separately.

## Mechanism of Weather in the Winter Season

*Surface Pressure and Winds* :

1. In winter months, a high pressure centre in the region lying to the north of the Himalayas develops during winter.




2. This centre of high pressure gives rise to the flow of air at the low level from the north towards the Indian subcontinent, south of the mountain range.

3. The surface winds blowing out of the high pressure centre over Central Asia reach Indian the form of a dry continental air mass.

4.The position of this contact zone is not, however, stable. Occasionally, it may shift its position as East as the middle Ganga valley with the result that the whole of the northwestern and northern India up to the middle Ganga valley comes under the influence of dry northwestern winds.

*Jet Stream and Upper Air Circulation* :

5.The pattern of air circulation discussed above is witnessed only at the lower level of the atmosphere near the surface of the earth. Higher up in the lower troposphere,

**6.** About three km above the surface of the earth, a different pattern of air circulation is observed. The variations in the atmospheric pressure closer to the surface of the earth have no role to play in the making of upper air circulation.

**7.** All of Western and Central Asia remain under the influence of westerly winds along the altitude of 9-13 km from west to east.

**8.** These winds blow across the Asian continent at latitudes north of the Himalayas roughly parallel to the Tibetan highlands. These are known as jet streams.

***9.*** Tibetan highlands act as a barrier in the path of these jet streams. As a result, jet streams get bifurcated.

*Western Cyclonic Disturbance and TropicalCyclones*

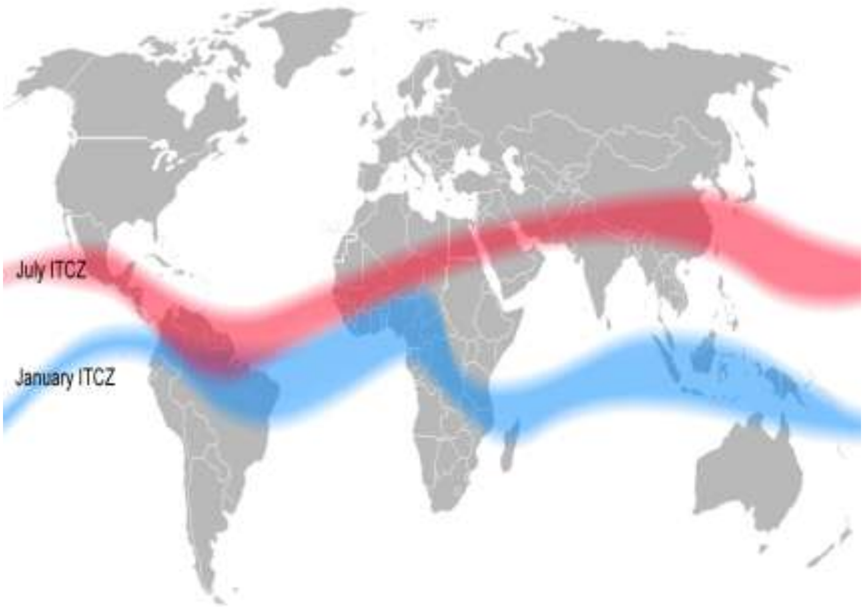
*1.* The western cyclonic disturbances which enter the Indian subcontinent from the west and the northwest during the winter months,

2. Originate over the Mediterranean Sea and are brought into India by the westerly jet stream.
3. Tropical cyclones originate over the Bay of Bengal and the Indian ocean. These tropical cyclones have very high wind velocity and heavy rainfall and hit the Tamil Nadu, Andhra Pradesh and Orissa coast

**Mechanism of Weather in the Summer Season**

*Surface Pressure and Winds*

1.As the summersets in and the sun shifts northwards,
2. By the middle of July, the low pressure belt nearer the surface [termed as Inter Tropical Convergence Zone (ITCZ)]shifts northwards, roughly parallel to the Himalayas between 20° N and 25° N.
3.By this time, the westerly jet stream withdraws from the Indian region.




4.It is generally believed that there is a cause and effect relationship between the two. The ITCZ being a zone of low pressure, attracts inflow of winds from different directions.
5. The maritime tropical Air mass (mT) from the southern hemisphere, after crossing the equator, rushes to the low pressure area in the general south westerly direction.
6. It is this moist air current which is popularly known as the southwest monsoon.

*Jet Streams and Upper Air Circulation* :

1.The pattern of pressure and winds as mentioned above is formed only at the level of the troposphere.
2. An easterly jet stream flows over the southern part of the Peninsula in June,

**Inter Tropical Convergence Zone (ITCZ)** The Inter Tropical Convergence Zone (ITCZ) is a low pressure zone located at the equator where trade winds converge, and so, it is a zone where air tends to ascend. In July, the ITCZ is located around 20°N-25°N latitudes (over the Gangetic plain), sometimes called the monsoon trough. This monsoon trough encourages the development of thermal low over north and northwest India. Due to the shift of ITCZ, the trade winds of the southern hemisphere cross the equator between 40° and 60°E longitudes and start blowing from southwest to northeast due to the Coriolis force. It becomes southwest monsoon. In winter, the ITCZ moves southward, and so the reversal of winds from northeast to south and southwest, takes place. They are called northeast monsoons.

*Easterly Jet Stream and Tropical Cyclones* :The easterly jet stream steers the tropical depressions into India. These depressions play a significant role in the distribution of monsoon rainfall over the Indian subcontinent.

**THE NATURE OF INDIAN MONSOON**

(i) The onset of the monsoon.
(ii) Rain-bearing systems (e.g. tropical cyclones) and the relationship between their frequency and distribution of monsoon rainfall.
(iii) Break in the monsoon.

**Onset of the Monsoon**

1.the differential heating of land and sea during the summer months is the mechanism which sets the stage for the monsoon winds to drift towards the subcontinent.
2.During April and May when the sun shines vertically over the Tropic of Cancer, the large landmass in the north of Indian ocean gets intensely heated.
3. This causes the formation of an intense low pressure in the northwestern part of the subcontinent.
Since he pressure in the Indian Ocean in the south of the landmass is high as water gets heated. slowly, the low pressure cell attracts the southeast trades across the Equator.
4. These conditions help in the northward shift in the position of the ITCZ.

5. The southwest monsoon may thus, be seen as a continuation of the southeast trades deflected towards the Indian subcontinent after crossing the Equator.

6. These winds cross the Equator between 40°E and 60°E longitudes.

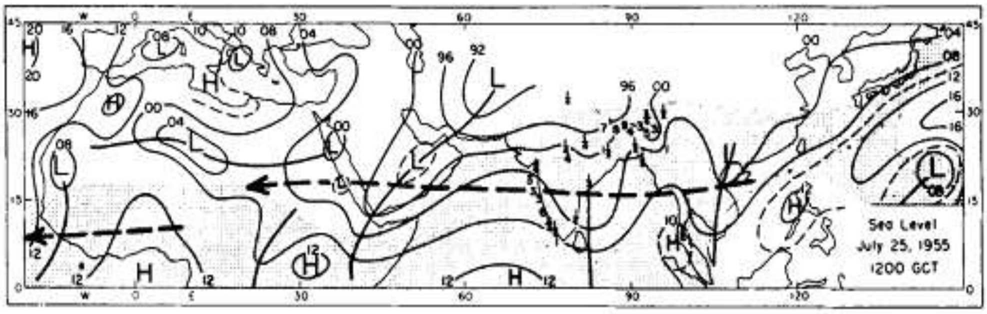



Fig. 4 a. Sea leval isobars (mb. first two digits omitted) July 25, 1955. Clouded area shaded. Figures over India and neighbourhood indicate 24 hours rainfall in inches.

The easterly jet stream sets in along 15°N latitude only after the western jet stream has withdrawn itself from the region. This easterly jet stream is held responsible for the burst of the monsoon in India.

*Entry of Monsoon into India :*The southwest monsoon sets in over the Kerala coast by 1st June and moves swiftly to reach Mumbai and Kolkata between 10th and 13th June. By midJuly, southwest monsoon engulfs the entire subcontinent

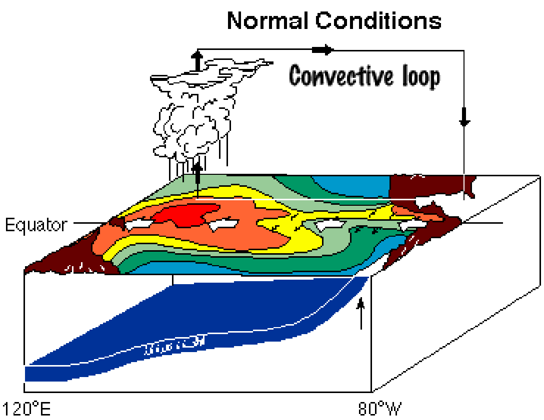
**Rain-bearing Systems and Rainfall Distribution**

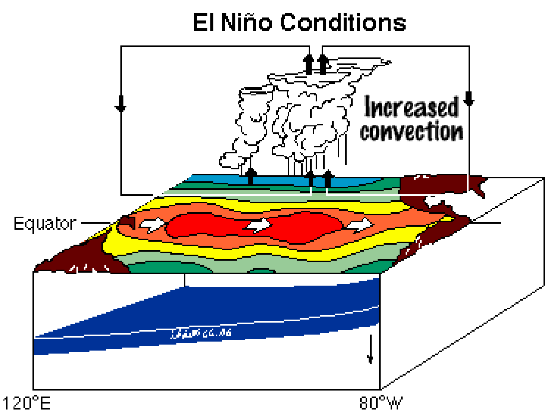
1. **Bay Of Bengal Branch**
2. **Arabian sea branch**

The rainfall distribution is based on two factors:

(i) The offshore meteorological conditions.

(ii) The position of the equatorial jet stream along the eastern coast of Africa.




**El-Nino and the Indian Monsoon**

El-Nino is a complex weather system that appears once every three to seven years, bringing drought, floods and other weather extremes to different parts of the world.

The system involves oceanic and atmospheric phenomena with the appearance of warm currents off the coast of Peru in the Eastern Pacific and affects weather in many places including India. El-Nino is merely an extension of the warm equatorial current which gets replaced temporarily by cold Peruvian current or Humbolt current (locate these currents in your atlas). This current increases the temperature of water on the Peruvian coast by 10°C. This results in:

(i) the distortion of equatorial atmospheric circulation;

(ii) irregularities in the evaporation of sea water;

(iii) reduction in the amount of planktons which further reduces the number of fish in the sea.

The word El-Nino means 'Child Christ' because this current appears around Christmas in December. December is a summer month in Peru (Southern Hemisphere).

El-Nino is used in India for forecasting long range monsoon rainfall. In 1990-91, there was a wild El-Nino event and the onset of southwest monsoon was delayed over most parts of the country ranging from five to twelve days.

**Break in the Monsoon**

During the south-west monsoon period after having rains for a few days, if rain fails to occur for one or more weeks, it is known as break in the monsoon. These dry spells are quite common during the rainy season. These breaks in the different regions are due to different reasons:
(i) In northern India rains are likely to fail if the rain-bearing storms are not very frequent along the monsoon trough or the ITCZ over this region.
(ii) Over the west coast the dry spells are associated with days when winds blow parallel to the coast.

## THE RHYTHM OF SEASONS

The climatic conditions of India can best be described in terms of an annual cycle of seasons. The meteorologists recognise the following four seasons :
(i) the cold weather season
(ii) the hot weather season
(iii) the southwest monsoon season
(iv) the retreating monsoon season.

### The Cold Weather Season

*Temperature* :

1. Found from November to February
2. December and January are the coldest months in the northern plain.
3. The mean daily temperature remains below 21°C , over most parts of northern India.
4. The night temperature may be quite low, sometimes going below freezing point in Punjab and Rajasthan.

There are three main reasons for the excessive cold in north India during this season :
(i) States like Punjab, Haryana and Rajasthan being far away from the moderating influence of sea experience continental climate.
(ii) The snowfall in the nearby Himalayan ranges creates cold wave situation; and
(iii) Around February, the cold winds coming from the Caspian Sea and Turkmenistan bring cold wave along with frost and fog over the northwestern parts of India.

***Pressure and Winds :***

1.By the end of December (22nd December), the sun shines vertically over the Tropic of Capricorn in the southern hemisphere.
2.The weather in this season is characterized by feeble high pressure conditions over the northern plain. In south India, the air pressure is slightly lower respectively
3.As a result, winds start blowing from northwestern high pressure zone to the low air pressure zone over the Indian Ocean in the south. Due to low pressure gradient, the light winds with a low velocity of about 3-5 km per hour begin to blow outwards.
4.By and large, the topography of the region influences the wind direction. They are westerly or northwesterly down the Ganga Valley. They become northerly in the Ganga-Brahmaputra delta.
Free from the influence of topography, they are clearly northeasterly over the Bay of Bengal.
5.During the winters, the weather in India is pleasant.
6.The pleasant weather conditions, however, at intervals, get disturbed by shallow cyclonic depressions originating over the east Mediterranean Sea and travelling eastwards across West Asia, Iran, Afghanistan and Pakistan before they reach the northwestern parts of India.

*Rainfall* :1. Winter monsoons do not cause rainfall as they move from land to the sea.
2. It is because firstly, they have little humidity;
3. secondly, due to anti cyclonic circulation on land, the possibility of rainfall from them reduces. So, most parts of India do not have rainfall in the winter season.
However, there are some exceptions to it:
(i) In northwestern India, some weak temperate cyclones from the Mediterranean sea cause rainfall in
Punjab, Haryana, Delhi and western Uttar Pradesh. Although the amount is meager, it is highly beneficial for rabi crops. The precipitation is in the form of snowfall in the lower Himalayas. It is this snow that sustains the flow of water in the Himalayan rivers during the summer months. The precipitation goes on decreasing from west to east in the plains and from north to south in the mountains.
(ii) Central parts of India and northern parts of southern Peninsula also get winter rainfall occasionally.

(iii) Arunachal Pradesh and Assam in the northeastern parts of India also have rains between 25 mm and 50 mm during these winter months.
(iv) During October and November, northeast monsoon while crossing over the Bay of Bengal, picks up moisture and causes torrential rainfall over the Tamil Nadu coast, southern Andhra Pradesh, southeast Karnataka and south east Kerala.

**The Hot Weather Season**

*Temperature:*

*1.*With the apparent northward movement of the sun towards the Tropic of Cancer in March, temperatures start rising in north India.
2.April, May and June are the months of summer in north India. In most parts of India, temperatures recorded are between 30˚-32˚C.
3. In March, the highest day temperature of about 38˚C occurs in the Deccan Plateau while in April, temperature ranging between 38˚C and 43˚C are found in Gujarat and Madhya Pradesh.
4. In May, the heat belt moves further north, and in the north-western part of India, temperatures around 48˚C are not uncommon
5. temperatures remain between 26˚C and 32˚C. Due to altitude, the temperatures in the hills of= Western Ghats remain below 25˚C.

*Pressure and Winds :*

1.The summer months are a period of excessive heat and falling air pressure in the northern half of the country.
2. Roughly, this elongated low pressure monsoon trough extends over the Thar desert in the north-west to Patna and Chotanagpur plateau in the east-southeast
3.The location of the ITCZ attracts a surface circulation of the winds which are southwesterly on the west coast as well as along the coast of West Bengal and Bangladesh.
4.They are easterly or southeasterly over north Bengal and Bihar. .
5.In the heart of the ITCZ in the northwest, the dry and hot winds known as *'Loo'*, blow in the afternoon, and very often, they continue to well into midnight.
6. Dust storms in the evening are very common during May in Punjab, Haryana, Eastern Rajasthan and
Uttar Pradesh.
7. These temporary storms bring a welcome respite from the oppressing heat since they bring with them light rains and a pleasant cool breeze.
8. Occasionally, the moisture-laden winds are attracted towards the periphery of the trough.
9. A sudden contact between dry and moist air masses gives rise to local storms of great intensity.
10. These local storms are associated with violent winds, torrential rains and even hailstorms.

**Some Famous Local Storms of Hot Weather Season**

*(i) Mango Shower :* Towards the end of summer, there are pre-monsoon showers which are a common
phenomena in Kerala and coastal areas of Karnataka. Locally, they are known as mango showers since they help in the early ripening of mangoes.
*(ii) Blossom Shower* : With this shower, coffee flowers blossom in Kerala and nearby areas.
*(iii) Nor Westers :*These are dreaded evening thunderstorms in Bengal and Assam. Their notorious nature can be understood from the local nomenclature of *'Kalbaisakhi'*, a calamity of the month of *Baisakh*.
(iv) These showers are useful for tea, jute and rice cultivation. In Assam, these storms are known as *"BardoliChheerha"*.
*(v) Loo :* Hot, dry and oppressing winds blowing in the Northern plains from Punjab to Bihar with higher intensity between Delhi and Patna.

**THE SOUTHWEST MONSOON SEASON**

1.Due to high temperature there is lo to attract the trade winds of Southern Hemisphere coming from the Indian Ocean.
2.These southeast trade winds cross the equator and enter the Bay of Bengal and the Arabian Sea,
3.After crossing the equator, they follow a southwesterly direction. That is why they are known as southwest monsoons.
4.The rain in the southwest monsoon season begins rather abruptly. One result of the first rain is that it brings down the temperature substantially.
5.This sudden onset of the moisture-laden winds associated with violent thunder and lightning, is often termed as the "break" or "burst" of the monsoons.

The monsoon approaches the landmass
in two branches:
(i) The Arabian Sea branch
(ii) The Bay of Bengal branch

## Monsoon Winds of the Arabian Sea

The monsoon winds originating over the Arabian Sea further split into three branches:
(i) Its one branch is obstructed by the Western Ghats. These winds climb the slopes of the Western Ghats from900-1200 m. Soon, they become cool, and as a result, the windward side of the Sahyadris and Western Coastal Plain receive very heavy rainfall ranging between 250 cm and 400 cm. After crossing the Western Ghats, these winds descend and get heated up.

(ii) Another branch of the Arabian sea monsoon strikes the coast north of Mumbai. Moving along the Narmada and Tapi river valleys, these winds cause rainfall in extensive areas of central India. The Chotanagpur plateau gets 15 cm rainfall from this part of the branch. Thereafter, they enter the Ganga plains and mingle with the Bay of Bengal branch.

(iii) A third branch of this monsoon wind strikes the Saurashtra Peninsula and the Kachchh. It then passes over west Rajasthan and along the Aravalis, causing only a scanty rainfall. In Punjab and Haryana, it too joins the Bay of Bengal branch. These two branches, reinforced by each other, cause rains in the western Himalayas,

## Monsoon Winds of the Bay of Bengal

1.The Bay of Bengal branch strikes the coast of Myanmar and part of south east Bangladesh. But the Arakan Hills along the coast of Myanmar deflect a big portion of this branch towards the Indian subcontinent.
2.The monsoon, therefore, enters West Bengal and Bangladesh from south and southeast instead of from the south-westerly direction. From here, this branch splits into two under the influence of the Himalayas and the thermal low is northwest India. Its one branch moves westward along the Ganga plains reaching as far as the Punjab plains. The other branch moves up the Brahmaputra valley in the north and the northeast, causing widespread rains. Its sub-branch strikes the Garo and Khasi hills of Meghalaya. Mawsynram, located on the crest of Khasi hills, receives the highest average annual rainfall in the world.
Here it is important to know why the Tamil Nadu coast remains dry during this season.
There are two factors responsible for it:
(i) The Tamil Nadu coast is situated parallel to the Bay of Bengal branch of southwest monsoon.
(ii) It lies in the rain shadow area of the Arabian Sea branch of the south-west monsoon.

## Characteristics of Monsoonal Rainfall

(i) Rainfall received from the southwest monsoons is seasonal in character, which occurs between June and September.
(ii) Monsoonal rainfall is largely governed by relief or topography. For instance the windward side of the Western Ghats register a rainfall of over 250 cm. Again, the heavy rainfall in the north -eastern states can be attributed to their hill ranges and the Eastern Himalayas.
(iii) The monsoon rainfall has a declining trend with increasing distance from the sea. Kolkata receives 119 cm during the southwest monsoon period, Patna 105 cm, Allahabad 76 cm and Delhi 56 cm.
(iv) The monsoon rains occur in wet spells of few days duration at a time. The wet spells are interspersed with rainless, interval known as 'breaks'. These breaks in rainfall are related to the cyclonic depressions mainly formed at the head of the Bay of Bengal, and their crossing into the mainland. Besides the frequency and intensity of these depressions, the passage followed by them determines the spatial distribution of rainfall.
(v) The summer rainfall comes in a heavy downpour leading to considerable run off and soil erosion.
(vi) Monsoons play a pivotal role in the agrarian economy of India because over three-fourths of the total rain in the country is received during the southwest monsoon season.
(vii) Its spatial distribution is also uneven which ranges from 12 cm to more than 250 cm.
(viii) The beginning of the rains sometimes is considerably delayed over the whole or a part of the country.

(viii) The rains sometimes end considerably earlier than usual, causing great damage to standing crops and making the sowing of winter crops difficult.

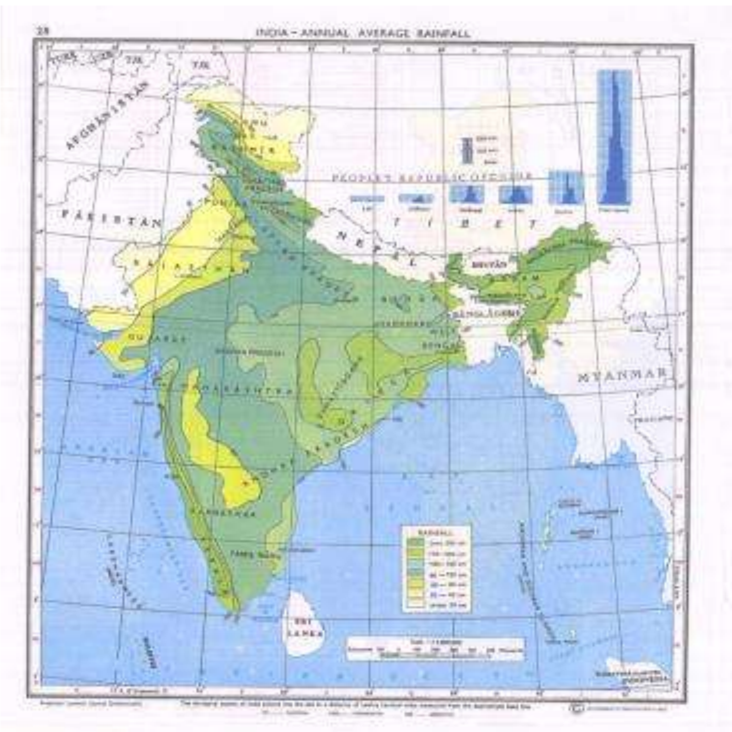
## Season of Retreating Monsoon

1.October and November are known for retreating monsoons.
2.By the end of September, the southwest monsoon becomes weak as the low pressure trough of
3.the Ganga plain starts moving southward in response to the southward march of the sun.
4.The monsoon retreats from the western Rajasthan by the first week of September.
5. It withdraws from Rajasthan, Gujarat, Western Ganga plain and the Central Highlands by the end of the month.
6.By the beginning of October, the low pressure covers northern parts of the Bay of Bengal and by early November, it moves over Karnataka and Tamil Nadu.
7.By the middle of December, the centre of low pressure is completely removed from the Peninsula.
8.The retreating southwest monsoon season is marked by clear skies and rise in temperature.
9.The land is still moist. Owing to the conditions of high temperature and humidity, the weather becomes rather oppressive. This is commonly known as the 'October heat'
10.Here, October and November are the rainiest months of the year.
11.The widespread rain in this season is associated with the passage of cyclonic depressions which originate over the Andaman Sea and manage to cross the eastern coast of the southern Peninsula.

**TRADITIONAL INDIAN SEASONS**

| Seasons | Months (According to the Indian Calendar) | Months (According to the Indian Calendar) |
|---|---|---|
| Vasanta | Chaitra-Vaisakha | March-April |
| Grishma | Jyaistha-Asadha | May-June |
| Varsha | Sravana-Bhadra | July-August |
| Sharada | Asvina-Kartika | September-October |
| Hemanta | Margashirsa-Pausa | November-December |
| Shishira | Magha-Phalguna | January-February |

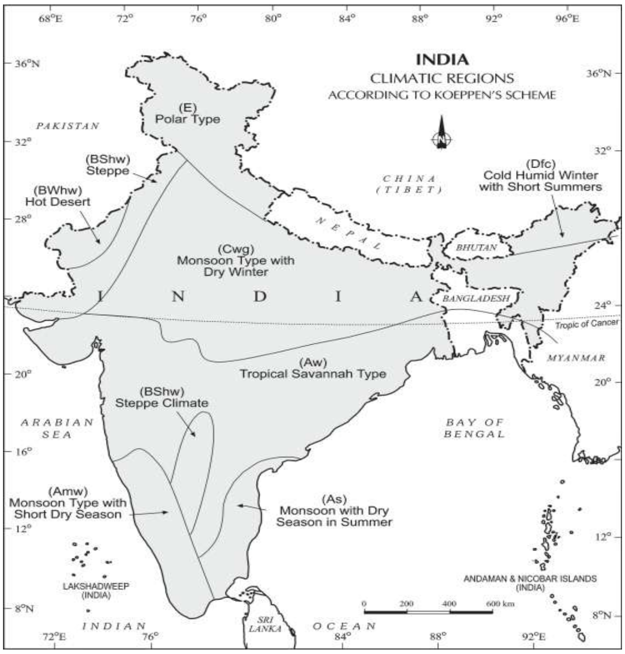
**Distribution of Rainfall**




The average annual rainfall in India is about125 cm, but it has great spatial variations

*Areas of High Rainfall* : The highest rainfall occurs along the west coast, on the Western Ghats, as well as in the sub-Himalayan areas is the northeast and the hills of Meghalaya. Here the rainfall exceeds 200 cm. In some parts of Khasi and Jaintia hills, the rainfall exceeds 1,000 cm. In the Brahmaputra valley and the adjoining hills, the rainfall is less than 200 cm.
*Areas of Medium Rainfall* : Rainfall between 100-200 cm is received in the southern parts of Gujarat, east Tamil Nadu, northeastern Peninsula covering Odisha, Jharkhand, Bihar, eastern Madhya Pradesh, northern Ganga plain along the sub-Himalayas and the Cachar Valley
and Manipur.
*Areas of Low Rainfall*: Western Uttar Pradesh, Delhi, Haryana, Punjab, Jammu and Kashmir,
eastern Rajasthan, Gujarat and Deccan Plateau receive rainfall between 50-100 cm.
*Areas of Inadequate Rainfall*: Parts of the Peninsula, especially in Andhra Pradesh,
Karnataka and Maharashtra, Ladakh and most of western Rajasthan receive rainfall below 50 cm.
Snowfall is restricted to the Himalayan region. Identify the pattern of rainfall after consulting the rainfall map

**Variability of Rainfall**




A characteristic feature of rainfall in India is its variability. The variability of rainfall is computed with the help of the following formula:

$$C.V. = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

Here C.V. is the coefficient of variation.
1. The values of coefficient of variation show the change from the mean values of rainfall.
2. The actual rainfall in some places deviates from 20-50 per cent.
3. A variability of less than 25 per cent exists on the western coasts, Western Ghats, northeastern
Peninsula, eastern plains of the Ganga, north eastern India, Uttarakhand and Himachal Pradesh and south-western part of Jammu and Kashmir. These areas have an annual rainfall of over 100 cm.
4.A variability of over 50 per cent exists in the western part of Rajasthan, northern part of Jammu and Kashmir and interior parts of the Deccan plateau. These areas have an annual rainfall of less than 50 cm.
5.Rest of India have a variability of 25-50 per cent and these areas receive an annual rainfall between
50 -100 cm

**Climatic Regions of India**
The whole of India has a monsoon type of climate. But the combination of elements of the weather, however, reveal many regional variations. These variations represent the subtypes of the monsoon climate. It is on this basis that the climatic regions can be identified.

Major climatic types of India based on *Koeppen's* scheme have been described below:
Koeppen based his scheme of Climatic classification on monthly values of temperature and precipitation. He identified five major climatic types, namely:
(i) Tropical climates, where mean monthly temperature throughout the year is over 18˚C.
(ii) Dry climates, where precipitation is very low in comparison to temperature, and hence, dry. If dryness is less, it is semiarid (S); if it is more, the climate is arid(W).
(iii) Warm temperate climates, where mean temperature of the coldest month is between 18˚C and minus 3˚C.
(iv) Cool temperate climates, where mean temperature of the warmest month is over 10˚C, and mean temperature of the coldest month is under minus 3˚C.
(v)Ice climates, where mean temperature of the warmest month is under 10˚C.

Koeppen used letter symbols to denote climatic types as given above. Each type is further sub-divided into sub-types on the basis of seasonal variations in the distributional pattern of rainfall and temperature. He used S for semi-arid and W for arid and the following small letters to define sub-types:
f (sufficient precipitation),
m (rainforest despite a dry monsoon season),
w (dry season in winter),
h (dry and hot),
c (less than four months with mean temperature over10˚C),
g (Gangetic plain).

Accordingly, India can be divided into eight climatic regions

**Monsoons and the Economic Life in India**

(i) Monsoon is that axis around which revolves the entire agricultural cycle of India. It is because about 64 percent people of India depend on agriculture for their livelihood and agriculture itself is based on southwest monsoon.

(ii) Except Himalayas all the parts of the country have temperature above the threshold level to grow the crops or plants throughout the year.

(iii) Regional variations in monsoon climate help in growing various types of crops.

(iv) Variability of rainfall brings droughts or floods every year in some parts of the country.

(v) Agricultural prosperity of India depends very much on timely and adequately distributed rainfall. If it fails, agriculture is adversely affected particularly in those regions where means of irrigation are

Not developed.

(vi) Sudden monsoon burst creates problem of soil erosion over large areas in India.

(vii) Winter rainfall by temperate cyclones in north India is highly beneficial for rabi crops.

(viii) Regional climatic variation in India is reflected in the vast variety of food, clothes and house types.

**GLOBAL WARMING**

**Table 4.1 : Climatic Regions of India According to Koeppen's Scheme**

| *Type of Climate* | *Areas* |
|---|---|
| Amw Monsoon with short dry season | West coast of India south of Goa |
| As - Monsoon with dry summer | Coromandel coast of Tamil Nadu |
| Aw - Tripical savannah | Most of the Peninsular plateaus, south of the Tropic of Cancer |
| Bwhw - Semi-arid steppe climate | North-western Gujarat, some parts of western Rajasthan and Punjab |
| Bwhw - Hot desert | Extreme western Rajasthan |
| Cwg - Monsoon with dry winter | Ganga plain, eastern Rajasthan, northern Madhya Pradesh, most of North-east India |
| Dfc - Cold humid winter with short summer | Arunachal Pradesh |
| E - Polar type | Jammu and Kashmir, Himachal Pradesh and Uttarakhand |

You know that change is the law of nature.

Climate has also witnessed change in the past at the global as well as at local levels. It is changing even now but the change is imperceptible. A number of geological evidences suggest that once upon a time,large part of the earth was under ice cover.

# CHAPTER -5 NATURAL VEGETATION

**Natural vegetation refers to a plant community that has been left undisturbed over a long time, so as to allow its individual species to adjust themselves to climate and soil conditions as fully as possible.**
Himalayan heights are marked with temperate vegetation;
the Western Ghats and the Andaman Nicobar Islands have tropical rain forests,
the deltaic regions have tropical forests and mangroves;
the desert and semi desert areas of Rajasthan are known for cacti, a wide variety of bushes and thorny vegetation.
Depending upon the variations in the climate and the soil, the vegetation of India changes from one region to another.
On the basis of certain common features such as predominant vegetation type and climatic regions, Indian forests can be divided into the following groups:

TYPES OF FORESTS
(i) Tropical Evergreen and Semi Evergreen forests
(ii) Tropical Deciduous forests
(iii) Tropical Thorn forests
(iv) Montane forests
(v) Littoral and Swamp forests.

**Tropical Evergreen and Semi Evergreen Forests**
1.These forests are found in the western slope of the Western Ghats, hills of the northeastern region and the Andaman and Nicobar Islands.
2.They are found in warm and humid areas with an annual precipitation of over 200 cm and mean

3.Tropical evergreen forests are well stratified, with layers closer to the ground and are covered with shrubs and creepers, with short structured trees followed by tall variety of trees.
4. trees reach great heights up to 60 m or above.
5. There is no definite time for trees to shed their leaves, flowering and fruition.
As such these forests appear green all the year round.
6.Species found in these forests include rosewood, mahogony, aini, ebony, etc.

SEMI EVERGREEN FOREST
1.The semi evergreen forests are found in the less rainy parts of these regions.
2.Such forests have a mixture of evergreen and moist deciduous trees.
3.The under growing climbers provide an evergreen character to these forests.
4.Main species are white cedar, hollock and kail.
5.The oak forests in Garhwal and Kumaon were replaced by pine (chirs) which was needed to lay railway lines.
6. Forests were also cleared for introducing plantations of tea, rubber and coffee.

## Tropical Deciduous Forests

1.These are the most widespread forests in India.
2.They are also called the monsoon forests.
3.They spread over regions which receive rainfall between 70-200 cm.
4.On the basis of the availability of water, these forests are further divided into moist and dry deciduous.

*The Moist deciduous forests*

*1.They are mostly found in* the regions which record rainfall between 100-200 cm.
2.These forests are found in the northeastern states along the foothills of Himalayas, eastern slopes of the Western Ghats and Odisha.
3. Teak, *sal, shisham, hurra,mahua, amla, semul, kusum,* and sandalwood etc. are the main species of these forests.

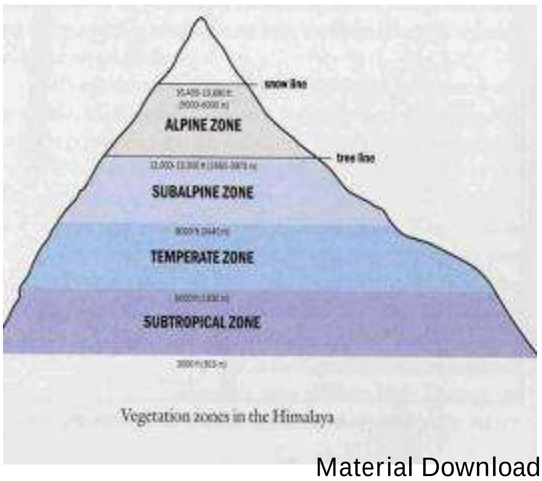
*Dry deciduous forest*

1.covers vast areas of the country,
2. rainfall ranges between 70 -100 cm.
3.On the wetter margins, it has a transition to the moist deciduous, while on the drier margins to thorn forests.
4.These forests are found in rainier areas of the Peninsula and the plains of Uttar Pradesh and Bihar.
5.park lands are found In the higher rainfall regions of the Peninsular plateau and the northern Indian plain,
6.As the dry season begins, the trees shed their leaves completely and the forest appears like a vast grassland with naked trees all around. *Tendu, palas, amaltas, bel, khair,* axlewood, etc. are the common trees of these forests.
In the western and southern part of Rajasthan, vegetation cover is very scanty due to low rainfall and overgrazing.

## Tropical Thorn Forests

1.Tropical thorn forests occur in the areas which receive rainfall less than 50 cm.
2.These consist of a variety of grasses and shrubs.
3.It includes semi-arid areas of south west Punjab,Haryana, Rajasthan, Gujarat, Madhya Pradesh and Uttar Pradesh.
4.In these forests, plants remain leafless for most part of the year and give an expression of scrub vegetation.
5.Important species found are *babool, ber*, and wild date palm, *khair, neem, khejri, palas*, etc. 6.Tussocky grass grows upto a height of 2 m as the under growth.

## Montane Forests




1.In mountainous areas, the decrease in temperature with increasing altitude leads to a corresponding change in natural vegetation.
2.Mountain forests can be classified into two types, the northern mountain forests and the southern mountain forests.
3.The Himalayan ranges show a succession of vegetation from the tropical to the tundra, which change in with the altitude.

5. Deciduous forests are found in the foothills of the Himalayas.

1. It is succeeded by the wet temperate type of forests between an altitude of 1,000-2,000 m.

# CHAPTER- 6 SOILS

## IMPORTANCE OF SOILS

1.provide support & nutrients to the plants
2.plants provide food and clothes are grown over the soils
3.Provide shelter to microorganisms
4.Supply nutrients to plants

The major factors affecting the formation of soil are 1.relief, 2.parent material, 3.climate, 4.vegetation 5.life-forms and 6.time. 7. human activities

Components of the soil

1.mineral particles, 2.humus, 3.water 4. air.

Structure of the soil

If we dig a pit on land and look at the soil, we find that it consists of three layers which are called horizons.

'Horizon A' is the topmost zone, where organic materials have got incorporated with the mineral matter, nutrients and water, which are necessary for
the growth of plants.

'Horizon B' is a transition zone between the 'horizon A' and 'horizon C', and contains matter derived from below as well as from above. It has some organic matter in it, although the mineral matter is noticeably weathered.

'Horizon C' is composed of the loose parent material.

This layer is the first stage in the soil formation process and eventually forms the above two layers.

This arrangement of layers is known as the soil profile.

Underneath these three horizons is the rock which is also known as the parent rock or the bedrock.

Soil, which is a complex and varied entity has always drawn the attention of the scientists.

## CLASSIFICATIONOF SOILS

In ancient times, soils used to be classified into two main groups - *Urvara* and *Usara*,
which were fertile and sterile, respectively. In the 16th centrury A.D., soils were classified on
the basis of their inherent characteristics and external features such as
1. texture, 2. colour, 3. slope of land and 4. moisture content in the soil.

Based on texture, main soil types were identified as 1.sandy, 2.clayey, 3.silty and 4.loam, etc.

On the basis of colour, they were 1.red, 2.yellow, 3.black, etc.

the ICAR has classified the Indian soils on the basis of their nature and character as per the United States Department of Agriculture (USDA) Soil Taxonomy.

(i)Inceptisols (ii) Entisols (iii) Alfisols (iv) Vertisols (v) Aridisols (vi) Ultisols (viii) Others

On the basis of genesis, colour, composition and location, the soils of Indiahave been classified into:

(i) Alluvial soils(ii) Black soils(iii) Red and Yellow soils(iv) Laterite soils(v) Arid soils
(vi) Saline soils(vii) Peaty soils(viii) Forest soils.

## Alluvial Soils

1.Alluvial soils are widespread in the northern plains and the river valleys.
2.These soils cover about 40 per cent of the total area of the country.
3.They are depositional soils, transported and deposited by rivers and streams.
4.Through a narrow corridor in Rajasthan, they extend into the plains of Gujarat.
5.In the Peninsular region, they are bound in deltas of the east coast and in the river valleys.
6.They are generally rich in potash but poor in phosphorous.
7.In the Upper and Middle Ganga plain, two different types of alluvial soils have developed, viz. *Khadar* and *Bhangar*. *Khadar* is the new alluvium and is deposited by floods annually, which enriches the soil by depositing fine silts.
*8.Bhangar* represents a system of older alluvium, deposited away from the flood plains.
9.Both the *Khadar* and *Bhangar* soils contain calcareous concretions *(Kankars)*.
These soils are more loamy and clayey in the lower and middle Ganga plain and the Brahamaputra valley.
10.The sand content decreases from the west to east.
11.The colour of the alluvial soils varies from the light grey to ash grey. Its shades depend on the depth of the deposition, the texture of the materials, and the time taken for attaining maturity.

## Black Soil

1.Black soil covers most of the Deccan Plateau which includes parts of Maharashtra, Madhya Pradesh,
Gujarat, Andhra Pradesh and some parts of Tamil Nadu.
2. In the upper reaches of the Godavari and the Krishna, and the northwestern part of the Deccan Plateau, the black soil is very deep.
4.These soils are also known as the 'Regur Soil' or the 'Black Cotton Soil'.
5.The black soils are generally clayey, deep and impermeable.
6.They swell and become sticky when wet and shrink when dried. So, during the dry season, these soil develop wide cracks.
7.Chemically, the black soils are rich in lime, iron, magnesia and alumina.
8.They also contain potash. But they lack in phosphorous, nitrogen and organic matter.
9.The colour of the soil ranges from deep black to grey.

## Red and Yellow Soil

1.Red soil develops on crystalline igneous rocks in areas of low rainfall in the eastern and southern part of the Deccan Plateau.
2.Along the piedmont zone of the Western Ghat, long stretch of area is occupied by red loamy soil. Yellow and red soils are also found in parts of Odisha and Chattisgarh and in the southern parts of the middle Ganga plain.
3.The soil develops a reddish colour due to a wide diffusion of iron in crystalline and metamorphic rocks.
4.It looks yellow when it occurs in a hydrated form.
5.The fine-grained red and yellow soils are normally fertile,
6.whereas coarse-grained soils found in dry upland areas are poor in fertility.
7.They are generally poor in nitrogen, phosphorous and humus.

## Laterite Soil

1.Laterite has been derived from the Latin word *'Later'* which means brick.
2.The laterite soils develop in areas with high temperature and high rainfall.
3.These are the result of intense leaching due to tropical rains.
4.With rain, lime and silica are leached away, and soils rich in iron oxide and aluminum compound are left behind.
5.Humus content of the soil is removed fast by bacteria that thrives well in high temperature.
6.These soils are poor in organic matter, nitrogen, phosphate and calcium, while iron oxide and potash are in excess.
7.Hence, laterites are not suitable for cultivation; however, application of manures and fertilizers are required for making the soils fertile for cultivation.
8.Red laterite soils in Tamil Nadu, Andhra Pradesh and Kerala are more suitable for tree crops like cashewnut.
9.Laterite soils are widely cut as bricks for use in house construction. These soils have mainly developed in the higher areas of the Peninsular plateau.
10 The laterite soils are commonly found in Karnataka, Kerala, Tamil Nadu, Madhya Pradesh and the hilly areas of Odisha and Assam.

## Arid Soils

1.Arid soils range from red to brown in colour.
2.They are generally sandy in structure and saline in nature. In some areas, the salt content is so high that common salt is obtained by evaporating the saline water.
3.Due to the dry climate, high temperature and accelerated evaporation, they lack moisture and humus.
4.Nitrogen is insufficient and the phosphate content is normal.
5. Lower horizons of the soil are occupied by *'kankar'* layers because of the increasing calcium content downwards.
6. The *'Kankar'* layer formation in the bottom horizons restricts the infiltration of water, and as such when irrigation is made available, the soil moisture is readily available for a sustainable plant growth.
7.Arid soils are characteristically developed in western Rajasthan, which exhibit characteristic arid topography.
8.These soils are poor and contain little humus and organic matter.

## Saline Soils

1.They are also known as *Usara* soils.

2.Saline soils contain a larger proportion of sodium, potassium and magnesium, and thus, they are infertile, and do not support any vegetative growth.

3.They have more salts, largely because of dry climate and poor drainage. They occur in arid and semi-arid regions, and in waterlogged and swampy areas.

4. Their structure ranges from sandy to loamy.

5.They lack in nitrogen and calcium. Saline soils are more widespread in western Gujarat, deltas of the eastern coast and in Sunderban areas of West Bengal.

6. In the Rann of Kuchchh, the Southwest Monsoon brings salt particles and deposits there as a crust. Seawater intrusions in the deltas promote the occurrence of saline soils. In the areas of intensive cultivation with excessive use of irrigation, especially in areas of green revolution, the fertile alluvial soils are becoming saline.

7.Excessive irrigation with dry climatic conditions promotes capillary action, which results in the deposition of salt on the top layer of the soil. In such areas, especially in Punjab and Haryana, farmers are advised to add gypsum to solve the problem of salinity in the soil.

## Peaty Soils

1.They are found in the areas of heavy rainfall and high humidity, where there is a good growth of vegetation.

2.Thus, large quantity of dead organic matter accumulates in these areas, and this gives a rich humus and organic content to the soil.

3.Organic matter in these soils may go even up to 40-50 per cent. These soils are normally heavy and black in colour.

4.At many places, they are alkaline also.

5.It occurs widely in the northern part of Bihar, southern part of Uttaranchal and the coastal areas of West Bengal, Orissa and Tamil Nadu.

## Forest Soils

1.Forest soils are formed in the forest areas where sufficient rainfall is available.

2.The soils vary in structure and texture depending on the mountain environment where they are formed.

3.They are loamy and silty on valley sides and coarse-grained in the upper slopes.

4.In the snow-bound areas of the Himalayas, they experience denudation, and are acidic with low humus content.

5.The soils found in the lower valleys are fertile.

## SOIL DEGRADATION

1. Soil degradation can be defined as the decline in soil fertility, when the nutritional status declines and depth of the soil goes down due to erosion and misuse.

2.Soil degradation is the main factor leading to the depleting soil resource base in India.

3.The degree of soil degradation varies from place to place according to the topography, wind velocity and amount of the rainfall.

## SOIL EROSION

1.The destruction of the soil cover is described as soil erosion. The soil forming processes and the erosional processes of running water and wind go on simultaneously.

2. There is a balance between these two processes.

3.The rate of removal of fine particles from the surface is the same as the rate of addition of particles to the soil layer. Human activities too are responsible for soil erosion to a great extent.

4.The human population increases, the demand on the land also increases.

5.Forest and other natural vegetation is removed for human settlement, for cultivation, for grazing animals and for various other needs.

6.Wind and water are powerful agents of soil erosion because of their ability to remove soil and transport it.

7.Wind erosion is significant in arid and semi-arid regions.

8 In regions with heavy rainfall and steep slopes, erosion by running water is more significant.
9.Water erosion which is more serious and occurs extensively in different parts of India, takes place mainly in the form of sheet and gully erosion.
10 Sheet erosion takes place on level lands after a heavy shower and the soil removal is not easily noticeable.
11.But it is harmful since it removes the finer and more fertile top soil. Gully erosion is common on steep slopes.
12.Gullies deepen with rainfall, cut the agricultural lands into small fragments and make them unfit for cultivation.
12.A region with a large number of deep gullies or ravines is called a badland topography. Ravines are widespread, in the Chambal basin.
13.Besidesthis, they are also found in Tamil Nadu and West Bengal.
14The country is losing about 8,000 hectares of land to ravines every year.
15.Deforestation is one of the major causes of soil erosion.
16.Plants keep soils bound in locks of roots, and thus, prevent erosion. They also add humus to the soil by shedding leaves and twigs.

Forests have been denuded practically in most parts of India but their effect on soil erosion are more in hilly parts of the country.

A fairly large area of arable land in the irrigated zones of India is becoming saline because of over irrigation.
The salt lodged in the lower profiles of the soil comes up to the surface and destroys its fertility. Chemical fertilizers in the absence of organic manures are also harmful to the soil. Unless the soil gets enough humus, chemicals harden it and reduce its fertility in the long run. This problem is common in all the command areas of the river valley projects, which were the First beneficiaries of the Green Revolution. According to estimates, about half of the total land of India is under some degree of degradation. Every year, India loses millions of tons of soil and its nutrients to the agents of its degradation, which adversely affects our national productivity. So, it is imperative to initiate immediate steps to reclaim and conserve soils.

## Soil Conservation

| NEED FOR SOIL CONSERVATION | METHODS TO CONSERVE SOILS |
|---|---|
| 1. Large scale soil erosion<br>2. Excessive use of fertilizers<br>3. Faulty methods of cultivation<br>4. Deforestation<br>5. Over use of land for cultivation.<br>6. Overgrazing<br>7. Shifting cultivation | 1.controlled grazing<br>2.terraced farming<br>3. ban on shifting cultivation<br>4. contour bunding<br>5.Regulated forestry<br>6.cover cropping<br>7. mixed forming<br>8. crop rotation |

UNITIV

## CHAPTER- 7 NATURAL HAZARDS AND DISASTERS: CAUSES, CONSEQUENCES AND MANAGEMENT

*This unit deals with• Floods and droughts• Earthquakes and tsunami• Cyclones • Landslides*

NATURAL HAZARDS AND DISASTERS

**What is a Disaster?**

*"Disaster is an undesirable occurrence resulting from forces that are largely outside human control, strikes quickly with little or no warning, which causes or threatens serious disruption of life and property including death and injury to a large number of people, and requires therefore, mobilisation of efforts in excess of that which are normally provided by statutory emergency services".*

disasters as a consequence of natural forces; and human beings were treated as innocent and helpless victims in front of the mighty forces of nature.

TYPES OF DISASTERS

NATURAL:

1. EARTH QUAKES. 2. VOLCANIC ERUPTIONS 3. LANDSLIDES 4. FOREST FIRES
5. FLOODS 6.TSUNAMIES 7. DISEASES

MAN MADE DISASTERS

1. NUCLEAR EXPLOSIONS 2. EARTH QUAKES CAUSED BY DAM CONSTRUCTION
3.HIV AIDS 4 MINING 5. ENVIRONMENTAL POLLUTION 6. LEAKAGE OF NUCLEAR MATERIAL

Establishment of National Institute of Disaster Management, India, Earth Summit at Rio de Janeiro, Brazil, 1993 and the World Conference on Disaster Management in May 1994 at Yokohama, Japan, etc. are some of the concrete steps towards this direction initiated at different levels.

*Natural Hazards are elements of circumstances in the Natural environment that have the potential to cause harm to people or property or both.*

*Natural disasters are relatively sudden and cause large scale, widespread death, loss of property and disturbance to social systems and life over which people have a little or no control.*

Thus, any event can be classed as disaster when the magnitude of destruction and damage caused by it is very high. Generally, disasters are generalized experiences of people the world over, and no two disasters are similar and comparable to each other. Every disaster is unique in terms of the local socio-environmental factors that control it, the social response it generates, and the way each social group negotiates with it.

However, the opinion mentioned above is indicative of three important things.

1. Firstly, the magnitude, intensity, frequency and damages caused by natural disasters have increased
over the years.
2.Secondly, there is a growing concern among people the world over to deal with the menace created by these so that the loss of human life and property can be minimized.
3.finally, significant changes have taken place in the pattern of natural disasters over the years.

There has also been a change in the perception of natural disasters and hazards. Areas prone to natural hazards, were more vulnerable to disasters.

Hence, this issue was raised at the *U.N. General Assembly* in 1989 and it was finally formalized at the *World Conference on Disaster Management* in May 1994 at Yokohama, Japan. This was subsequently called the *Yokohama Strategy and Plan of Action for a Safer World*.

**Table 7.1 : Some Natural Disasters Since 1948**

*Year Location Type*
1948 The Soviet Union (now Russia) Earthquakes
1949 China Floods
1954 China Floods
1965 East Pakistan (now Bangladesh) Tropical Cyclones
1968 Iran Earthquakes
1970 Peru Earthquakes
1970 East Pakistan (now Bangladesh) Tropical Cyclones
1971 India Tropical Cyclones
1976 China Earthquakes
1990 Iran Earthquakes
2004 Indonesia, Sri Lanka, India, etc. Tsunamis
2005 Pakistan, India Earthquakes
2011 Japan Tsunami

*Source :* United Nations Environmental Programme (UNEP), 1991
**News Report* from National Institute for Disaster Management, Government of India, New Delhi
**Table 7.2 : Classification of Natural Disasters**

| Table 7.2 : Classification of Natural Disasters | | | |
|---|---|---|---|
| *Atmospheric* | *Terrestrial* | *Aquatic* | *Biological* |
| Blizzards<br>Thunderstorms<br>Lightning<br>Tornadoes<br>Tropical Cyclone<br>Drought<br>Hailstorm<br>Frost, Heat Wave or Loo,Cold Waves, etc. | Earthquakes<br>Volcanic Eruptions<br>Landslides<br>Avalanches<br>Subsidence<br>Soil Erosion | Floods<br>Tidal Waves<br>Ocean Currents<br>Storm Surge<br>Tsunami | Plants and Animals as colonisers (Locusts, etc.). Insects infestation—fungal, bacterial and viral diseases such as bird flu, dengue, etc. |

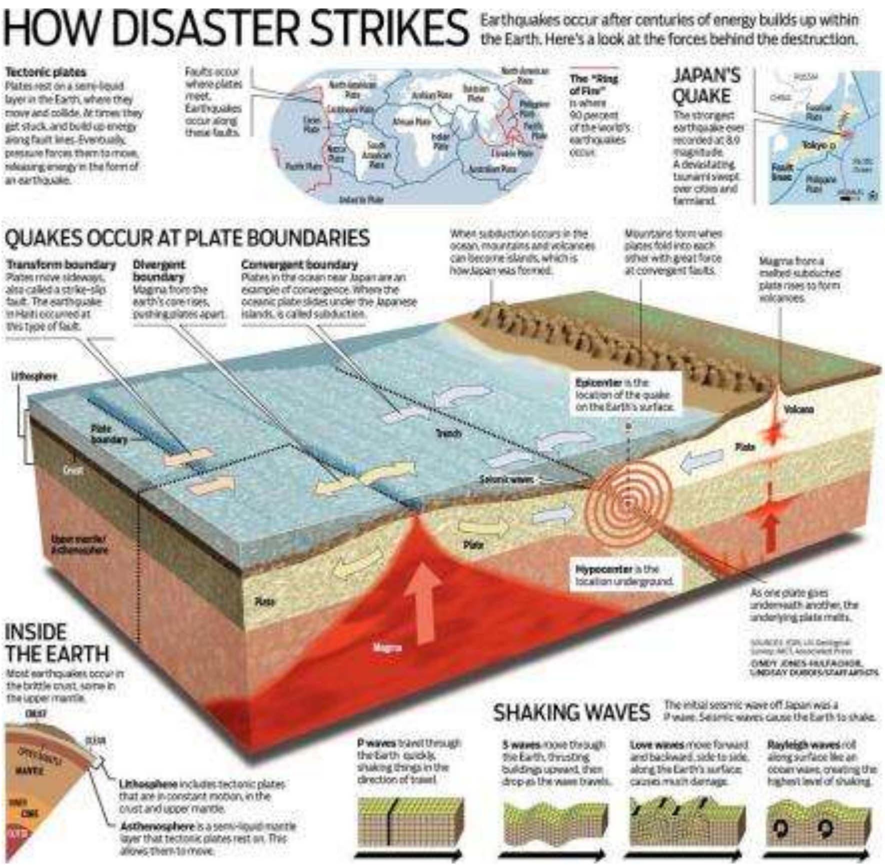
**Yokohama Strategy and International Decade for Natural Disaster Reduction (IDNDR)**
**Yokohama Strategy and Plan of Action for a Safer World**
All the member states of the United Nations and other states met at the **World Conference on Natural Disaster Reduction** in the city of Yokohama from May 23rd- 27th 1994. It acknowledged that the impact of natural disasters in terms of human and economic losses has risen in recent years, and society, in general, has become vulnerable to natural disasters. It also accepted that these disasters affected the poor and disadvantageous groups the worst, particularly in the developing countries, which are ill-equipped to cope with them.

Hence, the conference adopted the Yokohama strategy as a guide to rest of the decade and beyond, to mitigate the losses due to these disasters.
*The resolution of the World Conference on Natural Disasters Reduction is as mentioned below:*
(i) It will note that each country has the sovereign responsibility to protect its citizens from natural disasters;
(ii) It will give priority attention to the developing countries, particularly the least developed, land-locked countries and small-island developing states;
(iii) It will develop and strengthen national capacities and capabilities and, where appropriate, national legislation for natural and other disaster prevention, mitigation and preparedness, including the mobilisation of non-governmental organisations and participation of local communities;
(iv) It will promote and strengthen sub-regional, regional and international cooperation in activities to prevent, reduce and mitigate natural and other disasters, with particular emphasis on:
(a) human and institutional capacity-building and strengthening;
(b) technology sharing: the collection, the dissemination and utilisation of information; and
(c) mobilisation of resources.
It also declared the decade 1990-2000 as the *International Decade for Natural Disaster Reduction (IDNDR).*

**NATURAL DISASTERS AND HAZARDS IN INDIA**

REASONS FOR MORE DISASTERS IN INDIA
1.India is vast and diverse in terms of its physical and socio-cultural attributes.
2.It is largely due to its vast geographical area,
3.Environmental diversities and cultural pluralities that scholars often described it using two meaningful adjectives like the 'Indian-subcontinent' and the 'land of unity in diversity'.
4.Its vastness in terms of natural attributes combined with its prolonged colonial past, continuing various forms of social discriminations and also equally large population have enhanced its vulnerability to natural disasters.
**Earthquakes**
Earthquakes are by far the most unpredictable and highly destructive of all the natural disasters.
CAUSES OF EARTHQUAKES
1. NATURAL
   A. tectonic B. volcanic C land slides
2.MAN MADE
1. mining 2. Nuclear explosion 3. Dam induced

Earthquakes that are of tectonic origin have proved to be the most devastating and their area of influence is also quite large.




These earthquakes result from a series of earth movements brought about by a sudden release of energy during the tectonic activities in the earth's crust. As compared to these, the earthquakes associated with volcanic eruption, rock fall, landslides, subsidence, particularly in the mining areas, impounding of dams and reservoirs, etc. have limited area of influence and the scale of damage.

*National Geophysical Laboratory, Geological Survey of India, Department of Meteorology, Government of India,* along with the recently formed *National Institute of Disaster Management*, have made an intensive analysis of more than 1,200 earthquakes that have occurred in India in different years in the past, and based on these, they divided India into the following five earthquake zones:


(i) Very high damage risk zone
(ii) High damage risk zone
(iii) Moderate damage risk zone
(iv) Very low damage risk zone.

1.Out of these, the first two zones had experienced some of the most devastating earthquakes in India. As shown in the Figure areas vulnerable to these earthquakes are the North-east states, areas to the north of Darbhanga and Araria along the Indo-Nepal border in Bihar, Uttarakhand, Western Himachal Pradesh (around Dharamshala) and Kashmir Valley in the Himalayan region and the Kuchchh (Gujarat).

2. These are included in the Very High Damage Risk Zone.
Similarly, the remaining parts of Jammu and Kashmir, Himachal Pradesh, Northern parts of Punjab, Eastern parts of Haryana, Delhi, Western Uttar Pradesh, and Northern Bihar fall under the High Damage Risk Zone.

3. Remaining parts of the country fall under moderate to very Low Damage Risk Zone.
Most of the areas that can be considered safe are from the stable landmass covered under the Deccan plateau.

*Socio-Environmental Consequences of Earthquakes*

The idea of an earthquake is often associated with fear and horror due to the scale, magnitude and suddenness at which it spreads disasters on the surface of the earth without discrimination. It becomes a calamity when it strikes the areas of high density of population. It not only damages and destroys the settlements, infrastructure, transport and communication network, industries and other developmental activities but also robs the population of their material and socio-cultural gains that they have preserved over generations. It renders them homeless,
which puts an extra-pressure and stress, particularly on the weak economy of the developing countries.

*Effects of Earthquakes*

Earthquakes have all encompassing disastrous effects on the area of their occurrence. Some of the important ones are listed in Table 7.3.

**Table 7.3 : Effects of Earthquakes**

**Table 7.3 : Effects of Earthquakes**

| On Ground | On Manmade Structures | On Water |
|---|---|---|
| Fissures | Cracking | Waves |
| Settlements | Slidings | Hydro-Dynamic Pressure |
| Landslides | Overturning | Tsunami |
| Liquefaction | Buckling | |
| Earth Pressure | Collapse | |
| Possible Chain-effects | Possible Chain-effects | Possible Chain-effects |

*Earthquake Hazard Mitigation*

Methods to decrease the effects of Earthquake

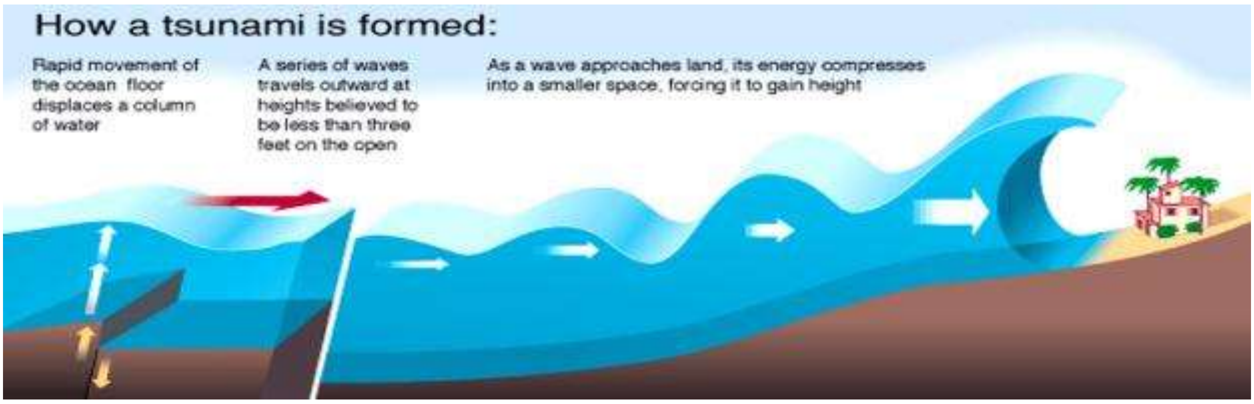
(i) Establishing earthquake monitoring centres (seismological centres) for regular monitoring and fast dissemination of information among the people in the vulnerable areas. Use of Geographical Positioning System (GPS) can be of great help in monitoring the movement of tectonic plates.

(ii) Preparing a vulnerability map of the country and dissemination of vulnerability risk information among the people and educating them about the ways and means minimizing the adverse impacts of disasters.

(iii) Modifying the house types and building designs in the vulnerable areas and discouraging construction of high-rise buildings, large industrial establishments and big urban centres in such areas.

(iv) Finally, making it mandatory to adopt earthquake-resistant designs and use light materials in major construction activities in the vulnerable areas.

*Earthquakes and volcanic eruptions that cause the sea-floor to move abruptly resulting in sudden displacement of ocean water in the form of high vertical waves are called tsunamis*



(harbour waves) or seismic sea waves. Normally, the seismic waves cause only one instantaneous vertical wave; but, after the initial disturbance, a series of after waves are created in the water that oscillate between high crest and low trough in order to restore the water level.
The speed of wave in the ocean depends upon the depth of water.
It is more in the shallow water than in the ocean deep.
As a result of this, the impact of *tsunami* is less over the ocean and more near the coast where they cause large-scale devastations.
when a tsunami enters shallow water, its wave-length gets reduced and the period remains unchanged, which increases the wave height. Sometimes, this height can be up to 15m or more, which causes large-scale destructions along the shores. Thus, these are also called *Shallow Water Waves*.
Tsunamis are frequently observed along the Pacific ring of fire, particularly along the coast of Alaska, Japan, Philippines, and other islands of Southeast Asia, Indonesia, Malaysia, Myanmar, Sri Lanka, and India etc.

**The effect of tsunami is more along the coast because the density of population is high.**

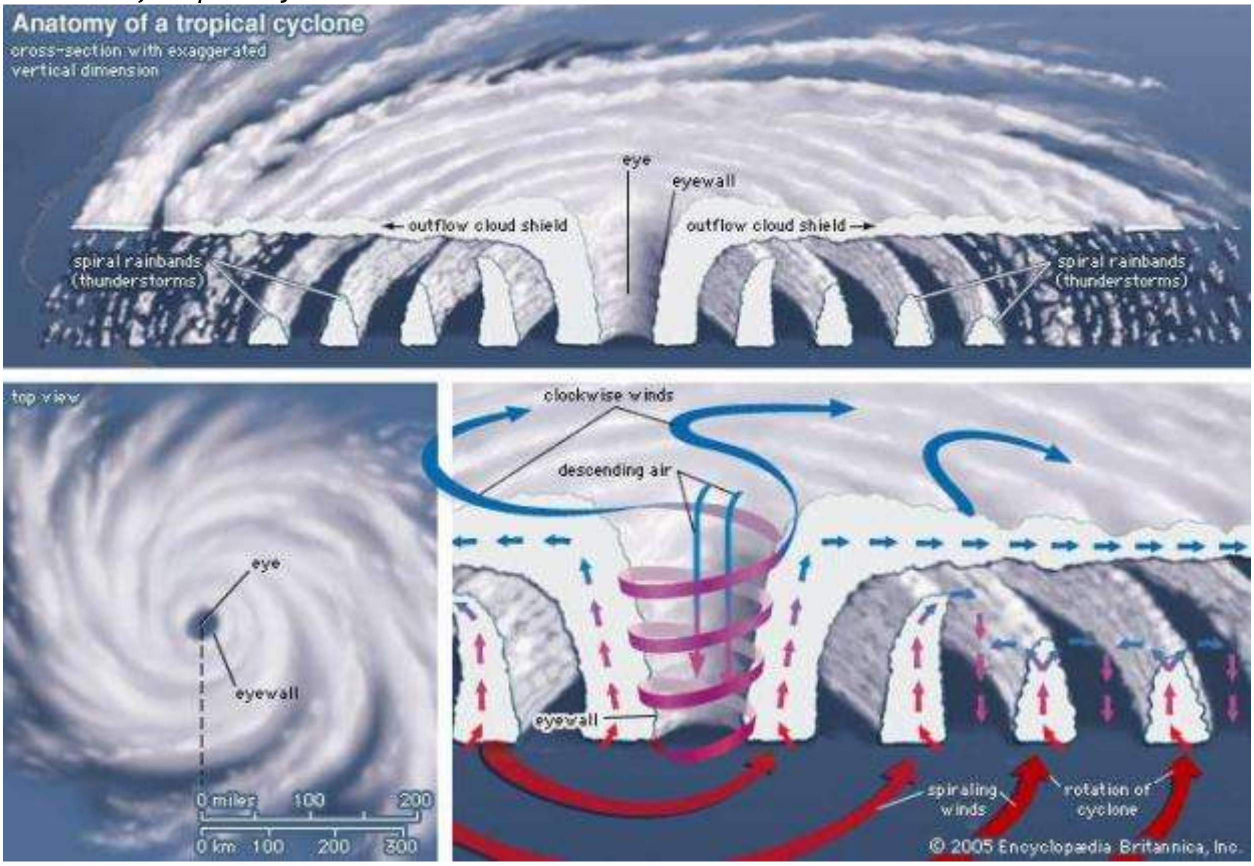
## MITIGATION

*It is beyond the capacity of individual state or government to mitigate the damage. Hence, combined efforts at the international levels are the possible ways of dealing with these disasters as has been in the case of the tsunami that occurred on 26th December 2004 in which more than 300,000 people lost their lives. India has volunteered to join the International Tsunami Warning System after the December 2004 tsunami disaster.*

## Tropical Cyclone

Tropical cyclones are intense low-pressure are as confined to the area lying between 30° N and 30° S latitudes, in the atmosphere around which high velocity winds blow. Horizontally, it extends up to 500-1,000 km and vertically from surface to 12-14 km. A tropical cyclone or hurricane is like a heat engine that is energized by the release of latent heat on account of the condensation of moisture that the wind initial conditions for the emergence of a tropical cyclone are:
*(i) Large and continuous supply of warm and moist air that can release enormous latent heat.*
*(ii) Strong Coriolis force that can prevent filling of low pressure at the centre (absence of Coriolis force near the equator prohibits the formation of tropical cyclone between 0° -5° latitude).*
*(iii) Unstable condition through the troposphere that creates local disturbances around which a cyclone develops.*
*(iv) Finally, absence of strong vertical wind wedge, which disturbs the vertical transport of latent heat.*

*Structure of Tropical Cyclone*




Tropical cyclones are characterised by large pressure gradients. The centre of the cyclone is mostly a warm and low-pressure, cloudless core known as *eye of the storm*. Generally, the isobars are closely placed to each other showing high-pressure gradients. Normally, it varies between 14-17mb/100 km, but sometimes it can be as high as 60mb/100km. Expansion of the wind belt is about 10-150 km from the centre.

*Spatio-temporal Distribution of Tropical Cyclone in India*

The tropical cyclones in India also originate in Arabian sea and Bay of Bengal
Though most of the cyclones originate between 10°-15° north latitudes during the monsoon season, Yet in case of the Bay of Bengal, cyclones mostly develop during the months of October and November. Here, they originate between 16°-2° N latitudes and to the west of 92° E. By July the place of origin of these storms shifts to around 18° N latitude and west of 90°E near the Sunderban Delta.

*Consequences of Tropical Cyclones*

It was mentioned that the energy to the tropical cyclone comes from the latent heat released by the warm moist air. Hence, with the increase in distance from the sea, the force of the cyclone decreases. In India, the force of the cyclone decreases with increase in distance from the Bay of Bengal and the Arabian Sea. So, the coastal areas are often struck by severe cyclonic storms with an average velocity of 180 km/h. Often, this results in abnormal rise in the sea level known as *Storm Surge*.
A surge is generated due to interaction of air, sea and land. The cyclone provides the driving force in the form of very high horizontal pressure-gradient and very strong surface winds. The sea water flows
across the coast along with strong winds and heavy downpour. This results in inundation of human settlements, agricultural fields, damaging crops and destruction of structures created by human beings.

**Floods**

Causes of Floods

1. Sudden and Heavy rainfall
2. Loose soil
3. Deforestation
4. Unconsolidated material
5. Encroachment of rivers by the settlements

Areas of India frequently affected by floods


*Rashtriya Barh Ayog* (National Flood Commission) identified 40 million hectares of land as flood-prone in India.

*Consequence and Control of Floods*

1.Frequent inundation of agricultural land and human settlement, particularly in Assam, West Bengal, Bihar and Eastern Uttar Pradesh
(flooding rivers), coastal areas of Orissa, Andhra Pradesh, Tamil Nadu and Gujarat (cyclone) and Punjab, Rajasthan, Northern Gujarat and Haryana (flash floods) have
2.Serious consequences on the national economy and society.
3.Floods do not only destroy valuable crops every year but these also 4. damage physical infrastructure such as roads, rails, bridges and human settlements.
5. Millions of people are rendered homeless and are also washed down along with their cattle in the floods.
6.Spread of diseases like cholera, gastro-enteritis, hepatitis and other water-borne diseases spread in the flood-affected areas.
7. Every year, floods deposit fertile silt over agricultural fields which is good for the crops.
8.Majuli (Assam), the largest riverine island in the world, is the best example of good paddy crops after the annual floods in Brahmaputra.

METHODS TO CONTROL THE FLOODS

1. Construction of flood protection embankments in the flood-prone areas,
2. Construction of dams,

3. Afforestation
4. Discouraging major construction activities in the upper reaches of most of the flood-creating rivers
5. Removal of human encroachment from the river channels 6. depopulating the flood plains can be the other steps.
7. Establishment of Cyclone centres may provide relief in coastal areas which are hit by a storm surge.

**Droughts**

The term ‘drought’ is applied to an extended period when there is a shortage of water availability due to inadequate precipitation, excessive rate of evaporation and over-utilization of water from the reservoirs and other storages, including the ground water.

Drought is a complex phenomenon as it involves elements of meteorology like

1. Precipitation
2. Evaporation,
3. Evapotranspiration,
4. Ground water,
5. Soil moisture,
6. Storage
7. Surface run-off,
8. Agricultural practices, particularly the types of crops grown, socio-economic practices and ecological conditions.

*Types of Droughts*

*Meteorological Drought* : It is a situation when there is a prolonged period of inadequate rainfall marked with mal-distribution of the same over time and space.

*Agricultural Drought*: It is also known as soil moisture drought, characterised by low soil moisture that is necessary to support the crops, thereby resulting in crop failures. Moreover, if an area has more than 30 per cent of its gross cropped area under irrigation, the area is excluded from the drought-prone category.
*Hydrological Drought*: It results when the availability of water in different storages and reservoirs like aquifers, lakes, reservoirs, etc. falls below what the precipitation can replenish.
*Ecological Drought* : When the productivity of a natural ecosystem fails due to shortage of water and as a consequence of ecological distress, damages are induced in the ecosystem

*Drought Prone Areas in India*


Droughts and floods are the two accompanying features of Indian climate.
According to some estimates, nearly 19 per cent of the total geographical area ofthe country and 12 per cent of its total population suffer due to drought every year.
About 30 per cent of the country’s total area is identified as drought prone affecting around
50 million people.
It is a common experience that while some parts of the country reel under floods, there are regions that face severe drought during the same period. Moreover, it is also a common sight to witness that one region suffers due to floods in one season and experiences drought in the other. This is mainly because of the large-scale variations and unpredictability in the behaviour of the monsoon in India.
On the basis of severity of droughts, India can be divided into the following regions:

*Extreme Drought Affected Areas* : most parts of Rajasthan, particularly areas to the west of the Aravali hills, i.e. Marusthali and Kachchh regions of Gujarat fall in this category. Included here are also the districts like Jaisalmer and Barmer from the Indian desert that receive less that 90 mm average annual rainfall.

*Severe Drought Prone Area*: Parts of eastern Rajasthan, most parts of Madhya Pradesh, eastern parts of Maharashtra, interior parts of Andhra Pradesh and Karnataka Plateau, northern parts of interior Tamil Nadu and southern parts of Jharkhand and interior Orissa are included in this category.

*Moderate Drought Affected Area* : Northern parts of Rajasthan, Haryana, southern districts of Uttar Pradesh, the remaining parts of Gujarat, Maharashtra except Konkan, Jharkhand and Coimbatore plateau of Tamil Nadu and interior Karnataka are included in this category.
The remaining parts of India can be considered either free or less prone to the drought.
*Consequences of Drought*
1.Crop failure leading to scarcity of food grains *(akal)*,
2.fodder *(trinkal)*,
3.inadequate rainfall, resulting in shortage of water *(jalkal)*,
4.and often shortage in all the three *(trikal)* is most devastating.
5.Large-scale death of cattle and other animals,
6.migration of humans and livestock are the most common sight to be seen in the drought affected areas.
7.Scarcity of water compels people To consume contaminated water resulting in spread of many waterborne diseases like gastro-enteritis, cholera, hepatitis, etc.

MITIGATION
1. Provision for the distribution of safe drinking water,
2. Medicines for the victims
3. Availability of fodder and water for the cattle
4. shifting of the people and their livestock to safer places,
5 .Identification of ground water potential in the form of aquifers,
6. Transfer of river water from the surplus to the deficit areas,
7. Planning for inter-linking of rivers
8. Construction of reservoirs and dams,
9. Remote sensing and satellite imageries can be useful in identifying the possible river-basins that can be inter-linked and in identifying the ground water potential.
10. Dissemination of knowledge about drought-resistant crops and proper training to practice the same can be some of the long-term measures that will be helpful in drought-mitigation.
11. Rainwater harvesting can also be an effective method in minimizing the effects of drought.

**Landslides**
1.landslides are largely controlled by highly localised factors. Hence, gathering information and monitoring the possibilities of landslide is not only difficult but also immensely cost-intensive.
2.It is always difficult to define in a precise statement and generalize the occurrence and behavior of a landslide.
CONTROLLING FACTORS :1. Geology 2.Geomorphicagents 3.Slope, 4.Land-use 5.Vegetation cover and
6.Human activities
India has been divided into a number of zones.

*Landslide Vulnerability Zones*
*Very High Vulnerability Zone* : Highly unstable, relatively young mountainous areas in the Himalayas and Andaman and Nicobar, high rainfall regions with steep slopes in the Western Ghats and Nilgiris, the north-eastern regions, along with areas that experience frequent ground-shaking due to earthquakes, etc. and areas of intense human activities, particularly those related to construction of roads, dams, etc. are included in this zone.

*High Vulnerability Zone* : Areas that have almost similar conditions to those included in the very high vulnerability zone are also included in this category. The only difference between these two is the combination, intensity and frequency of the controlling factors. All the Himalayan states and the states from the north-eastern regions except the plains of Assam are included in the high vulnerability zones.

*Moderate to Low Vulnerability Zone* : Areas that receive less precipitation such as Trans Himalayan areas of Ladakh and Spiti (Himachal Pradesh), undulated yet stable relief and low precipitation areas in the Aravali, rain shadow areas in the Western and Eastern Ghats and Deccan plateau also experience occasional landslides. Landslides due to mining and subsidence are most common in states like Jharkhand, Orissa, Chhattisgarh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Goa and Kerala.

*Other Areas* : The remaining parts of India, particularly states like Rajasthan, Haryana, Uttar Pradesh, Bihar, West Bengal (except district Darjiling), Assam (except district Karbi Anglong) and Coastal regions of the southern States are safe as far as landslides are concerned.

*Consequences of Landslides*
1. roadblock,
2. destruction of railway lines
3. channel-blocking due to rock-falls have far-reaching consequences.
4 Diversion of river courses due to landslides can also lead to flood and
5 .loss of life and property.

*Mitigation*
1. Restriction on the construction and other developmental activities such as roads and dams,
2. limiting agriculture to valleys and areas with moderate slopes,
3. control on the development of large settlements in the high vulnerability zones,
4. promoting large-scale afforestation programmes
5. construction of bunds to reduce the flow of water.
6. Terrace farming should be encouraged in the northeastern hill states where *Jhumming* (Slash and Burn/Shifting Cultivation) is still prevalent.

**DISASTER MANAGEMENT**
1. Construction of cyclone shelters, embankments, dykes, reservoirs
2.Afforestation to reduce the speed of the winds are some of the steps that can help in minimizing the damages by cyclones
3. implementation of The Disaster Management Bill, 2005,

**CONCLUSION**

MITIGATION AND PREPAREDNESS.
There are three stages involved in disaster mitigation and management:
(i) Pre-disaster management involves
1. generating data and information about the disasters,
2. preparing vulnerability zoning maps
3. spreading awareness among the people about these
4. disaster planning,
5. preparedness and preventive measures are other steps that need to be taken in the vulnerable areas.
(ii) During disasters,
1. rescue and relief operations such as
A. evacuation, B .construction of shelters C. relief camps, D. supplying of water, food, clothing and medical aids etc. should be done on an emergency basis.
(iii) Post-disaster operations should involve
A. rehabilitation
B. recovery of victims.
E. concentrate on capacity building in order to cope up with future disasters, if any.