WHY SHOULD WE STUDY GEOGRAPHY?

We live on the surface of the earth. Our lives are affected by our surroundings in many ways. We depend on the resources to sustain ourselves in the surrounding areas. Primitive societies subsisted on 'natural means of subsistence', i.e. edible plants and animals. With the passage of time, we developed technologies and started producing our food using natural resources such as land, soil and water. We adjusted our food habits and clothing according to the prevailing weather conditions. There are variations in the natural resource base, technological development, adaptation with and modification of physical environment, social organisations and cultural development. As a student of geography, you should be curious to know about all the phenomena which vary over space. You learn about the diverse lands and people. You should also be interested in understanding the changes which have taken place over time. Geography equips you to appreciate diversity and investigate into the causes responsible for creating such variations over time and space. You will develop skills to understand the globe converted into maps and have a visual sense of the earth's surface.

Fact Box

- **Chimpanzee, Gorilla and Modern man have evolved from a type of monkeys existed on the earth about ten million years ago.**
- **Australopithecus, Singenthropus, Pithecanthropus, Erectus, Sinanthropus, Neanderthal man, Cromagnon man are the different phases in the evolution of man.**

WHAT IS GEOGRAPHY?

You know that earth is our home. It is also the home of many other creatures, big and small, which live on the earth and sustain. The earth's surface is not uniform. It has variations in its physical features. There are mountains, hills, valleys, plains, plateaus, oceans, lakes, deserts and wilderness. There are variations in its social and cultural features too. There are villages, cities, roads, railways, ports, markets and many other elements created by human beings across the entire period of their cultural development. This variation provides a clue to the understanding of the relationship between the physical environment and social/cultural features. The physical environment has provided the stage, on which human societies enacted the drama of their creative skills with the tools and techniques which they invented and evolved in the process of their cultural development. In very simple words, it can be said that geography is the description of the earth. The term *geography* was first coined by *Eratosthenese*, a Greek scholar (276-194 BC.). The word has been derived from two roots from Greek language *geo* (earth) and *graphos* (description). Put together, they mean description of the earth. Geography derives its data base from all the natural and social sciences and attempts their synthesis.

Fact Box
Transhumance
The pastoral nomads who settled in the foothill zones are moving upslopes during summer to graze their animals. They remain there for the whole summer period and come down with the advent of winter. This movement of people with their cattle is known as transhumance. The Gujjar and Bakerwal tribes of Jammu and Kashmir are still practicing transhumance.

GEOGRAPHY AS AN INTEGRATING DISCIPLINE

Geography is a discipline of synthesis. It attempts spatial synthesis, and history attempts temporal synthesis. Its approach is holistic in nature. It recognises the fact that the world is a system of interdependencies.

BRANCHES OF GEOGRAPHY (BASED ON SYSTEMATIC APPROACH)

1. Physical Geography

(i) *Geomorphology* is devoted to the study of landforms, their evolution and related processes.
(ii) *Climatology* encompasses the study of structure of atmosphere and elements of weather and climates and climatic types and regions.
(iii) *Hydrology* studies the realm of water over the surface of the earth including oceans, lakes, rivers and other water bodies and its effect on different life forms including human life and their activities.
(iv) *Soil Geography* is devoted to study the processes of soil formation, soil types, their fertility status, distribution and use.

2. HUMAN GEOGRAPHY

i. *Social/Cultural Geography* encompasses the study of society and its spatial dynamics as well as the cultural elements contributed by the society.
ii. *Population and Settlement Geography* (Rural and Urban). It studies population growth, distribution, density, sex ratio, migration and occupational structure etc. Settlement geography studies the characteristics of rural and urban settlements.
iii. *Economic Geography* studies economic activities of the people including agriculture, industry, tourism, trade, and transport, infrastructure and services, etc.
iv. *Historical Geography* studies the historical processes through which the space gets organised. Every region has undergone some historical experiences before attaining the present day status**.** The geographical features also experience temporal changes and these form the concerns of historical geography.

v. *Political Geography* looks at the space from the angle of political events and studies boundaries, space relations between neighbouring political units, delimitation of constituencies, election scenario and develops theoretical *framework* to understand the political behaviour of the population.

3. BIOGEOGRAPHY

The interface between physical geography and human geography has lead to the development of Biogeography which includes:

i. *Plant Geography* which studies the spatial pattern of natural vegetation in their habitats.
ii. *Zoo Geography* which studies the spatial patterns and geographic characteristics of animals and their habitats.
iii. *Ecology /Ecosystem* deals with the scientific study of the habitats characteristic of species.
iv. *Environmental Geography* concerns world over leading to the realisation of environmental problems such as land gradation, pollution and concerns for conservation has resulted in the introduction of this new branch in geography.

Physical geography includes the study of lithosphere (landforms, drainage, relief and physiography), atmosphere (its composition, structure, elements and controls of weather and climate; temperature, pressure, winds, precipitation, climatic types, etc.), hydrosphere (oceans, seas, lakes and associated features with water realm) and biosphere (life forms including human being and macro-organism and their sustaining mechanism, viz. food chain, ecological parameters and ecological balance). Soils are formed through the process of *pedogenesis* and depend upon the parent rocks, climate, biological activity and time. Time provides maturity to soils and helps in the development of soil profiles. Each element is important for human beings. Landforms provide the base on which human activities are located.

The plains are utilised for agriculture. Plateaus provide forests and minerals. Mountains provide pastures, forests, tourist spots and are sources of rivers providing water to lowlands. Climate influences our house types, clothing and food habits. The climate has a profound effect on vegetation, cropping pattern, livestock farming and some industries, etc. Human beings have developed technologies which modify climatic elements in a restricted space such as air conditioners and coolers. Temperature and precipitation ensure the density of forests and quality of grassland. In India, monsoonal rainfall sets the agriculture rhythm in motion. Precipitation recharges the *ground water aquifers* which later provides water for agriculture and domestic use. We study oceans which are the store house of resources. Besides fish and other sea-food, oceans are rich in mineral resources.

India has developed the technology for collecting manganese nodules from oceanic bed. Soils are renewable resources, which influence a number of economic activities such as agriculture. The fertility of the soil is both naturally determined and culturally induced. Soils also provide the basis for the biosphere accommodating plants, animals and micro organisms. The study of physical geography is emerging as a discipline of evaluating and managing natural resources. In order to achieve this objective, it is essential to understand the intricate relationship between physical environment and human beings.

Physical environment provides resources, and human beings utilize these resources and ensure their economic and cultural development. Accelerated pace of resource utilization with the help of modern technology has created ecological imbalance in the world. Hence, a better understanding of physical environment is absolutely essential for sustainable development.

FACT BOX

- Human beings belong to primates, the highest order of mammals.
- Based on external appearance mankind can be classified into Negroid, Mongoloid, and Caucasoid.
- Movement of people from one place to another and settling there is known as migration.
- The permanent dwelling places of man are known as settlements.
- The shapes of settlements are greatly controlled by geographical conditions.
- Settlements can be divided into rural settlements and urban settlements.

OUR SOLAR SYSTEM

One of the earlier and popular hypotheses was by German philosopher Immanuel Kant which Mathematician Laplace revised in 1796. It is known as ***Nebular Hypothesis***. The hypothesis considered that the planets were formed out of a cloud of material associated with a youthful sun, which was slowly rotating. In 1950, Otto Schmidt in Russia and Carl Weizascar in Germany somewhat revised the 'nebular hypothesis', though differing in details. They considered that the sun was surrounded by solar nebula containing mostly the hydrogen and helium along with what may be termed as dust. The friction and collision of particles led to formation of a disk-shaped cloud and the planets were formed through the process of accretion. However, scientists in later period took up the problems of origin of universe rather than that of just the earth or the planets.

NEBULAR HYPOTHESIS-

Nebular hypothesis is the most widely accepted model explaining the formation and evolution of the Solar System. The **Solar System** consists of the Sun and those celestial objects bound to it by its gravity. It can be classified into following two categories-

1. **Inner Solar System-**

Internal Solar system consists of Sun, Asteroid belt between Mars and Jupiter and various other Planets

1. **Outer Solar System-**

Outer solar system consists of Comets, Artificial Satellites, Kupier belt and Space junk. The four smaller inner planets; Mercury, Venus, Earth and Mars, also called the terrestrial planets/inferior planets are primarily composed of rock and metal. The four outer planets, Jupiter, Saturn, Uranus and Neptune, also called the gas giants/superior planets are composed largely of hydrogen and helium and are far more massive than the terrestrials.

MODERN THEORIES Origin of the Universe

The most popular argument regarding the origin of the universe is the *Big Bang Theory*. It is also called *expanding universe hypothesis*. Edwin Hubble, in 1920, provided evidence that the universe is expanding. As time passes, galaxies move further and further apart. Scientists believe that though the space between the galaxies is increasing, observations do not support the expansion of galaxies.

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

i. In the beginning, all matter forming the universe existed in one place in the form of a "tiny ball" (singular atom) with an unimaginably small volume, infinite temperature and infinite density.

ii. At the Big Bang the "tiny ball" exploded violently. This led to a huge expansion. It is now generally accepted that the event of **big bang took place 13.7 billion years** before the present. The expansion continues even to the present day. As it grew, some energy was converted into matter. There was particularly rapid expansion within fractions of a second after the bang. Thereafter, the expansion has slowed down. **Within first three minutes from the Big Bang event, the first atom began to form.**

iii. Within 300,000 years from the Big Bang, temperature dropped to 4,500 K (Kelvin) and gave rise to atomic matter. The universe became transparent. The expansion of universe means increase in space between the galaxies. With greater evidence becoming available about the expanding universe, scientific community at present favours argument of expanding universe.

THE STAR FORMATION

The distribution of matter and energy was not even in the early universe. These initial density differences gave rise to differences in gravitational forces and it caused the matter to get drawn together. These formed the bases for development of galaxies. A *galaxy* contains a large number of stars. Galaxies spread over vast distances that are measured in thousands of *light-year*s. The diameters of individual galaxies range from 80,000-150,000 light years. A galaxy starts to form by accumulation of hydrogen gas in the form of a very large cloud called *nebula*. Eventually, growing nebula develops localised clumps of gas. These clumps continue to grow into even denser gaseous bodies, giving rise to formation of stars. The formation of stars is believed to have taken place some 5-6 billion years ago. A light year is a measure of distance and not of time. Light travels at a speed of 300,000 km/second. Considering this, the distances the light will travel in one year is taken to be one light year. This equals to 9.461×1012 km. The mean distance between the sun and the earth is 149,598,000 km. In terms of light years, it is 8.311.

SOLAR SYSTEM

Our Solar system consists of eight planets. The nebula from which our Solar system is supposed to have been formed, started its collapse and core formation some time 5-5.6 billion years ago and the planets were formed about 4.6 billion years ago. Our solar system consists of the sun (the star), 8 planets, 63 moons, millions of smaller bodies like *asteroids* and *comets* and huge quantity of dust-grains and gases. Out of the eight planets, mercury, venus, earth and mars are called as the *inner planets* as they lie between the sun and the belt of asteroids the other four planets are called the *outer planets*. Alternatively, the first four are called *Terrestrial,* meaning earth-like as they are made up of rock and metals, and have relatively high densities. The rest four are called *Jovian* or Gas Giant planets. Jovian means Jupiter-like. Most of them are much larger than the terrestrial planets and have thick atmosphere, mostly of helium and hydrogen. All the planets were formed in the same period sometime about 4.6 billion years ago. Till recently (August 2006), Pluto was also considered a planet. However, in a meeting of the International Astronomical Union, a decision was taken that Pluto like other celestial objects (2003 UB313)discovered in recent past may be called 'dwarf planet'. Some data regarding our solar system are given in the box below. Why are the inner planets rocky while others are mostly in gaseous form? The difference between terrestrial and jovian planets can be attributed to the following conditions:

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

ii. The solar wind was most intense nearer the sun; so, it blew off lots of gas and dust from the terrestrial planets. The solar winds were not all that intense to cause similar removal of gases from the Jovian planets.
iii. The terrestrial planets are smaller and their lower gravity could not hold the escaping gases.

ABOUT SUN-

- Compared with the billions of other stars in the universe, the sun is unremarkable. The **Sun** is the star at the center of the Solar System. The Earth and other matter (including other planets, asteroids, meteoroids, comets, and dust) orbit the Sun, which by itself accounts for about 99.86% of the Solar System's mass. It holds the solar system together; pours life-giving light, heat, and energy on Earth; and generates space weather.
- Sun is made up of two main gases hydrogen [73%] and helium [24%]. It is nuclear fusion reaction which converts hydrogen into helium and yield huge solar energy. The energy we get in from of sun light called photons. The energy stored in petroleum and other fossil fuels was originally converted from sunlight by photosynthesis in the distant past.
- The sun's surface, or atmosphere, is divided into three regions: the photosphere, the chromosphere, and the solar corona. The **photosphere** is the visible surface of the sun and the lowest layer of the atmosphere. Just above the photosphere are the **chromosphere** and the **corona**, which also emit visible light but are only, seen during a solar eclipse, when the moon passes between the Earth and sun.
- The Sun is a magnetically active star. The Sun's magnetic field gives rise to many effects that are collectively called solar activity, including sunspots on the surface of the Sun, solar flares, and variations in solar wind that carry material through the Solar System. Solar activity changes the structure of Earth's outer atmosphere.
- The Solar Terrestrial Relations Observatory (STEREO) mission was launched in October 2006 as latest mission to explore more about Sun.

Norway is known as the place of **Mid-Night Sun**

About Asteroid belt-

Asteroids are mostly small Solar System bodies composed mainly of refractory rocky and metallic minerals. The main asteroid belt occupies the orbit between Mars and Jupiter. The asteroid belt contains tens of thousands, possibly millions, of Asteroids with different size

Some notable asteroids are **Ceres** [(2.77 AU) is the largest body in the asteroid belt and a mass large enough for its own gravity to pull it into a spherical shape. In 2006, Ceres was added in the list of Dwarf Planet along with Pluto], **Gaspra, Vesta and Eros.**

Small size asteroids are known as **"Meteoroids."

ABOUT COMETS-

Comets are made of rocky and dusty ice material and they are small Solar System bodies. Comets are usually found in Kupier belt but sometimes they came near to inner solar system. When a comet enters the inner Solar System, its proximity to the Sun causes its icy surface to sublimate and ionize, creating a coma i.e. a long tail of gas and dust often visible to the naked eye. The tail of a comet always points away from Sun. Some notable comets are **Halley's Comet** [discovered by English Astronomer Edmond Halley in 1705 so named after him], **Hale-Boop Comet** [1995] and **Hayakutake** [1996]

COSMOLOGY-

The Study of stars/universe is called Cosmology. There are so many stars into universe. A group of stars is known as Galaxy.

Big-Bang Theory-

This theory given by a Belgium Astronomer/Cosmologist **George Lemaitre** used to believe the possible reason for creation of Universe [Atmosphere + Space] **15 billion years ago**

Our galaxy is **Milky Way galaxy** or called Akash Ganga.

Solar system consist a star called sun, 8 Planets, asteroids, meteors, comets and satellites of the planets.

Main source of energy is sun light which produced converting of hydrogen gas into helium by a chemical reaction called Fusion.

Sun is 109 times bigger than earth and sunlight takes 8 minutes 16 seconds to reach earth

BLACK HOLES-

As we know that there are copious of stars in universe. While most stars end up as **white dwarfs** or **neutron stars**, black holes are the last evolutionary stage in the lifetimes of enormous stars that had been at least 10 or 15 times as massive as our own sun. When giant stars reach the final stages of their lives they often detonate in cataclysms known as **supernovae**. Such an explosion scatters most of a star into the void of space but leaves behind a large "cold" remnant on which fusion no longer takes place. The stars own light becomes trapped in orbit, and the dark star becomes known as a black hole. A black hole is often defined as an object whose escape velocity exceeds the speed of light. The **escape velocity** is the minimum speed at which an object needs to travel so as to escape a source of gravity without falling back into orbit before stopping. **On the Earth, the escape velocity is equal to 11.2 km/s**, so no matter what the object is, whether a bullet or a baseball, it must go at least 11.2 km/s to avoid falling back to the Earth's surface. . It is now widely accepted that the center of every galaxy contains a super massive black hole.

Black holes capture the public's imagination and feature prominently in extremely theoretical concepts like **wormholes [Concept used in Science Fiction]**. These "tunnels" could allow rapid travel through space and time—but there is no evidence that they exist.

Few memorable points about our solar system-

Until 1977, it was believed that **only Saturn had rings,** but today it is very much **proved** that **Jupiter, Neptune and Uranus also have ring** system around them.

The meteoroids which fall on earth are called **shooting stars.**

It will take a **spacecraft 12 years** to reach the Kupier belt. NASA's **"New Horizon Mission"** is planned to arrive at this point in **2015**

Jupiter has sixty-three known satellites. Its Ganymede is the largest satellite in the Solar System, is larger than Mercury.

Saturn has sixty confirmed satellites; two of which, Titan and Enceladus, show signs of geological activity, though they are largely made of ice. **Titan** is larger than Mercury and the **only satellite in the Solar System with a substantial atmosphere.**

TERRESTRIAL PLANET

Are smaller in size; rocky in structure; slow rotation on the axis and have lesser satellite. Inner terrestrial planets are: Mercury, Venus, Earth, Mars.

JOVIAN PLANETS

- Are huge in size; spin very fast and have higher number of satellites. Outer or Jovian planets are: Jupiters, Saturn, Uranus, Neptune, and Pluto.
- Earth is the densest of all the planets; Saturn has the lowest density (less than water 0.5)
- Mercury is closest to the sun.
- Uranus and Venus rotates retrograde (i.e., from east to west), other planet rotates in the same way as earth (from west to east).

- Venus is the only planet whose period of rotation (243 days) is longer than the period of revolution (225 days) around the sun.
- Uranus is tilted at 90°, so it almost rolls around the sun. Mars tilted at 23° in the same way as the earth, so experi¬ences four seasons as earth.
- Mercury is the hottest planet; Venus is the second hottest planet (600°C), atmosphere mainly made of C02 (90%).
- Mars glows with reddish light because of high iron content; it has thin atmosphere (containing free oxygen at very low-level), also has frozen water at polar region. Due to these factors, Mars is considered as the first planet that will be colonised.
- Jupiter's internal temperature of Jupiter is very high, close to starting nuclear fusion. Mainly hydrogen is present around the Jupiter.
- Saturn is the second largest planet; it looks yellowish light (due to the presence of ammonia). Ring around Saturn is made up of dust particles, frozen ice, and frozen ammonia.
- Uranus glows with blue light.
- Neptune glows with the greenish blue light due to presence of methane.
- Pluto is the coldest, darkest, and the strongest planet. It is smaller in size and does not fall in giant planet category

Satellite:
THE MOON

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

ASTEROIDS:

- Mercury and Venus have no satellite.
- Earth has one satellite: moon
- Mars has two satellite: Deimos and Phobos.
- Jupiter has 19 satellites, one of the satellite known is Europa, containing large number of deep oceans. It contains possibility of extra-terrestrial life.
- Saturn has 21 satellites (10 discovered by Voyage 1&2)
- Uranus has 17 satellite (12 discovered by Voyage 1&2)
- Neptune has 11,-one of this is tital.
- Pluto's satellite is Charon.

COMETS:

Minor planets of the solar system, small rocky structure, revolving around sun mostly between Mars and Jupiter. These are considered as debris of large planets existing between Mars and Jupiter as is evident from the distance between them. Earth has long history of collision with: (i) comets, and (ii) asteroids. Sedimentary rocks of 65 million years ago have high iridium content which gives evidence of collision of celestial body.

- Miss distance: a celestial body coming closer beyond 9,00,000 km, may not strike earth. This is called as miss distance.

SYZYGY:

Member of the solar system, found revolving around the sun beyond the path of Pluto, generally, at outer edges of the solar system. Comets are made of pre-mordial substance from which solar system are made. Since, they are undisturbed due to far location, study of comets may give more information about evolution of earth or other planets. Comets are made up of frozen ammonia, dust par¬ticles and ice crystals and other chemicals.

- Halley Comet: appears after a period of 76 years.
- Halle Bopp: one of the larg¬est comet with 40 km diameter.
- Comet Swift Turtle: calculated to collide on 14 Aug.2126 A.D. in Australia
- Comets making journey towards sun develop small head and long tail, due to heat only as it approaches Jupiter. Tail extending millions of kilometers in the outer space. Tail always point away from the sun. Solar wind is responsible for the formation of tails since solar winds goes away from the sun.

It is the alignment of three celestial bodies along a straight line; Viewed from one of these bodies, the other two will either be in conjunction or in opposition. An inferior planet, whose orbit lies inside that of earth, can, in reference to the sun as seen from the earth, be either in inferior conjunction or in superior conjunction; unlike a superior planet, whose orbit lies outside the earth's, and unlike the moon, it can never be in opposition to the sun as seen from the earth

FACTBOX

Geostationary satellites and Sun synchronous satellites

Artificial satellites which orbit the earth at an altitude of about 36,000 km are called geo stationary satellites. As they orbit along with the earth, they remain fixed facing a particular region on earth. Hence, they can be utilized for gathering permanent information about a region. Generally, these satellites are used for climatic observations and telecommunications. The INSAT series of satellites launched by India are geostationary in nature. Satellites that orbit the poles at a height of about 800 to 950 km are called Sun synchronous satellites. As they travel along orbits much lower than that of the geostationary satellites, they can be used for collecting information about the earth's surface with greater clarity. Sun synchronous satellites pass over the same place at the same time at regular intervals and hence it is possible to collect information about that place on different days.

EARTH

THE SHAPE OF THE EARTH IS *GEOID*

-Looks bluish white, body due to the presence of ocean and ice-caps. -Earth's core is mainly made up of iron and nickle; mantle is mostly solid.Outer core due to its movement gives magnetic field of earth manifested in Van-alien Radiation bell. Van-Allen Radiation belts are two concentric circles. Inner belt is more energetic and situated at 3000 km above the equator. Outer concentric circle is less energetic and found at 16000 km above the earth. Van-Allen radiation belts are formed due to concentration of solar-winds.

EVOLUTION OF THE EARTH

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

EVOLUTION OF LITHOSPHERE

The earth was mostly in a volatile state during its primordial stage. Due to gradual increase in density the temperature inside has increased. As a result the material inside started getting separated depending on their densities. This allowed heavier materials (like iron) to sink towards the centre of the earth and the lighter ones to move towards the surface. With passage of time it cooled further and solidified and condensed into a smaller size. This later led to the development of the outer surface in the form of a crust. During the formation of the moon, due to the giant impact, the earth was further heated up. It is through the process of differentiation that the earth forming material got separated into different layers. Starting from the surface to the central parts, we have layers like the crust, mantle, outer core and inner core. From the crust to the core, the density of the material increases.

EVOLUTION OF ATMOSPHERE AND HYDROSPHERE

The present composition of earth's atmosphere is chiefly contributed by nitrogen and oxygen. There are three stages in the evolution of the present atmosphere. The first stage is marked by the loss of primordial atmosphere. In the second stage, the hot interior of the earth contributed to the evolution of the atmosphere. Finally, the composition of the atmosphere was modified by the living world through the process of *photosynthesis*. The early atmosphere, with hydrogen and helium, is supposed to have been stripped off as a result of the solar winds. This happened not only in case of the earth, but also in all the terrestrial planets, which were supposed to have lost their primordial atmosphere through the impact of solar winds. During the cooling of the earth, gases and water vapour were released from the interior solid earth. This started the evolution of the present atmosphere. The early atmosphere largely contained water vapour, nitrogen, carbon dioxide, methane, ammonia and very little of free oxygen. The process through which the gases were outpoured from the interior is called *degassing*. Continuous volcanic eruptions contributed water vapour and gases to the atmosphere. As the earth cooled, the water vapour released started getting condensed. The carbon dioxide in the atmosphere got dissolved in rainwater and the temperature further decreased causing more condensation and more rains. The rainwater falling onto the surface got collected in the depressions to give rise to oceans. The earth's oceans were formed within 500 million years from the formation of the earth. This tells us that the oceans are as old as 4,000 million years. Sometime around 3,800 million years ago, life began to evolve. However, around 2,500-3,000 million years before the present, the process of photosynthesis got evolved. Life was confined to the oceans for a long time. Oceans began to have the contribution of oxygen through the process of *photosynthesis*. Eventually, oceans were saturated with oxygen, and 2,000 million years ago, oxygen began to flood the atmosphere.

Separate Page

ORIGIN OF LIFE

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

Some Facts

Fastest Rotational Period (descending order) -Jupiter > Saturn > Neptune > Uranus > Earth > Mars > Pluto > Mercury > Venus

Density (Highest to Lowest) -Earth > Mercury > Venus > Mars > Neptune > Jupiter > Uranus > Saturn

- Sequence of planets' distance from the sun:

Mercury< Venus< Earth< Mars< Jupiter< Saturn< Uranus< Pluto traces

elongated elliptical orbit.

So, from 1980-1999, the distance of Neptune was more than Pluto.

Size (Biggest to Smallest) -

Jupiter > Saturn > Uranus > Neptune > Earth > Venus > Mars > Mercury > Pluto

Moon Important Facts

Average distance from Earth 3,84,365 km
Diameter 3,476 km
Ratio of diameter of moon to that of earth 1 : 3.7
Rotation speed 27 days, 2hrs, 43 min & 11.47Sec.
Revolution Speed 27 days, 7hrs, 43 min & 11.47 Sec.
Time taken by moonlight to reach earth 1.3 Sec
Percent of surface visible from earth 59%
First man to reach moon Neil Armstrong and Edvin Aldrin on Apollo XI (1969)

Global positioning System (GPS) helps us to find the geographic coordinates of a place, and its height and time on the basis of signals from about 24 satellites orbiting the earth.

What is Geographical Information System(GIS)?

Geographical Information System is the method of storing, retrieving and transforming geographical data in computers and their analysis, finding answers to queries and displaying them in the form of pictures, graphs, and charts. It is very much helpful to understand the spatial relation between objects and phenomena. As it involves analyses based on geography, this technology is called the Geographical Information System (GIS). In short, the Geographical Information System is the technique of collection of earth related information, their storage for use and analysis.

<u>Fact Box</u>

- **Remote sensing** is the method of analyzing the information about distant objects or phenomena without touching them by the use of a sensing device.
- Remote sensing technology can be classified into aerial remote sensing and satellite remote sensing.
- Taking pictures of ground with the help of cameras fitted on aircrafts is called aerial photography.
- The method of collecting information about the earth's surface with the help of sensors fitted in artificial satellites is called satellite remote sensing.
- The size of the smallest object that a sensor can distinguish is called its **spatial resolution**.
- The technique of collection, storage and analysis of earth related information is called the Geographic Information System.
- Geographic Information System holds great potential in different fields including geographic studies.

INTERIOR OF THE EARTH

The interior of the earth can be understood only by indirect evidences as neither any one has nor any one can reach the interior of the earth. The configuration of the surface of the earth is largely a product of the processes operating in the interior of the earth. Exogenic as well as endogenic processes are constantly shaping the landscape. A proper understanding of the physiographic character of a region remains incomplete if the effects of endogenic processes are ignored. Human life is largely influenced by the physiography of the region. Therefore, it is necessary that one gets acquainted with the forces that influence landscape development. To understand why the earth shakes or how a tsunami wave is generated, it is necessary that we know certain details of the interior of the earth. We Know that earth-forming materials have been distributed in the form of layers from the crust to the core. It is interesting to know how scientists have gathered information about these layers and what are the characteristics of each of these layers.

FactBox

There are seven continents on the surface of the earth and oceans occupy the space in between them.

- The crust of the earth can be bifurcated into sial and sima
- Some rocky portions of the continents are more than 3500 million years old.
- Portions of the sea floor older than 180 million years have not been discovered so far.
- The crust and the upper portion of the mantle together constitute the lithosphere of the earth.
- The rocks of the asthenosphere occurring just below the lithosphere are in partially molten condition.
- Earthquakes and volcanoes are found concentrated along certain linear zones of the earth's surface..

SOURCES OF INFORMATION ABOUT THE INTERIOR

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

DIRECT SOURCES

The most easily available solid earth material is surface rock or the rocks we get from mining areas. Scientists world over are working on two major projects such as "Deep Ocean Drilling Project" and "Integrated Ocean Drilling Project". The deepest drill at Kola, in Arctic Ocean, has so far reached a depth of 12 km. This and many deep drilling projects have provided large volume of information through the analysis of materials collected at different depths. Volcanic eruption forms another source of obtaining direct information. As and when the molten material (magma) is thrown onto the surface of the earth, during volcanic eruption it becomes available for laboratory analysis. However, it is difficult to ascertain the depth of the source of such magma.

INDIRECT SOURCES

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

However, it may be noted that the material that becomes available for analysis from meteors, is not from the interior of the earth. The material and the structure observed in the meteors are similar to that of the earth. They are solid bodies developed out of materials same as, or similar to, our planet. Hence, this becomes yet another source of information about the interior of the earth. The other indirect sources include gravitation, magnetic field, and seismic activity. The gravitation force (*g*) is not the same at different latitudes on the surface. It is greater near the poles and less at the equator. This is because of the distance from the centre at theequator being greater than that at the poles. The gravity values also differ according to the mass of material. The uneven distribution of mass of material within the earth influences this value. The reading of the gravity at different places is influenced by many other factors. These readings differ from the expected values. Such a difference is called *gravity anomaly*. Gravity anomalies give us information about the distribution of mass of the material in the crust of the earth. Magnetic surveys also provide information about the distribution of magnetic materials in the crustal portion, and thus, provide information about the distribution of materials in this part. Seismic activity is one of the most important sources of information about the interior of the earth

EARTHQUAKE

The study of seismic waves provides a complete picture of the layered interior. An earthquake in simple words is shaking of the earth. It is a natural event. It is caused due to release of energy, which generates waves that travel in all directions. *Why does the earth shake?* The release of energy occurs along a fault. A fault is a sharp break in the crustal rocks. Rocks along a fault tend to move in opposite directions. As the overlying rock strata press them, the friction locks them together. However, their tendency to move apart at some point of time overcomes the friction. As a result, the blocks get deformed and eventually, they slide past one another abruptly. This causes a release of energy, and the energy waves travel in all directions. The point where the energy is released is called the *focus* of an earthquake, alternatively, it is called the *hypocentre*. The energy waves travelling in different directions reach the surface. The point on the surface, nearest to the focus, is called *epicentre*. It is the first one to experience the waves. It is a point directly above the focus.

EARTHQUAKE WAVES

All natural earthquakes take place in the lithosphere. You will learn about different layers of the earth later in this . It is sufficient to note here that the lithosphere refers to the portion of depth up to 200 km from the surface of the earth. An instrument called 'seismograph' records the waves reaching the surface. A curve of earthquake waves recorded on the seismograph is given in Note that the curve shows three distinct sections each representing different types of wave patterns. Earthquake waves are basically of two types — *body waves* and *surface waves*. Body waves are generated due to the release of energy at the focus and move in all directions travelling through the body of the earth. Hence, the name body waves. The body waves interact with the surface rocks and generate new set of waves called surface waves.

These waves move along the surface. The velocity of waves changes as they travel through materials with different densities. The denser the material, the higher is the velocity. Their direction also changes as they reflect or refract when coming across materials with different densities. propagation. As a result, it creates density differences in the material leading to stretching and squeezing of the material. Other three waves vibrate perpendicular to the direction of propagation. The direction of vibrations of S-waves is perpendicular to the wave direction in the vertical plane. Hence, they create troughs and crests in the material through which they pass. Surface waves are considered to be the most damaging waves. *Emergence of Shadow Zone* Earthquake waves get recorded in seismographs located at far off locations. However, there exist some specific areas where the waves are not reported. Such a zone is called the 'shadow zone'. The study of different events reveals that for each earthquake, there exists an altogether different shadow zone. It was observed that seismographs located at any distance within 105° from the epicentre, recorded the arrival of both P and S-waves. However, the seismographs located beyond 145° from epicentre, record the arrival of P-waves, but not that of S-waves. Thus, a zone between 105° and 145° from epicentre was identified as the shadow zone for both the types of waves.

The entire zone beyond 105° does not receive S-waves. The shadow zone of S-wave is much larger than that of the P-waves. The shadow zone of P-waves appears as a band around the earth between 105° and 145° away from the epicentre. The shadow zone of S-waves is not only larger in extent but it is also a little over 40 per cent of the earth surface. You can draw the shadow zone for any earthquake provided you know the location of the epicentre. (See the activity box on page 28 to know how to locate the epicentre of a quake event). *Types of Earthquakes* (i) The most common ones are the *tectonic* earthquakes. These are generated due to sliding of rocks along a fault plane. (ii) A special class of tectonic earthquake is sometimes recognised as *volcanic* earthquake. However, these are confined to areas of active volcanoes. There are two types of body waves. They are called P and S-waves. P-waves move faster and are the first to arrive at the surface. These are also called 'primary waves'. The P-waves are similar to sound waves. They travel through gaseous, liquid and solid materials. S-waves arrive at the surface with some time lag. These are called secondary waves. An important fact about S-waves is that they can travel only through solid materials. This characteristic of the S-waves is quite important. It has helped scientists to understand the structure of the interior of the earth. Reflection causes waves to rebound whereas refraction makes waves move in different directions. The variations in the direction of waves are inferred with the help of their record on seismograph. The surface waves are the last to report on seismograph. These waves are more destructive. They cause displacement of rocks, and hence, the collapse of structures occurs. *Propagation of Earthquake Waves* Different types of earthquake waves travel in different manners. As they move or propagate, they cause vibration in the body of the rocks through which they pass. P-waves vibrate parallel to the direction of the wave. This exerts pressure on the material in the direction of the (v) The earthquakes that occur in the areas of large reservoirs are referred to as *reservoir induced* earthquakes.

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

EFFECTS OF EARTHQUAKE

Earthquake is a natural hazard. The following are the immediate hazardous effects of earthquake:
(i) Ground Shaking
(ii) Differential ground settlement
(iii) Land and mud slides
(iv) Soil liquefaction
(v) Ground lurching
(vi) Avalanches
(vii) Ground displacement
(viii) Floods from dam and levee failures
(ix) Fires
(x) Structural collapse
(xi) Falling objects
(xii) Tsunami

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

(ii) In the areas of intense mining activity, sometimes the roofs of underground mines collapse causing minor tremors. These are called *collapse* earthquakes.

(iii) Ground shaking may also occur due to the explosion of chemical or nuclear devices. Such tremors are called *explosion* earthquakes. *Frequency of Earthquake Occurrences* The earthquake is a natural hazard. If a tremor of high magnitude takes place, it can cause heavy damage to the life and property of people. However, not all the parts of the globe necessarily experience major shocks

STRUCTURE OF THE EARTH

The Crust

It is the outermost solid part of the earth. It is brittle in nature. The thickness of the crust varies under the oceanic and continental areas. Oceanic crust is thinner as compared to the continental crust. The mean thickness of oceanic crust is 5 km whereas that of the continental is around 30 km. The continental crust is thicker in the areas of major mountain systems. It is as much as 70 km thick in the Himalayan region. It is made up of heavier rocks having density of 3 g/cm3. This type of rock found in the oceanic crust is basalt. The mean density of material in oceanic crust is 2.7 g/cm3.

THE MANTLE

The portion of the interior beyond the crust is called the mantle. The mantle extends from Moho's discontinuity to a depth of 2,900 km. The upper portion of the mantle is called *asthenosphere*. The word *astheno* means weak. It is considered to be extending upto 400 km. It is the main source of magma that finds . Note that the quakes of high magnitude, i.e. 8+ are quite rare; they occur once in 1-2 years whereas those of 'tiny' types occur almost every minute. its way to the surface during volcanic eruptions. It has a density higher than the crust's (3.4 g/cm3). The crust and the uppermost part of the mantle are called lithosphere. Its thickness ranges from 10-200 km. The lower mantle extends beyond theasthenosphere. It is in solid state.

THE CORE

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

VOLCANOES AND VOLCANIC LANDFORMS

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

VOLCANOES

Volcanoes are classified on the basis of nature of eruption and the form developed at the surface. Major types of volcanoes are as follows: *Shield Volcanoes* Barring the basalt flows, the shield volcanoes are the largest of all the volcanoes on the earth. The Hawaiian volcanoes are the most famous examples. These volcanoes are mostly made up of basalt, a type of lava that is very fluid when erupted. For this reason, these volcanoes are not steep. They become explosive if somehow water gets into the vent; otherwise, they are characterised by low-explosivity. The upcoming lava moves in the form of a fountain and throws out the cone at the top of the vent and develops into cinder cone. *Composite Volcanoes* These volcanoes are characterised by eruptions of cooler and more viscous lavas than basalt.

These volcanoes often result in explosive eruptions. Along with lava, large quantities of pyroclastic material and ashes find their way to the ground. This material accumulates in the vicinity of the vent openings leading to formation of layers, and this makes the mounts appear as composite volcanoes. more than 50 m. Individual flows may extend for hundreds of km. The *Deccan Traps* from India, presently covering most of the Maharashtra plateau, are a much larger flood basalt province. It is believed that initially the trap formations covered a much larger area than the present. *Mid-Ocean Ridge Volcanoes* These volcanoes occur in the oceanic areas. There is a system of mid-ocean ridges more than 70,000 km long that stretches through all the ocean basins. The central portion of this ridge experiences frequent eruptions. We shall be discussing this in detail in the next.

VOLCANIC LANDFORMS

Intrusive Forms

The lava that is released during volcanic eruptions on cooling develops into igneous rocks. The cooling may take place either on reaching the surface or also while the lava is still in the crustal portion. Depending on the location of the cooling of the lava, igneous rocks are classified as *volcanic rocks* (cooling at the surface) and *plutonic rocks* (cooling in the crust). The lava that cools within the crustal portions assumes different forms. These forms are called *intrusive forms*. Some of the forms *Caldera* These are the most explosive of the earth's volcanoes. They are usually so explosive that when they erupt they tend to collapse on themselves rather than building any tall structure. The collapsed depressions are called *calderas*. Their explosiveness indicates that the magma chamber supplying the lava is not only huge but is also in close vicinity. *Flood Basalt Provinces* These volcanoes outpour highly fluid lava that flows for long distances. Some parts of the world are covered by thousands of sq. km of thick basalt lava flows. There can be a series of flows with some flows attaining thickness of *Batholiths* A large body of magmatic material that cools in the deeper depth of the crust develops in the form of large domes. They appear on the surface only after the denudational processes remove the overlying materials.

They cover large areas, and at times, assume depth that may be several km. These are granitic bodies. Batholiths are the cooled portion of magma chambers. *Lacoliths* These are large dome-shaped intrusive bodies with a level base and connected by a pipe-like conduit from below. It resembles the surface volcanic domes of composite volcano, only these are located at deeper depths. It can be regarded as the localised source of lava that finds its way to the surface. The Karnataka plateau is spotted with domal hills of granite rocks. Most of these, now exfoliated, are examples of lacoliths or batholiths. *Lapolith, Phacolith and Sills* As and when the lava moves upwards, a portion of the same may tend to move in a horizontal direction wherever it finds a weak plane. It may get rested in different forms. In case it develops into a saucer shape, concave to the sky body, it is called *lapolith*. A wavy mass of intrusive rocks, at times, is found at the base of synclines or at the top of anticline in folded igneous country. Such wavy materials have a definite conduit to source beneath in the form of magma chambers (subsequently developed as batholiths). These are called the phacoliths. The near horizontal bodies of the intrusive igneous rocks are called *sill* or *sheet*, depending on the thickness of the material. The thinner ones are called sheets while the thick horizontal deposits are called sills. *Dykes* When the lava makes its way through cracks and the fissures developed in the land, it solidifies almost perpendicular to the ground. It gets cooled in the same position to develop a wall-like structure. Such structures are called dykes. These are the most commonly found intrusive forms in the western Maharashtra area. These are considered the feeders for the eruptions that led to the development of the Deccan traps.

FACT BOX

It was the German meteorologist Alfred Wegener who gave a theoretical basis for the concept of continental drift.

- According to the Theory of continental drift there was only a single large continent on the surface of the Earth until the end of the Triassic Period.
- At about 200 million years ago, Pangaea broke up and formed into two continents named Gondwanaland and Laurasia.
- During the course of time earlier continents further fragmented and their portions drifted away from each other.
- Wegener failed in providing a scientifically sound explanation regarding the force that was necessary for drifting of continents.
- The Theory of Plate Tectonics has been formulated in 1968.
- The lithosphere of the Earth is made up of a number of large and small plates.
- Lithospheric plates slowly slide over the underlying asthenosphere.
- On the basis of relative motions of adjacent plates three types of plate margins have been recognised.
- Divergent plate margins in continents give rise to rift valleys.
- Convergent plate margins are of three types.
- Shear margins are those where adjacent plates move past each other in horizontal directions.
- Triple junctions are regions where three plates come into contact.

OCEANS AND CONTINENTS

The continents cover 29 per cent of the surface of the earth and the remainder is under oceanic waters. The positions of the continents and the ocean bodies, as we see them in the map, have not been the same in the past. Moreover, it is now a well-accepted fact that oceans and continents will not continue to enjoy their present positions in times to come. The continents and oceans have changed and are changing their positions

CONTINENTAL DRIFT

Observe the shape of the coastline of the Atlantic Ocean. You will be surprised by the symmetry of the coastlines on either side of the ocean. No wonder, many scientists thought of this similarity and considered the possibility of the two Americas, Europe and Africa, to be once joined together. From the known records of the history of science, it was *Abraham Ortelius*, a Dutch map maker, who first proposed such a possibility as early as 1596. *Antonio Pellegrini* drew a map showing the three continents together. However, it was *Alfred Wegener*—a German meteorologist who put forth a comprehensive argument in the form of "the continental drift theory" in 1912. This was regarding the distribution of the oceans and the continents. According to Wegener, all the continents formed a single continental mass and mega ocean surrounded the same. The super continent was named PANGAEA, which meant all earth. The mega-ocean was called PANTHALASSA, meaning all water. He argued that, around 200 million years ago, the super continent, Pangaea, began to split. Pangaea first broke into two large continental masses as Laurasia and Gondwanaland forming the northern and southern components respectively. Subsequently, Laurasia and Gondwanaland continued to break into various smaller continents that exist today. A variety of evidence was offered in support of the continental drift. Some of these are given below.

EVIDENCE IN SUPPORT OF THE CONTINENTAL DRIFT

The Matching of Continents (Jig-Saw-Fit)

The shorelines of Africa and South America facing each other have a remarkable and unmistakable match. It may be noted that a map produced using a computer programme to find the best fit of the Atlantic margin was presented by Bullard in 1964. It proved to be quite perfect. The match was tried at 1,000-fathom line instead of the present shoreline. *Rocks of Same Age Across the Oceans* The radiometric dating methods developed in the recent period have facilitated correlating the rock formation from different continents across the vast ocean. The belt of ancient rocks of 2,000 million years from Brazil coast matches with those from western Africa. The earliest marine deposits along the coastline of South America and Africa are of the Jurassic age. This suggests that the ocean did not exist prior to that time.

Tillite It is the sedimentary rock formed out of deposits of glaciers. The Gondawana system of sediments from India is known to have its counter parts in six different landmasses of the Southern Hemisphere. At the base the system has thick tillite indicating extensive and prolonged glaciation. Counter parts of this succession are found in Africa, Falkland Island, Madagascar, Antarctica and Australia besides India. Overall resemblance of the Gondawana type sediments clearly demonstrates that these landmasses had remarkably similar histories. The glacial tillite provides unambiguous evidence of palaeoclimates and also of drifting of continents. *Placer Deposits* The occurrence of rich placer deposits of gold in the Ghana coast and the absolute absence of source rock in the region is an amazing fact. The gold bearing veins are in Brazil and it is obvious that the gold deposits of the Ghana are derived from the Brazil plateau when the two continents lay side by side.

Distribution of Fossils

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

FORCE FOR DRIFTING

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

POST-DRIFT STUDIES

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

Convectional Current

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

Mapping of the Ocean Floor

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

Ocean Floor Configuration

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

Continental Margins

These form the transition between continental shores and deep-sea basins. They include continental shelf, continental slope, continental rise and deep-oceanic trenches. Of these, thedeep-oceanic trenches are the areas which are of considerable interest in so far as the distribution of oceans and continents isconcerned. *Abyssal Plains* These are extensive plains that lie between the continental margins and mid-oceanic ridges. The abyssal plains are the areas where the continental sediments that move beyond themargins get deposited.

Mid-Oceanic Ridges

This forms an interconnected chain of mountain system within the ocean. It is the longest mountain-chain on the surface of the earth though submerged under the oceanic waters. It is characterised by a central rift system at the crest, a fractionated plateau and flank zone all along its length. The rift system at the crest is the zone of intense volcanic activity. In the previous , you have been introduced to this type of volcanoes as midoceanic volcanoes.

Distribution of Earthquakes and Volcanoes

Study the maps showing the distribution of seismic activity and volcanoes. A line of dots in the central parts of the Atlantic Ocean almost parallel to the coastlines. It further extends into the Indian Ocean. It bifurcates a little south of the Indian subcontinent with one branch moving into East Africa and the other meeting a similar line from Myanmar to New Guiana. This line of dots coincides with the midoceanic ridges. The shaded belt showing another area of concentration coincides with the Alpine-Himalayan system and the rim of the Pacific Ocean. In general, the foci of the earthquake in the areas of mid-oceanic ridges are at shallow depths whereas along the Alpine-Himalayan belt as well as the rim of the Pacific, the earthquakes are deep-seated ones. The map of volcanoes also shows a similar pattern. The rim of the Pacific is also called rim of fire due to the existence of active volcanoes in this area.

CONCEPT OF SEA FLOOR SPREADING

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

i. It was realised that all along the midoceanic ridges, volcanic eruptions are common and they bring huge amounts of lava to the surface in this area.
ii. The rocks equidistant on either sides of the crest of mid-oceanic ridges show remarkable similarities in terms of period of formation, chemical compositions and magnetic properties. Rocks closer to the mid-oceanic ridges have normal polarity and are the youngest. The age of the rocks increases as one moves away from the crest.
iii. The ocean crust rocks are much younger than the continental rocks. The age of rocks in the oceanic crust is nowhere more than 200 million years old. Some of the continental rock formations are as old as 3,200 million years.
iv. The sediments on the ocean floor are unexpectedly very thin. Scientists were expecting, if the ocean floors were as old as the continent, to have a complete sequence of sediments for a period of much longer duration. However, nowhere was the sediment column found to be older than 200 million years.
v. The deep trenches have deep-seated earthquake occurrences while in the midoceanic ridge areas, the quake foci have shallow depths. These facts and a detailed analysis of magnetic properties of the rocks on either sides of the mid-oceanic ridge led Hess (1961) to propose his hypothesis, known as the "sea floor spreading". Hess argued that constant eruptions at the crest of oceanic ridges cause the rupture of the oceanic crust and the new lava wedges into it, pushing the oceanic crust on either side. The ocean floor, thus spreads. The younger age of the oceanic crust as well as the fact that the spreading of one ocean does not cause the shrinking of the other, made Hess think about the consumption of the oceanic crust. He further maintained that the ocean floor that gets pushed due to volcanic eruptions at the crest, sinks down at the oceanic trenches and gets consumed.

PLATE TECTONICS

Since the advent of the concept of sea floor spreading, the interest in the problem of distribution of oceans and continents was revived. It was in 1967, McKenzie and Parker and also Morgan, independently collected the available ideas and came out with another concept termed *Plate Tectonics*. A tectonic plate (also called lithospheric plate) is a massive, irregularly-shaped slab of solid rock, generally composed of both continental and oceanic lithosphere. Plates move horizontally over the asthenosphere as rigid units. The lithosphere includes the crust and top mantle with its thickness range varying between 5-100 km in oceanic parts and about 200 km in the continental areas. A plate may be referred to as the continental plate or oceanic plate depending on which of the two occupy a larger portion of the plate. Pacific plate is largely an oceanic plate whereas the Eurasian plate may be called a continental plate. The theory of plate tectonics proposes that the earth's lithosphere is divided into seven major and some minor

plates. Young Fold Mountain ridges, trenches, and/or faults surround these major plates (4.5). The major plates are as follows :
(i) Antarctica and the surrounding oceanic plate

4.5 : Major and minor plates of the world

ii. North American (with western Atlantic floor separated from the South American plate along the Caribbean islands) plate
iii. South American (with western Atlantic floor separated from the North American plate along the Caribbean islands) plate
iv. Pacific plate
v. India-Australia-New Zealand plate
vi. Africa with the eastern Atlantic floor plate
vii. Eurasia and the adjacent oceanic plate. Some important minor plates are listed below:

i. *Cocos plate* : Between Central America and Pacific plate
ii. *Nazca plate* : Between South America and Pacific plate
iii. *Arabian plate* : Mostly the Saudi Arabian landmass
iv. *Philippine plate* : Between the Asiatic and Pacific plate
v. *Caroline plate* : Between the Philippine and Indian plate (North of New Guinea)
vi. *Fuji plate* : North-east of Australia. These plates have been constantly moving over the globe throughout the history of the earth. It is not the continent that moves as believed by Wegener. Continents are part of a plate and what moves is the plate. Moreover, it may be noted that all the plates, without exception, have moved in the geological past, and shall continue to move in the future as well. Wegener had thought of all the continents to have initially existed as a super continent in the form of Pangaea. However, later discoveries reveal that the continental masses, resting on the plates, have been wandering all through the geological period, and Pangaea was a result of converging of different continental masses that were parts of one or the other plates. Scientists using the palaeomagnetic data have determined the positions held by each of the present continental landmass in different geological periods. Position of the Indian subcontinent(mostly Peninsular India) is traced with the help of the rocks analysed from the Nagpur area. There are three types of plate boundaries:

DIVERGENT BOUNDARIES

Where new crust is generated as the plates pull away from each other. The sites where the plates move away from each other are called *spreading sites*. The best-known example of divergent boundaries is the Mid-Atlantic Ridge.At this, the American Plate(s) is/are separated from the Eurasian and African Plates.

CONVERGENT BOUNDARIES

Where the crust is destroyed as one plate dived under another. The location where sinking of a plate occurs is called a *subduction zone.* There are three ways in which convergence can occur. These are: (i) between an oceanic and continental plate; (ii) between two oceanic plates; and (iii) between two continental plates.

TRANSFORM BOUNDARIES

Where the crust is neither produced nor destroyed as the plates slide horizontally past each other. Transform faults are the planes of separation generally perpendicular to the midoceanic ridges. As the eruptions do not take all along the entire crest at the same time, there is a differential movement of a portion of the plate away from the axis of the earth. Also, the rotation of the earth has its effect on the separated blocks of the plate portions.

FORCE FOR THE PLATE MOVEMENT

At the time that Wegener proposed his theory of continental drift, most scientists believed that the earth was a solid, motionless body. However, concepts of sea floor spreading and the unified theory of plate tectonics have emphasised that both the surface of the earth and the interior are not static and motionless but are dynamic. The fact that the plates move is now a well-accepted fact. The mobile rock beneath the rigid plates is believed to be moving in a circular manner. The heated material rises to the surface, spreads and begins to cool, and then sinks back into deeper depths. This cycle is repeated over and over to generate what scientists call a convection cell or convective flow. Heat within the earth comes from two main sources: radioactive decay and residual heat. Arthur Holmes first considered this idea in the 1930s, which later influenced Harry Hess' thinking about seafloor spreading. The slow movement of hot, softened mantle that lies below the rigid plates is the driving force behind the plate movement.

RATES OF PLATE MOVEMENT

The strips of normal and reverse magnetic field that parallel the mid-oceanic ridges help scientists determine the rates of plate movement. These rates vary considerably. The Arctic Ridge has the slowest rate (less than 2.5 cm/yr), and the East Pacific Rise near Easter Island, in the South Pacific about 3,400 km west of Chile, has the fastest rate (more than 15 cm/yr).

MOVEMENT OF THE INDIAN PLATE

The Indian plate includes Peninsular India and the Australian continental portions. The subduction zone along the Himalayas forms the northern plate boundary in the form of continent— *continent convergence*. In the east, it extends through Rakinyoma Mountains of Myanmar towards the island arc along the Java Trench. The eastern margin is a *spreading site* lying to the east of Australia in the form of an oceanic ridge in SW Pacific. The Western margin follows Kirthar Mountain of Pakistan. It further extends along the Makrana coast and joins the *spreading site* from the Red Sea rift southeastward along the Chagos Archipelago. The boundary between India and the Antarctic plate is also marked by oceanic ridge *(divergent boundary)* running in roughly W-E direction and merging into the *spreading site,* a little south of New Zealand. India was a large island situated off the Australian coast, in a vast ocean. The Tethys Sea separated it from the Asian continent till about 225 million years ago. India is supposed to have started her northward journey about 200 million years ago at the time when Pangaea broke. India collided with Asia about 40-50 million years ago causing rapid uplift of the Himalayas. About 140 million years before the present, the subcontinent was located as south as 50oS. latitude. The two major plates were separated by the Tethys Sea and the Tibetan block was closer to the Asiatic landmass. During the movement of the Indian plate towards the Asiatic plate, a major event that occurred was the outpouring of lava and formation of the Deccan Traps. This started somewhere around 60 million years ago and continued for a long period of time. Note that the subcontinent was still close to the equator. From 40 million years ago and thereafter, the event of formation of the Himalayas took place. Scientists believe that the process is still continuing and the height of the Himalayas is rising even to this date.

DESERTS
Overview

- A desert is a region that receives almost no rainfall. In general deserts are areas with a moisture deficit i.e. lose more moisture than receive
- **Deserts are defined as areas with average precipitation less than 250 mm per year or where more water is lost by evaporation and transpiration than falls by precipitation**
- Deserts are located where vegetation is sparse or nonexistent
- **Deserts constitute about one third (33%) of the Earth's land surface**
- **The largest desert on Earth is Antarctica**

CLASSIFICATION OF DESERTS

The world's largest deserts (excluding polar deserts)

- **Hot deserts**
  - This is the most common form of desert
  - They have large diurnal (daily) and seasonal temperature variation, with daytime temperatures reaching more than 45 C in the summer and dipping to 0 C at night in the winter
  - **Water acts to trap IR radiation from both the sun and the ground, and dry desert air is incapable of blocking sunlight during the day or trapping heat at night**
  - **The largest hot desert is the Sahara Desert**
- **Cold deserts**
  - **Cold deserts (aka polar deserts) are deserts which occur in extremely cold regions.** In cold deserts, the mean temperature during the warmest month is less than 10 C
  - Cold deserts form due to extreme lack of precipitation (in the form)
  - Cold deserts are covered in snow and ice. **Due to lack of liquid water, cold deserts cannot support life**
  - Instead of sand dunes, polar deserts have snow dunes (in areas where precipitation is locally available)
  - **The largest cold desert is the continent of Antarctica**
- **Montane deserts**
  - **Montane deserts are deserts that occur at very high altitudes**
  - **Example: Ladakh, Tibet**
  - These places are profoundly arid (low humidity) due to their large distance from the nearest available source of moisture
- **Rain shadow deserts**
  - **Rain shadow deserts form when tall mountain ranges block clouds from reaching areas in the direction of the wind**
  - As air moves over the mountains, air cools and moisture condenses, causing precipitation on the windward side of the mountain. When the air reaches the leeward side, it is dry since it has already lost all its moisture, resulting in a desert
  - Example: Tirunelveli area in southern Tamil Nadu

Flora and Fauna in deserts

- Although deserts are generally thought to support little life, in reality deserts do have high biodiversity
- Animals in the desert include kangaroo rat, coyote, jackal, jack rabbit and lizards
- **Most desert animals remain hidden during the daytime to control body temperature and limit moisture needs**
- **Animals that have adapted to live in deserts are called xerocoles.** A particularly well-studied adaptation is the specialisation of mammalian kidneys shown by desert-inhabiting species

- Deserts typically have plant cover that is sparse but diverse
- Most desert plants are salt and drought tolerant, such as xerophytes
- Some desert plants store water in their leaves, stems and roots. Others have long taproots that penetrate deep into the ground to reach the water table, or have roots that spread over a wider area in order absorb moisture from the ground
- Another desert adaptation is the development of long spiny needle-like leaves that lose less moisture to transpiration
- The giant Saguaro cacti, which grow to about 15 m height, are commonly found in the Sonora desert in Arizona (USA). The Saguaro cacti grow slowly but live up to 200 years, provide nests for desert birds and serve as desert trees

WATER IN DESERTS

- Rain does fall occasionally on deserts, and when they do, desert storms are often violent
- Large storms in the Sahara deliver up to 1mm of rain per minute
- **Normally dry streams, called arroyos or wadis, can quickly fill up following rain and cause dangerous flash floods**
- A few deserts are also crossed by 'exotic' rivers – **rivers that originate elsewhere but run through desert areas.** These rivers lose enormous quantities of water to evaporation while journeying through the desert, but have sufficient volume to ensure continuous flow. **Examples: Nile, Colorado and Yellow rivers**
- Desert lakes can form where rainwater or meltwater in interior drainage basins is sufficient. **Desert lakes are usually salty, shallow and temporary.**
- **Since they are shallow, wind stress can make the lake waters move over several sq km.**
- When desert lakes dry up, they leave a salt crust or hardpan. **This flat area of clay, silt and sand encrusted by sand is called a playa or sink.** The flat terrains of playas and hardpans makes them excellent speedways and natural runways for aircraft
- **Examples of desert lakes: Great Salt Lake (Utah, USA)**
- **The Atacama Desert in Chile is the driest place on Earth.** Blocked from moisture on both sides by the Andes and the Chilean coastal range, **the Atacama is virtually sterile and devoid of all life.** The average rainfall in the region is 1 mm per year. Some weather stations in the desert have never received rain.

Mineral resources in deserts

- Deserts may contain a great amount of mineral resources over their entire surface

- The red colour of many sand deserts is due to the occurrence of laterite. Laterite, rich in iron and aluminium, is commonly used in making bricks
- Evaporation enriches mineral accumulation in desert lakes, including gypsum, sodium salts and borates
- **The Great Basin Desert (USA) has been extensively used to mine borates**, which are used in the manufacture of glass
- **The Atacama Desert (Chile) is abundant in saline minerals.** Sodium nitrate for fertilisers and explosives has been mined from the Atacama since the middle of the 19^{th} century
- Significant petroleum deposits are found in desert regions. However, **these oil fields were originally formed when the areas were shallow marine environments.** Subsequent climate change has rendered these regions arid
- Deserts are also increasingly seen as sources of solar energy. **It is estimated that all the world's electricity needs could be met by 10% of the solar energy tapped from the Sahara Desert**

Oasis

- An oasis is an isolated area of vegetation in a desert, usually surrounding a spring or similar water source
- Oases provide natural habitats for animals, plants and even humans
- **Oases are formed from underground rivers or aquifers, where water reaches the surface by natural pressure**

LIST OF IMPORTANT DESERTS

S. No.	Desert	Location	Notes
1	Antarctica	Antarctica	Largest desert on earth
2	Arctic	Arctic	Second largest desert
3	Sahara	Northern Africa (Egypt, Libya, Sudan, Morocoo, Algeria)	Largest hot desert Third largest desert
4	Arabian desert	Arabia (Saudi Arabia, UAE, Yemen)	
5	Gobi desert	Mongolia, China	
6	Kalahari desert	Southern Africa (Botswana, parts of Namibia, South Africa)	Supports plants and animals since much of it is not a true desert Receives about 75-200 mm of rainfall per year
7	Patagonian desert	Argentina	Cold weather desert
8	Great Victoria Desert	Australia	

Overview

- **Desertification is the extreme deterioration of land in arid and dry areas due to loss of vegetation and soil moisture**
- Desertification results mainly from human activities but is influenced by climatic variations
- Desertification directly results in biodiversity loss and loss of productive capacity

Causes of desertification

- **The primary reasons for desertification are**
    - overgrazing
    - over-cultivation
    - increased fire frequency
    - water impoundment
    - deforestation
    - overdraft of ground water
    - increased soil salinity
    - climate change
- Droughts by themselves do not cause desertification. However, continued land abuse during droughts increases land degradation leading to desertification.
- Nomadic lifestyles with slash and burn agriculture can directly lead to desertification

Historical and current desertification

The Atacama Desert (Chile), the driest place on Earth, is almost completely sterile and devoid of all life. The only such place on Earth, it has often been compared to planet Mars.

- Desertification is a historic phenomenon: the world's largest deserts were formed by natural processes over long intervals of time.
- **Dated fossil pollen indicate that the Sahara has been changing between desert and fertile savanna.** The Sahara is currently expanding southward at a rate of 48 km per year
- Drought and overgrazing in the 1930s transformed parts of the Great Plains in the US into the Dust Bowl
- Slash and burn agriculture in Madagascar has caused almost 10% of the country to become barren, sterile land

Countering desertification

- Counter-desertification techniques usually focus on two major aspects

  - **Provisioning of water**
  - **Fixating and hyper-fertilising soils**
- Fixating of soils is done by means of shelter belts, woodlots and windbreaks. Made from trees and bushes, these **reduce soil erosion and evapotranspiration**
- **Soil fertilisation and enrichment is often achieved using leguminous plants** (which extract nitrogen from air and fix into soil). Grains, barley, beans and dates are used for this purpose
- Stacking stones around the base of trees and artificial groove digging can also help plant survival by collecting morning dew and retaining soil moisture
- Desertification can also be temporarily forestalled by using sand fences (using bushes and trees), which decrease wind velocity and hence soil erosion and moisture loss
- **The Green Wall project in Africa aims to plant trees in a 15 km strip from Senegal in the west to Djibouti in the east.** The project aims to counter desert progression while also providing economic opportunities to the local populations

United Nations Convention to Combat Desertification

- **The UN Convention to Combat Desertification (UNCCD) aims to combat desertification and mitigate the effects of drought**
- The Convention was adopted in Paris in 1994 and came into effect in 1996. **The UNCCD has 193 member nations including India**
- The Convention seeks to achieve its goals through national-level action programmes that incorporate long term strategies supported by international cooperation
- It is the first and only legally binding framework to address the problem of desertification
- **The nodal agency for implementing the UNCCD in India is the Ministry of Environment and Forests**

MINERALS AND ROCKS TYPES

The earth is composed of various kinds of elements. These elements are in solid form in the outer layer of the earth and in hot and molten form in the interior. About 98 per cent of the total crust of the earth is composed of eight elements like oxygen, silicon, aluminium, iron, calcium, sodium, potassium and magnesium and the rest is constituted by titanium, hydrogen, phosphorous, manganese, sulphur, carbon, nickel and other elements.

The Major Elements of the Earth's Crust

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

The elements in the earth's crust are rarely found exclusively but are usually combined with other elements to make various substances. These substances are recognised as minerals. Thus, a mineral is a naturally occurring organic and inorganic substance, having an orderly atomic structure and a definite chemical composition and physical properties. A mineral is composed of two or more elements. But, sometimes single element minerals like sulphur, copper, silver, gold, graphite etc. are found. Though the number of elements making up the lithosphere are limited they are combined in many different ways to make up many varieties of minerals. There are at least 2,000 minerals that have been named and identified in the earth crust; but almost all the commonly occurring ones are related to six major mineral groups that are known as major rock forming minerals. The basic source of all minerals is the hot magma in the interior of the earth. When magma cools, crystals of minerals appear and a systematic series of minerals are formed in sequence to solidify so as to form rocks. Minerals such as coal, petroleum and natural gas are organic substances found in solid,liquid and gaseous forms respectively. A brief information about some important minerals in terms of their nature and physical characteristics is given below :

PHYSICAL CHARACTERISTICS

i. External crystal form — determined by internal arrangement of the molecules — cubes, octahedrons, hexagonal prisms, etc.
ii. Cleavage — tendency to break in given directions producing relatively plane surfaces — result of internal arrangement of the molecules — may cleave in one or more directions and at any angle to each other.
iii. Fracture — internal molecular arrangement so complex there are no planes of molecules; the crystal will break in an irregular manner, not along planes of cleavage.
iv. Lustre — appearance of a material without regard to colour; each mineral has a distinctive lustre like metallic, silky, glossy etc.
v. Colour — some minerals have characteristic colour determined by their molecular structure — malachite, azurite, chalcopyrite etc., and some minerals are coloured by impurities. For example, because of impurities quartz may be white, green, red, yellow etc.
vi. Streak — colour of the ground powder of any mineral. It may be of the same colour as the mineral or may differ — malachite is green and gives green streak, fluorite is purple or green but gives a white streak.

vii. Transparency — transparent: light rays pass through so that objects can be seen plainly; translucent — light rays pass through but will get diffused so that objects cannot be seen; opaque — light will not pass at all.

viii. Structure — particular arrangement of the individual crystals;fine, medium or coarse grained; fibrous — separable, divergent, radiating.

ix. Hardness — relative resistance being scratched; ten minerals are selected to measure the degree of hardness from 1-10. They are: 1. talc; 2. gypsum; 3. calcite; 4. fluorite; 5. apatite; 6. feldspar; 7. quartz; 8. topaz; 9. corundum; 10. diamond. Compared to this for example, a fingernail is 2.5 and glass or knife blade is 5.5.

x. 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 air by the difference of the two weights.

SOME MAJOR MINERALS

FELDSPAR

Silicon and oxygen are common elements in all types of feldspar and sodium, potassium, calcium, aluminium etc. are found in specific feldspar variety. Half of the earth's crust is composed of feldspar. It has light cream to salmon pink colour. It is used in ceramics and glass making.

QUARTZ

It is one of the most important components of sand and granite. It consists of silica. It is a hard mineral virtually insoluble in water. It is white or colourless and used in radio and radar. It is one of the most important components of granite.

PYROXENE

Pyroxene consists of calcium, aluminum, magnesium, iron and silica. Pyroxene forms 10 per cent of the earth's crust. It is commonly found in meteorites. It is in green or black colour.

AMPHIBOLE

Aluminium, calcium, silica, iron, magnesium are the major elements of amphiboles. They form 7 per cent of the earth's crust. It is in green or black colour and is used in asbestos industry. Hornblende is another form of amphiboles.

MICA

It comprises of potassium, aluminium, magnesium, iron, silica etc. It forms 4 per cent of the earth's crust. It is commonly found in igneous and metamorphic rocks. It is used in electrical instruments.

OLIVINE

Magnesium, iron and silica are major elements of olivine. It is used in jewellery. It is usually a greenish crystal, often found in basaltic rocks. Besides these main minerals, other minerals like chlorite, calcite, magnetite, haematite, bauxite and barite are also present in some quantities in the rocks.

METALLIC MINERALS

These minerals contain metal content and can be sub-divided into three types:

1. *Precious metals* : gold, silver, platinum etc.
2. *Ferrous metals* : iron and other metals often mixed with iron to form various kinds of steel.
3. *Non-ferrous metals* : include metals like copper, lead, zinc, tin, aluminium etc.

Non-Metallic Minerals

These minerals do not contain metal content. Sulphur, phosphates and nitrates are examples of non-metallic minerals. Cement is a mixture of non-metallic minerals.

ROCKS

The earth's crust is composed of rocks. A rock is an aggregate of one or more minerals. Rock may be hard or soft and in varied colours. For example, granite is hard, soapstone is soft. Gabbro is black and quartzite can be milky white. Rocks do not have definitecomposition of mineral constituents. Feldspar and quartz are the most common minerals found in rocks. Petrology is science of rocks. A petrologist studies rocks in all their aspects viz., mineral composition, texture, structure, origin, occurrence, alteration and relationship with other rocks. As there is a close relation between rocks and landforms, rocks and soils, a geographer requires basic knowledge of rocks. There are many different kinds of rocks which are grouped under three families on the basis of their mode of formation. They are:

a) Igneous Rocks — solidified from magma and lava;
b) Sedimentary Rocks -— the result of deposition of fragments of rocks by exogenous processes;

c) Metamorphic Rocks — formed out of existing rocks undergoing recrystallisation.

IGNEOUS ROCKS

As igneous rocks form out of magma and lava from the interior of the earth, they are known as primary rocks. The igneous rocks (Ignis – in Latin means 'Fire') are formed when magma cools and solidifies. You already know what magma is. When magma in its upward movement cools and turns into solid form it is called igneous rock. The process of cooling and solidification can happen in the earth's crust or on the surface of the earth. Igneous rocks are classified based on texture. Texture depends upon size and arrangement of grains or other physical conditions of the materials. If molten material is cooled slowly at great depths, mineral grains may be very large. Sudden cooling (at the surface) results in small and smooth grains. Intermediate conditions of cooling would result in intermediate sizes of grains making up igneous rocks. Granite, gabbro, pegmatite, basalt, volcanic breccia and tuff are some of the examples of igneous rocks.

SEDIMENTARY ROCKS

The word 'sedimentary' is derived from the Latin word sedimentum, which means settling. Rocks (igneous, sedimentary and metamorphic) of the earth's surface are exposed to denudational agents, and are broken up into various sizes of fragments. Such fragments are transported by different exogenous agencies and deposited. These deposits through compaction turn into rocks. This process is called

***lithification*.**

In many sedimentary rocks, the layers of deposits retain their characteristics even after lithification. Hence, we see a number of layers of varying thickness in sedimentary rocks like sandstone, shale etc. Depending upon the mode of formation, sedimentary rocks are classified into three major groups:

1) Mechanically formed — sandstone, conglomerate, limestone, shale, loess etc. are examples;
2) Organically formed— geyserite, chalk, limestone, coal etc. are some examples;
3) Chemically formed — chert, limestone, halite, potash etc. are some examples.

METAMORPHIC ROCKS

The word metamorphic means 'change of form'. These rocks form under the action of pressure, volume and temperature (PVT) changes. Metamorphism occurs when rocks are forced down to lower levels by tectonic processes or when molten magma rising through the crust comes in contact with the crustal rocks or the underlying rocks are subjected to great amounts of pressure by overlying rocks. Metamorphism is a process by which already consolidated rocks undergo recrystallisation and reorganisation of materials within original rocks. Mechanical disruption and reorganization of the original minerals within rocks due to breaking and crushing without any appreciable chemical changes is called dynamic metamorphism. The materials of rocks chemically alter and recrystallise due to thermal metamorphism. There are two types of thermal metamorphism — contact metamorphism and regional metamorphism. In contact metamorphism the rocks come in contact with hot intruding magma and lava and the rock materials recrystallise under high temperatures. Quite often new materials form out of magma or lava are added to the rocks. In regional metamorphism, rocks undergo recrystallisation due to deformation caused by tectonic shearing together with high temperature or pressure or both. In the process of metamorphism in some rocks grains or minerals get arranged in layers or lines. Such an arrangement of minerals or grains in metamorphic rocks is called *foliation* or *lineation*. Sometimes minerals or materials of different groups are arranged into alternating thin to thick layers appearing in light and dark shades. Such a structure in metamorphic rocks is called *banding* and rocks displaying banding are called *banded rocks*. Types of metamorphic rocks depend upon original rocks that were subjected to metamorphism. Metamorphic rocks are classified into two major groups — foliated rocks and non-foliated rocks. Gneissoid, granite, syenite, slate, schist, marble, quartzite etc. are some examples of metamorphic rocks.

ROCK CYCLE

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

FORESTS
Overview

- Forests are areas with a high density of trees
- **Forests cover approximately 9.4% of the Earth's surface i.e. about 30% of total land area,** although they used to cover as much as 50% of land area
- Forests are differentiated from woodland by the extent of canopy coverage: in forests, the foliage of trees meet and interlock while in woodlands there is enough gap between trees allowing sunlight to penetrate to the ground
- Forests are one of the most important aspects of the Earth's biosphere
- The functions of forests include
    - **Habitat for organisms**
    - **Hydrologic flow modulation**
    - **Soil conservation**
- Human factors affecting forest sustenance include logging, urban sprawl, agriculture, industries, human-induced forest fires etc. Natural factors affecting forests include forest fires, insects, diseases, weather etc
- **Only about 20% of the world's original forests remain in undisturbed forest.** Of this, 75% are in Russia, Canada and Brazil

Distribution of forests

- In general, forests can be found in all regions capable of sustaining tree growth (at altitudes up to the tree line), except where natural disturbance is too high or human activity has altered the environment
- **The areas between latitudes 10 N and 10 S are mostly covered in tropical rainforests, and between 53N and 67N have boreal forests (taiga)**
- Forests can contain many species in a small area (like rainforests) or relatively few species in a large area (like taiga and montane coniferous forests)
- Forests have higher biomass per unit area compared to other vegetation types. **Much of the forest biomass occurs below the ground in root systems and partially decomposed detritus**
- The major types of forest systems are
    - **Rainforests** (both tropical and temperate)
    - **Taiga**
    - **Temperate broadleaf forests**
    - **Tropical dry forests**

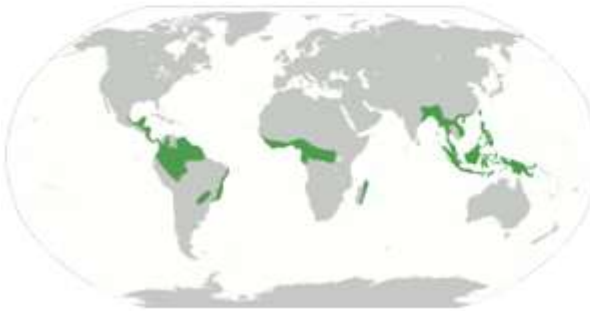
Old growth forests

- **Old growth forests (also called primary forests, ancient forests) are forests that contain trees which have attained great age**
- Old growth forests typically contain large and old live trees, large dead trees and large logs
- Death of individual trees creates gaps in the canopy layer allowing light to penetrate and create favourable conditions for undergrowth
- Old growth forests are often home to rare and threatened species, making them ecologically significant. For instance, **the Northern Spotted Owl is reliant on old growth forest**
- The importance of old growth forests include
    - They contain rich communities of plants and animals due to the long period of forest stability
    - They serve as a reservoir for species that cannot thrive or regenerate in younger forests
    - They store large amounts of carbon both above and below the ground (either as humus or in wet soils as peat)
- **Forests that are regenerated after disruptions must wait several centuries to millennia before they can reach the stable equilibrium that signifies old growth forests**
- Due to increased human activity, old growth forests have been substantially destroyed over the last century. Of the old growth forests that still remain, 35% are in Latin America (Brazil), 28% in North America (mainly Canada) and 19% in northern Asia (Siberia)

SECOND GROWTH FORESTS

- **Second growth forests (secondary forests) are forests that have re-grown after a major disturbance such as fire, insect infestation, logging, windthrow etc**
- Second growth forests tend to have trees closer spaced than primary forests and have more undergrowth
- Second growth forests usually have less biodiversity than old growth forests, since the former have had lesser time to develop and reach stable equilibrium
- Secondary forests are common in areas under shifting agriculture, areas with forest fires, and forests that are recovering from harvesting and agriculture
- **Secondary forests can several generations of trees (centuries) to resemble the original old growth forests.** However, in some areas, secondary forests do not succeed due to soil nutrient loss and erosion (especially in tropical rainforests)
- **Most of the forests of eastern North America and of Europe are secondary forests**

Distribution of tropical rainforests in the world



Overview

- **Rainforests are forests characterised by high rainfall**, with minimum annual rainfall as high as 1700-2000 mm
- **Rainforests are responsible for 28% of the world's oxygen turnover.** However, rainforests do not contribute much to the net oxygen additions to the atmosphere. Instead, they are vital in storing carbon in bio sequestration
- The Intertropical Convergence Zone (ITCZ), the area near the equator where winds originating in the northern and southern hemispheres meet, plays a significant role in creating the rainforests
- Despite the growth of vegetation, **soil quality in a rainforest is poor.** Most trees have roots near the surface due to lack of nutrients below the ground
- **More than half the world's species of plants and animals are found in rainforests**

Tropical Rainforests

- Tropical rainforests are rainforests in the tropics, near the equator between the Tropic of Cancer and the Tropic of Capricorn
- Tropical rainforests are found in South America (Brazil), Central America (Yucatan Peninsula), Sub-Saharan African (Congo), Northeast India, Southeast Asia (Indo-Malaya, Indonesia, Papua New Guinea)
- **Tropical rainforests are called 'world's largest pharmacy', since over 25% of modern medicines originate from these plants**
- **Tropical rainforests are home to half of all the plant and animal species on earth**
- Tropical rainforests are characterised by heavy rainfall, resulting in poor soil due to leaching of nutrients
- Temperatures range 15 C to 50 C. Rainfall ranges from 1250 mm to 6600 mm annually

Temperate Rainforests

- Temperate rainforests are rainforests that occur in the temperate zone and receive high rainfall

- Temperature range 4 to 12 C. Rainfall minimum is around 1400 mm annually
- **Temperate rainforests are found in close proximity to oceans, and usually occur in coastal mountains.** This is because temperate rainforests depend on the proximity to oceans to moderate seasons, creating milder winters and cooler summers. Coastal mountains increase rainfall on the ocean facing slopes
- **Wildfires are uncommon in temperate forests due to the high moisture content in the forest**
- Mosses are abundant in temperate rainforests
- **Temperate rainforests sustain the highest levels of biomass of any terrestrial ecosystem**
- **Temperate rainforests are notable for trees of massive proportions,** including coast redwood, coast douglas fir, sikta spruce etc
- Temperate rainforests are found in western North America, south-western South America, Norway, northern Spain, south-eastern Australia and New Zealand

DISTRIBUTION OF TEMPERATE RAINFORESTS IN THE WORLD

- Rainforests are typically divided into four layers, each with different plants and animals adapted for life in that environment
- **Emergent layer**
    - **The highest layer, formed by a small number of very tall trees that grow above the general canopy**
    - They reach heights of 45-55 m, occasionally even 70-80 m
    - Need to be able to withstand high temperatures and strong winds

- Eagles, butterflies, bats and some monkeys inhabit this layer

- **Canopy layer**
  - The canopy layer consists of the largest number of tall trees, which provides a more or less continuous cover of foliage by adjacent treetops
  - Usually reach heights of around 30-45 m
  - **The canopy layer is the densest area of biodiversity in a rainforest.** It is estimated that the canopy layer is home to about 50% of all plant species and 25% of all insect species
- **Understory**
  - The understory layer lies between the canopy and the forest floor
  - Leaves are much larger at this level
  - **Only about 5% of sunlight incident on the rainforest reaches the understory layer**
  - This layer is home to a number of birds, snakes, lizards, and predators like jaguar, boa constrictors etc
- **Forest floor**
  - The forest floor is the bottom most layer
  - **The forest floor receives only about 2% of the sunlight.** Only plants adapted to low light can grow in this region
  - **Due to low sunlight penetration, forest floor is relatively clear of vegetation.** This makes it possible to walk through a rainforest

Effect on global climate

- Rainforests emit and absorb massive quantities of carbon dioxide. **Undisturbed rainforests usually have no net impact on atmospheric carbon dioxide levels**
- **However, rainforests play a vital role in other climatic effects such as cloud formation and water vapour recycling**
- Deforestation caused by human activities and drought can cause rainforests to release massive amounts of carbon dioxide into the atmosphere

TROPICAL DRY FORESTS

Overview

- Tropical dry forests are located in the tropical and subtropical latitudes
- **These forests occur in areas that are warm and receive plentiful rainfall (several hundred centimetres) but experience long dry seasons which last several months.** These seasonal droughts have great impact on the forest
- Deciduous trees dominate in these forests
- Tropical dry forests are less biologically diverse than rainforests

- However, they are home to a wide variety of wildlife including monkeys, deer, parrots, large cats etc. **Mammalian biomass tends to be higher in dry forests than in rainforests.**

CHARACTERISTICS

- **During the drought season a leafless season occurs.** The shedding of leaves allows trees like teak and ebony to conserve water during these dry periods
- When the trees enter the dry leafless season, the canopy layer opens up allowing sunlight to reach the ground, thereby enabling **growth of thick undergrowth**
- However, certain areas of tropical dry forests can have evergreen trees. This happens especially when the forests are on moisture sites or have access to groundwater
- Three tropical dry forest regions have evergreen forests:
    - East Deccan dry evergreen forests (India)
    - Sri Lanka dry zone evergreen forests (Sri Lanka)
    - Southeastern Indochina dry evergreen forests (Cambodia, Laos, Thailand, Vietnam)
- **The forests of central India are tropical dry forests**
- **Dry forests are extremely sensitive to forest fires, overgrazing and deforestation.** Restoration of dry forests is possible, but challenging

DISTRIBUTION

- Dry forests tend to exist north and south of the equatorial rainforest belt, and south and north of the subtropical deserts
- They usually occur in two bands: one between 10 and 20 N latitudes and the other between 10 and 20 S latitudes
- **The most diverse dry forests of the world are found in southern Mexico and Bolivia**
- The dry forests of central India and Indochina are notable for their diverse and large vertebrate fauna
- Other tropical dry forests are found in New Caledonia, Madagascar, south eastern Africa and the Pacific coast of South America

TEMPERATE BROADLEAF AND MIXED FORESTS

Overview

- **Temperate broadleaf and mixed forests are a temperate and humid biome (ecological system)**
- These forests typically have four layers
    - Canopy layer: contains mature trees 100-200 ft high

  - Understory: shade tolerant layer of trees that grow to about 30-50 feet shorter than the canopy
  - Shrub layer: low growing woody plants
  - Herbaceous layer: this is the ground cover, most diverse layer
- **Characteristic broadleaf trees these forests include oaks, birches, beeches and maples. Mixed trees are basically coniferous trees such as pines, firs and spruces**
- Areas of temperate broadleaf and mixed forests include northeast USA, northern India, eastern Australia, New Zealand, southwest China

DISTRIBUTION

- **Temperate broadleaf and mixed forests occur in areas with distinct warm and cool seasons, with moderate annual average temperature (5-15 C)**
- They usually occur in moderately warm and rainy climates, sometimes with a distinct dry season
- Annual rainfall is typically over 600 mm and sometimes over 1500 mm

The Taiga, the world's largest terrestrial biome, is found throughout the high nothern latitudes

Overview

- **Taiga is a biome characterised by coniferous forests**
- **The Taiga is the world's largest terrestrial biome**
- The taiga experiences relatively low precipitation (250mm – 750 mm), mostly in the form of fog, snow and summer rain. However, since evaporation is also low, there is enough moisture to enable dense vegetation growth
- Taiga soils tend to be young and nutrient-poor. The soil tends to be acidic and hence the forest floor only has lichens and mosses growing

Characteristics

- The taiga has harsh continental climate and large range of temperatures: -54 C to 27 C
- Except for the tundra and permanent ice caps, the taiga is the coldest biome on earth

- There are two main types of taiga:
    - **Closed forest:** closely spaced trees with mossy ground cover
    - **Lichen woodland:** trees that are farther apart and have lichen ground cover. More common in colder areas
- In the northern taiga areas, forest cover is not only sparse but also stunted
- **The forests of taiga are mainly coniferous consisting of larch, spruce, fir and pine**
- Taiga trees tend to have shallow roots to take advantage of thin soils.
- Since the sun is low on the horizon most of the time, it is difficult to photosynthesise. Pine and spruce do not lose their leaves in winter and can photosynthesise using their older leaves
- **The adaptation of evergreen needles (on pines) limits water lost to transpiration and the dark green colour increases sunlight absorption**

DISTRIBUTION

- **The taiga covers most of Canada, Alaska, Sweden, Finland, Norway, the Scottish Highlands and Russia.** It is also found in parts of northern USA, northern Kazakhstan, northern Mongolia and northern Japan
- Large areas of Siberia's taiga have been destroyed in recent years
- In Canada, less than 8% is protected development and more than 50% has been allocated for logging
- The taiga is home to a large number herbivorous mammals and smaller rodents
- Some of the animals, like bears, eat in summer and hibernate in winter. Others have evolved layers of fur to insulate them from the cold
- **Due to the climate, carnivorous diets are inefficient for obtaining energy.**
- A significant number of birds like Siberian thrush, white throated sparrow, black throated green warbler migrate to the taiga to take advantage of long summer days

GEOMORPHIC PROCESSES

The earth's crust is dynamic. It has moved and moves vertically and horizontally. Of course, it moved a bit faster in the past than the rate at which it is moving now. The differences in the internal forces operating from within the earth which built up the crust have been responsible for the variations in the outer surface of the crust. The earth's surface is being continuously subjected to external forces induced basically by energy (sunlight). Of course, the internal forces are still active though with different intensities. That means, the earth's surface is being continuously subjected to by external forces originating within the earth's atmosphere and by internal forces from within the earth. The external forces are known as *exogenic forces* and the internal forces are known as *endogenic forces*. The actions of exogenic forces result in wearing down (degradation) of relief/elevations and filling up (aggradation) of basins/depressions, on the earth's surface.

The phenomenon of wearing down of relief variations of the surface of the earth through erosion is known as *gradation*. The endogenic forces continuously elevate or build up parts of the earth's surface and hence the exogenic processes fail to even out the relief variations of the surface of the earth. So, variations remain as long as the opposing actions of exogenic and endogenic forces continue. In general terms, the endogenic forces are mainly land building forces and the exogenic processes are mainly land wearing forces. The surface of the earth is sensitive. Humans depend on it for their sustenance and have been using it extensively and intensively. So, it is essential to understand its nature in order to use it effectively without disturbing its balance and diminishing its potential for the future. Almost all organisms contribute to sustain the earth's environment. However, humans have caused over use of resources.

Use we must, but must also leave it potential enough to sustain life through the future. Most of the surface of the earth had and has been shaped over very long periods of time (hundreds and thousands of years) and because of its use and misuse by humans its potential is being diminished at a fast rate. If the processes which shaped and are shaping the surface of the earth into varieties of forms (shapes) and the nature of materials of which it is composed of, are understood, precautions can be taken to minimise the detrimental effects of human use and to preserve it for posterity.

GEOMORPHIC PROCESSES

Meaning of geomorphic processes. The endogenic and exogenic forces causing physical stresses and chemical actions on earth materials and bringing about changes in the configuration of the surface of the earth are known as *geomorphic processes*. Diastrophism and volcanism are endogenic geomorphic processes. These have already been discussed in brief in the preceding unit. Weathering, mass wasting, erosion and deposition are exogenic geomorphic processes. These exogenic processes are dealt with in detail in this . Any exogenic element of nature (like wat er, ice, wind, etc.,) capable of acquiring and transporting earth materials can be called a geomorphic agent. When these elements of nature become mobile due to gradients, they remove the materials and transport them over slopes and deposit them at lower level. Geomorphic processes and geomorphic agents especially exogenic, unless stated separately, are one and the same. A process is a force applied on earth materials affecting the same. An agent is a mobile medium (like running water, moving ice masses, wind, waves and currents etc.) which removes, transports and deposits earth materials. Running water, groundwater, glaciers, wind, waves and currents, etc., can be called *geomorphic agents*. Gravity besides being a directional force activating all downslope movements of matter also causes stresses on the earth's materials. Indirect gravitational stresses activate wave and tide induced currents and winds. Without gravity and gradients there would be no mobility and hence no erosion, transportation and deposition are possible. So, gravitational stresses are as important as the other geomorphic processes. Gravity is the force that is keeping us in contact with the surface and it is the force that switches on the movement of all surface material on earth. All the movements either within the earth or on the surface of the earth occur due to gradients — from higher levels to lower levels, from high pressure to low pressure areas etc.

ENDOGENIC PROCESSES

The energy emanating from within the earth is the main force behind endogenic geomorphic processes. This energy is mostly generated by radioactivity, rotational and tidal friction and primordial heat from the origin of the earth. This energy due to geothermal gradients and heat flow from within induces diastrophism and volcanism in the lithosphere. Due to variations in geothermal gradients and heat flow from within, crustal thickness and strength, the action of endogenic forces are not uniform and hence the tectonically controlled original crustal surface is uneven.

DIASTROPHISM

All processes that move, elevate or build up portions of the earth's crust come under *diastrophism*. They include:

i. O*rogenic* processes involving mountain building through severe folding and affecting long and narrow belts of the earth's crust;
ii. *Epeirogenic* processes involving uplift or warping of large parts of the earth's crust;
iii. Earthquakes involving local relatively minor movements;
iv. Plate tectonics involving horizontal movements of crustal plates. In the process of orogeny, the crust is severely deformed into folds. Due to epeirogeny, there may be simple deformation. Orogeny is a mountain building process whereas epeirogeny is continental building process. Through the processes of orogeny, epeirogeny, earthquakes and plate tectonics, there can be faulting and fracturing of the crust. All these processes cause pressure, volume and temperature (PVT) changes which in turn induce metamorphism of rocks. Epeirogeny and orogeny, cite the differences.

VOLCANISM

Volcanism includes the movement of molten rock (magma) onto or toward the earth's surface and also formation of many intrusive and extrusive volcanic forms. Many aspects ofvolcanism have already been dealt in detail processes and their respective driving forces. It should become clear from this chart that for each process there exists a distinct driving force or energy. As there are different climatic regions on the earth's surface owing to thermal gradients created by latitudinal, seasonal and land and water spread variations, the exogenic geomorphic processes vary from region to region. The density, type and distribution of vegetation which largely depend upon under volcanoes in the Unit II and under igneous rocks in the preceding in this unit. What do the words volcanism and volcanoes indicate?

EXOGENIC PROCESSES

The exogenic processes derive their energy from atmosphere determined by the ultimate energy from the sun and also the gradients created by tectonic factors. Gravitational force acts upon all earth materials having a sloping surface and tend to produce movement of matter in down slope direction. Force applied per unit area is called *stress*. Stress is produced in a solid by pushing or pulling. This induces deformation. Forces acting along the faces of earth materials are shear stresses (separating forces). It is this stress that breaks rocks and other earth materials. The shear stresses result in angular displacement or slippage. Besides the gravitational stress earth materials become subjected to molecular stresses that may be caused by a number of factors amongst which temperature changes, crystallisation and melting are the most common. Chemical processes normally lead to loosening of bonds between grains, dissolving of soluble minerals or cementing materials.

Thus, the basic reason that leads to weathering, mass ovements, erosion and deposition is development of stresses in the body of the earth materials. As there are different climatic regions on the earth's surface the exogenic geomorphic processes vary from region to region. Temperature and precipitation are the two important climatic elements that control various processes. All the exogenic geomorphic processes are covered under a general term, *denudation*. The word 'denude' means to strip off or to uncover. Weathering, mass wasting/movements, erosion and transportation are included in denudation. Within different climatic regions there may be local variations of the effects of different climatic elements due to altitudinal differences, aspect variations and the variation in the amount of insolation received by north and south facing slopes as compared to east and west facing slopes. Further, due to differences in wind velocities and directions, amount and kind of precipitation, its intensity, the relation between precipitation and evaporation, daily range of temperature, freezing and thawing frequency, depth of frost penetration, the geomorphic processes vary within any climatic region. What is the sole driving force behind all the exogenic processes? Climatic factors being equal, the intensity of action of exogenic geomorphic processes depends upon type and structure of rocks.

The term structure includes such aspects of rocks as folds, faults, orientation and inclination of beds, presence or absence of joints, bedding planes, hardness or softness of constituent minerals, chemical susceptibility of mineral constituents; the permeability or impermeability etc. Different types of rocks with differences in their structure offer varying resistances to various geomorphic processes. A particular rock may be resistant to one process and nonresistant to another. And, under varying climatic conditions, particular rocks may exhibit different degrees of resistance to geomorphic processes and hence they operate at differential rates and give rise to differences in topography. The effects of most of the exogenic geomorphic processes are small and slow and may be imperceptible in a short time span, but will in the long run affect the rocks severely due to continued fatigue. Finally, it boils down to one fact that the differences on the surface of the earth though originally related to the crustal evolution continue to exist in some form or the other due to differences in the type and structure of earth materials, differences in geomorphic processes and in their rates of operation. Some of the exogenic geomorphic processes have been dealt in detail here.

WEATHERING

Weathering is action of elements of weather and climate over earth materials. There are a number of processes within weathering which act either individually or together to affect the earth materials in order to reduce them to fragmental state. Weathering is defined as mechanical disintegration and chemical decomposition of rocks through the actions of various elements of weather and climate. As very little or no motion of materials takes place in weathering, it is an *in-situ* or on-site process. Is this little motion which can occur sometimes due to weathering synonymous with transportation? If not, why? Weathering processes are conditioned by many complex geological, climatic, topographic and vegetative factors. Climate is of particular importance. Not only weathering processes differ from climate to climate, but also the depth of the weathering mantle

Activity

Mark the latitude values of different climatic regimes in 6.2 and compare the details. There are three major groups of weathering processes :

(i) chemical;
(ii) physical or mechanical;
(iii) biological weathering processes.

Very rarely does any one of these processes ever operate completely by itself, but quite often a dominance of one process can be seen.

CHEMICAL WEATHERING PROCESSES

A group of weathering processes viz; solution, carbonation, hydration, oxidation and reduction act on the rocks to decompose, dissolve or reduce them to a fine clastic state through chemical reactions by oxygen, surface and/or soil water and other acids. Water and air (oxygen and carbon dioxide) 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 quantity of carbon dioxide underground. These chemical reactions on various minerals are very much similar to the chemical reactions in a laboratory. *Solution* When something is dissolved in water or acids, the water or acid with dissolved contents is called *solution*. This process involves removal of solids in solution and depends upon solubility of a mineral in water or weak acids. On coming in contact with water many solids disintegrate and mix up as suspension in water. Soluble rock forming minerals like nitrates, sulphates, and potassium etc. are affected by this process. So, these minerals are easily leached out without leaving any residue in rainy climates and accumulate in dry regions. Minerals like calcium carbonate and calcium magnesium bicarbonate present in limestones are soluble in water containing carbonic acid (formed with the addition of carbon dioxide in water), and are carried away in water as solution. Carbon dioxide produced by decaying organic matter along with soil water greatly aids in this reaction. Common salt (sodium chloride) is also a rock forming mineral and is susceptible to this process of solution.

Carbonation

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

Hydration

Hydration is the chemical addition of water. Minerals take up water and expand; this expansion causes an increase in the volume of the material itself or rock. Calcium sulphate takes in water and turns to gypsum, which is more unstable than calcium sulphate. This process is reversible and long, continued repetition of this process causes fatigue in the rocks and may lead to their disintegration. Many clay minerals swell and contract during wetting and drying and a repetition of this process results in cracking of overlying materials. Salts in pore spaces undergo rapid and repeated hydration and help in rock fracturing. The volume changes in minerals due to hydration will also help in physical weathering through exfoliation and granular disintegration.

Oxidation and Reduction

In weathering, oxidation means a combination of a mineral with oxygen to form oxides or hydroxides. Oxidation occurs where there is ready access to the atmosphere and oxygenated waters. The minerals most commonly involved in this process are iron, manganese, sulphur etc. In the process of oxidation rock breakdown occurs due to the disturbance caused by addition of oxygen. Red colour of iron upon oxidation turns to brown or yellow. When oxidised minerals are placed in an environment where oxygen is absent, reduction takes place. Such conditions exist usually below the water table, in areas of stagnant water and waterlogged ground. Red colour of iron upon reduction turns to greenish or bluish grey. These weathering processes are interrelated. Hydration, carbonation and oxidation go hand in hand and hasten the weathering process.

PHYSICAL WEATHERING PROCESSES

Physical or mechanical weathering processes depend on some applied forces. The applied forces could be:

i. Gravitational forces such as overburden pressure, load and shearing stress;
ii. Expansion forces due to temperature changes, crystal growth or animal activity;
iii. Water pressures controlled by wetting and drying cycles. Many of these forces are applied both at the surface and within different earth materials leading to rock fracture. Most of the physical weathering processes are caused by thermal expansion and pressure release. These processes are small and slow but can cause great damage to the rocks because of continued fatigue the rocks suffer due to repetition of contraction and expansion.

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 roughly parallel to the ground surface. In areas of curved ground surface, arched fractures tend to produce massive sheets or exfoliation slabs of rock. Exfoliation sheets resulting from expansion due to unloading and pressure release may measure hundreds or even thousands of metres in horizontal extent. Large, smooth rounded domes called *exfoliation domes* result due to this process. temperatures, this internal movement among the mineral grains of the superficial layers of rocks takes place regularly. This process is most effective in dry climates and high elevations where diurnal temperature changes are drastic. As has been mentioned earlier though these movements are very small they make the rocks weak due to continued fatigue. The surface layers of the rocks tend to expand more than the rock at depth and this leads to the formation of stress within the rock resulting in heaving and fracturing parallel to the surface. Due to differential heating and resulting expansion and contraction of surface layers and their subsequent exfoliation from the surface results in smooth rounded surfaces in rocks. In rocks like granites, smooth surfaced and rounded small to big boulders called *tors* form due to such exfoliation. What is the difference between exfoliationdomes and exfoliated tors?

FREEZING, THAWING AND FROST WEDGING

Frost weathering occurs due to growth of ice within pores and cracks of rocks during repeated cycles of freezing and melting. This process is most effective at high elevations in mid-latitudes where freezing and melting is often repeated. Glacial areas are subject to frost wedging daily. In this process, the rate of freezing is important. Rapid freezing of water causes its sudden expansion and high pressure. The resulting expansion affects joints, cracks and small inter granular fractures to become wider and wider till the rock breaks apart. *Salt Weathering* Salts in rocks expand due to thermal action, hydration and crystallisation. Many salts like calcium, sodium, magnesium, potassium and barium have a tendency to expand. Expansion of these salts depends on temperature and their thermal properties. High temperature ranges between 30 and 50oC of surface temperatures in deserts favour such salt expansion. Salt crystals in near-surface pores *Temperature Changes and Expansion* Various minerals in rocks possess their own limits of expansion and contraction. With rise in temperature, every mineral expands and pushes against its neighbour and as temperature falls, a corresponding contraction takes place. Because of diurnal changes in the cause splitting of individual grains within rocks, which eventually fall off. This process of falling off of individual grains may result in granular disintegration or granular foliation.Salt crystallisation is 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 salt crystal growth, chalk breaks down most readily, followed by limestone, sandstone, shale, gneiss and granite etc.

BIOLOGICAL ACTIVITY AND WEATHERING

Biological weathering is contribution to or removal of minerals and ions from the weathering environment and physical changes due to growth or movement of organisms. Burrowing and wedging by organisms like earthworms, termites, rodents etc., help in exposing the new surfaces to chemical attack and assists in the penetration of moisture and air. Human beings by disturbing vegetation, ploughing and cultivating soils, also help in mixing and creating new contacts between air, water and minerals in the earth materials. Decaying plant and animal matter help in the production of humic, carbonic and other acids which enhance decay and solubility of some elements. Plant roots exert a tremendous pressure on the earth materials mechanically breaking them apart.

SPECIAL EFFECTS OF WEATHERING

Exfoliation

This has already been explained under physical weathering processes of unloading, thermal contraction and expansion and salt weathering. Exfoliation is a result but not a process. Flaking off of more or less curved sheets of shells from over rocks or bedrock results in smooth and rounded surfaces Exfoliation can occur due to expansion and contraction induced by temperature changes. Exfoliation domes and tors result due to unloading and thermal expansion respectively.

SIGNIFICANCE OF WEATHERING

Weathering processes are responsible for breaking down the rocks into smaller fragments and preparing the way for formation of not only regolith and soils, but also erosion and mass movements. Biomes and biodiversity is basically a result of forests (vegetation) and forests depend upon the depth of weathering mantles. Erosion cannot be significant if the rocks are not weathered. That means, weathering aids mass wasting, erosion and reduction of relief and changes in landforms are a consequence of erosion. Weathering of rocks and deposits helps in the enrichment and concentrations of certain valuable ores of iron, manganese, aluminium, copper etc., which are of great importance for the national economy. Weathering is an important process in the formation of soils. When rocks undergo weathering, some materials are removed through chemical or physical leaching by groundwater and thereby the concentration of remaining (valuable) 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. the three forms of movements. The relationships among different types of mass movements, their relative rates of movement and moisture limits.

MASS MOVEMENTS

These movements transfer the mass of rock debris down the slopes under the direct influence of gravity. That means, air, water or ice do not carry debris with them from place to place but on the other hand the debris may carry with it air, water or ice. The movements of mass may range from slow to rapid, affecting shallow to deep columns of materials and include creep, flow, slide and fall. Gravity exerts its force on all matter, both bedrock and the products of weathering. So, weathering is not a pre-requisite for mass movement though it aids mass movements. Mass movements are very active over weathered slopes rather than over unweathered materials. Mass movements are aided by gravity and no geomorphic agent like running water, glaciers, wind, waves and currents participate in the process of mass movements. That means mass movements do not come under erosion though there is a shift (aided by gravity) of materials from one place to another. Materials over the slopes have their own resistance to disturbing forces and will yield only when force is greater than the shearing resistance of the materials. Weak unconsolidated materials, thinly bedded rocks, faults, steeply dipping beds, vertical cliffs or steep slopes, abundant precipitation and torrential rains and scarcity of vegetation etc., favour mass movements. Several activating causes precede mass movements. They are :

a. removal of support from below to materials above through natural or artificial means;
b. increase in gradient and height of slopes;
c. overloading through addition of materials naturally or by artificial filling;
d. overloading due to heavy rainfall, saturation and lubrication of slope materials;
e. removal of material or load from over the original slope surfaces;
f. occurrence of earthquakes, explosions or machinery;
g. excessive natural seepage;
h. heavy drawdown of water from lakes, reservoirs and rivers leading to slow outflow of water from under the slopes or river banks;
i. indiscriminate removal of natural vegetation. *Heave* (heaving up of soils due to frost growth and other causes), *flow* and *slide* are Mass movements can be grouped under two major classes:

(i) slow movements; (ii) rapid movements.

SLOW MOVEMENTS

Creep is one type under this category which can occur on moderately steep, soil covered slopes. Movement of materials is extremely slow and imperceptible except through extended observation. Materials involved can be soil or rock debris. Have you ever seen fence posts, telephone poles lean down slope from their vertical position and in their linear alignment? If you have, that is due to the creep effect. Depending upon the type of material involved, several types of creep viz., soil creep, talus creep, rock creep, rock-glacier creep etc., can be identified. Also included in this group is *solifluction* which involves slow downslope flowing soil mass or fine grained rock debris saturated or lubricated with water. This process is quite common in moist temperate areas where surface melting of deeply frozen ground and long continued rain respectively, occur frequently. When the upper portions get saturated and when the lower parts are impervious to water percolation, flowing occurs in the upper parts.

RAPID MOVEMENTS

These movements are mostly prevalent in humid climatic regions and occur over gentle to steep slopes. Movement of water-saturated clayey or silty earth materials down low-angle terraces or hillsides is known as *earthflow*. Quite often, the materials slump making steplike terraces and leaving arcuate scarps at their heads and an accumulation bulge at the toe. When slopes are steeper, even the bedrock especially of soft sedimentary rocks like shale or deeply weathered igneous rock may slide downslope. Another type in this category is *mudflow*. 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 stream of mud within a valley. When the mudflows emerge out of channels onto the piedmont or plains, they can be very destructive engulfing roads, bridges and houses. Mudflows occur frequently on the slopes of erupting or recently erupted volcanoes. Volcanic ash, dust and other fragments turn into mud due to heavy rains and flow down as tongues or streams of mud causing great destruction to human habitations. A third type is the debris *avalanche*, which is more characteristic of humid regions with or without vegetation cover and occurs in narrow tracks on steep slopes. This debris avalanche can be much faster than the mudflow. Debris avalanche is similar to snow avalanche.

LANDSLIDES

These are known as relatively rapid and perceptible movements. The materials involved are relatively dry. The size and shape of the detached mass depends on the nature of discontinuities in the rock, the degree of weathering and the steepness of the slope. Depending upon the type of movement of materials several types are identified in this category. *Slump* is slipping of one or several units of rock debris with a backward rotation with respect to the slope over which the movement takes place . Rapid rolling or sliding of earth debris without backward rotation of mass is known as *debris slide*. Debris fall is nearly a free fall of earth debris from a vertical or overhanging face. Sliding of individual rock masses down bedding, joint or fault surfaces is *rockslide*. Over steep slopes, rock sliding is very fast and destructive. Slides occur as planar failures along discontinuities like bedding planes that dip steeply. Rock fall is free falling of rock blocks over any steep slope keeping itself away from the slope. Rock falls occur from the superficial layers of the rock face, an occurrence that distinguishes it from rockslide which affects materials up to a substantial depth.

EROSION AND DEPOSITION

Erosion involves acquisition and transportation of rock debris. When massive rocks break into smaller fragments through weathering and any other process, erosional geomorphic agents like running water, groundwater, glaciers, wind and waves remove and transport it to other places depending upon the dynamics of each of these agents. Abrasion by rock debris carried by these geomorphic agents also aids greatly in erosion. By erosion, relief degrades, i.e., the landscape is worn down. That means, though weathering aids erosion it is not a pre-condition for erosion to take place. Weathering, mass-wasting and erosion are degradational processes.

It is erosion that is largely responsible for continuous changes that the earth's surface is undergoing. Denudational processes like erosion and transportation are controlled by kinetic energy. The erosion and transportation of earth materials is brought about by wind, running water, glaciers, waves and ground water. Of these the first three agents are controlled by climatic conditions.They represent three states of matter — gaseous (wind), liquid (running water) and solid (glacier) respectively. The erosion can be defined as "application of the kinetic energy associated with the agent to the surface of the land along which it moves". Kinetic energy is computed as KE = 1/2 mv2 where 'm' is the mass and 'v' is the velocity. Hence the energy available to perform work will depend on the mass of the material and the velocity with which it is moving. Obviously then you will find that though the glaciers move at very low velocities due to tremendous mass are more effective as the agents of erosion and wind, being in gaseous state, is less effective. The work of the other two agents of erosionwaves and ground water is not controlled by climate. In case of waves it is the location along the interface of litho and hydro sphere — coastal region — that will determine the work of waves, whereas the work of ground water is determined more by the lithological character of the region. If the rocks are permeable and soluble and water is available only then karst topography develops. In the next we shall be dealing with the landforms produced by each of these agents of erosion. Deposition is a consequence of erosion. The erosional agents loose their velocity and hence energy on gentler slopes and the materials carried by them start to settle themselves. In other words, deposition is not actually the work of any agent. The coarser materials get deposited first and finer ones later. By deposition depressions get filled up. The same erosional agents viz., running water, glaciers, wind, waves and groundwater act as aggradational or depositional agents also. There is a shift of materials in mass movements as well as in erosion from one place to the other.

SOIL FORMATION

Soil and Soil Contents

A pedologist who studies soils defines soil as a collection of natural bodies on the earth's surface containing living matter and supporting or capable of supporting plants. Soil is a dynamic medium in which many chemical, physical and biological activities go on constantly. Soil is a result of decay, it is also the medium for growth. It is a changing and developing body. It has many characteristics that fluctuate with the seasons. It may be alternatively cold and warm or dry and moist. Biological activity is slowed or stopped if the soil becomes too cold or too dry. Organic matter increases when leaves fall or grasses die. The soil chemistry, the amount of organic matter, the soil flora and fauna, the temperature and the moisture, all change with the seasons as well as with more extended periods of time. That means, soil becomes adjusted to conditions of climate, landform and vegetation and will change internally when these controlling conditions change.

PROCESS OF SOIL FORMATION

Soil formation or pedogenesis depends first onweathering. It is this weathering mantle (depth of the weathered material) which is the basic input for soil to form. First, the weathered material or transported deposits are colonized by bacteria and other inferior plant bodies like mosses and lichens. Also, several minor organisms may take shelter within the mantle and deposits. The dead remains of organisms and plants help in humus accumulation. Minor grasses and ferns may grow; later, bushes and trees will start growing through seeds brought in by birds and wind. Plant roots penetrate down, burrowing animals bring up particles, mass of material becomes porous and spongelike with a capacity to retain water and to permit the passage of air and finally a mature soil, a complex mixture of mineral and organic products forms. Pedology is soil science. A pedologist is a soil-scientist.

SOIL-FORMING FACTORS

Five basic factors control the formation of soils:
(i) parent material; (ii) topography; (iii) climate;
(iv) biological activity; (v) time.
In fact soil forming factors act in union and affect the action of one another.

Parent Material

Parent material is a passive control factor in soil formation. Parent materials can be any *insitu* or on-site weathered rock debris (residual soils) or transported deposits (transported soils). Soil formation depends upon the texture (sizes of debris) and structure (disposition of individual grains/particles of debris) as well as the mineral and chemical composition of the rock debris/deposits. Nature and rate of weathering and depth of weathering mantle are important considerations under parent materials. There may be differences in soil over similar bedrock and dissimilar bedrocks may have similar soils above them. But when soils are very young and have not matured these show strong links with the type of parent rock. Also, in case of some limestone areas, where the weathering processes are specific and peculiar, soils will show clear relation with the parent rock.

Topography

Topography like parent materials is another passive control factor. The influence of topography is felt through the amount of exposure of a surface covered by parent materials to sunlight and the amount of surface and sub-surface drainage over and through the parent materials. Soils will be thin on steep slopes and thick over flat upland areas. Over gentle slopes where erosion is slow and percolation of water is good, soil formation is very favourable. Soils over flat areas may develop a thick layer of clay with good accumulation of organic matter giving the soil dark colour. In middle latitudes, the south facing slopes exposed to sunlight have different conditions of vegetation and soils and the north facing slopes with cool, moist conditions have some other soils and vegetation.

Climate

Climate is an important active factor in soil formation. The climatic elements involved in soil development are :

1. Moisture in terms of its intensity, frequency and duration of precipitation - evaporation and humidity;
2. Temperature in terms of seasonal and diurnal variations. Precipitation gives soil its moisture content which makes the chemical and biological activities possible. Excess of water helps in the downward transportation of soil components through the soil (eluviation) and deposits the same down below (illuviation). In climates like wet equatorial rainy areas with high rainfall, not only calcium, sodium, magnesium, potassium etc. but also a major part of silica is removed from the soil. Removal of silica from the soil is known as *desilication*. In dry climates, because of high temperature, evaporation exceeds precipitation and hence ground water is brought up to the surface by capillary action and in the process the water evaporates leaving behind salts in the soil. Such salts form into a crust in the soil known as hardpans. In tropical climates and in areas with intermediate precipitation conditions, calcium carbonate nodules (*kanker*) are formed. Temperature acts in two ways — increasing or reducing chemical and biological activity. Chemical activity is increased in higher temperatures, reduced in cooler temperatures (with an exception of carbonation) and stops in freezing conditions. That is why, tropical soils with higher temperatures show deeper profiles and in the frozen tundra regions soils contain largely mechanically broken materials.

Biological Activity

The vegetative cover and organisms that occupy the parent materials from the beginning and also at later stages help in adding organic matter,moisture retention, nitrogen etc. Dead plants provide humus, the finely divided organic matter of the soil. Some organic acids which form during humification aid in decomposing the minerals of the soil parent materials. Intensity of bacterial activity shows up differences between soils of cold and warm climates. Humus accumulates in cold climates as bacterial growth is slow. With undecomposed organic matter because of low bacterial activity, layers of peat develop in sub-arctic and tundra climates. In humid tropical and equatorial climates, bacterial growth and action is intense and dead vegetation is rapidly oxidised leaving very low humus content in the soil. Further, bacteria and other soil organisms take gaseous nitrogen from the air and convert it into a chemical form that can be used by plants. This process is known as nitrogen fixation. Rhizobium, a type of bacteria, lives in the root nodules of leguminous plants and fixes nitrogen beneficial to the host plant. The influence of large animals like ants, termites, earthworms, rodents etc., is mechanical, but, it is nevertheless important in soil formation as they rework the soil up and down. In case of earthworms, as they feed on soil, the texture and chemistry of the soil that comes out of their body changes.

Time

Time is the third important controlling factor in soil formation. The length of time the soil forming processes operate, determines maturation of soils and profile development. A soil becomes mature when all soil-forming processes act for a sufficiently long time developing a profile. Soils developing from recently deposited alluvium or glacial till are considered young and they exhibit no horizons or only poorly developed horizons. No specific length of time in absolute terms can be fixed for soils to develop and mature. Is it necessary to separate the process of soil formation and the soil forming control factors? Why are time, topography and parent material considered as passive control factors in soil formation?

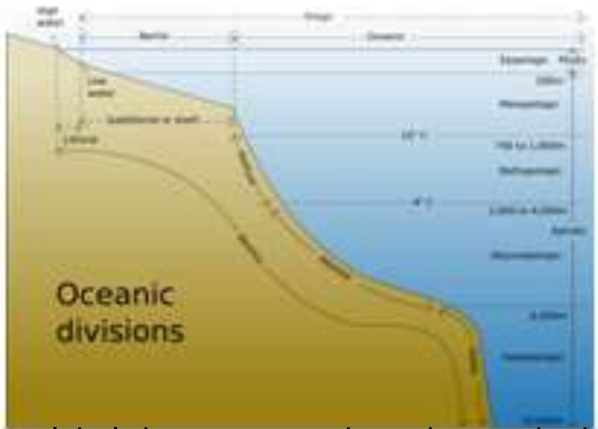
OCEANS

Fact box

About 71 percent of the surface of the earth is covered by water.

- Hydrosphere is that realm of the earth that holds all the water resources.
- he bottom of the ocean comprises of continental shelf continental slope, abyssal plains, submarine trenches and submarine ridges.Oceans are connected together and it can be called as the World Ocean.
- The surface temperature of the sea water is not the same everywhere.
- Waves result from the undulating movements of sea water.
- Tides are the phenomena of rise and fall of the sea surface due to the gravitational effects produced by the moon and the sun.
- Ocean current is the uninterrupted movement of sea water in a fairly defined direction.
- On the basis of temperature, ocean currents are classified into warm currents and cold currents.
- In the Pacific Ocean the two equatorical currents, Kuroshio, North Pacific, British Columbia, East Australian and Equatorial Counter Currents are warm currents and Oyashio, California, Peru and West Wind Drift are cold currents.

Division of ocean depths



- The World Ocean is a global, interconnected continuous body of saline water. **Approximately 71% of the earth's surface is covered by the ocean**
- For human convenience, the ocean has been divided into several smaller divisions known as oceans and seas
- There are five major divisions of the world ocean: Pacific Ocean, Atlantic Ocean, Indian Ocean, Arctic Ocean and Southern Ocean
- Evaporation of water from the oceans is the source of most rainfall, and ocean temperatures determine climate and wind patterns on land
- **Life within the ocean evolved about 3 billion years prior to life on land.** More than 230,000 marine life forms are currently known, but the actual number may be 10 times as much

Physical properties

- The total area of world ocean is 361 x 10^6 sq km, and volume is approx 1.3 billion cu km
- **The average depth of the ocean is 3790 m and maximum depth is 10,923 m**
- The average density of sea water is 1.025 g/ml and has a freezing point of -2 C
- Sea water contains more dissolved ions than all types of freshwater, especially sodium and chloride. On average, **sea water has a salinity of 3.5 %.**
- **The causes of high salinity of sea water include**
  - River runoff causing concentration of sodium in the ocean
  - Sodium leaching out of the ocean floor when the ocean was formed
  - Chloride abundance due to volcanic activity and hydrothermal vents on the ocean floor
- Ocean salinity has been stable for billions of years

SEA LEVEL

- **Mean Sea Level (MSL) is a measure of the average height of the ocean's surface**
- Mean Sea level is usually taken to be the half way point between mean high tide and mean low tide
- Sea level change can be measured in two ways
  - **Local change:** local mean sea level can be affected by vertical movement of land, and changes in atmospheric pressure, ocean currents and local ocean temperature
  - **Eustatic change:** is the alteration of global sea levels, such as changes in volume of water in the world oceans and changes in volume of ocean basins
- **Short term changes** in sea level can arise from tides, atmospheric pressure, storm surges, El Nino etc
- **Medium term changes** in sea level arise mainly from two factors: atmospheric temperature and the mass of water locked up as fresh water in rivers, lakes, glaciers, ice caps etc
- **Geological changes** in sea levels mainly arise from changes in the configuration of continents and sea floors due to plate tectonics and seafloor spreading
- On a geological time scale, **long term sea level has always been higher than today** (except at the Permian-Triassic boundary 250 million years ago). As a result, sea level is more likely to rise than fall today, even due to small changes in climate
- **Over the past 100 years, sea level has been rising at an average of 1.8 mm per year.** The majority of this rise is attributed to thermal expansion of ocean water due to increase in ocean temperatures

Ocean currents

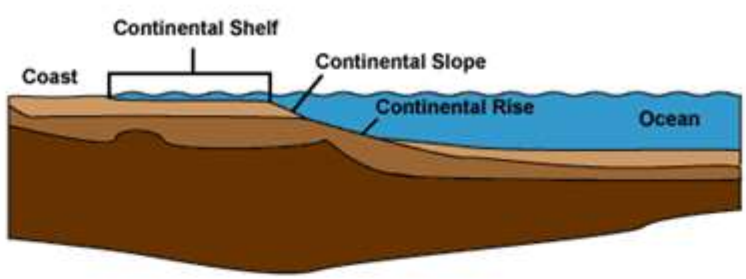
- **Ocean current is a continuous directed movement of ocean water generated by wind, Coriolis force, temperature and salinity gradients, and tides**

  Major ocean currents of the world

- **Ocean currents greatly affect earth's climate by transferring heat from the tropics to polar regions, and transferring precipitation to coastal regions**
- The most famous example of ocean currents is the Gulf Stream, which makes northwest Europe much more temperate than any other region at that latitude
- **Surface ocean currents are generally driven by wind,** and circulate in clockwise direction in the northern hemisphere and anticlockwise in the southern hemisphere (due to prevailing winds). Surface currents make up about 10% of all ocean currents
- **Deep ocean currents, called thermohaline circulation, are driven by water density and temperature gradients.** Also known as the world's conveyor belts, these deep ocean currents supply heat to polar regions and thereby regulate sea ice formation. Deep ocean currents make up about 90% of all ocean currents
- **Ocean currents are measured in Sverdrup (Sv),** with 1 Sv being equivalent to a flow rate of 1 million cu. m per second

Oceanic basins

- Oceanic basins are large geologic basins (large scale rock strata) that are below sea level
- In a sense, oceanic basins are the complement to continents
- Ocean basins serve as sedimentary basins that collect sediments eroded from continents
- Ocean basins can be actively changing or inactive depending on plate tectonics. The Atlantic and Antarctic Ocean basins are actively growing while the Mediterranean is shrinking. Inactive ocean basins include the Gulf of Mexico, the Sea of Japan and the Bering Sea



Schematic of a continental shelf

- **The continental shelf is the extended perimeter of a continent which is currently under sea**
- Continental shelves were part of the continents during glacial periods (when sea levels were low) but are under sea during interglacial periods (like today)
- The continental shelf usually ends at a point of decreasing slope, called the **shelf break**. The sea floor below the shelf break is called the **continental slope**. Below the slope is the **continental rise**, which merges into the deep ocean floor (called **abyssal plain**)
- **Due to the availability of sunlight in shallow waters, continental shelves teem with life**, compared to the biotic deserts in the deep ocean abyssal plains
- Continental shelves consist of thick sediments from the continents
- **Continental shelves extend on average about 80 km from the coast.** The largest shelf, the Siberian Shelf in the Arctic Ocean, stretches to about 1500 km, while certain areas have no shelves at all such as the coast of Chile and the west coast of Sumatra (Indonesia)
- **The United Nations Convention on the Law of the Sea (UNCLOS) defines the extent and regulates usage of continental shelves by sovereign nations**
  - The continental shelf was defined as **the natural prolongation of land to the continental margin's outer edge, or 200 nautical miles from the coast**, whichever is greater.
  - However, the shelf is to not exceed 350 nautical miles, and it is to not exceed 100 nautical miles beyond the 2500m isobath
  - **The coastal nations have the exclusive right to harvest mineral and non-living material in the subsoil of the continental shelf**
  - Coastal states also have exclusive rights to living resources "attached" to the shelf, but not to creatures living there freely

Mid Ocean Ridges

- A mid ocean ridge is an underwater mountain range formed by plate tectonics
- Mid ocean ridges are caused by seafloor spreading i.e. magma rising through the crust and emerging as lava which then cools to form new oceanic crust
- A mid ocean ridge demarcates the boundary between two tectonic plates, and is called a divergent plate boundary
- The various mid-ocean ridges of the world are connected and form a single global mid ocean ridge system which covers every ocean. Thus, **the mid ocean ridge system is the longest mountain range in the world** (over 65,000 km)
- **Mid ocean ridges are geologically active, with new magma constantly emerging onto the ocean floor**

OCEAN TRENCHES

- Ocean trenches are large scale long but narrow depressions on the sea floor. **They are the deepest parts of the ocean floor**
- Trenches are found at convergent plate boundaries, where one plate subducts (descends) beneath another. On average, oceanic crust moves into trenches at a rate of about 0.1 sq m per second
- They are usually located parallel to volcanic arcs at a distance of about 200 km
- Ocean trenches typically extend about 3-4 km below the level of the surrounding sea floor
- **The deepest ocean depth known is the Challenger Deep point of the Mariana Trench in the Pacific Ocean (10,911 m)**

Trench	Location	Depth	Notes
Mariana Trench	Western Pacific Ocean (near Philippines and Japan)	10,911 m	Deepest known part of the ocean Lowest elevation on the surface of the earth's crust Maximum depth is recorded at Challenger Deep, a small valley at its southern end Formed by the subduction of Pacific plate under Mariana plate
Tonga Trench	Southern Pacific (near New Zealand)	10,882 m	Formed by subduction of Pacific plate under Tonga plate and Indo-Australian plate Fastest plate velocity recorded on earth (24 cm per year)
Kuril-Kamchatka Trench	Northern Pacific	10,542 m	
Philippine Trench	Philippines (Pacific Ocean)	10,540 m	
Kermadec Trench	New Zealand (Pacific Ocean)	10,047 m	

EXTRATERRESTRIAL OCEANS

- The earth is the only known planet to have liquid water on its surface
- However, **liquid water is known to be present under the surface on Jupiter's moons Europa**, and possibly on Ganymede and Callisto
- It is believed that Venus once had liquid water and oceans on its surface, but they have now vanished
- **Saturn's moon Titan is thought to have subterranean water ocean under its crust** (which consists of ice and hydrocarbons)

Corals are nocturnal feeders. Here, in the dark, the coral polyps extend their tentacles to feed on zooplankton

- **Coral reefs are aragonite structures formed by living animal colonies.** Aragonite is a carbonate mineral, one of the two major naturally occurring crystalline forms of calcium carbonate (the other being calcite)

- Reefs consist mostly of stony corals. These corals are built from polyps that secrete an exoskeleton of calcium carbonate
- Coral reefs grow best in shallow, clear, sunny waters. They are usually found in shallow depths in the tropics, but deep cold water reefs also exist although on a much smaller scale
- **Coral reefs are some of the richest and most diverse ecosystems in the world.** They occupy less than 1% of world ocean surface, but provide habitat to about 25% of all marine species
- Reefs are found in ocean waters containing few nutrients. High nutrient levels, such as found in agricultural runoff, can harm reefs by encouraging excess algae growth
- Coral reefs are under threat from climate change, ocean acidification, overfishing and overuse of reef resources

Coral reef	Location	Notes
Great Barrier Reef	Queensland, Australia (northeast Australia)	Largest coral reef system in the world World's biggest structure made by living organisms Area of approx 344,000 sq km
Belize Barrier Reef	Belize	Second largest coral reef in the world Part of the Mesoamerican Barrier Reef that stretches along eastern coast of Central America from Mexico to Honduras
New Caledonia Barrier Reef	New Caledonia (southwest Pacific)	French territory in southwest Pacific Home to endangered dugong, and nesting site for green sea turtle
Andros (Bahamas) Barrier Reef	Bahamas (Caribbean)	
Red Sea Coral Reef	Red Sea	
Pulley Ridge	Florida, USA (southeast USA)	Deepest photosynthetic coral reef in the world (about 60-80 m)
Maldives	Indian ocean	Consists of about 1200 coral islands
Raja Ampat Islands	Indonesia	Contains the highest marine life diversity in the world

Deep sea and trenches

- As the ocean depth increases, sunlight decreases and water pressure increases.
- In general, sunlight is not able to penetrate the ocean water beyond a **depth of 200 m. This depth is considered to be the beginning of aphotic zone** (deep sea). Unusual and unique creatures inhabit these depths including giant squid, gluper eel, angler fish and vampire squid

- **In the trenches, water pressure is extreme and sunlight is non existent.** However, small flounder fish (family Soleidae) and shrimp have been observed even at these depths
- Seamounts (extinct undersea volcanoes that rise to shallow depths) provide natural habitats for fish and other species to spawn and feed
- **Hydrothermal vents on the ocean floor support unique life forms,** deriving essential nutrients from the chemicals released by volcanic activity

OPEN OCEAN

- The open ocean is relatively unproductive due to lack of nutrients. However, simply due to its vastness, it possesses the largest number of life forms in total
- **In the aphotic zone, energy for life forms is mainly supplied in the form of detritus**, which is non living organic material consisting of dead organisms and fecal material
- The open ocean consists mainly of jelly fish and its predators like the mola mola

BAY AND GULF

Bay is a wide segment of an ocean extending into land. Gulf is a narrow portion of an ocean extending into land.

INTERTIDAL AND SHORES

- Intertidal zones are those areas close to the shore, which are constantly being covered and exposed by the tides
- These areas can be underwater anywhere from daily to very infrequently
- A huge array of life forms is found in this zone. This includes crabs, snails etc

THE SALT PANS OF INDIA

On the eastern and western coasts of India common salt is manufactured by solar evaporation of sea water. Sea water is collected in flat, enclosed fields and kept exposed to the sun. As the amount of water drains gradually through solar evaporation common salt gets separated from this brine. Places where common salt is produced in this way are called salt pans. There are vast salt pans in the Kachchh region of Gujarat and the Rameswaram area of Tamil Nadu.

WATER (OCEANS)

The hydrological cycle describes the movement of water on, in, and above the earth. The water cycle has been working for billions of years and all the life on earth depends on it. Next to air, water is the most important element required for the existence of life on earth. The distribution of water on earth is quite uneven. Many locations have plenty of water while others have very limited quantity. 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. Water It is said that the water is life. Water is an essential component of all life forms that exist over the surface of the earth. The creatures on the earth are lucky that it is a water planet, otherwise we all would have no existence. Water is a rare commodity in our solar system. There is no water on the sun or anywhere else in the solar system. The earth, fortunately has an abundant supply of water on its surface. Hence, our planet is called the *'Blue Planet'.*

HYDROLOGICAL CYCLE

Water is a cyclic resource. It can be used and re-used. Water also undergoes a cycle from atmosphere, landsurface and subsurface and the organisms. 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.

RELIEF OF THE OCEAN FLOOR

The oceans are confined to the great depressions of the earth's outer layer. In this section, we shall see the nature of the ocean basins of the earth and their topography. The oceans, unlike the continents, merge so naturally into one another that it is hard to demarcate them. The geographers have divided the oceanic part of the earth into four oceans, namely the Pacific, the Atlantic, the Indian and the Arctic. The various seas, bays, gulfs and other inlets are parts of these four large oceans. A major portion of the ocean floor is found between 3-6 km below the sea level. The 'land' under the waters of the oceans, that is, the ocean floor exhibits complex and varied features as those observed over the land .The floors of the oceans are rugged with the world's largest mountain ranges, deepest trenches and the largest plains. These features are formed, like those of the continents, by the factors of tectonic, volcanic and depositional processes.

DIVISIONS OF THE OCEAN FLOORS

The ocean floors can be divided into four major divisions:
(i) the Continental Shelf; (ii) the Continental Slope;
(iii) the Deep Sea Plain; (iv) 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

The continental shelf is the extended margin of each continent occupied by relatively shallow seas and gulfs. It is the shallowest part of the ocean showing an average gradient of 1° or even less. The shelf typically ends at a very steep slope, called the shelf break. The width of the continental shelves varies from one ocean to another. The average width

Reservoir Volume Percentage

(Million of the Total Cubic km)

Oceans	1,370	97.25
Ice Caps	29 2.05 and Glaciers	
Groundwate r	9.5	0.68
Lakes 0.125	0.01	
Soil Moisture	0.065	0.005
Atmosphere	0.013	0.001
Streams 0.0017	0.0001 and Rivers	
Biosphere	0.0006	0.00004

Components Processes Water storage Evaporation in oceans Evapo transpiration Sublimation Water in the Condensation atmosphere Precipitation Water storage in Snowmelt runoff ice and snow to streams Surface runoff Stream flow freshwater storage infiltration Groundwater storage Groundwater discharge springs of continental shelves is about 80 km. The shelves are almost absent or very narrow along some of the margins like the coasts of Chile, the west coast of Sumatra, etc. On the contrary, the Siberian shelf in the Arctic Ocean, the largest in the world, stretches to 1,500 km in width. 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. 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. Massive sedimentary deposits received over a long time by the continental shelves, become the source of fossil fuels.

Continental Slope

The continental slope connects the continental shelf and the ocean basins. It begins where the bottom of the continental shelf sharply drops off into a steep slope. The gradient of the slope region varies between 2-5°. The depth of the slope region varies between 200 and 3,000 m. The slope boundary indicates the end of the continents. Canyons and trenches are observed in this region.

Deep Sea Plain

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

Oceanic Deeps or Trenches

These areas are the deepest parts of the oceans. The trenches are relatively steep sided, narrow basins. They are some 3-5 km deeper than the surrounding ocean floor. They occur at the bases of continental slopes and along island arcs and are associated with active volcanoes and strong earthquakes. That is why they are very significant in the study of plate movements. 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.

MINOR RELIEF FEATURES

Apart from the above mentioned major relief features of the ocean floor, some minor but significant features predominate in different parts of the oceans. *Mid-Oceanic Ridges* A mid-oceanic ridge is composed of two chains of mountains separated by a large depression. The mountain ranges can have peaks as high as 2,500 m and some even reach above the ocean’s surface. Iceland, a part of the mid- atlantic ridge.

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.

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

This section deals with the spatial and vertical variations of temperature in various oceans. 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

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 isolation decreases poleward.
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. All these factors influence the temperature of the ocean currents locally. The enclosed seas in the low latitudes record relatively higher temperature than the open seas; whereas the enclosed seas in the high latitudes have lower temperature than the open seas.

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 The *third layer* is very cold and extends upto the deep ocean floor. In the Arctic and Antartic 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. The average temperature of surface water of the oceans is about 27°C and it gradually decreases from the equator towards the poles. The rate of decrease of temperature with increasing latitude is generally 0.5°C per latitude. The average temperature is around 22°C at 20° latitudes, 14° C at 40° latitudes and 0° C near poles. The oceans in the northern hemisphere record relatively higher temperature than in the southern hemisphere.

The highest temperature is not recorded at the equator but slightly towards north of it. The average annual temperatures for the northern and southern hemisphere are around 19° C and 16° C respectively. This variation is due to the unequal distribution of land and water in the northern and southern hemispheres It is a well known fact that the maximum temperature of the oceans is always at their surfaces because they directly receive the heat from the sun and the heat is transmitted to the lower sections of the oceans through the process of convection. It results into decrease of temperature with the increasing depth, but the rate of decrease is not uniform throughout. The temperature falls very rapidly up to the depth of 200 m and thereafter, the rate of decrease of temperature is slowed down.

SALINITY OF OCEAN WATERS

All waters in nature, whether rain water or ocean water, contain dissolved mineral salts. 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/oo) or ppt. Salinity is an important property of sea water. Salinity of 24.7 o/oo has been considered as the upper limit to demarcate 'brackish water'. Factors affecting ocean salinity are mentioned below:

a. The salinity of water in the surface layer of oceans depend mainly on evaporation and precipitation.
b. 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.
c. Wind, also influences salinity of an area by transferring water to other areas.

d. 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.

13.3 : Thermocline

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.

Red Sea, it is as high as 41o/oo, 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/oo. The salinity variation in the Pacific Ocean is mainly due to its shape and larger areal extent. Salinity decreases from 35 o/oo - 31 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 o/oo .

The average salinity of the Atlantic Ocean is around 36 o/oo. 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 Sea

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				

Highest salinity in water bodies Lake Van in Turkey (330 o/oo), Dead Sea (238 o/oo), Great Salt Lake (220 o/oo)

HORIZONTAL DISTRIBUTION OF SALINITY

The salinity for normal open ocean ranges between 33o/oo and 37 o/oo. In the land locked records higher salinity due to high evaporation. Salinity is, however, very low in Black Sea due to enormous fresh water influx by rivers. See the atlas to find out the rivers joining Black Sea. The average salinity of the Indian Ocean is 35 o/oo. The low salinity trend is observed in the Bay of Bengal due to influx of river water. On the contrary, the Arabian Sea shows higher salinity due to high evaporation and low influx of fresh water.

Vertical Distribution of Salinity

Salinity changes with depth, but the way it changes depends upon the location of the sea. 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. Salinity at depth is very much fixed, because there is no way that water is 'lost', or the salt is 'added.' There is a marked difference in the salinity between the surface zones and the deep zones of the oceans. The lower salinity water rests above the higher salinity dense water. 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 seawater causes its density to increase. High salinity seawater, generally, sinks below the lower salinity water. This leads to stratification by salinity.

MOVEMENTS OF OCEAN WATER

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. The motion of the surface water seldom affects the stagnant deep bottom water of the oceans. As a wave approaches the beach, it slows down.

This is due to the friction occurring between the dynamic water and the sea floor. And, when the depth of water is less than half the wavelength of the wave, the wave breaks. The largest waves are found in the open oceans. Waves continue to grow larger as they move and absorb energy from the wind. Most of the waves are caused by the wind driving against water. When a breeze of two knots or less blows over calm water, small ripples form and grow as the wind speed increases until white caps appear in the breaking waves. Waves may travel thousands of km before rolling ashore, breaking and dissolving as surf. A wave's size and shape reveal its origin. Steep waves are fairly young ones and are probably formed by local wind. Slow and steady waves originate from far away places, possibly from another hemisphere. The maximum wave height is determined by the strength of the wind, i.e. how long it blows and the area over which it blows in a single direction. Waves travel because wind pushes the water body in its course while gravity pulls the crests of the waves downward. The falling water pushes the former troughs upward, and the wave moves to a new position. The actual motion of the water beneath the waves is circular. It indicates that things are carried up and forward as the wave approaches, and down and back as it passes.

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 study of tides is very complex, spatially and temporally, as it has great variations in frequency, magnitude and height. The moon's gravitational pull to a great extent and to a lesser extent the sun's gravitational pull, are the major causes for the occurrence of tides. Another factor is centrifugal force, which is the force that acts to counter balance the gravity. Together, the gravitational pull and the centrifugal force are responsible for creating the two major tidal bulges on the earth. On the side of the earth facing the moon, a tidal bulge occurs while on the opposite side though the gravitational attraction of the moon is less as it is farther away, the centrifugal force causes tidal bulge on the other side .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, nearest the oon, pull or the attractive force of the moon is greater than the centrifugal force, and so there is a net force causing a bulge towards the moon. On the opposite side of the earth, the attractive force is less, as it is farther away from the moon, the centrifugal force is dominant. Hence, there is a net force away from the moon. It creates the second bulge away from the moon. 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 harbours 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 Sunderbansof 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:

a. Primary forces that initiate the movement of water;
b. Secondary forces that influence the currents to flow. The primary forces that influence thecurrents 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. Differences in water density affect vertical mobility of ocean currents. Water with high salinity is denser than water with low salinity and in the same way cold water is denser than warm water. Denser water tends to sink, while relatively lighter water tends to rise. Cold-water ocean currents occur when the cold water at the poles sinks and slowly moves towards the equator. Warm-water currents travel out from the equator along the surface, flowing towards the poles to replace the sinking cold water.

Types of Ocean Currents

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

1. *surface currents* constitute about 10 per cent of all the water in the ocean, these waters are the upper 400 m of the ocean;
2. *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:
3. *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;
4. *warm currents* bring warm water into cold water areas and are usually observed on the east coast of continents in the low and middle latitudes (true in both hemispheres). In the northern hemisphere they are found on the west coasts of continents in high latitudes. *Major Ocean Currents* Major ocean currents are greatly influenced by the stresses exerted by the prevailing winds and coriolis force. The oceanic circulation pattern roughly corresponds to the earth's atmospheric circulation pattern. The air circulation over the oceans in the middle latitudes is mainly anticyclonic (more pronounced in the southern hemisphere than in the northern hemisphere). The oceanic circulation pattern also corresponds with the same. At higher latitudes,

CHARACTERISTICS OF OCEAN CURRENTS

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

where the wind flow is mostly cyclonic, the oceanic circulation follows this pattern. In regions of pronounced monsoonal flow, the monsoon winds influence the current movements. Due to the coriolis force, the warm currents from low latitudes tend to move to the right in the northern hemisphere and to their left in the southern hemisphere. The oceanic circulation transports heat from one latitude belt to another in a manner similar to the heat transported by the general circulation of the atmosphere. The cold waters of the Arctic and Antarctic circles move towards warmer water in tropical and equatorial regions, while the warm waters of the lower latitudes move polewards.
Oceans.

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

LANDFORMS AND THEIR EVOLUTION

After weathering processes have had their actions on the earth materials making up the surface of the earth, the geomorphic agents like running water, ground water, wind, glaciers, waves perform erosion. It is already known to you that erosion causes changes on the surface of the earth. Deposition follows erosion and because of deposition too, changes occur on the surface of the earth. As this chapter deals with landforms and their evolution 'first' start with the question, what is a landform? In simple words, small to medium tracts or parcels of the earth's surface are called landforms. Several related landforms together make up landscapes, (large tracts of earth's surface). Each landform has its own physical shape, size, materials and is a result of the action of certain geomorphic processes and agent(s). Actions of most of the geomorphic processes and agents are slow, and hence the results take a long time to take shape. Every landform has a beginning. Landforms once formed may change in their shape, size and nature slowly or fast due to continued action of geomorphic processes and agents.

Due to changes in climatic conditions and vertical or horizontal movements of landmasses, either the intensity of processes or the processes themselves might change leading tonew modifications in the landforms. Evolution here implies stages of transformation of either a part of the earth's surface from one landform into another or transformation of individual landforms after they are once formed. That means, each and every landform has a history of development and changes through time. A landmass passes through stages of development somewhat comparable to the stages of life — youth, mature and old age. What are the two important aspects of the evolution of landforms? The evolutionary history of the continually changing surface of the earth is essential to be understood in order to use it effectively without disturbing its balance and diminishing its potential for the future. Geomorphology deals with the reconstruction of the history of the surface of the earth through a study of its forms, the materials of which it is made up of land the processes that shape it.

Changes on the surface of the earth owe mostly to erosion by various geomorphic agents. Of course, the process of deposition too, by covering the land surfaces and filling the basins, valleys or depressions, brings changes in the surface of the land. Deposition follows erosion and the depositional surfaces too are ultimately subjected to erosion. Running water, ground-water, glaciers, wind and waves are powerful erosional and depositional agents shaping and changing the surface of the earth aided by weathering and mass wasting processes. These geomorphic agents acting over long periods of time produce systematic changes leading to sequential development of landforms. Each geomorphic agent produces

its own assemblage of landforms. Not only this, each geomorphic process and agent leave their distinct imprints on the landforms they produce. You know that most of the geomorphic processes are imperceptible functions and can only be seen and measured through their results. What are the results? These results are nothing but landforms and their characteristics. Hence, a study of landforms, will reveal to us the process and agent which has made or has been making those landforms. Most of the geomorphic processes are imperceptible. Cite a few processes which can be seen and a few which can't be seen. As the geomorphic agents are capable of erosion and deposition, two sets — erosional or destructional and depositional or constructional — of landforms are produced by them. Many varieties of landforms develop by the action of each of the geomorphic agents depending upon especially the type and structure i.e. folds, faults, joints, fractures, hardness and softness, permeability and impermeability, etc. There are some other independent controls like

(i) Stability of sea level; (ii) Tectonic stability of landmasses;
(iii) Climate, which influence the evolution of landforms. Any disturbance in any of these three controlling factors can upset the systematic and sequential stages in the development and evolution of landforms. In the following pages, under each of the geomorphic regimes i.e. running water, groundwater, glaciers, waves, and winds, first a brief discussion is presented as to how landmasses are reduced in their relief through erosion and then, development of some of the erosional and depositional landforms is dealt with.

RUNNING WATER

In humid regions, which receive heavy rainfall running water is considered the most important of the geomorphic agents in bringing about the degradation of the land surface. There are two components of running water. One is overland flow on general land surface as a sheet. Another is linear flow as streams and rivers in valleys. Most of the erosional landforms made by running water are associated with vigorous and youthful rivers flowing along gradients. With time, stream channels over steep gradients turn gentler due to continued erosion, and as a consequence, lose their velocity, facilitating active deposition. There may be depositional forms associated with streams flowing over steep slopes.

But these phenomena will be on a small scale compared to those associated with rivers flowing over medium to gentle slopes. The gentler the river channels in gradient or slope, the greater is the deposition. When the stream beds turn gentler due to continued erosion, downward cutting becomes less dominant and lateral erosion of banks increases and as a consequence the hills and valleys are reduced to plains.

OVERLAND FLOW CAUSES SHEET EROSION.

Depending upon irregularities of the land surface, the overland flow may concentrate into narrow to wide paths. Because of the sheer friction of the column of flowing water, minor or major quantities of materials from the surface of the land are removed in the direction of flow and gradually small and narrow rills will form. These rills will gradually develop into long and wide gullies; the gullies will further deepen, widen, lengthen and unite to give rise to a network of valleys. In the early stages, down-cutting dominates during which irregularities such as waterfalls and cascades will be removed. In the middle stages, streams cut their beds slower, and lateral erosion of valley sides becomes severe. Gradually, the valley sides are reduced to lower and lower slopes. The divides between drainage basins are likewise lowered until they are almost completely flattened leaving finally, a lowland of faint relief with some low resistant remnants called *monadnocks* standing out here and there. This type of plain forming as a result of stream erosion is called a *peneplain* (an almost plain). The characteristics of each of the stages of landscapes developing in running water regimes may be summarised as follows:

YOUTH

Streams are few during this stage with poor integration and flow over original slopes showing shallow V-shaped valleys with no floodplains or with very narrow floodplains along trunk streams. Streams divides are broad and flat with marshes, swamp and lakes. Meanders if present develop over these broad upland surfaces. These meanders may eventually entrench themselves into the uplands. Waterfalls and rapids may exist where local hard rock bodies are exposed.

MATURE

During this stage streams are plenty with good integration. The valleys are still V-shaped but deep; trunk streams are broad enough to have wider floodplains within which streams may flow in meanders confined within the valley. The flat and broad inter stream areas and swamps and marshes of youth disappear and the stream divides turn sharp. Waterfalls and rapids disappear.

OLD

Smaller tributaries during old age are few with gentle gradients. Streams meander freely over vast floodplains showing natural levees, oxbow lakes, etc. Divides are broad and flat with lakes,swamps and marshes. Most of the landscape is at or slightly above sea level.

EROSIONAL LANDFORMS

Valleys

Valleys start as small and narrow rills; the rills will gradually develop into long and wide gullies; the gullies will further deepen, widen and lengthen to give rise to valleys. Depending upon dimensions and shape, many types of valleys like *V-shaped valley, gorge, canyon*, etc. can be recognised. A gorge is a deep valley with very steep to straight sides and a canyon is characterised by steep step-like side slopes and may be as deep as a gorge. A gorge is almost equal in width at its top as well as its bottom. In contrast, a canyon is wider at its top than at its bottom. In fact, a canyon is a variant of gorge. Valley types depend upon the type and structure of rocks in which they form. For example, canyons commonly form in horizontal bedded sedimentary rocks and gorges form in hard rocks.

POTHOLES AND PLUNGE POOLS

Over the rocky beds of hill-streams more or less circular depressions called *potholes* form because of stream erosion aided by the abrasion of rock fragments. Once a small and shallow depression forms, pebbles and boulders get collected in those depressions and get rotated by flowing water and consequently the depressions grow in dimensions. A series of such depressions eventually join and the stream valley gets deepened. At the foot of waterfalls also, large potholes, quite deep and wide, form because of the sheer impact of water and rotation of boulders. Such large and deep holes at the base of waterfalls are called *plunge pools*. These pools also help in the deepening of valleys. Waterfalls are also transitory like any other landform and will recede gradually and bring the floor of the valley above waterfalls to the level below.

INCISED OR ENTRENCHED MEANDERS

In streams that flow rapidly over steep gradients, normally erosion is concentrated on the bottom of the stream channel. Also, in the case of steep gradient streams, lateral erosion on the sides of the valleys is not much when compared to the streams flowing on low and gentle slopes. Because of active lateral erosion, streams flowing over gentle slopes, develop sinuous or meandering courses. It is common to find meandering courses over floodplains and delta plains where stream gradients are very gentle. But very deep and wide meanders can also be found cut in hard rocks. Such meanders are called *incised or entrenched meanders*. Meander loops develop over original gentle surfaces in the initial stages of development of streams and the same loops get entrenched into the rocks normally due to erosion or slow, continued uplift of the land over which they start. They widen and deepen over time and can be found as deep gorges and canyons in hard rock areas. They give an indication on the status of original land surfaces over which streams have developed.

RIVER TERRACES

River terraces are surfaces marking old valley floor or floodplain levels. They may be bedrock surfaces without any alluvial cover or alluvial terraces consisting of stream deposits. River terraces are basically products of erosion as they result due to vertical erosion by the stream into its own depositional floodplain. There can be a number of such terraces at different heights indicating former river bed levels. The river terraces may occur at the same elevation on either side of the rivers in which case they are called *paired terraces*

7.3 : PAIRED AND UNPAIRED RIVER TERRACES

When a terrace is present only on one side of the stream and with none on the other side or one at quite a different elevation on the other side, the terraces are called *non-paired terraces*. Unpaired terraces are typical in areas of

slow uplift of land or where the water column changes are not uniform along both the banks. The terraces may result due to
(i) receding water after a peak flow;
(ii) change in hydrological regime due to climatic changes;
(iii) tectonic uplift of land;
(iv) sea level changes in case of rivers closer to the sea.

DEPOSITIONAL LANDFORMS

Alluvial Fans

Alluvial fans are formed when streams flowing from higher levels break into foot slope plains of low gradient. Normally very coarse load is carried by streams flowing over mountain slopes. This load becomes too heavy for the streams to be carried over gentler

Gradients and gets dumped and spread as a broad low to high cone shaped deposit called *alluvial fan*. Usually, the streams which flow over fans are not confined to their original channels for long and shift their position across the fan forming many channels called *distributaries*. Alluvial fans in humid areas show normally low cones with gentle slope from as a low cone. Unlike in alluvial fans, the deposits making up deltas are very well sorted with clear stratification. The coarsest materials settle out first and the finer fractions like silts and clays are carried out into the sea. As the delta grows, the river distributaries continue to increase in length and deltacontinues to build up into the sea.

FLOODPLAINS, NATURAL LEVEES AND POINT BARS

Deposition develops a floodplain just as erosion makes valleys. Floodplain is a major landform of river deposition. Large sized materials are deposited first when stream channel breaks into a gentle slope. Thus, normally, fine sized materials like sand, silt and clay are carried by relatively slow moving waters in gentler channels usually found in the plains and deposited over the bed and whenthe waters spill over the banks during flooding above the bed. A river bed made of river deposits is the active floodplain. The floodplain above the bank is inactive floodplain. Inactive floodplain above the banks basically contain two types of deposits — flood deposits and channel deposits. In plains, channels shift laterally and change their courses occasionally leaving cut-off courses which get filled up gradually. Such areas over flood plains built up by abandoned or cut-off channels contain coarse deposits.

The flood deposits of spilled waters carry relatively finer materials like silt and clay. The flood plains in a delta are called *delta plains*. *Natural levees and point bars* are some of the important landforms found associated with floodplains. *Natural levees* are found along the banks of large rivers. They are low, linear and parallel ridges of coarse deposits along the banks of rivers, quite often cut into individual mounds. During flooding as the water spills over the bank, the velocity of the water comes down and large sized and high specific gravity materials get dumped in the immediate vicinity of the bank as ridges. They are high nearer the banks and slope gently away from the river. The levee deposits are coarser than the deposits spread by flood waters away from the river. When rivers shift laterally, a series of natural levees can form. head to toe and they appear as high cones with steep slope in arid and semi-arid climates.

DELTAS

Deltas are like alluvial fans but develop at a different location. The load carried by the rivers is dumped and spread into the sea. If this load is not carried away far into the sea or distributed along the coast, it spreads and accumulates

Point bars are also known as *meander bars*. They are found on the convex side of meanders of large rivers and are sediments deposited in a linear fashion by flowing waters along the bank. They are almost uniform in profile and in width and contain mixed sizes of sediments. If there more than one ridge, narrow and elongated depressions are found in between the point bars. Rivers build a series of them depending upon the water flow and supply of sediment. As the rivers build the point bars on the convex side, the bank on the concave side will erode actively.

MEANDERS

In large flood and delta plains, rivers rarely flow in straight courses. Loop-like channel patterns called *meanders* develop over flood and delta plains

Meander is not a landform but is only a type of channel pattern. This is because of

(i) propensity of water flowing over very gentle gradients to work laterally on the banks;
(ii) unconsolidated nature of alluvial deposits making up the banks with many irregularities which can be used by water exerting pressure laterally;
(iii) coriolis force acting on the fluid water deflecting it like it deflects the wind. When the gradient of the channel becomes extremely low, water flows leisurely and starts working laterally. Slight irregularities along the banks slowly get transformed into a small curvature in the banks; the curvature deepens due to deposition on the inside of the curve and erosion along the bank on the outside. If there is no deposition and no erosion or undercutting, the tendency to meander is reduced. Normally, in meanders of large rivers, there is active deposition along the convex bank and undercutting along the concave bank. The concave bank is known as cut-off bank which shows up as a steep scarp and the convex bank presents a long, gentle profile and is known as slip-off bank. As meanders grow into deep loops, the same may get cut-off due to erosion at the inflection points and are left as *ox-bow lakes*.

Braided Channels

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 get deposited as islands and lateral bars developing a number of separate channels of water flow. Deposition and lateral erosion of banks are essential for the formation of braided pattern. Or, alternatively, when discharge is less and load is more in the valley, channel bars and islands of sand, gravel and pebbles develop on the floor of the channel and the water flow is divided into multiple threads. These thread-like streams of water rejoin and subdivide repeatedly to give a typical braided pattern

GROUNDWATER

Here the interest is not on groundwater as a resource. Our focus is on the work of groundwater in the erosion of landmasses and evolution of landforms. The surface water percolates well when the rocks are permeable, thinly bedded and highly jointed and cracked.

After vertically going down to some depth, the water under the ground flows horizontally through the bedding planes, joints or through the materials themselves. It is this downward and horizontal movement of water which causes the rocks to erode. Physical or mechanical removal of materials by moving groundwater is insignificant in developing landforms. That is why, the results of the work of groundwater cannot be seen in all types of rocks. But in rocks like limestones or dolomites rich in calcium carbonate, the surface water as well as groundwater through the chemical process of solution and precipitation deposition develop varieties of landforms. These two processes of solution and precipitation are active in limestones or dolomites occurring either exclusively or interbedded with other rocks. Any limestone or dolomitic region showing typical landforms produced by the action of groundwater through the processes of solution and deposition is called *Karst topography* after the typical topography developed in limestone rocks of Karst region in the Balkans adjacent to Adriatic sea. The karst topography is also characterized by erosional and depositional landforms.

EROSIONAL LANDFORMS

Pools, Sinkholes, Lapies and Limestone Pavements

Small to medium sized round to sub-rounded shallow depressions called *swallow holes* form on the surface of limestones through solution. Sinkholes are very common in limestone/karst areas. *A sinkhole* is an opening more or less circular at the top and funnel-shapped 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. Some of these form solely through solution action (solution sinks) and others might start as solution forms first and if the bottom of a sinkhole forms the roof of a void or cave underground, it might collapse leaving a large hole opening into a cave or a void below (collapse sinks). Quite often, sinkholes are covered up with soil mantle and appear as shallow water pools. Anybody stepping over such pools would go down like it happens in quicksands in deserts. 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 sink holes and dolines join together because of slumping of materials along their margins or due to roof collapse of caves, long, narrow to wide trenches called *valley sinks* 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 (shales, sandstones, quartzites) with limestones or dolomites in between or in areas where limestones 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* result. There can be a maze of caves at different elevations depending upon the limestone beds and intervening rocks. Caves normally have an opening through which cave streams are discharged. Caves having openings at both the ends are called tunnels.

DEPOSITIONAL LANDFORMS

Many depositional forms develop within the limestone caves. The chief chemical in limestone 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

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* .The movement of glaciers is slow unlike water flow. The movement could be a few centimetres to a few metres a day or even less or more. Glaciers move basically because of the force of gravity. We have many glaciers in our country moving down the slopes and valleys in Himalayas. Higher reaches of Uttaranchal, Himachal Pradesh and Jammu and Kashmir, are places to see some of them. Do you know where one can see river Bhagirathi is basically fed by meltwaters from under the snout (Gaumukh) of the Gangotri glacier. In fact, Alkapuri glacier feeds waters to Alakananda river. Rivers Alkananda and Bhagirathi join to make river Ganga near Deoprayag. Erosion by glaciers is tremendous because of friction caused by sheer weight of the ice. The material plucked from the land by glaciers (usually large-sized angular blocks and fragments) get dragged along the floors or sidesof the valleys and cause great damage through abrasion and plucking. Glaciers can cause significant damage to even un-weathered rocks and can reduce high mountains into low hills and plains.

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.

As glaciers continue to move, debris gets removed, divides get lowered and eventually the slope is reduced to such an extent that glaciers will stop moving leaving only a mass of low hills and vast outwash plains along with other depositional features. s

EROSIONAL LANDFORMS

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 be 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 headward until their cirques meet, high, sharp pointed and steep sided peaks called *horns* form. The divides between cirque side walls 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. The highest peak in the Alps, Matterhorn and the highest peak in the Himalayas, Everest are in fact horns formed through headward erosion of radiating cirques.

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 up shorelines (in high latitudes) are called *fjords*/*fiords*. What are the basic differences between glacial valleys and river valleys?

DEPOSITIONAL LANDFORMS

The unassorted coarse and fine debris dropped by the melting glaciers is called *glacial till*. Most of the rock fragments in till are angular to subangular 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 glaciofluvial 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,

MORAINES

They are long ridges of deposits of glacial till. Terminal moraines are long ridges of debris deposited at the end (toe) 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 glaciofluvial 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 centre 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. What is the difference between till and alluvium?

WAVES AND CURRENTS

Coastal processes are the most dynamic and hence most destructive. So, don’t you think it is important to know about the coastal processes and forms? Some of the changes along the coasts take place very fast. At one place, there can be erosion in one season and deposition in another. Most of the changes along the coasts are accomplished by waves. When waves break, the water is thrown with great force onto the shore, and simultaneously, there is a great churning of sediments on the sea bottom. Constant impact of breaking waves drastically affects the coasts. Storm waves and tsunami waves can cause far-reaching changes in a short period of time than normal breaking waves. As wave environment changes, the intensity of the force of breaking waves changes. Do you know about the generating forces behind waves and currents? If not, refer to the chapter on movements in ocean waters. 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. The hill sides drop off sharply into the water. Shores do not show any depositional landforms initially. Erosion features dominate.

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. Waves gradually minimise the irregularities along the shore. The materials which fall off, and removed from the sea cliffs, gradually break into smaller fragments and roll to roundness, will get deposited in the offshore. After a considerable period of cliff development and retreat when coastline turns somewhat smooth, with the addition of some more material to this deposit in the offshore, a wave-built terrace would develop in front of wave-cut terrace. As the erosion along the coast takes place a good supply material becomes available to longshore currents and waves to deposit them as beaches along the shore and as bars (long ridges of sand and/or shingle parallel to the coast) in the nearshore zone. 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 maintenance of these depositional features depends upon the steady supply of materials. Storm and tsunami waves cause drastic changes irrespective of supply of sediments. Large rivers which bring lots of sediments build deltas along low sedimentary coasts. 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. What are the various differences between a high rocky coast and a low sedimentary coast in terms of processes and landforms?

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*. 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. Just behind the beach, the sands lifted and winnowed from over the beach surfaces will be deposited as sand dunes. Sand dunes forming long ridges parallel to the coastline are very common along low sedimentary coasts.

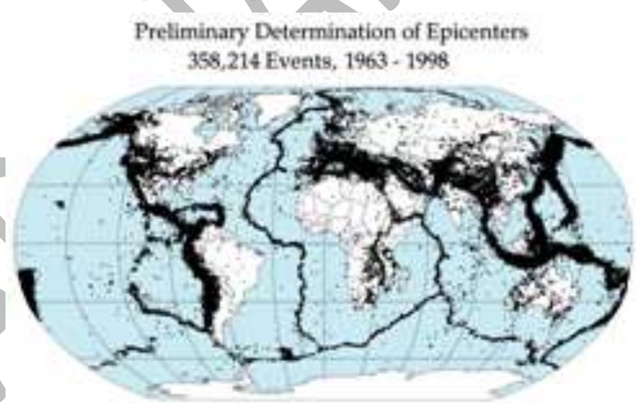
BARS, BARRIERS AND SPITS

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* 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. Do you know, the coastal off-shore bars offer the first buffer or defence against storm or tsunami by absorbing most of their destructive force. Then come the barriers, beaches, beach dunes and mangroves, if any, to absorb the destructive force of storm and tsunami waves. So, if we do anything which disturbs the 'sediment budget' and the mangroves along the coast, these coastal forms will get eroded away leaving human habitations to bear first strike of storm and tsunami waves.

EARTHQUAKES

Global distribution of earthquake epicentres,

1963-1998



- An earthquake is a result of a sudden release of energy in the earth's crust that creates seismic waves
- Earthquakes are recorded with a seismograph and are reported on a magnitude on the Richter scale.
- **In general, earthquakes of magnitude less than 3 are imperceptible, and more than 7 cause serious damage**
- The intensity of an earthquake can also be measured on the Modified Mercalli (MM) scale. **The MM scale quantifies the effect an earthquake has on humans, natural objects and man-made structures**

- The shaking caused by earthquakes can result in landslides, and in volcanic activity as well. When a large earthquake occurs in the oceans, the ocean floor can suffer sufficient displacement to cause a tsunami
- Earthquakes are usually caused by rupture of geological faults, but can also be caused by volcanic activity, landslides, mine blasts and nuclear experiments
- **The point of initial rupture of an earthquake is called its hypocentre, while the point on the surface directly above it is called the epicentre**
- **Earthquakes that occur under the ocean and of high magnitude can generate tsunamis** (eg 2004 Indian Ocean tsunami)
- **The most powerful earthquake ever recorded is the Valdivia earthquake in Chile in 1960.** It measured 9.5 on the Richter scale

MECHANISM OF ACTION

- **Earthquakes can occur anywhere within the earth where there is stored elastic energy sufficient enough to drive fault propagation along a fault plane**
- Tectonic plates move past each other smoothly only if there are no irregularities and asperities. Most plate boundaries do have asperities and this leads to stick-slip behaviour
- Once the boundary has locked into a relative stable position, continued relative motion between the plates leads to increased stress and stored strain energy
- This continues until the stress rises sufficiently to break through the relative stable position, suddenly sliding over the locked position of the fault and thereby releasing the stored energy
- The energy is released as a combination of elastic seismic waves, frictional heating of the surface and cracking of rock, thereby causing an earthquake
- **This process of gradual build up of stress and sudden release of energy in the form of earthquakes is called elastic-rebound theory**
- **It is estimated that less than 10 % of the total energy of an earthquake is radiated as seismic energy.** Most of the earthquake's energy is used to power fracture growth or is converted as heat generated by friction

OCCURRENCE OF EARTHQUAKES

- **Minor earthquakes occur nearly constantly.** Most of these happen in places like California and Alaska in the US, as well as in Guatemala, Chile, Peru, Indonesia, Iran, Pakistan, Turkey, Greece, Italy, Japan and New Zealand. Larger earthquakes occur less frequently
- **However, in general, earthquakes can occur almost anywhere** (even away from plate boundaries)

- The relationship between frequency and intensity of earthquakes is roughly exponential i.e. for instance, there are roughly 10 times as many earthquakes of magnitude 4 as of magnitude 5
- **Most of the world's earthquakes occur in Pacific Ring of Fire seismic belt.** Massive earthquakes occur along other plate boundaries too, such as the Himalayas

INDUCED SEISMICITY

- While most earthquakes occur due to natural movement of the earth's tectonic plates, **human activity can produce earthquakes** as well
- Four main human activities that contribute to earthquakes include
  - **Large dams**
  - **Drilling and injecting liquids into wells**
  - **Coal mining**
  - **Oil drilling**
- For instance, the 2008 Sichuan earthquake in China is believed to have been caused by the Zipingpu dam which caused the pressure of a nearby fault to fluctuate, increasing the movement of the fault and the magnitude of the earthquake

EARTHQUAKES AND VOLCANIC ACTIVITY

- Earthquakes often occur in volcanic areas
- They are caused both by tectonic faults and the movement of magma in volcanoes
- **Such earthquakes can serve as early warning of impending volcanic eruptions.** Eg: Mount St Helens eruption of 1980 (USA)

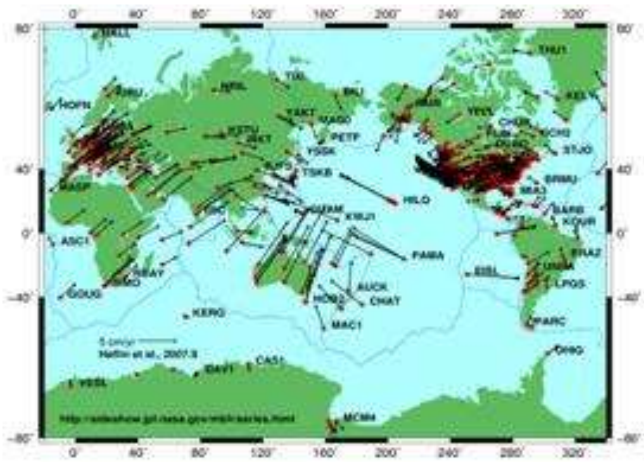
SEISMIC WAVES

- Seismic waves are waves of force that travel through the earth
- Earthquakes produces different types of seismic waves that travel through the earth at different velocities:
  - **P waves (Pressure or Primary waves):** they are longitudinal waves that **travel fastest** through solids, and are therefore the **first waves to appear on a seismogram**
  - **S waves (shear or secondary waves):** transverse waves that **travel slower than P waves.**

    They do not exist in fluids such as air or water
  - **Surface waves (Rayleigh waves and Love waves):** slower than P and S waves, but have much larger amplitude**. These surface waves cause most damage during an earthquake**

- The propagation velocity of the seismic waves depends on density and elasticity of the medium
- In solid rock, P waves travel at about 6-7 km/s (within the mantle about 13 km/s), while S waves travel at about 2-3 km/s (mantle 9 km/s)

GLOBAL TECTONIC PLATE MOVEMENT



- Earthquakes can be recorded at great distances, since seismic waves travel through the whole of the earth's interior
- **The absolute magnitude of a quake is reported on the Moment Magnitude scale, while perceived magnitude is reported on the Modified Mercalli (MM) scale.** The Richter scale is another scale that measures the absolute magnitude – it is no longer used in academic circles but is still used in popular parlance.
- As a rule of thumb, **the distance to the earthquake epicentre is the number of seconds between the P and S waves multiplied by 8**

Major earthquakes

S. No.	Date	Location	Magnitude
1	1960	Valdivia, Chile	9.5
2	Dec 2004	Sumatra, Indonesia	9.3
3	1964	Alaska, USA	9.2
4	1952	Kamchatka, Russia	9.0
5	1700	Cascadia Subduction Zone (Pacific Ocean rim)	9.0

SEMI-VOLCANIC PHENOMENA
HOT SPRINGS

OVERVIEW

- **Hot springs are springs that are produced by geothermally heated groundwater**
- Hot springs range from tiny seeps to veritable rivers of hot water
- Hot springs are present all over the world, on all continents and even under the ocean
- **The Dalhousie Springs in southern Australia are the largest hot springs in the world in terms of volume of water**
- **Water from hot springs has high mineral content, containing everything from calcium to lithium and even radium.** For their high mineral content, hot spring are widely sought after spa destinations
- **Thermophiles – organisms that thrive in temperatures 45-80 C – are found in hot springs and geysers**

SOURCES OF HEAT

- **Hot springs are heated by geothermal heat**
- Geothermal heat is the heat from the interior of the earth
- Geothermal heat can be produced by two natural phenomena: geothermal gradient and volcanic activity
- **Geothermal gradient is the increase of temperature with depth inside the earth.** Water that percolates deep inside the crust comes into contact with hot rocks and gets heated
- **In areas of volcanic activity, water can also be heated by coming into contact with magma.** The high temperature gradient near magma causes water to boil and even become superheated
- Hot springs in volcanic areas are almost always at or near the boiling point

GEYSERS

- **A geyser is a spring characterised by intermittent discharge of water ejected turbulently.** The water discharge is accompanied by vapour (or steam) as well
- The word geyser comes from a spring in Haukadalur, Iceland called *Geysir*
- Geysers are temporary geological phenomena. **The lifespan of geysers is a few thousand years at most.**
- Generally all geyser sites are located close to active volcanic areas
- There are about a thousand known geysers in the world. **Half of the world's geysers are in the Yellowstone National Park, USA.**

- **Geysers are fragile phenomena and if conditions change, they can die.** Many geysers have been destroyed by people throwing litter and debris into them, others have ceased due to dewatering by Geothermal power plants
- Geysers have been observed on the moons of other planets as well

SOURCES OF ACTIVITY

- **Geysers are generally associated with volcanic areas, as the geyser effect is due to proximity of magma**
- Surface water works its way down to a depth of about 2000 m, where it meets hot rocks of magma.
- The resultant boiling of the pressurised water results in the geyser effect of hot water and steam spraying out of the surface vent
- Geysers are relatively rare phenomena. They require a combination of three geological conditions
    - **Intense heat:** geysers need intense heat, which is provided by magma. The high pressures deep inside the earth raises the boiling point of water resulting in superheated water
    - **Water:** for geysers to exist, water must be available in the area. The water must be able to travel underground through deep pressurised fissures
    - **Plumbing system:** this includes a reservoir to hold the water while it is being heated and a vent on the surface for ejecting it. The plumbing system is made of a system of fissures, fractures, porous spaces that are essential for building up pressure before an eruption
- **The geyser produces a material called geyserite that deposits onto the walls of the plumbing system making it pressure-tight.** Geyserite is produced by rocks in the vicinity of the geyser, and consists mainly of silicon dioxide

TYPES OF GEYSERS

- **Fountain geysers:** erupt from pools of water in a series of intense violent bursts. Eg: Grand Geyser in Yellowstone National Park (USA)
- **Cone geysers:** erupt from cones or mounds of geyserite in steady jets that last from a few seconds to several minutes. Eg: Old Faithful Geyser in Yellowstone National Park (USA)

IMPORTANT GEYSERS IN THE WORLD

Geyser	Location	Notes
Yellowstone National Park	Northwest USA	Home to half the world's geysers World's tallest predictable geyser: Grand geyser World's tallest geyser: Steamboat geyser (300 ft) One of the most predictable geysers: Old Faithful
Valley of Geysers	Kamchatka Peninsula, Russia	Second largest concentration of geysers in the world Only geyser field in Eurasia
El Tatio	Chile	Very low height of eruptions (max 6 m)
Taupo Volcanic Zone	North Island, New Zealand	Was home to the world's largest geyser: Waimangu Geyser (500 m) However, geothermal changes have changed the geyser field
Haukadalur Other places	Iceland	Geysers are distributed all over Iceland Famous geysers include *Great Geysir* and *Stokkur*

COLD WATER GEYSERS

- Cold water geysers are similar to hot water geysers, except that **carbon dioxide bubbles drive the eruption instead of steam**
- In cold water geysers, carbon dioxide laden water lies in a confined aquifer trapped by less permeable overlying strata
- The column of water exerts enough pressure on the CO2 such that it remains in water in small bubbles
- When the pressure decreases due to formation of fissures, the CO2 bubbles expand and cause eruption
- CO2 laden water in **cold water geysers are more white and frothy than hot water geysers**
- **Eg: Crystal Geyser in northwest USA, Geysir Andernach (Germany)**

A fumarole at the Halema Umau crater in Hawaii

GEYSERS IN THE SOLAR SYSTEM

- Geysers have been observed elsewhere in the solar system
- Unlike eruptions on earth, **these geysers mainly consist of gas, dust and ice particles, without liquid**
- **Geysers have been observed on Saturn's moon Enceladus, Neptune's moon Triton and in the south pole of Mars**

FUMAROLES

- **A fumarole is an opening in the earth's crust that emits steam and gases.** Fumaroles occur in the neighbourhood of volcanoes
- **Typical emitted gases include carbon dioxide, sulphur dioxide, hydrochloric acid and hydrogen sulphide**
- Fumaroles occur when magma at shallow depths release gases or interact with groundwater releasing steam
- Fumaroles may persist for centuries if they occur over a persistent heat source, or disappear in weeks if they occur over fresh volcanic deposit that quickly cools off
- Eg: Valley of Ten Thousand Smokes (Alaska, USA), Yellowstone National Park (USA)

MUD POTS

- **A mud pot is a hot spring or fumarole consisting of a pool of bubbling mud**
- **Mud pots form in high temperature geothermal areas where water is in short supply**
- The little water that is available rises to the surface at a spot rich in volcanic ash, clay and other particles
- The mud takes the form of a viscous bubbling slurry
- Eg: Yellowstone National Park (USA)

VOLCANOES

Overview

- A volcano is an opening in a planet's surface or crust that allows hot magma, ash and gases to escape from below the surface
- Volcanoes erupt enormous quantities of toxic gases and water vapour, and can cause significant changes in global climate patterns
- The magma from volcanoes, upon cooling, solidifies into igneous rocks like basalt and granite
- **Volcanism is mainly responsible for the formation of the earth's atmosphere**

- Active volcanoes are those that have erupted within the Holocene period (last 10,000 years)
- Dormant volcanoes are those that have not erupted in recent times, but might potentially erupt in the future.
- Extinct volcanoes are those that are not likely to erupt again, because the volcano no longer has a supply of lava. It is difficult to differentiate extinct volcanoes from dormant ones since many volcanoes that lie inactive for tens of thousands of years suddenly erupt without warning
- **The explosiveness of a volcanic eruption is measured by the Volcanic Eruption Index (VEI).** The index goes from 0 to 8, with 0 representing non-explosive eruptions and 8 representing mega-colossal eruptions from supervolcanoes

OCCURRENCE OF VOLCANOES

The 1991 eruption of Mt Pinatubo (Philippines) was the world's largest in living memory. The eruption sent an ash plume 19 km into the atmosphere and caused global temperatures to drop by 0.5 C

- **Most volcanic activity occurs in the oceans, continuously forming new sea floor**
- **The most active volcanic belt is the *Ring of Fire*, which occurs along the boundaries of the Pacific Ocean**
- In addition to the Earth, volcanoes occur on other planets as well
- **Jupiter's moon Io is the most volcanically active object in the solar system**
- **The tallest mountain in the solar system, the Olympus Mons on Mars (21 km tall), was built by volcanic activity**

VOLCANOES AND PLATE TECTONICS

- **Volcanoes are generally found tectonic plates are diverging or converging, but not where two tectonic plates slide past each other**
- **Divergent boundaries:** At mid ocean ridges, tectonic plates diverge from one another. The release of pressure due to thinning of the crust leads to volcanism. Examples: deep sea vents, Iceland
- **Convergent boundaries:** when two tectonic plates, one subsides over the other, creating subduction zones. Water released from the subducting plate lowers the melting temperature of the other, creating magma. Examples: Mt. Etna, Pacific Ring of Fire
- **Hotspots:** Hotspots are not located at the boundaries of tectonic plates but above mantle plumes (narrow stream of hot mantle convecting up towards surface). The temperature of the plume causes crust to melt and form venting pipes. Examples: Hawaii, Yellowstone Caldera

EFFECTS OF VOLCANOES

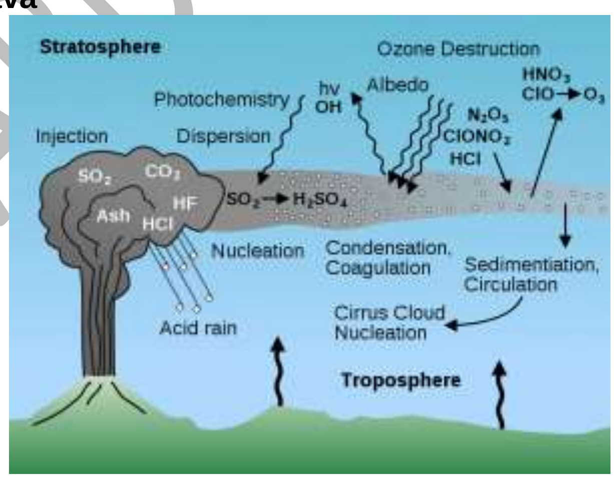
- Earthquakes, hot springs, geysers etc often accompany volcanic activity
- Volcanoes typically emit large quantities of water vapour, carbon dioxide and sulphur dioxide
- **Large explosive volcanic eruptions inject these gases into the stratosphere to heights of 16-32 km**
- Conversion of the sulphur dioxide into sulphuric acid increases the earth's albedo, increasing the reflection of radiation from the sun
- **This leads to significant and protracted global cooling**
- Gas emissions from volcanoes results in acid rain
- **Volcanic activity releases about 0.13-0.23 giga tonnes of carbon dioxide every year** (about 1% of amount released by human activity)

DECADE VOLCANOES

- Decade Volcanoes are those volcanoes that have been identified by the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) as being worthy of particular study
- **Decade Volcanoes are bring particular attention due to their history of large destructive eruptions and their proximity to population areas**
- They are named Decade Volcanoes because they were initiated as part of the UN International Decade for Natural Disaster Reduction (the 1990s)
- The Decade Volcanoes project encourages studies and public awareness activities with the aim of better understanding the volcanoes and the dangers they represent

FEATURES OF VOLCANOES

Composition of Lava



Volcanoes release enormous quantities of gases into the atmosphere in an effect called Volcanic Injection

- Lava is the name given to magma once it has escaped to the surface

- **Felsic lava: If the magma erupted contains a high percentage of silica (> 63%), the lava is called felsic lava**
  - Felsic lava tends to be highly viscous and are erupted as domes or short stubbly flows.
  - They tend to form stratovolcanoes or volcanic domes
- **Intermediate lava: silica content 52-63%**
  - Generally occur at subduction zones
- **Mafic lava: silica content 52-45%**
  - These lavas have higher content of Magnesium and iron
  - Less viscous but much hotter than felsic lavas
  - They occur in mid ocean ridges, shield volcanoes and continental flood basalts
- **Ultramafic lava: silica content less than 45%**
  - Ultramafic lava flows are very rare
  - They have not erupted in millions of years
  - **Ultramafic lavas were the hottest lavas**

PYROCLASTIC FLOWS

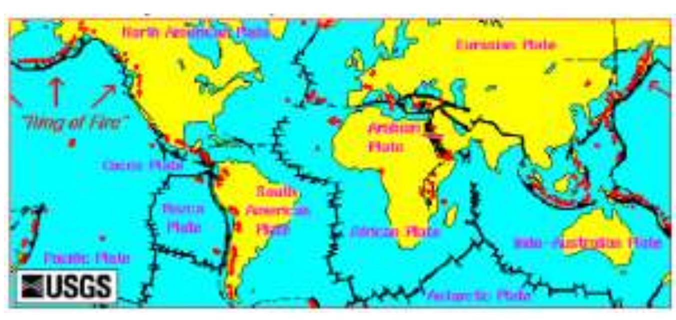
- **Pyroclastic flows are fast moving currents of tephra (hot gas and rock), which travel from volcanoes at speeds up to 700 km/h**
- Pyroclastic flows are a devastating result of explosive volcanic eruptions
- **The gas can reach temperatures up to 1000 C**
- Pyroclastic surges are flows where the proportion of gas is much higher than rock. This makes pyroclastic surges more turbulent and can rise above hills and ridges. **Pyroclastic surges are even more devastating than pyroclastic flows and can reach speeds up to 1000 km/h**
- **Famous pyroclastic flows include the ones that engulfed the towns of Pompeii and Herculaneum in Italy in 79 CE**

CALDERAS

- A caldera is a cauldron-like volcanic feature usually formed by the collapse of land following a volcanic eruption
- Calderas arise because the emptying of the magma chamber beneath the volcano, with the result that the emptied chamber is unable to support the weight of the volcanic material above it
- **Calderas are formed as a result of a large volcanic eruption**

TYPES OF VOLCANOES

SHIELD VOLCANOES



Map of major volcanoes around the world

- Shield volcanoes are formed by the eruption of low viscosity lava
- The lava flows a great distance from the vent
- Shield volcanoes do not explode catastrophically
- They are more common in oceans than in continents
- Eg: Hawaii, Iceland

MUD VOLCANOES

- Mud volcanoes (not strictly volcanoes) are formations created by the geo-excretion of liquids and gases
- Temperatures in mud volcanoes are much cooler than in igneous processes
- Ejected material primarily consists of methane, carbon dioxide and water vapour (acidic)
- Mud volcanoes can reach 10 km in diameter and about 700 m in height

SUBMARINE VOLCANOES

Barren Island, the only active volcano in India, as seen from the ISS

- Submarine volcanoes are underwater fissures in the earth's crust from which magma can erupt
- **Submarine volcanoes account for over 75% of the world's magma releases**
- Submarine volcanoes are mainly located near ocean ridges, where tectonic plate movement in maximum
- Due to the presence of water, **lava from submarine volcanoes cools and solidifies quickly, turning into volcanic glass**
- **Submarine volcanoes are concentrated in the Ring of Fire in the Pacific Ocean**
- The West Mata volcano, in the Pacific Ocean, is currently the deepest erupting submarine volcano (1100 m)

SUBGLACIAL VOLCANOES

- Subglacial volcanoes erupt beneath the surface of glaciers or ice sheets
- The rising lava causes the ice to melt and form a lake
- The rapid melting of ice into water due to lava can lead to glacial lake outburst floods
- Subglacial volcanoes are most common in Iceland and Antarctica

STRATOVOLCANOES

- Stratovolcanoes are tall conical volcanoes with many layers (strata) of hardened lava and ash
- **Stratovolcanoes are characterised by steep slopes and explosive eruptions**
- **Stratovolcanoes are the most common type of volcanoes found**
- They are common in subduction zones, forming chains of volcanoes along tectonic plate boundaries
- Stratovolcano explosions tend to result in destructive pyroclastic flows that have affected civilization through history
- **The explosion of Tambora Volcano (Indonesia) in 1815, the most powerful eruption in recorded history, lowered global temperatures by about 3 C.**
- Eg: Mt. Vesuvius (Italy), Mt. Fuji (Japan), Mt. St Helens (USA), Mt Pinatubo (Philippines)

SUPERVOLCANOES

- **Supervolcanoes are volcanoes with ejected material greater than 1000 cubic km, which is millions of times larger than any volcanic event in known history**
- Supervolcanoes can produce devastation on an enormous continental scale
- Supervolcanoes occur when magma rises to the crust in hotspots but is enable to break through the crust. Pressure build in the large and growing magma pool until the crust is unable to contain the pressure
- **Super volcanic eruptions cause long lasting climate change (esp. global cooling) and directly result in the large scale extinction of species**
- There are only seven known supervolcanoes: **Yellowstone Caldera (USA), Long Valley Caldera (USA), Valles Caldera (USA), Lake Toba (Indonesia), Lake Taupo (New Zealand), Aira Caldera (Japan), Siberian Traps (Russia)**
- Large igneous provinces are also considered supervolcanoes due to the amount of lava released, but they are non-explosive in nature

- There have been no supervolcanic eruptions in the Holocene period (10,000 yrs BP). **The last supervolcano eruption was the Lake Taupo (New Zeland) about 26,500 yrs ago**

LIST OF VOLCANOES

See here for a full list of volcanoes

LIST OF DECADE VOLCANOES

S. No.	Volcano	Classification	Location	Notes
1	Avachinsky-Koryaksky	Active Stratovolcano	Kamchatka Peninsula, Russia	
2	Colima's Volcano	Active Stratovolcano	Mexico	One of the most active volcanoes in North America
3	Mount Etna	Active Stratovolcano	Sicily, Italy	Largest active volcano in Europe (3300 m) One of the most active volcanoes in the world Last eruption 2008
4	Galeras	Active Stratovolcano	Colombia	
5	Mauna Loa	Active Shield volcano	Hawaii, USA	Largest volcano on Earth in terms of volume and area covered One of five volcanoes that constitute island of Hawaii Eruptions tend to be non-explosive
6	Mount Merapi	Active Stratovolcano	Indonesia	
7	Mount Nyiragongo	Active Stratovolcano	Congo	Famous for its crater that contains a lake of lava

Volcano	Location	Notes
Lake Taupo	North Island, New Zealand	Latest known supervolcanic eruption (26,500 yrs BP). Ejected 1170 cu km of material Last major eruption in 180 CE (ejected 100 cu km) Eruption of 180 CE was noticed as far away as China and Rome
Lake Toba	Sumatra, Indonesia	Largest volcanic lake in the world Supervolcanic eruption 74,000 yrs ago of VEI 8 (2800 cu km) Believed to be largest eruption on Earth in last 25 million yrs ago Eruption deposited ash layer 15 cm thick all over India, some parts up to 6 m thick Caused major extinctions of plant and animal species, including severely endangering human species
Whakamaru	North Island, New Zeland	
Yellowstone Caldera	Wyoming, USA	Last eruption 640,000 years ago
Island Park Caldera	Idaho, USA	Last eruption 2.1 million years ago
Kilgore Tuff	Idaho, USA	Last eruption 4.5 million years ago
Blacktail Creek	Idaho, USA	Last eruption 6.6 million years ago
La Garita Caldera	Colarado, USA	Last eruption 28 million years ago Largest known explosive eruption in history of Earth (5000 cu km)

LIST OF VOLCANOES IN INDIA

Volcano	Classification	Location	Notes
Barren Island	Active stratovolcano	Andaman Islands	Only active volcano in India Last eruption in July 2009
Baratang	Mud volcano	Andaman Islands	Last eruption in 2005
Narcondam	Potentially active stratovolcano	Andaman Islands	Thought to have been inactive, but recently mud and smoke activity in June 2005 Recent activity possibly related to 2004 Indian Ocean Earthquake Narcondam is famous for the Narcondam Hornbill, an endangered species Narcondam island is the eastern-most point of the Andaman & Nicobar Islands. It is claimed by Burma
Deccan Traps	Large Igneous Province	Deccan Plateau	One of the largest volcanic features on Earth Multiple layers of basalt more than 2 km thick Technically it may classified as a supervolcano

<u>WINDS</u>

Wind is one of the two dominant agents in hot deserts. The desert floors get heated up too much and too quickly because of being dry and barren. The heated floors heat up the air directly above them and result in upward movements in the hot lighter air with turbulence, and any obstructions in its path sets up eddies, whirlwinds, updrafts and downdrafts. Winds also move along the desert floors with great speed and the obstructions in their path create turbulence. Of course, there are storm winds which are very destructive. 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.

It is similar to sandblasting operation. The wind action creates a number of interesting erosional and depositional features in the deserts. In fact, many features of deserts owe their formation to mass wasting and running water as sheet floods. Though rain is scarce in deserts, it comes down torrentially in a short period of time. The desert rocks devoid of vegetation, exposed to mechanical and chemical weathering processes due to drastic diurnal temperature changes, decay faster and the torrential rains help in removing the weathered materials easily. That means, the weathered debris in deserts is moved by not only wind but also by rain/sheet wash. The wind moves fine materials and general mass erosion is accomplished mainly through sheet floods or sheet wash. Stream channels in desert areas are broad, smooth and indefinite and flow for a brief time after rains.

EROSIONAL LANDFORMS

Pediments and Pediplains

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 formedwith 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 backwasting. 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 *pediplains*.

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 centre of the basin and due to gradual deposition of sediment from basin margins, a nearly level plain forms at the centre 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 able top and quite often, the remnants stand out like pedestals. List the erosional features carved out by wind action and action of sheet floods.

DEPOSITIONAL LANDFORMS

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 stabilised especially near human habitations.

MOUNTAINS

OVERVIEW

- A mountain is a large landform that stretches above the surrounding land in a limited area
- Mountains are sometimes referred to by the Greek name: *montes or mons* (singular)
- The highest mountain on earth is Mount Everest (8848 m)
- **The highest mountain in the solar system is Olympus Mons on Mars (21,171 m)**
- Mountains cover 24% of earth's land mass
- **The study of mountains is called Orology**

CHARACTERISTICS OF MOUNTAINS

- Mountains are colder than lower ground because the Sun heats the Earth from the ground up.
- When the Sun's rays travel through the atmosphere and reach the ground, the earth absorbs the heat. In general air closest to the earth's surface is warmest
- **Air temperature usually decreases 1-2 C for every 300 m of altitude**
- The flora and fauna in tall mountains tend to be isolated to one particular altitude zone. **These isolated ecological systems are called sky islands.**
- **The peak shape of mountains is produced by glaciation and erosion through frost action**
- **As altitude increases, the atmospheric pressure decreases.** Thus, although the percentage of oxygen remains constant (21%), the amount of oxygen decreases.
- Altitude sickness (aka Acute Mountain Sickness) is caused by lack of oxygen at high altitudes. Altitude sickness can lead to High Altitude Pulmonary Edema (HAPE) or High Altitude Cerebral Edema (HACE)
- Availability of oxygen decreases significantly over 3000 m (10,000 ft). for this reason, the **cabin altitude in passenger aircraft is kept to 8000 ft**
- Higher altitudes also mean lesser protection to UV radiation

FORMATION OF MOUNTAINS

- **Mountains are usually produced by the movement of lithospheric plates**
- Major mountains tend to occur along long linear arcs, indicating tectonic plate boundaries
- Compressional forces in continental collisions cause the compressed region to thicken and force the upper surface upwards

- Meanwhile, in order to balance the weight, much of the compressed rock is forced downwards as well, forming deep "mountain roots". As a result, **mountains form upwards as well as downwards.**

TYPES OF MOUNTAINS

- **Fold Mountains**
    - Formed by the effects of folding on layers within the upper part of the earth's crust
    - Fold mountains are generally formed on the less deformed areas adjacent to areas strongly affected by thrust tectonics
    - Most fold mountains are likely to relative young in geological terms since they will start to erode as soon as they are formed
    - Examples: Zagros mountains (Iran), Jura mountains (near the Alps i.e. France, Switzerland, Germany)
- **Fault-block mountains**
    - Formed when large areas of bedrock are broken up by faults creating large vertical displacements of continental crust
    - These mountains are formed by the crust being stretched and extended by tensional forces
    - The uplifted blocks are called block mountains or horsts. The intervening dropped blocks are called *graben*, and can form extensive rift valleys
    - Examples: Vosges (northeast France), Basin and Range (western USA)
- **Volcanic mountains**
    - Isolated mountains produced by volcanoes
    - Includes small islands that reach great heights beyond the ocean floor
    - Example: Mount Kilimanjaro (Tanzania)
- **Inselberg (or Monadnock)**
    - They are isolated hills or small mountains that rise abruptly from a surrounding plain
    - They arise when a rock resistant to erosion is enclosed within a softer rock like limestone. When the limestone erodes away to form the nearby plains, the resistant rock is left behind as an island-mountain
    - Example: sugarloaf mountain (Brazil), Pilot Mountain (USA)

THE SEVEN SUMMITS

- The Seven Summits are the highest mountain peaks of each of the seven continents
- The Seven Summits are
  - Africa: Mount Kilimanjaro – Tanzania
  - Antarctica: Vinson Massif – British Antarctic Territory
  - Australia: Kosciuszko – Australia
  - Asia: Mount Everest – Nepal, Tibet
  - Europe: Elbrus – Russia
  - North America: Mount McKinley (Denali) – Alaska
  - South America: Aconcagua – Argentina

Important Mountain ranges in the world

Mountain Range	Location	Length (km)	Notes
Mid ocean ridge		65,000	Underwater mountain range Longest mountain range in the world Demarcates boundary b/w tectonic plates Consists of seven ridges connected together: Gakkel Ridge, Mid Atlantic, Southwest Indian, Central Indian, Southeast Indian, Pacific Antarctic, East Pacific Rise
Andes	South America	7000	Longest continental mountain range Highest mountain range outside Asia
Rocky	North America	4800	
Himalayas	Asia	3800	Highest mountain range on earth Includes Karakoram, Hindu Kush Separates Indian subcontinent from Tibetan plateau
Great Dividing Range	Australia	3700	
Transantarctic Mountains	Antarctica	3500	Serve as division b/w East Antarctica from West Antarctica

IMPORTANT MOUNTAIN PEAKS IN THE WORLD

Mountain peak	Height (m)	Mountain Range	Location	Notes
Mount Everest	8848	Himalayas	Nepal/ Tibet	Highest mountain on earth
K2(Mt. Godwen-usten)	8611	Karakoram	Pakistan/China	Second highest mountain Second highest fatality rate (25%)
Kangchenjunga	8586	Himalayas	Nepal/India	Highest in India
Annapurna	8091	Himalayas	Nepal	Highest fatality rate (40%)
Aconcagua	6961	Andes	Argentina	Highest mountain outside Asia
Mt. Kilimanjaro	5895	Kilimanjaro	Tanzania	Highest volcanic mountain Highest in Africa
Mt Erebus	3794		Antarctica (Ross Island)	Southernmost active volcano
Mt Chimborazo	6268	Andes	Ecuador	Point on surface most distant from earth’s centre

IMPORTANT MOUNTAIN RANGES IN INDIA

Mountain range	Location	Notes
Himalayas		
Aravalli	Rajasthan, Haryana, Gujarat	Were extremely tall in ancient times, now completely worn down due to weathering
Vindhyas	Gujarat, Madhya Pradesh	Earliest known fossil of eukaryotes discovered here (1.6 billion years)
Satpura	Gujarat, Maharashtra, Madhra Pradesh, Chattisgarh	
Sivalik Hills	Sikkim, Nepal, Uttarakhand, Kashmir, Pakistan	Southernmost and geologically youngest of the Himalayan system

Eastern Ghats	West Bengal, Orissa, Andhra Pradesh, Tamil Nadu	Discontinuous range of mountains Older than Western Ghats
Western Ghats	Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu	60% of Western Ghats located in Karnataka Rivers from Western Ghats drain 40% of India One of world's ten "Hottest Biodiversity Spots"
Nilgiri Hills	Tamil Nadu	UNESCO World Heritage Site
Anamalai Hills (Western Ghats)	Kerala, Tamil Nadu	Under consideration for UNESCO World Heritage Site
Cardamom Hills (Western Ghats)	Kerala, Tamil Nadu	Under consideration for UNESCO WHS
Southwest Indian Ridge	Indian Ocean	Separates African Plate from Antarctic Plate
Central Indian Ridge	Indian Ocean	Boundary between African Plate and Indo-Australian Plate
Southeast Indian Ridge	Indian Ocean	Separates Indo-Australian Plate from Antarctic Plate

IMPORTANT MOUNTAIN PEAKS IN INDIA

Mountain peak	Mountain range	Location	Notes
Kangchenjunga	Himalayas	Sikkim	Highest peak in India Third highest in the world
Nanda Devi	Himalayas	Uttarakhand	Highest peak entirely within India
Anamudi	Anaimalai Hills (Western Ghats)	Kerala	Highest peak in India outside the Himalayas
Mount Abu	Aravalli Hills	Rajasthan	Highest peak in the Aravallis

The Deccan traps, one of the largest volcanic features on Earth, were instrumental in the extinction of Dinosours. Located in the Deccan plateau, they are more than 2 km thick and cover more than 500,000 sq. Km . The volcanic eruptions that formed thr traps about 66 million years ago were so enormous that they led to the extionction on non-avian dinosaurs.

COMPOSITION AND STRUCTURE OF 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. 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

COMPOSITION OF THE ATMOSPHERE

The atmosphere is composed of gases, water vapour and dust particles. Table below shows details of various gases in the air, particularly in the lower atmosphere. 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.

Table

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	

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 other gases is constant but 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

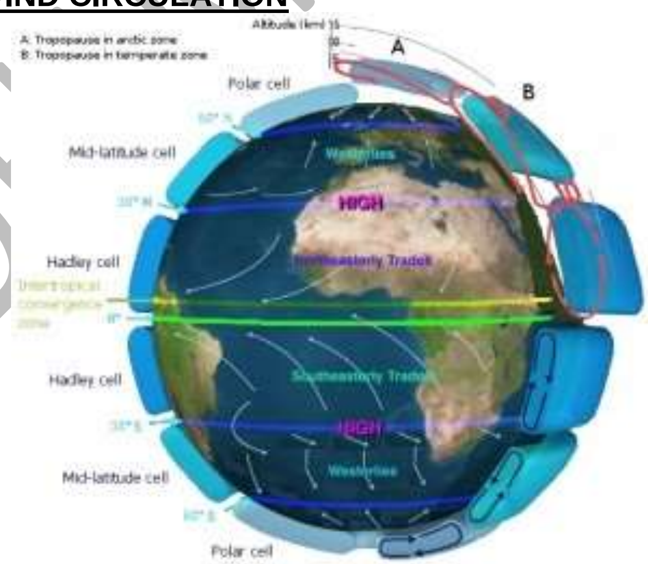
Water vapour is also a variable gas in the atmosphere, which decreases with altitude. In the warm and wet tropics, it may account for four per cent of the air by volume, while in the dry and cold areas of desert and polar regions, it may be less than one per cent of the air. Water vapour also decreases 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.

WIND CIRCULATION

OVERVIEW



The global circulation patterns of wind on Earth

- Winds that blow predominantly from a single direction over a particular point on the Earth's surface are called **Prevailing Winds**
- The general trends in wind direction are called **dominant winds**
- In general regional winds can be divided into two groups
    - **Global winds** like easterlies, westerlies
    - **Local winds** like land breeze, sea breeze

- **Prevailing winds greatly influence climate patterns such as rainfall gradients**, where the windward side of mountains have high rainfall while leeward side experience desert conditions
- **Wind rose** is a graphic plotting tool that is used to describe the speed and direction of wind at a particular location
- Insects drift along prevailing winds, while birds are able to fly independent of them

Distribution of prevailing winds

- In general, **easterly winds flow at low and high altitudes** i.e. near the tropics and the poles
- **Westerly winds flow at the mid-latitudes**
- Directly under the subtropical ridge i.e. close to the equator, winds are lighter in intensity. **These subtropical regions are called the doldrums, or horse latitudes**
- **The strongest winds are usually in the mid-latitudes,** where cold air from the Artic meets warm air from the tropics
- **Most of the earth's deserts are found near the subtropical ridge,** with high pressure leading to low humidity

GLOBAL WINDS

- **Trade Winds**
    - **Trade winds are the prevailing easterly winds that blow across the tropics**
    - They blow from the northeast in the northern hemisphere and from the southeast in the southern hemisphere
    - **Trade winds act as the steering for tropical storms that form in the Atlantic, Pacific and south Indian Oceans.** These storms make landfall in North America, Southeast Asia and India, respectively
    - **Trade winds steer African desert dust across the Atlantic Ocean towards North America** (esp. the Caribbean and Florida)
    - The weaker a trade wind becomes, the more rainfall it brings
    - Trade winds are stronger in winter than summer
    - The one region of the Earth where trade winds are absent is the north Indian Ocean

- **WESTERLIES**
    - **Westerlies are the prevailing winds in the mid-latitudes i.e. between 35 and 65 degrees latitude**
    - They blow from high pressure areas in the horse latitudes towards the poles
    - Westerlies blow from the southwest in the northern hemisphere and from the northwest in the southern hemisphere

- **Westerlies are instrumental in carrying warm equatorial winds towards the western coasts of continents**
- **They are responsible for carrying desert dust from the Gobi Desert into North America**
- They are stronger in winter than in summer, and over regions that have less land to interrupt their flow. They are stronger in the Southern Hemisphere because of the vast ocean expanses uninterrupted by land mass
- **Westerlies are strongest in the Roaring Forties i.e. between 40 and 50 degrees latitude**

- **POLAR EASTERLIES**
  - **Polar easterlies are the prevailing winds that blow at the north and south poles**
  - They are cold and dry winds
  - **They blow from high pressure areas near the poles towards low pressure areas within the mid-latitudes**
  - They blow from the east to the west
  - Polar easterlies are often weak and irregular
  - **They are also called Polar Hadley Cells**, named after George Hadley who discovered them in 1753

LOCAL WINDS

NOTABLE LOCAL WINDS

1. Sea and land Breeze

1. Sea and land breezes are caused by the temperature differential between the sea and coastal areas
2. Sea breeze occurs when the land gets heated during the day creating a low pressure, and cool air from the sea rushes in
3. Land breeze occurs when the land cools off rapidly at night causing low pressure over the sea, and warm air flows from the land to the sea
4. Sea breeze occurs during the day while land breeze occurs at night

2. Mountain winds

1. In elevated surfaces heating of the ground exceeds heating of surrounding air, thereby changing wind circulation
2. Hills and valleys significantly distort airflow by acting as physical barriers. **This is known as barrier jet**
3. Jagged terrain results in unpredictable flow patterns and turbulence
4. Passes in the mountain range experience lower pressure resulting in high wind speeds and erratic and turbulent air currents
5. These conditions are dangerous to ascending and descending airplanes

MONSOON WINDS

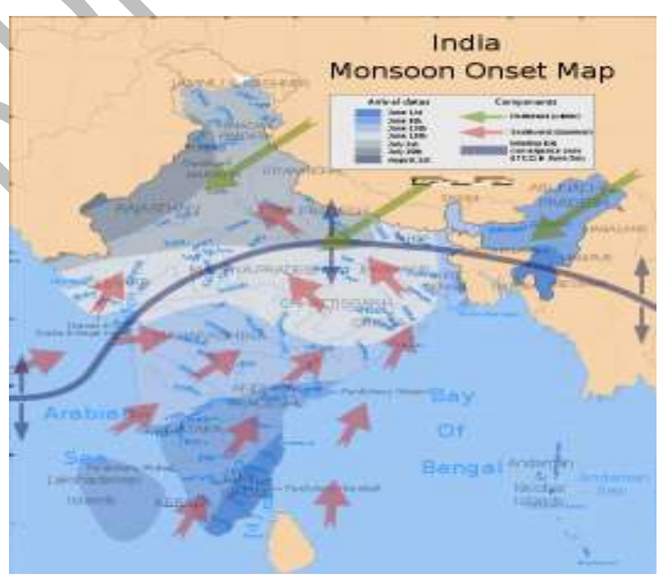
OVERVIEW

- **Monsoons are defined as seasonal reversing winds accompanied by seasonal changes in precipitation**
- The major monsoon systems of the world are the West African and Asia-Australian monsoon systems
- **The origin of monsoons about 15-20 million years ago has been linked to the uplift of the Tibetan Plateau after the collision of India and Asia 50 million years ago**

CAUSE OF MONSOONS

- Monsoons are caused by the larger amplitude of seasonal land temperature cycle compared to that of nearby oceans. This temperature differential arises because air over land warms faster and reaches higher temperature than the air over nearby ocean
- The hot air over land tends to rise creating a low pressure
- This creates a steady wind blowing from the ocean towards land, bringing moist air from the oceans
- In winter the land cools off quickly creating a high pressure that blows wind from land to sea
- In essence, monsoons are similar to sea and land breezes, except that they occur on a much larger scale

THE SOUTHWEST MONSOON



The Southwest monsoon in India. It brings about 80% of India's annual rainfall

- The southwest monsoon occurs from June to September

- The southwest monsoon is caused by rapid heating of the Thar desert and north-central India in summer, creating a low pressure that is filled by moisture laden winds from the Indian Ocean
- The Himalayas prevent the wind from blowing towards Central Asia and redirect them inwards to cause rainfall
- The Arabian Sea branch of the southwest monsoon brings rainfall to the Malabar coast and central India
- The Bay of Bengal branch of the southwest monsoon picks up additional moisture in the Bay of Bengal and arrives at the eastern Himalayas, and then turns west towards the Indo-Gangetic plains
- **Mawsynram in Shillong is the wettest place on Earth with about 12,000 mm of rainfall annually**
- The traditional start date of the southwest monsoon is June 01
- **The southwest monsoon accounts for 80% of rainfall in India**

THE NORTHEAST MONSOON

- The northeast monsoon occurs October to December in India
- Around September, northern India begins to cool rapidly creating a high pressure zone
- This brings dry cold winds from the Himalayas towards the Deccan and into the Indian Ocean
- While travelling towards the Indian Ocean, the wind picks up moisture in the Bay of Bengal and pours it over southern peninsular India
- **The northeast monsoon accounts for 50-60% of rainfall in Tamil Nadu**

JET STREAMS

Overview

The polar and subtropical jet streams

- Jet streams are fast, narrow air currents in the atmosphere
- Jet streams are usually located near the tropopause (transition between troposphere and stratosphere)

- **The main jet streams are westerly winds, flowing from the west to the east**
- Jet streams are used for weather forecasting and aviation. It is hypothesised that they could be used as an energy source as well
- **Jet streams have been observed in the atmosphere of Jupiter as well**

CAUSE OF JET STREAMS

- Jet streams are caused by a combination of atmospheric heating and the rotation of the earth
- They form near boundaries of adjacent air masses with significant differences in temperature

OCCURRENCE OF JET STREAMS

- **The strongest jet streams are the polar jets (23,000-39,000 ft) and the somewhat weaker subtropical jets (33,000-52,000 ft)**
- Other weaker jets also exist, especially over central USA
- There is one polar jet stream and one subtropical jet stream each in the northern and southern hemispheres
- The northern hemisphere polar jet is situated over the northern latitudes of North America, Europe and Asia, while the southern polar jet always circles Antarctica
- The northern and southern hemisphere jet streams have been found to be drifting towards the poles at a rate of 2.1 km per year
- **Jet streams are typically a few hundred miles wide and about 3 miles thick vertically**
- **Wind speeds usually exceed 92 km/h**, although speeds of over 398 km/h have been observed

Jet streams and aviation

- Jet streams are often as the preferred flight plans for commercial airliners
- **Flying with the jet streams decreases travel time and reduced fuel consumption**
- Conversely, flying against jet streams can add to travel time and increase fuel consumption. For this reason, flight plans use circuitous routes to avoid flying against jet streams
- Commercial use of jet streams began in 1952 on the Tokyo-Honolulu route cutting travel time from 18 hours to 11.5 hours

A FEW NOTEWORTHY LOCAL WINDS

Wind	Location	Description
Calima	Sahara to Canary Islands (west African coast)	Carries dust from the Sahara
Chinook	Rocky mountains	Warm, dry westerly winds
Elephanta	Malabar coast	South easterly wind Marks end of southwest monsoon
Nor'easter	North east USA	Strong storm winds from the northeast
Nor'wester	East coast of New Zealand	Warm dry winds
Santa Ana winds	Southern California	Strong, extremely dry winds Responsible for frequent wildfires
Sirocco	North Africa, Europe	Strong winds from the Sahara that cause dusty dry conditions in north Africa and cold wet conditions in Europe Reaches hurricane speeds, can last hours to days
Shamal	Persian Gulf	Strong Northwesterly wind Causes large sandstorms in Iraq

<u>WIND</u>

CAUSES OF WIND

- **Wind is caused by differences in pressure**
- It always flows from high pressure to low pressure
- The two major driving factors of large scale atmospheric circulation are
  - **Heating difference between the equator and the poles**
  - **Rotation of the planet**, which leads to air being deflected according to the Coriolis effect. Coriolis effect is the apparent deflection of moving objects when viewed from a rotating reference frame
- Near the Earth's surface, **friction causes wind to be slower** than it otherwise would be
- Away from the surface, large scale winds tend to approach a **state of equilibrium called Geostropic Balance**

MEASUREMENT OF WIND

A rock formation in Bolivia, sculpted by wind erosion

- Wind direction is reported based on the **direction from which it originates**. Eg: a northerly wind blows from the north to the south
- Wind direction is observed using **weather vanes** (atop buildings) and **windsocks** (at airports)
- Wind speed is measured using **anemometers**
- **Weather balloons and RADAR/LIDAR** can also be used for measuring wind speed and direction
- Sustained winds are usually observed 10 m from the surface of the Earth
- Globally, wind speeds are reported over a 10 minute average. **India reports winds over a 3 minute average**

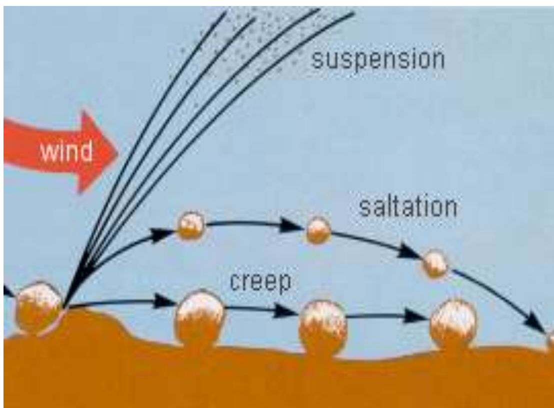
WIND CATEGORIZATION ON THE BEAUFORT SCALE

Beaufort scale	Wind speed (knots)	General term	Terminology of IMD (covers north Indian Ocean)
0 – 6	0 – 27	Breeze	Depression
7	28-33	Gale	Deep depression
8 – 9	34 – 47	Strong gale	Cyclonic storm
10 – 11	48 – 63	Storm	Severe cyclonic storm
12 – 16	64 – 120	Hurricane	Very severe cyclonic storm
17	> 120	Hurricane	Super cyclonic storm

AEOLIAN PROCESSES

Aeolian process refers to the action of wind in shaping the surface of the Earth.

1. **Wind erosion**
    1. Wind erodes the earth by **deflation and abrasion**. Deflation is the removal of fine, loosely grained particles while abrasion is the wearing down of surfaces by grinding action
    2. Regions that experience intense and sustained erosion are called **deflation zones**
    3. Desert rocks that have been exposed to wind for long periods of time exhibit a dark shiny stain called **desert varnish**
    4. **Blowouts** are hollows formed by the removal of particles by wind
2. **Wind transport**



Suspension, saltation and creep

1. Particles are transported by wind through the processes of suspension, saltation and creep
2. **Suspension is the holding of small particles in the atmosphere due to upward currents in air.** Dust and haze are examples of suspension.
3. **Saltation is the movement of particles in jumps and skips by lifting up slightly from the surface.** Examples of saltation include sand drift over deserts, soil blowing over fields.
4. **Creep is the slow downward progression of rock and soil down a low grade slope.** Creep is responsible for the rounded shape of hillsides

Other wind transport phenomena include dust storms and dust devils. Covered in detail below

3. **Wind deposition**
    1. Wind-deposited bodes occur as sand sheets, ripples and dunes
    2. **Sand sheets are flat, gently undulating surfaces of sand.** They form about 40% of Aeolian deposition surfaces.
    3. **Wind blowing on a sand surface also causes ripples,** which form into crests and troughs. In ripples, the coarsest materials collect on the crests
    4. **Sand dunes are hills of sand** similar to ripples, except that they are larger and have the coarsest materials on the troughs

ROLE OF WIND IN NATURE

1. **DESERT DUST MIGRATION**
    1. Dust from deserts is carried across huge distances over to other continents
    2. Example: dust from the Sahara desert blows via the Caribbean to North America
    3. Desert dust migration can affect rainfall patterns
    4. It also causes the sky to change colour from blue to white

2. **EFFECT ON PLANTS**
    1. **The dispersal of seeds through wind is called anemochory**
    2. Examples of seeds that disperse through wind: dandelions, maples, weeds
    3. Wind also limits tree growth. **The tree line is often lower in coasts and isolated mountains because high winds reduce tree growth**
    4. Wind also causes soil erosion leading to uprooting of trees

3. **EFFECT ON ANIMALS**
    1. Cattle and sheep are prone to wind chill when high wind speeds render their protective covering inffective
    2. For penguins, their flippers and feet are susceptible as well
    3. Bird migration and insect return tend to flow with wind patterns

WIND IN OUTER SPACE

1. **Planetary wind**
    1. The loss of gas from a planet to outer space is called planetary wind
    2. This happens when light elements such as hydrogen move up to the exobase (limit of atmosphere), and then reach escape velocity to escape to outer space
    3. The planet Venus is said to have its atmosphere due to planetary wind

2. **Solar wind**
    1. **Solar wind is a stream of charged particles (plasma) ejected from the sun**
    2. This plasma is ejected from the upper atmosphere of the sun at up to 400 km/s
    3. Solar wind creates the heliosphere, a vast bubble in interstellar medium

4. Planets require large magnetic fields to reduce the ionization of their upper atmosphere by solar wind. **Mars is said to have lost its atmosphere due to solar wind**
5. The surfaces of Venus and the Moon are bombarded directly by solar wind, resulting in high radiation levels

GEOLOGICAL PHENOMENA CAUSED BY WIND

1. **SAND DUNES**
    1. Sand dunes are hills of sand built by wind
    2. **Dunes are usually longer on the windward side and shorter on the leeward side**
    3. Sand dunes can form in dry inland regions and also in coastal areas and underwater as well
    4. **Dunes can move over tens of metres due to the consistent action of strong wind.** Through saltation, wind picks up particles from the windward side and deposits it on the leeward side, gradually moving the dune
    5. **The tallest sand dunes in the world are found in the Namib Desert**
2. **ERG**
    1. **An Erg is a large area of desert covered with wind-swept sand with little or no vegetative cover**
    2. In essence, ergs are large dune fields
    3. Ergs are mainly found in Africa, central and western Asia and central Australia
    4. Ergs have been found on Venus, Mars and Titan as well
3. **Loess**

The rich fertile soil of the Loess plateau has been the mainstay of Chinese agriculture for centuries

1. **Loess is a sediment formed by the accumulation of wind-blown silt, sand and clay, loosely cemented by calcium carbonate**

2. **Loess deposits often occur in very thick layers, sometimes more than 100 m thick.** It occurs as a blanket deposit covering areas of hundreds of square km
3. Loess is highly prone to erosion
4. Loess can occur from glacial or non-glacial soils. Example of glacial loess: Mississippi Valley, USA. Example of non-glacial loess: Shanxi, China
5. **Loess tend to develop into highly fertile soils**

4. **WIND WAVES**
    1. Wind waves are surface waves that occur in oceans, lakes etc due to the action of wind
    2. Wind waves can range from ripples to more than 30 m in height
    3. A wind wave system generated by local winds in called wind sea. Wind wave system not generated by local winds is called swell
    4. Factors that influence the formation of waves include: wind speed, distance of open water, time duration and water depth
    5. **Tsunamis and tides are specific types of waves caused not by wind, but by geological effects.** They have longer wavelength than wind waves
    6. Waves can be measured using buoys that record the motion of the water surface
    7. A breaking wave is one whose one can no longer support its top causing it to collapse
    8. There are three main types of waves
        1. **Spilling or rolling waves: Safest waves for surfing.** Most common type of waves found at shores.
        2. **Plunging or dumping waves: preferred by experienced surfers.** Found where there is a sudden rise in ocean floor like a sandbar
        3. **Surging waves: very dangerous for surfing.** Tend to form on steep shorelines, where the depth results in waves not breaking as they approach the shore

GEOGRAPHICAL FEATURES SHAPED BY WIND

Feature	Location	Wind effect	Notes
Mississippi River Alluvial Valley	South-central USA	Glacial loess	
Loess plateau	Shanxi, Northern China	Non-glacial loess	Thickest loess in the world (335 m) Most erodible soil on earth
Selima sand sheet	Egypt, Sudan	Wind deposition	Largest sand sheet

Feature	Location	Wind effect	Notes
Namib desert sand dunes	Namibia, Angola	Wind deposition	Oldest desert in the world (55 million years)
Paha	Iowa, USA	Sand dunes	
Badain Jaran desert	Inner Mongolia (China, Mongolia)	Sand dunes	Tallest stationary sand dunes in the world (500 m)
Great dune of Pilat	France	Sand dune	Largest sand dune in Europe
Merheb	UAE	Sand dune	Used for motor sports
Kelso dunes	USA	Sand dune	
Cerro Blanco	Sechura Desert, Peru	Sand dune	Highest sand dune in the world

Keywords: India, ias, upsc, civil service, study material, general studies, global geography, free

STRUCTURE OF THE ATMOSPHERE

The atmosphere consists of different layers with varying density and temperature. Density is highest near the surface of the earth and decreases with increasing altitude. The column of atmosphere is divided into five different layers depending upon the temperature condition. They are: troposphere, stratosphere, mesosphere, thermosphere and exosphere. *The troposphere* is the lowermost layer of the atmosphere. Its average height is 13 km and extends roughly to a height of 8 km near the poles and about 18 km at the equator. Thickness of the troposphere is greatest at the equator because heat is transported to great heights by strong convectional currents. This layer contains dust particles and water vapour.

All changes in climate and weather take place in this layer. The temperature in this layer decreases at the rate of 1°C for every 165m of height. This is the most important layer for all biological activity. The zone separating the tropsophere from stratosphere is known as the *tropopause*. The air temperature at the tropopause is about minus 800C over the equator and about minus 45oC over the poles. The temperature here is nearly constant, and hence, it is called the tropopause. *The stratosphere* is found above the tropopause and extends up to a height of 50 km. One important feature of the stratosphere is that it contains the *ozone layer*. This layer absorbs ultra-violet radiation and shields life on the earth from intense, harmful form of energy. *The mesosphere* lies above the stratosphere, which extends up to a height of 80 km. In this layer, once again, temperature starts decreasing with the increase in altitude and reaches up to minus 100°C at the height of 80 km. The upper limit of mesosphere is known as the *mesopause*. *The ionosphere* is located between 80 and 400 km above the mesopause.

It contains electrically charged particles known as ions, and hence, it is known as ionosphere. Radio waves transmitted from the earth are reflected back to the earth by this layer. Temperature here starts increasing with height. The uppermost layer of the atmosphere above the thermosphere is known as the *exosphere*. This is the highest layer but very little is known about it. Whatever contents are there, these are extremely rarefied in this layer, and it gradually merges with the outer space. Although all layers of the atmosphere must be exercising influence on us, geographers are concerned with the first two layers of the atmosphere.

ELEMENTS OF WEATHER AND CLIMATE

The main elements of atmosphere which are subject to change and which uman life on earth are tinfluence hemperature, pressure, winds, humidity, clouds and precipitation. These elements have been dealt in detail in.

SOLAR RADIATION, HEAT BALANCE AND TEMPERATURE

The earth receives almost all of its energy from the sun. The earth in turn radiates back to space the energy received from the sun. As a result, the earth neither warms up nor does it get cooled over a period of time. Thus, the amount of heat received by different parts of the earth is not the same. This variation causes pressure differences in the atmosphere. This leads to transfer of heat from one region to the other by winds. This chapter explains the process of heating and cooling of the atmosphere and the resultant temperature distribution over the earth's surface.

SOLAR RADIATION

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*. 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. On an average the earth receives 1.94 calories per sq. cm per minute at the top of its atmosphere. 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 3rd 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 66½ 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 given in

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 sun rays. The area covered by vertical rays is always less than the slant rays. If more area is covered, the energy gets distributed and the net energy received per unit area decreases. Moreover, the slant rays are required to pass through greater depth of the atmosphere resulting in more absorption, scattering and diffusion. colour of the sky are the result of scattering of light within the atmosphere. *The Passage of Solar Radiation through the Atmosphere* The atmosphere is largely transparent to short wave solar radiation. The incoming solar radiation passes through the atmosphere before striking the earth's surface. Within the troposphere water vapour, ozone and other gases absorb much of the near infrared radiation. Very small-suspended particles in the troposphere scatter visible spectrum both to the space and towards the earth surface. This process adds colour to the sky. The red colour of the rising and the setting sun and the blue *Spatial Distribution of Insolation at the Earth's Surface* The insolation received at the surface varies from about 320 Watt/m2 in the tropics to about 70 Watt/m2 in 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

There are different ways of heating and cooling of the atmosphere. The earth after being heated by insolation transmits the heat to the atmospheric layers near to the earth in long wave form. The air in contact with the land gets heated slowly and the upper layers in contact with the lower layers also get heated. This process is called *conduction*. Conduction takes place when two bodies of unequal temperature are in contact with one another, there is a flow of energy from the warmer to cooler body. The transfer of heat continues until both the bodies attain the same temperature or the contact is broken. Conduction is important in heating the lower layers of the atmosphere. The air in contact with the earth rises vertically on heating in the form of currents and further transmits the heat of the atmsphere. This process of vertical heating of the atmosphere is known as *convection*. The convective transfer of energy is confined only to the troposphere. The transfer of heat through horizontal movement of air is called *advection*. Horizontal movement of the air is relatively more important accumulate or loose heat. It maintains its temperature. This can happen only if the amount of heat received in the form of insolation equals the amount lost by the earth through terrestrial radiation. Consider that the insolation received at the top of the atmosphere is 100 per cent.

While passing through the atmosphere some amount of energy is reflected, scattered and absorbed. Only the remaining part reaches the earth surface. Roughly 35 units are reflected back to space even before reaching the earth's surface. Of these, 27 units are reflected back from the top of the clouds and 2 units from the snow and ice-covered areas of the earth. The reflected amount of radiation is called the *albedo of the earth*. The remaining 65 units are absorbed, 14 units within the atmosphere and 51 units by the earth's surface. The earth radiates back 51 units in the form of terrestrial radiation. Of these, 17 units are radiated to space directly and the remaining 34 units are absorbed by the atmosphere (6 units absorbed directly by the atmosphere, 9 units through convection and turbulence and 19 units through latent heat of condensation). 48 units absorbed by the atmosphere (14 units from insolation +34 units from than the vertical movement. In middle latitudes, most of dirunal (day and night) variation in daily weather are caused by advection alone. In tropical regions particularly in northern India during summer season local winds called 'loo' is the outcome of advection process.

TERRESTRIAL RADIATION

The insolation received by the earth is in short waves forms and heats up its surface. The earth after being heated itself becomes a radiating body and it radiates energy to the atmosphere in long wave form. This energy heats up the atmosphere from below. This process is known as terrestrial radiation. 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.

HEAT BUDGET OF THE PLANET EARTH

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. *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. In the net radiation balance of the earth-the atmosphere system. The 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. 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 airmass circulation; (iv) the presence of warm and cold ocean currents; (v) local aspects. *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.

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 and Ocean currents*: 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 airmasses experience low temperature. Similarly,

TEMPERATURE

The interaction of insolation with the atmosphere and the earth's surface creates 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. *Distribution of Temperature* The global distribution of temperature can well be understood by studying the temperature distribution in January and July. The temperature distribution is generally shown on the map with the help of isotherms. The *Isotherms* are lines joining places having equal temperature. In general the effect of the latitude on temperature is well pronounced on the map, as the isotherms are generally parallel to the latitude. The deviation from this general trend is more pronounced in January than in July, especially in the northern hemisphere. In the northern hemisphere the land surface area is much larger than in the southern hemisphere. 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. The presence of warm ocean currents, Gulf Stream and North Atlantic drift, make the Northern Atlantic Ocean warmer and the isotherms bend towards the north. Over the land the temperature decreases sharply and the isotherms bend towards south in Europe. It is much pronounced in the Siberian plain. The mean January temperature along 60° E longitude is minus 20° C both at 80° N and 50° N latitudes. The mean monthly temperature for January is over 27° C, in equatorial oceans over 24° C in the tropics and 2° C - 0° C in the middle latitudes and –18° C to –48° C in the Eurasian continental interior. The effect of the ocean is well pronounced in the southern hemisphere. Here the isotherms are more or less parallel to the latitudes and the variation in temperature is more gradual than in the northern hemisphere. The isotherm of 20° C, 10° C, and 0° C runs parallel to 35° S, 45° S and 60° S latitudes respectively. In July the isotherms generally run parallel to the latitude. The equatorial oceans record warmer temperature, more than 27°C. Over the land more than 30°C is noticed in the subtropical continental region of Asia, along the 30° N latitude. Along the 40° N runs the isotherm of 10° C and along the 40° S the temperature is 10° C. 9.5 shows the range of temperature between January and July. The highest range of temperature is more than 60° C over the north-eastern part of Eurasian continent. This is due to continentality. The least range of temperature, 3°C, is found between 20° S and 15° N.

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. Over polar areas, temperature inversion is normal throughout the year. Surface inversion promotes stability in the lower layers of the atmosphere. Smoke and dust particles get collected beneath the inversion layer and spread horizontally to fill the lower strata of the atmosphere. Dense fogs in mornings are common occurrences especially during winter season. This inversion commonly lasts for few hours until the sun comes up and beings to warm the earth. The inversion takes place in hills and mountains due to air drainage. Cold air at the hills and mountains, produced during night, flows under the influence of gravity. Being heavy and dense, the cold air acts almost like water and moves down the slope to pile up deeply in pockets and valley bottoms with warm air above. This is called *air drainage.* It protects plants from frost damages. Plank's law states that hotter a body, the more energy it will radiate and shorter the wavelength of that radiation. Specific heat is the energy needed to raise the temperature of one gram of substance by one Celsius.

ATMOSPHERIC CIRCULATION AND WEATHER SYSTEMS

Earlier Chapter 9 described the uneven distribution of temperature over the surface of the earth. Air expands when heated and gets compressed when cooled. This results in variations in the atmospheric pressure. The result is that it causes the movement of air from high pressure to low pressure, setting the air in motion. You already know that air in horizontal motion is wind. Atmospheric pressure also determines when the air will rise or sink. The wind redistributes the heat and moisture across the planet, thereby, maintaining a constant temperature for the planet as a whole. The vertical rising of moist air cools it down to form the clouds and bring precipitation. This chapter has been devoted to explain the causes of pressure differences, the forces that control the atmospheric circulation, the turbulent pattern of wind, the formation of air masses, the disturbed weather when air masses interact with each other and the phenomenon of violent tropical storms.

ATMOSPHERIC PRESSURE

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.

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 purposes of comparison. The sea level pressure distribution is shown on weather maps. Low pressure system is enclosed by one or more isobars with the lowest pressure in the centre. High-pressure system is also enclosed by one or more isobars with the highest pressure in the centre.

WORLD DISTRIBUTION OF SEA LEVEL PRESSURE

Near the equator the sea level pressure is low and the area is known as *equatorial low*. Along 30° N and 30o S are found the high-pressure areas known as the subtropical highs. Further pole wards along 60o N and 60o 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 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.

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.

Frictional Force

It affects the speed of the wind. It is greatest at the surface and its influence generally extends upto 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 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. The wind at the surface experiences friction. In 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. Thus, the horizontal winds near the earth surface respond to the combined effect of three forces – the pressure gradient force, the frictional force and the Coriolis force. In addition, the gravitational force acts downward, 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 are the net result of the wind generating forces. The winds in the upper atmosphere, 2 - 3 km above the surface, are free from frictional effect of the surface and are controlled mainly by the pressure gradient and the Coriolis force. When isobars are straight and when there is no friction, the pressure gradient force is balanced by the Coriolis force and the resultant wind blows parallel to the isobar. This wind is known as the geostrophic wind

Pressure System Pressure Condition Pattern of Wind Direction at the Centre Northern Hemisphere Southern Hemisphere Cyclone Low Anticlockwise Clockwise Anticyclone High Clockwise Anticlockwise 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. The wind circulation at the earth's surface around low and high on many occasions is 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. Apart 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.

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 watercirculation which influences the earth's climate. A schematic description of the general circulation is shown in 10.6. The general circulation of the atmosphere also affects the oceans. The large-scale winds of the atmosphere initiate large and slow moving currents of the ocean. Oceans in turn provide input of energy and water vapour into the air. These interactions take place rather slowly over a large part of the ocean.

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 in different 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. 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.

10. 6 : SIMPLIFIED GENERAL CIRCULATION OF THE ATMOSPHERE

The air at the Inter Tropical Convergence Zone (ITCZ) rises because of convection caused by high insolation and a low pressure 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 30o 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 30o N and S latitudes. Down below near the land surface the air flows towards the equator as the easterlies. The easterlies from either side of the equator converge in the Inter Tropical Convergence Zone (ITCZ). Such circulations from the surface upwards and *vice-versa* are called cells. Such a cell in the tropics is called *Hadley Cell*. In the middle latitudes the circulation is that of sinking cold air that comes from the poles and the rising warm air that blows from the subtropical high. At the surface these winds are called westerlies and the cell is known as the *Ferrel cell*. At polar latitudes the cold dense air subsides near the poles and blows towards middle latitudes as the polar easterlies. This cell is called the polar cell. These three cells set the pattern for the general circulation of the atmosphere. The transfer of heat energy from lower latitudes to higher latitudes maintains the general circulation.

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

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 Masses

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 airmass. 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 airmasses are recognised:
(i) Maritime tropical (mT);
(ii) Continental tropical (cT);
(iii) Maritime polar (mP); (iv) Continental polar (cP);
(v) Continental arctic (cA). 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 *front genesis*. 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 characterised 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*. 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. The plan and cross section of a well developed cyclone is given in 10.9. There are pockets of warm air or warm sector wedged between the forward and the rear old air or cold sector. The warm air glides over the cold air and a sequence of clouds appear over the sky ahead of the warm front and cause precipitation. The cold front approaches the warm air from behind and pushes the warm air up. As a result, cumulus clouds develop along the cold front. The cold front moves faster than the warm front ultimately overtaking the warm front. The warm air is completely lifted up and the front is occluded and the cyclone dissipates. The processes of wind circulation both at the surface and aloft are closely interlinked. The extra tropical cyclone differs from the tropical cyclone in number of ways. The extra tropical cyclones have a clear frontal system which is not present in the tropical cyclones. They cover a larger area and can originate over the land and sea. Whereas the tropical cyclones originate only over the seas and on reaching the land they dissipate. The extra tropical cyclone affects a much larger area as compared to the tropical cyclone. The wind velocity in a tropical cyclone is much higher and it is more destructive. The extra tropical cyclones move from west to east but tropical cyclones, move from east to west.

Tropical Cyclones

Tropical cyclones are violent storms that originate over oceans in tropical areas and move over to the coastal areas bringing about 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) Presence of the Coriolis force;
(iii) Small variations in the vertical wind speed;
(iv) A pre-existing weaklow- pressure area or low-level-cyclonic circulation;
(v) Upper divergence above the sea

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 20o N latitude generally, recurve and they are more destructive. 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 spiralling 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.

WATER IN THE ATMOSPHERE

Water 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 capacity at a given temperature is known as the *relative humidity*. With the change of air temperature, the capacity to retain moisture increases or decreases and the relative humidity is also affected. It is greater over the oceans and least over the continents. The air containing moisture to its full capacity at a given temperature is said to be *saturated*. It means that the air at the given temperature is incapable of holding any additional amount of moisture at that stage. The temperature at which saturation occurs in a given sample of air is known as *dew point*.

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 vapourisation*. Increase in temperature increases water absorption and retention capacity of the given parcel of air. Similarly, if the moisture content is low, air has a potentiality of absorbing and retaining moisture. Movement of air replaces the saturated layer with the unsaturated layer. 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;
(iv) 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 clear sky, calm air, high relative humidity, and 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 (00C), 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.

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 (8,000-12,000m). They are thin and detatched 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 100 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.

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 00C, 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 into 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 – the convectional, orographic or relief and 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 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. 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.

OROGRAPHIC RAIN

When the saturated air mass comes across a mountain, it is forced to ascend and as it rises, it expands; the temperature falls, and the moisture is condensed. 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

As given in earlier part

World Distribution of Rainfall

Different places on the earth's surface receive different amounts of rainfall in a year and that too in different seasons. In general, as we proceed from the equator towards the poles, rainfall goes on decreasing steadily. The coastal areas of the world receive greater amounts of rainfall than the interior of the continents. The rainfall is more over the oceans than on the landmasses of the world because of being great sources of water. Between the latitudes 350 and 400 N and S of the equator, the rain is heavier on the eastern coasts and goes on decreasing towards the west. But, between 450 and 650 N and S of equator, due to the westerlies, the rainfall is first received on the western margins of the continents and it goes on decreasing towards the east. Wherever mountains run parallel to the coast, the rain is greater on the coastal plain, on the windward side and it decreases towards the leeward side. On the basis of the total amount of annual precipitation, major precipitation regimes of the world are identified as follows. The equatorial belt, the windward slopes of the mountains along the western coasts in the cool temperate zone and the coastal areas of the monsoon land receive heavy rainfall of over 200 cm per annum. Interior continental areas receive moderate rainfall varying from 100 - 200 cm per annum. The coastal areas of the continents receive moderate amount of rainfall. The central parts of the tropical land and the eastern and interior parts of the temperate lands receive rainfall varying between 50-100 cm per annum. Areas lying in the rain shadow zone of the interior of the continents and high latitudes receive very low rainfall-less than 50 cm per annum. Seasonal distribution of rainfall provides an important aspect to judge its effectiveness. In some regions rainfall is distributed evenly throughout the year such as in the equatorial belt and in the western parts of cool temperate regions.

GLOBAL CLIMATE AND CLIMATE CHANGE

The world climate can be studied by organising information and data on climate and synthesising 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 organise climates according to their causes. Applied classification is for specific purpose.

KOEPPEN’S SCHEME OF CLASSIFICATION OF CLIMATE

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 lettersto 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 recognised five major climatic groups, four of them are based on temperature and one on precipitation. Table below 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,

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. The distribution of climatic groups and types is shown in

GROUP A: TROPICAL HUMID CLIMATES

Tropical humid climates exist between Tropic of Cancer and Tropic of Capricorn. The sun being overhead throughout the year and the presence of Inter Tropical Convergence Zone (ITCZ) make the climate hot and humid. Annual range of temperature is very low and annual rainfall is high. 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)* Tropical wet climate is found near the equator. The major areas are the Amazon Basin in South America, western equatorial Africa and the islands of East Indies. Significant amount of rainfall occurs in every month of the year as thunder showers in the afternoon. The temperature is uniformly high and the annual range of temperature is negligible. The maximum temperature on any day is around 30°C while the minimum temperature is around 20°C. 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. The detailed climatic account of this climatic type is given in the book on *India:*

***Physical Environment*.**

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

Climatic Types According to Koeppen

Group Type Letter Code Characteristics

Tropical wet Af No dry season Tropical monsoon Am Monsoonal, short dry season Tropical wet and dry Aw Winter dry season 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 Humid subtropical Cfa No dry season, warm summer Mediterranean Cs Dry hot summer Marine west coast Cfb No dry season, warm and cool summer Humid continental Df No dry season, severe winter Subarctic Dw Winter dry and very severe Tundra ET No true summer Polar ice cap EF Perennial ice Highland H Highland with snow cover
A-Tropical Humid Climate
B-Dry Climate
C-Warm temperate (Midlatitude) Climates
D-Cold Snowforest Climates
E-Cold Climates
H-Highland 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 characterised by very low rainfall that is not adequate for the growth of plants. These climates cover a very large area of 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 equatorwards 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 poleward 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 than for 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) Dw- cold climate with dry winter. The severity of winter is more pronounced in higher latitudes. *Cold Climate with Humid Winters (Df)* Cold climate with humid winter occurs poleward 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 (Dw)* Cold climate with dry winter occurs mainly over Northeastern Asia. The development of pronounced winter anti cyclone and its weakening in summer sets in monsoon like reversal of wind in this region. Poleward 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 water logging 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 Antartica. 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.

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 earlier chapters on climate summarized our understanding of climate as it prevails now. The type of climate we experience now might be prevailing over the last 10,000 years with minor and occasionally wide fluctuations. The planet earth has witnessed many variations in climate since the beginning. Geological records show alteration of glacial and inter-glacial periods. The geomorphologic features, especially in high altitudes and high latitudes, exhibit traces of advances and retreats of glaciers. The sediment deposits in glacial lakes also reveal the occurrence of warm and cold periods. The rings in the trees provide clues about wet and dry periods. Historical records describe the vagaries in climate.

All these evidences indicate that change in climate is a natural and continuous process. 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 3,000- 1,700 B.C. had higher rainfall. From about 2,000-1,700 B.C., this region was the centreof the Harappan civilisation. Dry conditions accentuated 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 was about 18,000 years ago. The present inter-glacial period started 10,000 years ago.

CLIMATE IN THE RECENT PAST

Variability in climate occurs all the time. The nineties decade of the last century witnessed extreme weather events. The 1990s recorded the warmest temperature of the century and some of the worst floods around the world. The worst devastating drought in the Sahel region, south of the Sahara desert, from 1967-1977 is 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 and terrestrial causes. The astronomical causes are 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. According to some meteorologists, when the number of sunspots increase, cooler and wetter weather and greater storminess occur. A decrease in sunspot numbers is associated with warm and drier conditions. Yet, these findings are not statistically significant. 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. All these alter the amount of insolation received from the sun, which in turn, might have a bearing on the climate. 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 the 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. When you enter a car or a bus, during summers, where windows are closed, you feel more heat than outside. Likewise during winter the vehicles with closed doors and windows remain warmer than the temperature outside. This is another example of the greenhouse effect.

Greenhouse Gases(GHGs)

The primary GHGs of concern today are carbon dioxide (CO_2), Chlorofluorocarbons (CFCs), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3). 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 molecule 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*. The emission of CO2 comes mainly from fossil fuel combustion (oil, gas and coal). Forests and oceans are the sinks for the carbon dioxide. Forests use CO2 in their growth. So, deforestation due to changes in land use, also increases the concentration of Co2. 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 CO2 over pre-industrial level is 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 industrialised 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 te trend towards global warming.

Let us hope the world community responds to this challenge and adopts a lifestyle that leaves behind a livable world for the generations to come. One of the major concerns of the world today is global warming. Let us look at how much the planet has warmed up from the temperature records. Temperature data are available from the middle of the 19th century mostly for western Europe. The reference period for this study is 1961-90. The temperature anomalies for the earlier and later periods are estimated from the average temperature for the period 1961-90. The annual average near-surface air temperature of the world is approximately 14°C. The time series show anomalies of annual near surface temperature over land from 1856-2000, relative to the period 1961-90 as normal for the globe. An increasing trend in temperature was discernible in the 20th century. 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. Write an explanatory note on "global warming".

ROCKS

OVERVIEW

- Rocks are naturally occurring solid aggregates of minerals or mineraloids (a mineral-like substance that does not exhibit crystallinity)
- The Earth's outer solid layer, the lithosphere, is made of rocks
- Rocks are generally classified into three types
    - Igneous rocks
    - Sedimentary rocks
    - Metamorphic rocks
- **The structure and composition of rocks change over time**, causing one type of rock to be reclassified as another
- **The study of rocks is called petrology**

IGNEOUS ROCKS

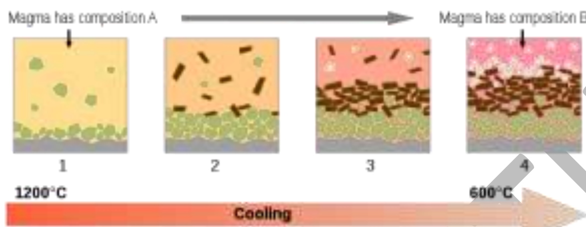
Overview

- **Igneous rocks are rocks which form from the cooling and solidification of magma**
- They are the results of volcanic processes
- The magma can be derived from melts of pre-existing rocks in either the crust or mantle. Typically, rocks melt under conditions of extremely high temperatures, low pressures or changes in composition
- **Igneous rocks can be of two types:**
    - Intrusive (plutonic) rocks

  - Extrusive (volcanic) rocks

- **Igneous rocks make up about 90% of the Earth's crust.** However, they are hidden from the surface by a thin layer of sedimentary and metamorphic rocks
- Igneous rocks can be seen at mid ocean ridges, areas of volcanism and intra-plate hotspots
- They are crystalline and impervious
- They are resistant to erosion and weathering

GEOLOGICAL SIGNIFICANCE OF IGNEOUS ROCKS



Crystallisation of magma leading to igneous rocks

- **Since igneous rocks come from the mantle, the minerals and chemistry of igneous rocks give information about the composition of the mantle**
- Their features are characteristic of a particular tectonic environment, allowing reconstitution of tectonic conditions
- They host important mineral deposits such as uranium, tungsten, tin, chromium, platinum

MINERALOGICAL COMPOSITION OF IGNEOUS ROCKS

- Felsic rock: highest content of silicon with predominance of quartz and feldspar. These rocks are usually light coloured and have low density
- Mafic rock: lesser content of silicon, predominance of mafic minerals (manganese and iron). These rocks are usually dark coloured and have higher density than felsic rocks
- Ultramafic rocks: lowest silicon content, with more than 90% of mafic minerals

	Felsic	Mafic	Ultramafic
Intrusive	Granite	Gabbro	Peridotite
Extrusive	Rhyolite	Basalt	Komatite

INTRUSIVE IGNEOUS ROCKS (PLUTONIC ROCKS)

- Intrusive igneous rocks are formed from magma that cools and solidifies within the crust
- These rocks are coarse-grained. Mineral grains in these rocks can be identified by the naked eye

- **The central cores of most mountain ranges are made of intrusive rocks (usually granite).** These large formations of intrusive rocks are called *batholiths*
- Examples of intrusive igneous rocks include granite and diorite

Extrusive igneous rocks (volcanic rocks)

- Extrusive igneous rocks are formed at the surface, from magma released into the surface from volcanic eruptions
- Extrusive rocks cool and solidify quicker than intrusive
- Extrusive rocks are fine grained in nature
- Examples of extrusive rocks include basalt and rhyolite

Large Igneous Province (LIP)

The Deccan Traps in the Western Ghats

- Large Igneous Provinces are extremely large accumulations of igneous rocks (both intrusive and extrusive)
- **They refer to igneous rocks extending over 100,000 sq km, that formed in a short geological time scale of a few million years or less**
- LIPs usually consist of basalt and rhyolite rocks
- When created, LIPs often have an area of few million sq km and volume on the order of a million cubic km. Majority of the LIP's volume is emplaced in less than a million years.
- **LIP's are postulated to arise from hotspots of linear chains of volcanoes**
- **LIPs are often linked to mass extinction events.** This is said to arise from the enormous quantities of sulphuric acid released into the atmosphere, the subsequent global cooling and absorption of oceanic oxygen.
- **The Deccan Traps, one of the largest volcanic features on Earth, is an example of a Large Igneous Province.** The Traps consist of multiple

layers of basalt, more than 2 km thick and cover an area over 500,000 sq km, and were formed as a result of volcanic eruptions in the Western Ghats about 66 million years ago. It is believed that the enormous volcanic eruptions led to global cooling of around 2C, and were instrumental in the mass extinction of non-avian dinosaurs.

SEDIMENTARY ROCKS
Overview

- **Sedimentary rock is the type of rock formed sedimentation of material.** This sedimentation can occur on the Earth's surface or within bodies of water
- **Sedimentary rocks form the thin outermost layer of the earth's crust, making up about 5% of the total volume of the crust**
- Sedimentary rocks are deposited in strata called bedding
- **Coal is a sedimentary rock**
- Examples of sedimentary rocks include shale, sandstone, limestone

Geological significance of sedimentary rocks

- The study of sedimentary rock strata serves as the main source of scientific knowledge about the Earth's geological history
- **Sedimentary rocks are the only rocks that contain fossils.** Sedimentary rocks contains fossils because, unlike igneous and metamorphic rocks, they form at temperatures and pressures that do not destroy fossils

Sedimentary rocks are the only rocks that contain fossils

- Study of sedimentary rocks provides information about subsurface, which is important in civil engineering for construction of roads, bridges etc
- **Sedimentary rocks are also important sources of natural resources like fossil fuels, water, ores etc**

COMPOSITION OF SEDIMENTARY ROCKS

- **Most sedimentary rocks contain either quartz or calcite**
- Unlike igneous and metamorphic rocks, sedimentary rocks do not contain multiple major minerals

- Carbonate rocks contain carbonate minerals like calcite, aragonite or dolomite
- Siliclastic rocks contain silica-bearing minerals like quartz

CLASTIC SEDIMENTARY ROCKS

- **Clastic rocks are composed of fragments, called *clasts*, of pre-existing rocks**
- Clastic sedimentary rocks are those that are formed from rocks that have been broken down due to weathering, which are then transported and deposited elsewhere
- Clastic sedimentary rocks come in various grain sizes. They range from fine clay in shales, to sand in sandstone and gravel, cobbles and boulder size fragments in conglomerates and breccias
- Conglomerates are clastic sedimentary rocks with rounded fragments, while breccias consist of clasts with angular fragments. **Both conglomerates and breccias contain clasts larger than sand (> 2 mm)**
- Examples include shale, sandstone, siltstone

ORGANIC SEDIMENTARY ROCKS

- **Organic sedimentary rocks contain materials generated by living organisms**
- They usually contain carbonate minerals generated by these organisms
- Examples include corals, chalk, coal and oil shale

CHEMICAL SEDIMENTARY ROCKS

- Chemical sedimentary rocks are formed from minerals in solution that become oversaturated
- They usually occur as a result of evaporation
- Examples include limestone, barite, gypsum

METAMORPHIC ROCKS
Overview

- **Metamorphic rocks form as a result of transformation of an existing rock, in a process called metamorphism.** The existing rock is called *protolith*
- Metamorphic rocks are formed when the *protoliths* are subject to extreme temperatures and pressures
- **They form from tectonic process, intrusion of magma, or simply by being deep beneath the earth's surface** (being subject to high temperatures and pressures of rock layers above)
- Much of the lower continental crust is metamorphic
- Examples of metamorphic rocks include gneiss, slate, marble

COMPOSITION OF METAMORPHIC ROCKS

- Metamorphic rocks are composed of metamorphic minerals
- **Metamorphic minerals are those that form only at high temperatures and pressures.** These include sillimanite, kyanite, andalusite, staurolite and garnet (all of which are silicates)
- Metamorphic rocks also contain smaller amounts of micas, feldspars and quartz. However, these are not products of metamorphism, and are instead leftovers from the *protoliths*

CONTACT METAMORPHIC ROCKS

- Contact metamorphic rocks are those that form when magma is injected into surrounding rock
- The cooling magma leads to igneous rocks, and around this is a zone called *contact metamorphism aureole* where metamorphic rocks are formed
- The extreme temperatures cause sandstones to metamorphise into quartz, limestone into marble and shale into cordierite
- Igneous rocks are harder to transform than sedimentary rocks since they form at even greater temperatures

Regional metamorphic rocks

- Regional metamorphic rocks are those that form due to metamorphism over a wide area
- Regional metamorphism tends to make rocks foliated
- Regional metamorphic rocks tend to form at great depths simply under the temperature and pressures of upper layers of rock
- Continental crusts are examples of regional metamorphic rocks

IMPORTANT ROCK TYPES

Rock	Classification	Composition	Notes
Basalt	Igneous – extrusive volcanic	Feldspar, pyroxene	Present on moon, Mars, Venus Basalt rocks sustain microbial life Fine texture
Granite	Igneous (intrusive, felsic)	Quartz, feldspar	Coarse texture Massive, hard and tough Exhibit radioactivity (uranium)
Shale	Sedimentary (clastic)	Clay	Contain organic matter Contains multiple thin layers
Limestone	Sedimentary	Calcite (calcium carbonate)	Used in quicklime, mortar, cement, concrete Soluble in

			water Host of most cave systems
Sandstone	Sedimentary	Quartz, feldspar	Common building material Porous, allows water percolation Host of water aquifers and petroleum reservoirs
Slate	Metamorphic	Clay, volcanic ash	Used to make roofing, flooring It is an electrical insulator, used for switchboards Can host even microscopic amounts of fossils
Gneiss	Metamorphic	Garnet, biotite	

Rock	Classification	Composition	Notes
Marble	Metamorphic	Calcite (calcium carbonate)	Comes from metamorphism of limestone Pure white marble comes from pure limestone Colours, swirls, veins come from mineral impurities Important source of calcium carbonate, used in toothpaste, paint
Quartzite	Metamorphic	Quartz	Comes from metamorphism of sandstone Used as a decorative stone Used for railway ballast

IMPORTANT ROCK FORMATIONS/STRUCTURES

Formation/structure	Location	Classification	Notes
Deccan Traps	Deccan Plateau, India	Large Igneous Province (LIP)	One of the largest volcanic features on earth
Siberian Traps	Siberia, Russia	LIP	One of the largest known volcanic events (250 million years ago)
Acasta Gneiss	Quebec, Canada	Metamorphic	Oldest known rock in the world (4.28 billion years)
Devil’s Tower	Wyoming, USA	Igneous	Monolithic rock that rises 1200 feet above surrounding terrain
Blue Lias	England	Limestone and shale	Rich in dinosaur fossils
Red Fort	Delhi	Sandstone	

Hawa Mahal	Jaipur	Sandstone	
Mahabalipuram sculptures	Mahabalipuram	Granite	
Mount Augustus	Western Australia	Sandstone and conglomerate	Largest monolith in the world
Savandurga	Karnataka	Gneiss and granite	Largest monolith in India
Sphinx	Egypt	Limestone	Oldest known monumental sculpture Largest monolith statue in world
Phobos monolith	Mars	Igneous	

ECOLOGY

The environment as you know, is made up of abiotic and biotic components. It would be interesting to understand how the diversity of life-forms is maintained to bring kind of balance. This balance is maintained in a particular proportion so that a healthy interaction between the biotic and the abiotic components goes on. 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*.

Life on the earth is found almost everywhere. Living organisms are found from the poles to the equator, from the bottom of the sea to several km in the air, from freezing waters to dry valleys, from under the sea to underground water lying below the earth's surface. organisms that live on the planet earth and their interactions with the surrounding environment. Most of the organisms exist on the lithosphere and/or the hydrosphere as well as in the atmosphere. There are also many organisms that move freely from one realm to the other. 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 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*, whoused 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. All these components in ecosystem are inter related and interact with each other. 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. Therefore, 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. 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. Organisms of an ecosystem are linked together through a food chain. For example, a plant eating beetle feeding on a paddy stalk is eaten by a frog, which is, in turn, eaten by a snake, which is then consumed by a hawk. 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 foodchain from one level to another is known as *flow of energy*. However, food-chains are not isolated from one another. For example, a mouse feeding on grain may be eaten by different secondary consumers (carnivores) and these carnivores may be eaten by other different tertiary consumers (top carnivores).

In such situations, each of the carnivores may consume more than one type of prey. As a result, the food- chains get interlocked with one another. This interconnecting network of species is known as *food web.* Generally, two types of food-chains are recognised: *grazing food-chain* and *detritus food-chain*. In a grazing food-chain, the first level starts with plants as producers and ends with carnivores as consumers at the last level, with the herbivores being at the intermediate level. There is a loss of energy at each level which may be through respiration, excretion or decomposition. The levels involved in a foodchain 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.

BIOGEOCHEMICAL CYCLES

The sun is the basic source of energy on which all life depends. This energy initiates life rocesses 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. Life on earth consists of a great variety of living organisms. These living organisms exist and survive in a diversity of associations. Such survival involves the presence of systemic flows such as flows of energy, water and nutrients. These flows show variations in different parts of the world, in different seasons of the year and under varying local circumstances. Studies have shown that for the last one billion years, the atmosphere and hydrosphere have been composed of approximately the same balance of chemical components. 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 energised 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 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*. Such conversion results in the production of carbohydrate, glucose that may be converted to other organic compounds such as sucrose, starch, cellulose, etc. Here, some of the carbohydrates are utilised directly by the plant itself. During this process, more carbon dioxide is generated and is released through its leaves or roots during the day.

The remaining carbohydrates not being utilised by the plant become part of the plant tissue. Plant tissues are either being eaten by the herbivorous animals or get decomposed by the microorganisms. The herbivores convert some of the consumed carbohydrates into carbon dioxide for release into the air through respiration. The micro-organisms decompose the remaining carbohydrates after the animal dies. The carbohydrates that are decomposed by the micro-organisms then get oxidised into carbon dioxide and are returned to the atmosphere

Aquatic A. Freshwater B. Marine Altitudinal ———

A. Lakes, streams, rivers and wetlands
B. Oceans, coral reefs, lagoons and estuaries Slopes of high mountain ranges like the Himalayas, the Andes and the Rockies
A-B Temperatures vary widely with cooler air temperatures and high humidity
A. Water, swamps and marshes
B.Water, tidal swamps and marshes Algal and other aquatic and marine plant communities with varieties of water dwelling animals oceros, wild horses, lions, varieties of birds, worms, snakes etc., are common animals Temperature and precipitation vary depending upon latitudinal zone Regolith over Slopes Deciduous to tundra vegetation varying according to altitude

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, aluminium 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 can also 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* Other than carbon, oxygen, nitrogen and hydrogen being the principal geochemical components of the biosphere, many other inerals also occur as critical nutrients for plant and animal life.

These mineral elements required by living organisms are obtained initially from inorganic sources such as phosphorus, sulphur, calcium and potassium. They usually occur as salts dissolved in soil water or lakes, streams and seas. Mineral salts come directly from the earth's crust by weathering where the soluble salts enter the water cycle, eventually reaching the sea. Other salts are returned to the earth's surface through sedimentation, and after weathering, they again enter the cycle. All living organisms fulfill their mineral requirements from mineral solutions in their environments. Other animals receive their mineral needs from the plants and animals they consume. After the death of living organisms, the minerals are returned to the soil and water through decomposition and flow.

ECOLOGICAL BALANCE

Ecological balance is a state of dynamic equilibrium within a community of organisms in a habitat or ecosystem. It can happen when the diversity of the living organisms remains relatively stable. Gradual changes do take place but that happens only through natural succession. It can also be explained as a stable balance in the numbers of each species in an ecosystem. This occurs through competition and cooperation between different organisms where population remains stable. This balance is brought about by the fact that certain species compete with one another determined by the environment in which they grow. This balance is also attained by the fact that some species depend on others for their food and sustenance. Such accounts are encountered in vast grasslands where the herbivorous animals (deer, zebras, buffaloes, etc.) are found in plenty. On the other hand, the carnivorous animals (tigers, lions, etc.) that are not usually in large numbers, hunt and feed on the herbivores, thereby controlling their population. In the plants, any disturbance in the native forests such as clearing the forest change in the species distribution. This change is due to competition where the secondary forest species such as grasses, bamboos or pines overtakes the native species changing the original forest structure. This is called *succession*. Ecological balance may be disturbed due to the introduction of new species, natural hazards or human causes.

Human interference has affected the balance of plant communities leading to disturbances in the ecosystems. Such disturbances bring about numerous secondary successions.

BIODIVERSITY AND CONSERVATION

Weathering mantle is the basis for the diversity of vegetation and hence, the biodiversity. The basic cause for such weathering variations and resultant biodiversity is the input of solar energy and water. No wonder that the areas that are rich in these inputs are the areas of wide spectrum of biodiversity. 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 two words, *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. Biodiversity is our living wealth. It is a result of hundreds of millions of years of evolutionary history. Biodiversity can be discussed at three levels:

(i) Genetic diversity; (ii) Species diversity; (iii)Ecosystem diversity.

Genetic Diversity

Genes are the basic building blocks of various life forms. 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

ECOSYSTEM DIVERSITY

You have studied about the ecosystem in the earlier chapter. 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. ecosystem evolves and sustains without any reason. That means, every organism, besides extracting its needs, also contributes something of useful to other organisms. Can you think of the way we, humans contribute to the sustenance of ecosystems. 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. These functions are important for ecosystem function and human survival. The more diverse an ecosystem, better are the chances for the species to survive through adversities and attacks, and consequently, is more productive. Hence, the loss of species would decrease the ability of the system to maintain itself. Just like a species with a high genetic diversity, an ecosystem with high biodiversity may have a greater chance of adapting to environmental change. In other words, the more the variety of species in an ecosystem, the more stable the ecosystem islikely to be.

Economic Role of Biodiversity

For all humans, biodiversity is an important resource in their day-to-day life. One important part of biodiversity is 'crop diversity', which is also called agro-biodiversity. Biodiversity is seen as a reservoir of resources to be drawn upon for the manufacture of food, pharmaceutical, and cosmetic products. This concept of biological resources is responsible for the deterioration of biodiversity. At the same time, it is also the origin of new conflicts dealing with rules of division and appropriation of natural resources. Some of the important economic commodities that biodiversity supplies to humankind are: food crops, livestock, forests, fish, medicinal resources, etc.

SCIENTIFIC ROLE OF BIODIVERSITY

Biodiversity is important because each species can give us some clue as to how life evolved and will continue to evolve. Biodiversity also helps in understanding how life functions and the role of each species in sustaining

IMPORTANCE OF BIODIVERSITY

Biodiversity has contributed in many ways to the development of human culture and, 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: ecological, economic and scientific.

ECOLOGICAL ROLE OF BIODIVERSITY

Species of many kinds perform some function or the other in an ecosystem. Nothing in an ecosystems of which we are also a species. This fact must be drawn upon every one of us so that we live and let other species also live their lives. It is our ethical responsibility to consider that each and every species along with us have an intrinsic right to exist. Hence, it is morally wrong to voluntarily cause the extinction of any species. 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

Since the last few decades, growth in human population has increased the rate of consumption of natural resources. It has accelerated the loss of species and habitation in different parts of the world. Tropical regions which occupy only about one-fourth of the total area of the world, contain about three fourth of the world human population. Overexploitation of resources and deforestation have become rampant to fulfil the needs of large population. As these tropical rain forests contain 50 per cent of the species on the earth, destruction of natural habitats have proved disastrous for the entire biosphere. 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. Pesticides and other pollutants such as hydrocarbons and toxic heavy metals destroy the weak and sensitive species. 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

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

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

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 Mexico, Columbia, Ecuador, Peru, Brazil, Democratic Republic of Congo, Madagascar, China, India, Malaysia, Indonesia and Australia in which these centres are located. In order to concentrate resources on those areas that are most vulnerable, 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

CONSERVATION OF BIODIVERSITY

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

INDIAN GEOGRAPHY-
QUICK FACTS-

- India is **one of the oldest civilizations** in the world with a **kaleidoscopic variety** and **rich cultural heritage**
- All the **five major racial types** – Australoid, Mongoloid, Europoid, Caucasian, and Negroid **find representation** among the people of India **[Unity in diversity]**
- There are **22 National Languages** have been recognized by the Constitution of India, of which **Hindi is the Official Union Language**. Besides these, there are **844** different **dialects** that are practiced in various parts of the Country
- India is a **developing country** with a healthy growth rate of 9% since last 5 years [It was dropped to **6.7% in 2009** due to global economic recession]

CENSUS 2001 [INDIA]-

Census is a process to acquire information about demography of a particular region/territory. Census is **conducted** in India regularly **at an interval of 10 years**. 1^{st} Census was conducted in **1860** but 1^{st} modern census in India started from **1901.** Latest census **(14^{th})** was conducted in February-**2001** and next census is **due in 2011**. The census is carried out by the **office of the Registrar General and Census Commissioner, India, Delhi** an office in the **Ministry of Home Affairs**, Government of India, under the 1948 Census of India Act. One of the most important provisions of law is the guarantee for the **maintenance of secrecy** of the information collected at the census of each individual. The census records are not open to inspection and also not admissible in evidence. In India census is carried out **by the canvassing method 9^{th} February** 2001, the first day of the 2001 census was celebrated as the **census day** and DC acts as census officer in India

Census-2001 [Data at a Glance]- **Highest Population States** 1. Uttar Pradesh (16.16% of India's total population) 2. Maharashtra (9.42%) 3. Bihar (8.07%) 4. West Bengal (7.79%)	**Highest Decadal Growth Rate of Population States** 1. Nagaland (64.53%) 2. Sikkim (33.06%) 3. Meghalaya (30.65%) 4. Jammu and Kashmir (29.43%)
Lowest Population States 1. Sikkim (0.05%) 2. Mizoram (0.09%) 3. Arunachal Pradesh (0.11%) 4. Goa (0.13%)	**Lowest Decadal Growth Rate of Population States** 1. Kerala (9.43%) 2. Tamil Nadu (11.72%) 3. Andhra Pradesh (14.59%) 4. Goa (15.21%)
Highest Density of Population States 1. West Bengal (903 persons per sq	**Highest Literacy States** 1. Kerala (90.9%)

km) 2. Bihar (881) 3. Kerala (819) 4. Uttar Pradesh (690) **Lowest Density of Population States** 1.Arunachal Pradesh(13 persons per sq km) 2. Mizoram (42) 3. Sikkim (76) 4. Manipur (97)	2. Mizoram (88.8%) 3. Goa (82.0%) 4. Maharashtra (76.9%) **Lowest Literacy States** 1. Bihar (47%) 2. Sikkim (50.6%) 3. Jharkhand (53.6%) 4. Arunachal Pradesh (54.3%) Least populous district- Yanam Most literate district- Aizawl

INDIAN GEOGRAPHY IN DETAIL-

The **geography of India** describes the physical features of India, a country in South Asia that lies entirely on the Indian Plate in the northern portion of the Indo-Australian Plate. The country lies to the north of the equator between 8°4′ and 37°6′ north latitude and 68°7′ and 97°25′ east longitude. It is the seventh-largest country in the world. India measures 3,214 km from north (J & K) to South (Kanya Kumari). It has a coastline of 7,517 Km. Gujarat is the state with longest coast line followed by Andhra Pradesh. India is bounded to the southwest by the Arabian Sea, to the southeast by the Bay of Bengal and the Indian Ocean to the south. Cape Comorin constitutes the southern tip of the Indian peninsula, which narrows before ending in the Indian Ocean. The southernmost part of India is Indira Point in the Andaman and Nicobar Islands. The territorial waters of India extend into the sea to a distance of twelve nautical miles (22 km) measured from the appropriate baseline.

The Ganges is the longest river in India and forms the Indo-Gangetic Plain. The Ganges-Brahmaputra system occupies most of northern, central and eastern India, while the Deccan Plateau occupies most of southern India. Along its western frontier is the Thar Desert, which is the seventh-largest desert in the world.

India is divided into seven physiographic regions. They are-

1) The northern mountains including the Himalayas, which include the Kuen Lun and the Karakoram ranges and the northeast mountain ranges
2) Indo-Gangetic plains
3) Thar Desert
4) Central Highlands and Deccan Plateau
5) East Coast
6) West Coast
7) Bordering seas and islands

HIMALAYAS-

I will explain later under heading Mountain System of World

INDO-GANGETIC PLAINS-

The Indo-Gangetic plains, also known as the Great Plains are large floodplains of the Indus and the Ganga-Brahmaputra river systems. They run parallel to the Himalaya Mountains, from Jammu and Kashmir in the west to Assam in the east and draining most of northern and eastern India. The major rivers in this region are the Ganges and the Indus along with their tributaries– Beas, Yamuna, Gomti, Ravi, Chambal, Sutlej and Chenab. The great plains are sometimes classified into four divisions known as Bhabar Belt, Terai Belt, Bangar Belt and Khadar Belt

The Indo-Gangetic belt is the world's most extensive expanse of uninterrupted alluvium formed by the deposition of silt by the numerous rivers. The plains are flat making it conducive for irrigation through canals. The area is also rich in ground water sources. The plains are one of the world's most intensely farmed areas. The main crops grown are rice and wheat, which are grown in rotation. Other important crops grown in the region include maize, sugarcane and cotton. The Indo-Gangetic plains rank among the world's most densely populated areas

CENTRAL HIGHLANDS-

The Central Highlands comprise of three main plateaus — the Malwa Plateau in the west, the Deccan Plateau in the south (covering most of the Indian peninsula) and the Chota Nagpur Plateau in the east. The Malwa Plateau is spread across Rajasthan, Madhya Pradesh and Gujarat. The average elevation of the Malwa plateau is 500 metres, and the landscape generally slopes towards the north. Most of the region is drained by the Chambal River and its tributaries; the western part is drained by the upper reaches of the Mahi River.

The Deccan Plateau is a large triangular plateau, bounded by the Vindhyas to the north and flanked by the Eastern and Western Ghats. Deccan Plateau is mostly flat, with elevations ranging from 300 to 600 m. It slopes gently from west to east and gives rise to several peninsular rivers such as the Godavari, the Krishna, the Kaveri and the Narmada, which drain into the Bay of Bengal. This region is mostly semi-arid as it lies on the leeward side of both Ghats. Much of the Deccan is covered by thorn scrub forest scattered with small regions of deciduous broadleaf forest. Climate in the Deccan ranges from hot summers to mild winters.

The Chota Nagpur Plateau is situated in eastern India, covering much of Jharkhand and adjacent parts of Orissa, Bihar and Chhattisgarh. It is made of 3 smaller plateaus — the Ranchi, Hazaribagh, and Kodarma plateaus. The Ranchi plateau is the largest, with an average elevation of 700 m. Much of the plateau is forested, covered by the Chota Nagpur dry deciduous forests. Vast reserves of metal ores and coal have been found in the Chota Nagpur plateau. The Kathiawar peninsula in western Gujarat is bounded by the Gulf of Kutch and the

Gulf of Khambat. In western India, the Kutch region in Gujarat and Koyna in Maharashtra are classified as a Zone IV region (high risk) for earthquakes. The Kutch city of Bhuj was the epicenter of the 2001 Gujarat earthquake, which claimed the lives of more than 20,000 people

COASTS-

The temperature in the coastal regions exceeds 30 °C (86 °F) coupled with high levels of humidity. The region receives both the northeast and southwest monsoon rains. The southwest monsoon splits into two branches, the Bay of Bengal branch and the Arabian Sea branch. The Bay of Bengal branch moves northwards crossing northeast India in early June and Arabian Sea branch moves northwards and discharges much of its rain on the windward side of Western Ghats. Annual rainfall in this region averages between 1,000 mm (40 in) and 3,000 mm (120 in)

WESTERN GHATS-

The **Western Ghats** also known as the **Sahyadri Mountains** is a mountain range along the western side of India. It runs north to south along the western edge of the Deccan Plateau, and separates the plateau from a narrow coastal plain along the Arabian Sea. The range starts near the border of Gujarat and Maharashtra, south of the River Tapti, and runs approximately 1600 km through the states of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala ending at Kanyakumari, at the southern tip of India. The coast is divided into 3 parts namely, Konkan, which is situated in Maharashtra, Goa and northern parts of Karnataka; the Kanara in Karnataka and the Malabar Coast in Kerala. Vegetation is mostly deciduous, but the Malabar Coast moist forests constitute a unique ecoregion. About sixty percent of the Western Ghats are located in the state of Karnataka.

The average elevation is around 1,200 meters. The area is one of the world's ten "Hottest biodiversity hotspots" and has over 5000 species of flowering plants, 139 mammal species, 508 bird species and 179 amphibian species. At least 325 globally threatened species occur in the Western Ghats

EASTERN GHATS-

The **Eastern Ghats** are a discontinuous range of mountains along India's eastern coast. The Eastern Ghats run from West Bengal state in the north, through Orissa and Andhra Pradesh to Tamil Nadu in the south. They are eroded and cut through by the four major rivers of southern India, the Godavari, Mahanadi, Krishna, and Kaveri. The plains are divided into six regions — the Mahanadi delta, the southern Andhra Pradesh plain, the Krishna-Godavari deltas, the Kanyakumari coast, the Coromandel Coast and sandy coastal.

The mountain ranges run parallel to the Bay of Bengal. The Eastern Ghats are not as high as the Western Ghats. The highest point in Eastern Ghats is Mahendra Giri (1501 m) but the average width of Eastern Ghats is more than Western Ghats. The region boasts of fertile soil but hydropower generation here is not as profitable as it is in the Western Ghats. The Eastern Ghats are older than the Western Ghats.

The Eastern and Western Ghats meet at the southern part of the Indian Peninsula which is formed by the Nilgiri Hills (Blue Mountains)

PORTS IN INDIA-

India has a long coastline spanning 7600 kilometers forming one of the biggest peninsulas in the world. It is serviced by 12 **major ports** and 185 notified **minor and intermediate ports**. However the words “major”, “intermediate” and “minor” do not have a strict association with the traffic volumes served by these ports. As an example, Mundra Port, a newly developed minor port in the state of Gujarat registered a cargo traffic of around 28.8 million tons per annum during the financial year of 2008, which is higher than that of many major ports. Major ports handled over 80% cargo traffic of India. The classification of Indian ports into major, minor and intermediate has an administrative significance. Indian government has a federal structure, and according to its constitution, maritime transport falls under the “concurrent list”, to be administered by both the Central and the State governments.

While the Central Shipping Ministry administer the major ports, the minor and intermediate ports are administered by the relevant departments or ministries in the nine coastal states of West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Goa, Maharashtra and Gujarat. Several of these 185 minor and intermediate ports are merely “notified”, with little or no cargo handling actually taking place. These ports have been identified by the respective governments to be developed, in a phased manner, a good proportion of them involving Public-private partnership. Some 60% of India’s container traffic is handled by the Jawaharlal Nehru Port Trust in Mumbai. It has just 9 berths compared to 40 in the main port of Singapore. It takes an average of 21 days to clear import cargo in India compared to just 3 in Singapore.

LIST OF MAJOR PORTS IN INDIA-

Total coast line of India- 7517 K.M. In India total 9 states shared coast line and longest is in Gujarat [1600 KM]. There are 12 major ports in India out of which 6 are situated at West Coast and 6 are at East Coast. All major ports, except one (Ennore Port), are government administered, but private-sector participation in ports has increased.

On West coast	On East Coast
Mumbai [Biggest and Busiest]	Haldia or Kolkata [In news due to decrease in traffic]
Jawahar Lal Nehru at Nava Sheva [Fastest growing]	Pradeep [Exports raw iron to Japan]
Kandla [The Child of partition]	Vishakhapatnam
Marmugao [There is Naval base also]	Chennai [Oldest Port]
New Mangalore [Exports Kudremukh iron-Ore]	Ennore under Ennore Port Ltd Company [Modern and only port in private hands]
Kochi or Cochin [Natural Harbour of India]	Tuticorn [Southernmost]

RECENT DEVELOPMENTS-

The Gangavaram Port in Andhra Pradesh, inaugurated in July 2009, is India's deepest port, with a depth of 21m

Indian States International Boundaries

1 Bordering Pakistan Jammu and Kashmir, Punjab, Rajasthan, Gujarat.
2 Bordering China Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, Arunachal Pradesh.
3 Bordering Nepal Bihar, Uttaranchal, UP, Sikkim, West Bengal
4 Bordering Bangladesh West Bengal, Mizoram, Meghalaya, Tripura, Assam
5 Bordering Bhutan West Bengal, Sikkim, Arunachal Pradesh, Assam
6 Bordering Myanmar Arunachal Pradesh, Nagaland, Manipur, Mizoram
7 Bordering Afghanistan Jammu and Kashmir (Pakistan - occupied area)

Heights of Some Important Indian Peaks

SNo Peak Height in metres above mean Sea Level

1 K2 8,611
2 Kanchen Junga 8,598
3 Nanga Parvat 8,126
4 Gasher Brum 8,068
5 Broad Peak 8,047
6 Disteghil Sar 7,885
7 Masher Brum E 7,821
8 Nanda Devi 7,817
9 Masher Brum W 7,806
10 Rakaposhi 7,788
11 Kamet 7,756
12 Saser Kangri 7,672
13 Skyang Kangri 7,544
14 Sia Kangri 7,422
15 Chaukhamba (Badrinath Peak) 7,138
16 Trisul West 7,138
17 Nunkun 7,135
18 Pauhunri 7,128
19 Kangto 7,090
20 Dunagiri 7,066

GEOGRAPHICAL TERMS OF IMPORTANCE

Abiotic: Non-living thing. Usually refers to the physical and chemical components of an organism's *environment*.

Adiabatic Lapse Rate: The rate of change of temperature by an ascending or descending airmass. If no other non-adiabatic processes (i.e. no heat enters or leaves the system) occur (like condensation, evaporation and radiation), expansion causes the parcel of air to cool at a set rate of 0.98° per 100 m. The opposite occurs when a parcel of air descends in the atmosphere. The air in a descending parcel becomes compressed. Compression causes the temperature within the parcel to increase at a rate of 0.98° per 100 m.

Air Mass: A body of air whose temperature and humidity characteristics, acquired in source region, remain relatively constant over a horizontal distance of hundreds to thousands of km. Air masses develop their climatic characteristics by remaining stationary over a source region for a number of days. Air masses are classified according to their temperature and humidity characteristics.

Acid precipitation (Acid Rainfall): is now regarded as a serious problem in some European and Asian countries, the main cause and source of which is emissions of sulphur oxides and nitrogen oxides from thermal power plants and burning of fossil fuels. These oxides dissolve in atmospheric water vapour and fall back on earth as acid rainfall. Acid rainfall can cause destruction of crops and trees; destruction of fish; and damage to buildings.

Agronomy: Soil management and production of field crops is known as Agronomy.

Aleurone layer: is that part of the grain in cereals where much of the protein lies.

Alluvial soil: is the richest and most fertile soil of India spread over large areas in northern plains of India.

Arakan Yoma: is the extension of the Himalayas located in Myanmar.

Asthamudi Lake: is located in Kerala State.

Aphelion : It is the point in the Earth's orbit when it is farthest from the *sun* (152.5 million km). Aphelion occurs on the 3rd or 4th of July.

Asthenosphere: Zone in the Earth's *mantle* that exhibits plastic properties. Located below the *lithosphere* at between 100 and 200 km.

Atmospheric Pressure : Weight of the *atmosphere* on a surface. At *sea-level*, the average atmospheric pressure is 1013.25 mb. Pressure is measured by a device called a *barometer*.

Aurora : Multicoloured lights that appear in the upper *atmosphere (ionosphere)* over the polar regions and visible from locations in the middle and high latitudes. Caused by the interaction of *solar wind* with oxygen and nitrogen gas in the atmosphere. Aurora in the Northern Hemisphere are called *aurora borealis* and *aurora australis* in the Southern Hemisphere.

Agriculture The science and art of cultivating the soil, raising crops and rearing livestock. It is also called farming.

Agro-climatic The climatic and land resource conditions in totality which are crucial for the development of agriculture and allied economic conditions of a region.

Aquifer A saturated geological unit (e.g. sands, gravels, fractured rock) which can yield water to wells at a sufficient rate to support a well.

Artificial Recharge to Groundwater Artificial Recharge to Groundwater means the process by which groundwater reservoir is augmented at a rate exceeding that under natural condition of replenishment.

Alluvial Plain : A level tract of land made up of alluvium or fine rock material brought down by a river.

Archipelago : A group of islands that lie in fairly close proximity.

Arid: Denoting any climate or region in which the rainfall is insufficient or barely sufficient to support vegetation.

Backwater : A stretch of water that has become bypassed by the main flow of a stream, although still joined to it. It has a very low rate of flow.

Bedrock: The solid rock lying beneath soil and weathered material.

Biosphere Reserve : These are multi-purpose protected areas, where every plant and animal size is to be protected in its natural habitat. Its major objectives are : (i) to conserve and maintain diversity and integrity of the natural heritage in its full form, i.e. physical environment, the flora and the fauna; (ii) to promote research on ecological conservation and other aspects of environment at preservation; (iii) to provide facilities for education, awareness and explaining.

Bunding : The practice of constructing embankments of earth or stone for conserving water and soil to increase crop production.

Balance of Trade The difference between the total value of a country's exports and imports. An excess of export over import makes a favourable balance of trade, and the onverse an unfavourable balance.

Barter A direct exchange of excess produce between two parties to the mutual advantages of both, without the use of tokens, credit or money in the transaction

Batholith : A large mass of subsurface *intrusive igneous rock* that has its origins from *mantle magma*.

Big Bang : Theory about the origin of universe. It suggests that about 15 billion years ago all of the matter and energy in the *Universe* was concentrated into an area smaller than an atom. At this instant, matter, energy, space and time were not existant. Then suddenly with a bang, the Universe began to expand at an incredible rate and matter, energy, space and time came into being. As the Universe expanded, matter began to coalesce into gas clouds, and then stars and planets. Some scientists believe that this expansion is finite and will one day cease. After this point in time, the Universe will begin to collapse until a *Big Crunch* occurs.

Bailadila: in Bastar district of Madhya Pradesh, is known for its wealth of Manganese.

Barhara (Tribes): The Barhara tribes mentioned in the Mahabharata who had settled in the north-western regions of India, are associated with—(1) Ambashthas (a mixed Mongolian Aryan race); (2) Gandharas (Afghans); (3) Pavas.

Bhabhar region: in south of the Shivaliks, is an example of Piedmont situation i.e., belonging to or related to the foot of a mountain.

Bushmen (Tribes): They live in the Kalahari desert. They are probably the descendants of the earliest inhabitants of Africa. They rank among the most uncivilized and backward peoples in the world. Their food consists almost entirely of meat, often raw or decomposed, and in times of scarcity they will eat insects, snakes etc.

Biodiversity : The *diversity* of different species (*species diversity*), genetic variability among individuals within each species (*genetic diversity*), and variety of ecosystems (*ecosystem diversity*).

Biomass : The weight of living tissues usually measured per unit area over a particular time interval. Can include the dead parts of organisms like bark, hair, and nails.

Biome : Largest recognisable assemblage of *animals* and *plants* on the Earth. The distribution of the biomes is controlled mainly by climate.

Calcification : A dry environment soil-forming process that results in the accumulation of *calcium carbonate* in surface *soil* layers.

Caldera Volcano : Explosive type of *volcano* that leaves a large circular depression. Some of these depressions can be as large as 40 km in diameter. These volcanoes form when wet *granitic magma* quickly rises to the surface of the Earth.

Chlorofluorocarbons (CFCs) : Is an artificially created gas that has become concentrated in the Earth’s *atmosphere*. This very strong *greenhouse* gas is released from aerosol sprays, refrigerants, and the production of fumes.

Cirrocumulus Clouds : Patchy white high altitude *cloud* composed of ice crystals. Found in an altitude range from 5,000 - 18,000 m.

Cirrostratus Clouds : High altitude sheet like *clouds* composed of ice crystals. These thin clouds often cover the entire sky. Found in an altitude range from 5,000 - 18,000 m.

Cold Front : A transition zone in the *atmosphere* where an advancing cold *air mass* displaces a warm air mass.

Continental Crust : *Granitic* portion of the Earth's *crust* that makes up the continents. Thickness of the continental crust varies between 20 - 75 km. See *sial layer*.

Cardamom: Karnataka is the largest producer of cardamom. India is the largest exporter of cardamom in the world.

Chinook: Warm, dry wind experienced along the eastern side of the Rocky Mountains in Canada and the U.S.A.

Climograph: is a graphical representation of the differentiation between various types of climate. It reveals the type of climate at a glance—a climograph showing wet bulb temperatures and relative humidities which are high, for instance, depicts a constantly hot damp climate.

Calcareous : Composed of or containing a high proportion of calcium carbonate.

Catchment Area : The area drained by a major river and its tributaries.

Climate : The average weather conditions of a sizeable area of the earth's surface over a period of time (usually spread over a span of at least 30 years).

Coast : The boundary between land and sea. It includes the strip of land that borders the sea shore.

Conservation: The protection of natural environment and natural resources for the future. It includes the management of minerals, landscape, soil and forests to prevent their destruction and over exploitation.

Coastal Plain : It is a flat low lying land between the coast and higher ground inland.

Coral : It is a small calcium secreting marine polyp that occurs in colonies, mainly in warm shallow sea water. It forms the coral reefs.

Coastline of India, Length of: The length of India's coastline is 7,516 km and its territory includes 1,256 islands. Tamil Nadu has the longest coastline in India.

Cosmic year: One cosmic year is equal to the time taken by the sun to complete one orbit around the galactic centre.

Cotopaxi: is the highest volcano in the world. It is situated in Ecuador.

Coriolis Force : An apparent force due to the *Earth's rotation*. Causes moving objects to be deflected to the right in the Northern Hemisphere and to the left in the Southern hemisphere. Coriolis force does not exist on the equator. This force is responsible for the direction of flow in meteorological phenomena like *mid-latitude cyclones*, *hurricanes*, and *anticyclones.*

Cumulus Cloud : Large *clouds* with relatively flat bases. These are found in an altitude range from 300 - 2,000 m.

Cumulonimbus Cloud : A well developed vertical *cloud* that often has top shaped like an anvil. These clouds can extend in altitude from a few hundred m above the surface to more than 12,000 m.

Census Official enumeration of population along with certain economic and social statistics in a given territory at some time interval.

Chemical Fertilisers Substance of natural or artificial origin containing chemical elements such as phosphorus, potassium and nitrogem that are necessary to plan life. They are added to the soil for increasing its productivity.

Contour Ploughing Tilling or ploughing hillsides or sloping lands along the contour lines, that is, round rather than up and down a slope mainly with a view to conserving soil and water.

Command Area The area served by a canal system through supply of water for irrigation and other purposes.

Culturable command area It refers to the culturable land irrigated by a canal system. It is different from gross command area. The later includes all the area served by a canal system including unculturatble.

Crop Rotation Growing of different crops in succession on the same field from season to season to maintain soil fertility

Dairy Farming A kind of agriculture in which major emphasis is on breeding and rearing milch cattle. Agriculture crops are raised mainly to feed these cattle.

Desert Pavement : A veneer of coarse particles left on the ground after the *erosion* of finer particles by *wind*.

Density of Population The average number of inhabitants living within a specified unit of area, such as a sq km.

Date Line, International: International Date Line is an internationally agreed line drawn parallel to the 180° meridian. It divides the Pacific Ocean into two equal parts. A crossing of the International Date Line entails repeating one day when travelling westwards.

Detroit of India: Pithampur in Madhya Pradesh, where a large number of auto-mobile industries have been set up, is called the "Detroit of India".

Doldrums Belt: is a zone of the tropics where the calm lasting for some weeks prevails, broken at times by erratic squalls and baffling winds. It is an area of low pressure. The wind system in the Equatorial areas is known as doldrums.

Dust Devil: is a dusty whirlwind normally a few feet in diameter and about 100 feet tall, sometimes also wider and higher.

Dry Farming A method of farming adopted in certain regions of inadequate rainfall and devoid of irrigation facilities by conserving moisture in the soil and by raising drought-enduring crops.

Depression : In meteorology; it denotes an area of relatively low atmospheric pressure, which is found mainly in temperate regions. It is also used as synonym for temperate cyclones.

Earthquake: A sudden motion or shaking in the Earth. The motion is caused by the quick release of slowly accumulated energy in the form of *seismic waves*.

Estuary: The tidal mouth of a river where fresh and saline water get mixed.

Earthquake Focus: Point of stress release in an *earthquake* (also known as hypocentre).

Ebb Tide : Time during the *tidal period* when the *water* level in the sea is falling.

Earth mass: The mass of the earth is about 81 times that of the moon.

Earth's core: is mainly composed of iron and nickel. Lithosphere is the innermost layer of the earth.

El Nino: is the weather phenomenon brewing in the tropical Pacific Ocean. It is the largest climate event of the 20th century setting off more global disasters than ever before. El Nino is warming of the waters off Equatorial South America which causes climate abnormalities around the world. The impact can be flooding drought in California, Brazil, Africa and Australia, severe storms in the Central Pacific and a decline in hurricanes hitting the south-eastern United States.
Exfoliation: This type of weathering is common both in the cold as well as in the hot climate regions.

Ecosystem : A system consisting of biotic and abiotic components. Both these groups are interrelated and interacting.

El Nino : The name given to the occasional development of warm ocean surface waters along the coast of Ecuador and Peru. Recently this phenomenon has been used for forecasting of climatic conditions in different parts of the world. The El Nino normally occurs around Christmas and lasts usually for a few weeks to a few months.

Epicentre : A place on the surface of the earth located at the shortest distance from the focus of the earthquake, the point at which the seismic energy gets released.

Economic Geography The aspect or branch of geography which deals with the influences of the environment, both physical and cultural, on the economic activity of man, bringing out similarities and differences from place to place in the ways people make a living.

Eco-development The process of development of a region by means of conservation and regeneration of degraded ecosystem and ecological sustainability.

Emigration Movement of people from one place to another usually from one country to another with a purpose of earning, living, residing and settling.

Extensive irrigation A strategy of irrigation development where the emphasis is on providing irrigation water for a large area. Per unit area use of water is low in this case.

Environment Surroundings or the conditions under which a person or things exist and develop his or its character. It covers both physical and cultural elements.

Exports Goods despatched from one country to another.

Extensive Agriculture Farming in which the amount of capital and labour applied to a given area is relatively small.

Fazenda A coffee plantation in Brazil.

Fertilizer plant, First: The first fertilizer plant in India was set up at Sindri (Bihar).

Foreign Exchange The mechanism or process by which payments between any two places operating under different national currency systems are effected without passing of actual money or gold, etc.

Freeways The wide highways on which cross-roads are avoided by providing overhead links where one turns in only one direction to ensure smooth and speedy traffic.

Flow system or channel A channel of canal where water flows under the influence of gravity.
Fauna : The animal life of a given area or time.

Fold : A bend in rock strata resulting from compression of an area of the earth's crust.

Glacier : A mass of snow and ice that moves slowly away from its place of accumulation carving gradually a broad and steepsided valley on its way.
Gneiss : A coarse grained metamorphic rock with a banded structure. It is formed by the large scale application of heat and pressure associated with mountain building and volcanic activity.

Gorge : A deep valley with steep and rocky side walls. 100 GLOSSARY

Gully Erosion : It is the erosion of the soil and rock by the concentration of runoff into gullies.

Global Warming : Warming of the Earth's *average global temperature* because of an increase in the concentration of *greenhouse gases*.

Geomagnetism : A property of magnetically susceptible minerals to get aligned to the earth's magnetic field during the period of rock formation.

Geostrophic Wind : Horizontal wind in the upper atmosphere that moves parallel to *isobars*. Results from a balance between *pressure gradient force* and *Coriolis force*.

Garo (Tribes): Garos are the tribe of Garo Hills in Meghalaya.

Glacial lake—example in India: Dal Lake in Srinagar.

Great Circle: A circle on the earth's surface whose plane passes through its centre, and bisects it into two hemispheres. Two opposing meridians together form a Great Circle. The shortest distance between any two points on the earth's surface is the arc of the Great Circle which passes through them. 0° latitude forms a Great Circle. (The latitude or longitude 75°W should be combined with 75°E to obtain the Great Circle).

Greenhouse Effect: The greenhouse effect causes the *atmosphere* to trap more heat energy at the Earth's surface and within the atmosphere by absorbing and re-emitting longwave energy.

Greenhouse Gases: Gases responsible for the *greenhouse effect*. These gases include: *carbon dioxide* (CO2); *methane* (CH4); *nitrous oxide* (N2O); *hlorofluorocarbons* (CFC); and *tropospheric ozone* (O3).

Groundwater Groundwater means the water which exists below the ground surface in the zone of saturation and can be extracted through wells or any other means or emerges as springs and base flows in streams and rivers.

Ground Water Table The top of the zone in which all pore spaces or fissures are totally filled with water.

Habitat : Location where a *plant* or *animal* lives.

Hail : It is a type of precipitation received in the form of ice pellets or hail stones. The size of hailstones can be between 5 and 190 mm in diameter.

Halocline : The dinstinct zone in the ocean below which the salinity increases sharply.

Horse Latitudes: Sub-tropical belts of high atmospheric pressure over the oceans situated in both hemispheres. These are called Belts of Calm between regions of the Trade Winds and Westerlies of higher latitudes.

Hydroponics: means cultivation of the plants without use of soil.

Hyetology: is the study of rainfall.

Hydration: A form of *chemical weathering* that involves the rigid attachment of H+ and OH- *ions* to the *atoms* and *molecules* of a *mineral*.

Hydrolysis: *Chemical weathering* process that involves the reaction between *mineral* ions and the ions of water (OH- and H+), and results in the decomposition of the *rock* surface by forming new compounds.

Harbour An extensive stretch of deep water where vessels can anchor securely to obtain protection from sea and swell either through natural features or artificial works.

Highway Public road connecting distant places. Such a road of national importance is called the national highway.

Horticulture Cultivation of vegetables and fruits; often on small plots, involving higher intensiveness than in field cultivation.

Humus : The dead organic content of the soil.

Island : A mass of land that is surrounded by water and is smaller than a continent.

Imports Goods brought into a country from another country.

Infiltration : A portion of the precipitation which reaches the earth surface seeps into the ground in the permeable strata. This process is known as infiltration.
Indira Point: in Andaman and Nicobar Islands is the southern-most tip of India.

Insolation : Incoming solar radiation in short wave form.

Inter Tropical Convergence Zone (ITCZ) : Zone of *low atmospheric pressure* and ascending air located at or near the equator. Rising air currents are due to global wind *convergence* and *convection* from thermal heating.
Irrigated area, Indian State having largest: The Indian State with the largest irrigated area is Uttar Pradesh.

Industrial Revolution The change in manufacturing from hand operated tools to power-driven achinery began in England during the middle of the eighteenth century.

Industry Systematic production characterised by division of labour and extensive use of machinery.

Intensive Agriculture Farming in which large amounts of capital and labour are applied per unit area of land, in order to obtain high yield.

Inter Cropping It is a practice of growin g two or more crops together on the same field in the same season

International Trade Trade carried on between nations primarily to exchange their surpluses and make up their deficits.

Immigration Movement of a person as a permanent resident into another area, usually into a foreign country.

Intrusive irrigation A strategy of irrigation development where per unit application of water is high.

Jhum: It is a slash and burn method of shifting cultivation (called jhum) practised on rainfall-bed slopes of forest hills and dales in Arunachal Pradesh.

Jet Stream : A very strong and steady westerly wind blowing just below the tropopause.

Kandla: is a sea port situated at the head of the Gulf of Kuch in Gujarat State. It was the first port to be developed after independence. It has a free trade zone.

Katabatic Wind : Any *wind* blowing down the slope of a mountain.

Khonds (Tribes): were primitive tribes living in Orissa.

Kikuyu (Tribes) : are a race of Bantu negroes who live to the north of Mount Kenya. These people combine agriculture with pastoralism.

Kirghiz (Tribes): of Central Asia are an example of people adapted to a grassland environment. The Kirghiz are pastoral nomads who move from pasture to pasture with the flocks and herds of horses, camels, oxen, sheep and goats. Meat forms only a small portion of their food. The Kirghiz are fearless horsemen, and even their children are expert riders

Lift system or channel A channel of canal where water is forced to flow against the slope of land by upliftment.

Land Breeze : Local *thermal circulation* pattern found at the interface between land and water. In this circulation system, surface winds blow from land to water during the night.

Lake : A body of water that lives in a hollow in the earth's surface and is entirely surrounded by land.

Landslide : A form of mass movement in which rock and debris moves rapidly downslope under the influence of gravity as a result of failure along a shear plane.

Lambadies (Tribes): are concentrated in Karnataka.

Lapse Rate: is the rate of change in temperature with increase of altitude.

Laterite soils: Laterite soils are formed by the weathering of laterite rocks. These can be distinguished from other soils by their acidity. Laterite soils are generally poor on the higher levels and cannot retain moisture. In the plains, however, they consist of heavy loams and clay and can retain moisture. Laterite soils occur in Madhya Pradesh, Assam and along the eastern and western Ghats. Tea plantation require acidity which is there in the laterite soil. It is, therefore, common in these areas.

Loams (loamy soil): Amixture of sand, clay and silt is known as loamy soil. Loams are formed where the soils have equal proportion of sand, silt and clay.

Local winds and their areas: Khamsin—Egypt; Zonda—Argentina; Santa Ana—California; Simoon—Iran.

Lushais (Tribes): are tribes of Mizoram.

La Nina : Condition opposite of an *El Nino*. In a La Nina, the tropical Pacific *trade winds* become very strong and an abnormal accumulation of cold water occurs in the central and eastern Pacific Ocean.

Latent Heat : It is the energy required to change a substance to a higher state of matter (solid > liquid > gas). This same energy is released from the substance when the change of state is reversed (gas > liquid > solid).

Metropolis A very large city or agglomeration of population in a district or a country, and is often the chief centre or seat of some form of activity—administrative, commercial or industrial. It generally serves a large hinterland.

Mine An excavation made in the earth for digging out minerals such as coal, iron-ore and precious stones. A mine usually denotes underground working except in open-pit mines.

Mineral A substance that is found in the earth's crust, and which generally has a definite chemical composition unlike most rocks.

Mineral Fuel Non-metallic minerals such as coal and petroleum which are used as fuel.

Mineral Oil A mixture of hydrocarbons in solid, gaseous or liquid form found in the earth. It is commonly known as petroleum. It became a commercial product only in 1859.

Mineral Ore Metals in their raw state as extracted from the earth.

Mining An economic activity concerned with the extraction of commercially valuable minerals from the bowels of the earth.

Mansarover Lake: is in Tibet. Near it, the rivers having their source are the Brahamputra, the Sutlej and the Indus.

Maoris (Tribes): are the original inhabitants of New Zealand.

Masai (Tribes): of the East African plateau are the example of pastoral peoples. They are a tall, strong, warlike race, partly negroid in type. They treat their cattle with great respect and affection and do not kill them for food or for sale as meat.

Monsoon in India: is related to differential heating and cooling of the huge landmass of Asia and the Indian Ocean and the origin of cyclones in the Bay of Bengal. The term Monsoon was introduced by the Arabs.

Munda (Tribes): are mostly located in Madhya Pradesh.

Mixed Farming A type of farming in which cultivation of crops and raising of livestock go hand in hand. Both these activities play an important part in the economy.

Migration Movement of the people for the specific purpose from one place to another in the country or to a foreign country.

Migration stream Migration stream refers to a group of migrants with the common origin and destination.

Meander : A pronounced curve or loop in the course of a river channel.

Monsoon : A complete reversal of winds over a large area leading to a change of seasons.
[
National Park : A National park is an area which is strictly reserved for the protection of the wildlife and where activities such as forestry, grazing or cultivation are not allowed.

Natural Resources Wealth supplied by nature-mineral deposits, soil fertility, timber, fuel, water, potential water-power, fish and wild life, etc.

Neap Tide : *Tide* that occurs every 14 - 15 days and coincides with the first and last quarter of the moon. This tide has a small tidal range because the *gravitational* forces of the moon and sun are perpendicular to each other.

Negritos (Tribes): are the ancient tribes of Andamans.

Nutrification: is the process of conversion by action of bacteria, of nitrates in the soil.
Nimbostratus Clouds: Dark, gray low altitude *cloud* that produces continuous *precipitation* in the form of rain or snow. Found in an altitude range from the surface to 3,000 m.

Net migration or balance of migration The difference of total numbers of persons arrived in and left out the place. In other words, it is sum of in migrants and immigrants minus sum of out migrants and emigrants. In mathematical term it is defined as:

Net migration (in migrants + immigrants) - (out migrants + emigrants)

Nomadism A way of life of the people who are required to shift their dwellings frequently from place to place in search of pastures for their animals— the mainstay of their economy.

Occluded Front: A transition zone in the *atmosphere* where an advancing cold *air mass* sandwiches a warm air mass between another cold air mass pushing the warm air into the upper atmosphere.

Ozone : Tri-atomic oxygen that exists in the earth’s *atmosphere* as a gas. Ozone is highest in concentration in the *stratosphere* (10-50 km above the earth’s surface) where it absorbs the sun’s ultraviolet radiation. Stratospheric ozone is produced naturally and helps to protect life from the harmful effects of solar ultraviolet radiation.

Ozone Hole: It is a sharp seasonal decrease in stratospheric ozone concentration that occurs over Antarctica in the spring. First detected in the late 1970s, the ozone hole continues to appear as a result of complex chemical reaction in the atmosphere that involves *CFCs***.**

Open-cast Mine: A place where soil and its outward cover are first removed and a mineral or ore is extracted by quarrying. In a way, it is a quarry on a large scale. This method of mining is known as open-cast mining.

Onges: are tribes of Andaman and Nicobar Islands.

Oraon (Tribes): are aboriginal people of the Chhota Nagpur region in the State of Bihar. They call themselves Kurukh and speak a Dravidian language.

Palaeomagnetism : The alignment in terms of inclination from horizon acquired by magnetically susceptible minerals in the rock during the period of their formation.

Photosynthesis: It is the chemical process where *plants* and some *bacteria* can capture and organically fix the energy of the *sun*.

Plate Tectonics : Theory suggesting that the earth's surface is composed of a number of *oceanic* and *continental plates*. Driven by convection currents in the *mantle*, these plates have the ability to slowly move across the earth's plastic *asthenosphere*.

Precipitation : Showering of the raindrops, snow or hailstones from the clouds onto the surface of the earth. Rainfall, snowfall, cloud burst and hailstones are forms of precipitation.

Pastoralism An economy that solely depends upon animals. Whereas nomadic pastoralism is practised mainly for subsistence, the modern ranches present an example of commercial pastoralism.

Plantation Agriculture A large-scale one-crop farming resembling factory production. It is usually characterised by large estate, huge capital investment, and modern and scientific techniques of cultivation and trade.

Pangong Tso: is one of the world's highest and brackish lakes in Jammu & Kashmir.

Pressure zones on earth: are created due to differential heating of the earth's surface by the sun.

Proxima Centauri: is a star nearest to the earth.

Port The commercial part of a harbour containing facilities for embarking and disembarking passengers, loading and unloading, and some facilities for the storage of cargo.

Primary Activity Activities concerned with collecting or making available materials, provided by nature, for example, agriculture, fishing, forestry, hunting or mining.

Pass: A route through a mountain range which follows the line of a color a gap.

Peninsula : A piece of land jutting out into the sea.

Plain : An extensive area of flat or gently undulating land.

Plateau : An extensive elevated area of relatively flat land.

Playa : The low flat central area of a basin of inland drainage. Playas occur in areas of low rainfall.

Protected Forest : An area notified under the provisions of Indian Forest Act or the State Forest Acts having limited degree of protection. In Protected Forests, all activities are permitted unless prohibited.

Quarry An open-air excavation from which stone is obtained by cutting, blasting, etc.

Ranches Large stock farms, usually fenced in, where animals are bred and reared on a commercial scale. They are found especially in the United States.

Rain Water Harvesting Rain Water Harvesting is the technique of collection and storage of rain water at surface or in sub-surface aquifer.

Refugee People who are forced to take shelter in other country due to life threatening situation, insecurity, war or violation of human rights in their own country.

Remittance All cash or kinds sent by the migrants to their place of origin. Money order is one form of remittance.

Rotation of Crops A systematic succession of different crops on a given piece of land carried out in order to avoid exhaustion of the soil.

Runoff : It is the flow of water over land through different channels.

Rare earths (Or Lignite and Monazite): are found on the beaches of Kerala and Tamil Nadu. Monazite is an ore of thorium.

Roaring Forties: are westerly winds.

Rapids : A stretch of swift flowing water where a river bed suddenly becomes steeper due to the presence of hard rocks.

Reserved Forest : An area notified under the provisions of Indian Forest Act or the State Forest Acts having full degree of protection. In Reserved Forests, all activities are prohibited unless permitted.

Solar Wind: Mass of ionised gas emitted to space by the *sun*. Plays a role in the formation of *auroras*.

Subsurface flow : It is the movement of water below the surface of the earth. After infiltration, the subsurface water returns to the surface through seepage into the streams or eventually goes into the ocean. The subsurface water flow is influenced by land slope, rainfall, intensity of groundwater extraction, etc.

Secondary Activity Activities which transform the material provided by primary activities into commodities more directly useful to man.

Sedentary Agriculture Farming practised more or less permanently on the same piece of land, the same as settled agriculture.

Shaft Mine An underground excavation made deep into the earth for digging minerals like coal, precious stones and iron. Such mines contain vertical and inclined shafts and horizontal tunnels at various levels.

Shifting Agriculture A method of farming in which a patch of ground is cultivated for a period of few years until the soil is partly exhausted or overrun by weeds, and after which the land is left to natural vegetation while cultivation is carried on elsewhere. In due course, the original patch of land is cultivated again when the natural growth has restored fertility.

Subsistence Agriculture Farming in which its produce is mainly consumed in the farmer's household unlike commercial agriculture whose products enter into trade on a very large scale.

Saddle peak: is the highest peak of Andaman and Nicobar islands, located in Great Nicobar.

Savannas: are found between latitudes 5° and 20° North and South of Equator. These are tropical grasslands bordering the equatorial forests in each hemisphere. The Llanos and Pampas of South America are chief examples of Savannas but extensive Savannas are in Africa. Savanna grasslands are also found in Australia. The three-tier growth of vegetation is found in these regions. The natural vegetation of Savannas consists of tall grass.

Selvas: The rain forest of Amazon basin is called Selvas. These are rainy tropical forests.

Sanctuary : A sanctuary is an area, which is reserved for the conservation of animals only and operations such as harvesting of timber, collection of minor forest products are allowed so long as they do not affect the animals adversely.

Soil Profile: It is the vertical section of soil from the ground surface to the parent rock.

Subcontinent: A big geographical unit which stands out distinctly from the rest of the continent.

Semangs (Tribes): are tribal people living in Malaysia.

Spring Tides: are caused when the sun and the moon are in a straight line. The tide on its maximum height is known as Spring Tide.

Thermocline : Boundary in a body of water where the greatest vertical change in *temperature* occurs. This boundary is usually the transition zone between the layer of warm water near the surface that is mixed and the cold deep water layer.

Transhumance A seasonal movement of herdsmen with their livestock and from and to the mountains or between the regions of differing climates.

Transport The action of carrying persons and goods from one place to another.

Truck Farming Growing of vegetables around the urban centres to meet the daily demand of the people is known as truck farming. It is governed by the distance a truck can cover overnight between the farm and the market.

Transhuemance: The practice of seasonal migration where the pastoral communities migrate to the pastures along with their herds during summer season. These communities return to their permanent residence in winter.

Taiga Belt: lies between the Tibet-type climate and the Tundras.

Telegu Ganga Project: in Tamil Nadu envisages optimal use of surplus water of the Krishna river. It is a joint venture of Tamil Nadu, Andhra Pradesh and Karnataka.

Time Zone: A zone on the terrestrial globe that is 15° longitude wide and extends from pole to pole and within which a uniform clock time is used. Time zones are the functional basis of standard time. The world is divided into 24 time zones.

Tsunamis: are huge sea waves caused by earthquakes.

Terai : A belt of marshy ground and vegetation on the lower parts of the alluvial fans.

Tectonic : Forces originating within the earth and responsible for bringing widespread changes in the landform features.

Urbanisation A general movement of people from small rural or agricultural communities or villages to larger towns engaged in varied activities such as government, trade, transport and manufacture. It also indicates the concentration of an increasing proportion of total population in towns and cities.

Unclassed Forest : An area recorded as forest but not included in reserved or protected forest category. Ownership status of such forests varies from state to state

Warebandi system It is a system of equitable distribution of water in the command area of canal outlet.

Watershed A watershed is a natural geo-hydrological unit of land, which collects water and drains it through a common point by a system of streams. Such a unit can be a small area of a few hectares or it could be an area of hundreds of square kilometres like the Ganga river basin.
Willy Willy: is a tropical cyclone of the north-west Australia.

HUMAN GEOGRAPHY

Nature and Scope

Human geography studies "the relationship between the physical/natural and the human worlds, the spatial distributions of human phenomena and how they come about, the social and economic differences between different parts of the world". Core concern of geography as a discipline is to understand the earth as home of human beings and to study all those elements which have sustained them. Houses, villages, cities, road-rail networks, industries, farms, ports, items of our daily use and all other elements of material culture have been created by human beings using the resources provided by the physical environment. While physical environment has been greatly modified by human beings, it has also, in turn, impacted human lives.

Discoveries of Charles Darwin

Charles Darwin, who made studies on the evolution of species, established similarities in the basic character and blood groups among different human races. That shows a common ancestor for different races.

Human Beings

Homosapiens can be broadly grouped into three racial groups on the basis of their external features.

- **Negroid**
- **Mongoloid**
- **Caucasoid**

Negroid

The characteristics of this race are clearly seen in the Negroes of Sudan. We call them 'Kappiris'. Black curly hair, black or dark brown complexion, brown iris, broad and flat nose, long head, thick lips and slightly protruded teeth are the characteristics of the Negroid race.

Mongoloid

The important characteristic of the race is their epicanthic fold. Flat nose, and saffron or yellowish brown skin are the other characteristics. Body hair is comparatively less for this short statured people. The people of China, Korea, and Japan are of Mongoloid race. People of this race are also found in India.

Caucasoid

Their complexion is pale red or white or the colour of olive oil. They have light brown or golden hair. Light blue or dark iris, long nose, thin lips, tall and well built body etc., are
the physical traits of Caucasoid.

The Vanishing racial purity

As time elapsed marital relations between different races led to the emergence of mixed racial groups. Today each major race has a number of sub races and mixed races. In short, there is no such thing as racial purity. All are alike.

WWF, World Environment Conservation Organization declare following rivers at risk (March 2007) River – Continent

Denube – Europe	Rio Grande – North America,
La Plata – South America,	Yangtze – Nepal – Tibet,
Mekonge – Asia,	Salween – Asia,
Ganga – Asia,	Indus – Asia,
Nile – Africa,	Murray – Darling - Australia

THE WORLD POPULATION

Distribution, Density and Growth

The people of a country are its real wealth. It is they who make use of the country's resources and decide its policies. Ultimately a country is known by its people. It is important to know how many women and men a country has, how many children are born each year, how many people die and how? Whether they live in cities or villages, can they read or write and what work do they do? The world at the beginning of 21st century recorded the presence of over 6 billion population.

The population of the world is unevenly distributed. Patterns of population distribution and density help us to understand the demographic characteristics of any area. The term population distribution refers to the way people are spaced over the earth's surface. Broadly, 90 per cent of the world population lives in about 10 per cent of its land area. The 10 most populous countries of the world contribute about 60 per cent of the world's population. Of these 10 countries, 6 are located in Asia **China 127.76, India 102.7, USA 28.14 , Indonesia 21.21 , Brazil 17.01 , Pakistan 15.65 , CIS 14.69 , Bangladesh 12.92 , Japan 12.69 , Nigeria 11.15**

DENSITY OF POPULATION

Each unit of land has limited capacity to support people living on it. Hence, it is necessary to understand the ratio between the numbers of people to the size of land. This ratio is the density of population. It is usually measured in persons per sq km

Density of Population = Total population / Area
For example, area of Region A is 10 sq km and the population is 15,000 persons. The density of population is calculated as: 15,000 /10 = 1,500 person/sq km

The densely populated parts of the world are the ones with more than 200 persons on every sq km. These are the North –Eastern part of U.S.A., North-Western part of Europe, South, South-East and East Asia. Other areas like those near the North and South Poles, the hot and the cold deserts and high rainfall zones near the Equator have very low density of population. These are the sparsely populated regions of the world with less than 01 person per sq km. In between these two types are the areas of medium density. There are 11 to 50 persons per sq km in these areas. Western China, Southern India in Asia, Norway, Sweden in Europe are some examples.

LONGEST RIVER

River-Continental

1) Nile –Africa
2) Amazon - South America
3) Yangtze – Asia
4) Mississippi – Missouri - North America
5) Huang Ho – Asia
6) Zaire - Africa
7) Parana - South America
8) Irtysh - Asia
9) Amur – Asia
10) Lena - Asia

FACTORS INFLUENCING THE DISTRIBUTION OF POPULATION

I. Geographical Factors

i. ***Availability of water*** People prefer to live in areas where fresh water is easily available. Water is used for drinking, bathing and cooking – and also for cattle, crops, industries and navigation. It is because of this that river valleys are among the most densely populated areas of the world.

ii. ***Landforms****:* People prefer living on flat plains and gentle slopes. This is because such areas are favourable for the production of crops and to build roads and industries. The mountainous and hilly areas hinder the development of transport network and hence initially do not favour agricultural and industrial development. So, these areas tend to be less populated. The Ganga plains are among the most densely populated areas of the world while the mountains zones in the Himalayas are scarcely populated.

iii. ***Climate****:* An extreme climate such as very hot or cold deserts are uncomfortable for human habitation. Areas with a comfortable climate, where there is not much seasonal variation attract more people. Areas with very heavy rainfall or extreme and harsh climates have low population. Mediterranean regions were inhabited from early periods in history due to their pleasant climate.

iv. ***Soils:*** Fertile soils are important for agricultural and allied activities. Therefore, areas which have fertile loamy soils have more people living on them as these can support intensive agriculture.

II. Economic Factors

i. ***Minerals:*** Areas with mineral deposits attract industries. Mining and industrial activities generate employment. So, skilled and semi–skilled workers move to these areas and make them densely populated. Katanga Zambia copper belt in Africa is one such good example.

ii. ***Urbanisation:*** Cities offer better employment opportunities, educational and medical facilities, better means of transport and communication. Good civic amenities and the attraction of city life draw people to the cities. It leads to rural to urban migration and cities grow in size. Mega cities of the world continue to attract large number of migrants every year.

iii. ***Industrialisation:*** Industrial belts provide job opportunities and attract large numbers of people. These include not just factory workers but also transport operators, shopkeepers, bank employees, doctors, teachers and other service providers. The Kobe-Osaka region of Japan is thickly populated because of the presence of a number of industries.

III. Social and Cultural Factors

Some places attract more people because they have religious or cultural significance. In the same way – people tend to move away from places where there is social and political unrest. Recent cases as Darfur, or Lybia are good examples. Many a times governments offer incentives to people to live in sparsely populated areas or move away from overcrowded places as in newly industrialized areas or satellite towns.

FactBox The Multipurpose project which will be National Property

The centre has decided to proclaim 14 river projects as the national property in order to increase irrigation and electricity production. For it, the central government will provide 90% financial support and there will be no nationalization of rivers, Among 14 projects, Tista Bairrage, Shahpur Kandi, Second Rawi – Vyas Link, Ujjh and Gipsa projects have international and startegical importance. The projects are:

1. Tista Bairrage (West Bengal)
2. Shahpur Kandi (Punjab)
3. Second Rawi – Vyas Link (Punjab)
4. Ujjh Multi – purpose Project (J&K), Chenab River
5. Bursar (J&K), Chenab River
6. Gipsa Project (Himachal Pradesh), Chenab River
7. Renuka (Himachal Pradesh), Giri River
8. Lakhwar Vyasi (Uttarakhand), Yamuna River
9. Kishau (Himachal Pradesh – Uttarakhand), Tons River
10. Noa Dehang Dam Project (Arunachal Pradesh)
11. Upper Saing (Arunachal Pradesh), Brahmaputra River
12. Kulsi Dam Project (Asom), Siang River
13. Gosikhurd (Maharashtra), Wainganga River
14. Ken – Betwa (MP)

POPULATION GROWTH

The population growth or population change refers to the change in number of inhabitants of a territory during a specific period of time. This change may be positive as well as negative. It can be expressed either in terms of absolute numbers or in terms of percentage. Population change in an area is an important indicator of economic development, social upliftment and historical and cultural background of the region.

***Growth of Population*:** Change of population in particular area between two points of time is known as growth of population. For example, if we deduct the population of India 1991 (84.63 crore) from population of 2001 (102.70 crore) then we shall get the growth of population (18.07 crores) in actual numbers.

***Growth Rate of Population*:** This is the change of population expressed in percentage.

***Natural Growth of Population*:** This is the population increased by difference between births and deaths in a particular region between two points of time.
*Natural Growth = Births – Deaths Actual Growth of Population***:** This is *Births – Deaths + In Migration – Out Migration*

***Positive Growth of Population*:** This happens when the birth rate is more than the death rate between two points of time or when people from other countries migrate permanently to a region.

***Negative Growth of Population*:** If the population decreases between two points of time it is known as negative growth of population. It occurs when the birth rate falls below the death rate or people migrate to other countries.

Components of Population Change There are three components of population change – **births, deaths and migration**.
The **crude birth rate** (CBR) is expressed as number of live births in a year per thousand of population. It is calculated as
CBR = (Bi / P) x 1000
Here,
CBR = Crude Birth Rate;
Bi = live births during the year;
P=Mid year population of the area.
Death rate plays an active role in population change. Population growth occurs not only by increasing births rate but also due to decreasing death rate.
Crude Death Rate (CDR) is a simple method of measuring mortality of any area. CDR is expressed in terms of number of deaths in a particular year per thousand of population in a particular region.
CDR = (D / P) x1000

Here,
CDR=Crude Death Rate;
D= Number of deaths;
P=Estimated mid-year population of that year.
By and large mortality rates are affected by the region's demographic structure, social advancement and levels of its economic development.

MIGRATION

Apart from birth and death there is another way by which the population size changes. When people move from one place to another, the place they move from is called the **Place of Origin** and the place they move to is called the **Place of Destination**. The place of origin shows a decrease in population while the population increases in the place of destination. Migration may be interpreted as a spontaneous effort to achieve a better balance between population and resources. Migration may be permanent, temporary or seasonal. It may take place from rural to rural areas, rural to urban areas, urban to urban areas and urban to rural areas. Do you realise that the same person is both an immigrant and an emigrant? ***Immigration**:* Migrants who move into a new place are called Immigrants. ***Emigration:*** Migrants who move out of a place are called Emigrants.

Different races during different periods of history left their native places and settled in different regions. This process is still going on and this is known as migration.

Different ways of Migration

Many people from India are migrating to gulf countries, the USA, Britain and such other nations. The migration across the national boundaries is known as international migration. Migration within a country is known as internal migration. People move daily from one place to another for the purposes of education, business, employment etc. This movement is called commutation. A person who performs commutation is known as a commuter. Commutation cannot be considered as migration.

International migration include two processes.

The outward migration of people of one country to another country is known as emigration and the incoming of people to a country is known as immigration. Several factors force people to leave their homelands. These factors are known as 'push factors'. There are some other factors that attract people to a region. These are known as 'pull factors'. Many people from all over the world left their motherland and became refugees. Motherland became "foreign" to them.

Following might be the **reasons** which prompted them to leave their motherland and to migrate to other places?

- Better employment opportunities
- Environmental hazards
- Resource availability
- Political instability
- Extension of national boundaries
- Facilities for higher education
- Epidemics
- Slavery
- Suitable climatic conditions
- Religious factors

The following are some of the migrations that occurred in the world.

- The migrations of the Europeans to the USA.
- The migrations of doctors, nurses and technocrats of Indian origin to the USA,

Australia and Europe.

- The immigration to India from Sri lanka and Tibet.
- The recent migration from Chernobyl in Russia and Bhopal in India.
- Migrations of the Whites to South Africa.
- Migrations of working class to Gulf countries.
- Migrations of Ethiopeans to Sudan.
- Invasion of Europeans to India.
- Migrations of people from Central Travancore to Malabar.

Impact of migration

Migrations to different regions caused changes in the prevailed conditions of the regions concerned. Given below are the various impacts of such migrations.

- Influence on language and literature.
- Transfer of human resources.
- Exchange of new knowledge.
- Over exploitation and the resultant scarcity of resources.
- Difference in the population structure of a particular region.
- Cultural diffusion.
- Economic progress.
- Introduction of land use practices which are not conducive to the land.
- Changes and diversification in the field of agriculture.
- Environmental degradation and pollution.
- Progress in transport and communication.
- Scarcity of Land.
- High density of population.

CAN YOU THINK OF REASONS WHY PEOPLE MIGRATE?

People migrate for a better economic and social life. There are two sets of factors that influence migration. The **Push** factors make the place of origin seem less attractive for reasons like unemployment, poor living conditions, political turmoil, unpleasant climate, natural disasters, epidemics and socio-economic backwardness. The **Pull** factors make the place of destination seem more attractive than the place of origin for reasons like better job opportunities and living conditions, peace and stability, security of life and property and pleasant climate.

TRANSHUMANCE

The pastoral nomads who settled in the foothill zones are moving upslopes during summer to graze their animals. They remain there for the whole summer period and come down with the advent of winter. This movement of people with their cattle is known as transhumance. The Gujjar and Bakerwal tribes of Jammu and Kashmir are still practicing transhumance.

TRENDS IN POPULATION GROWTH

The population on the earth is more than six billion. It has grown to this size over centuries. In the early periods population of the world grew very slowly. It is only during the last few hundred years that population has increased at an alarming rate. After the evolution and introduction of agriculture about 8,000 to 12,000 years ago, the size of population was small – roughly 8 million. In the first century A.D. it was below 300 million. The expanding world trade during the sixteenth and seventeenth century, set the stage for rapid population growth. Around 1750, at the dawn of the Industrial Revolution, the world population was 550 million. World population exploded in the eighteenth century after the Industrial Revolution. Technological advancement achieved so far helped in the reduction of death rate and provided a stage for accelerated population growth.

Factbox

- Human population increased more than ten times in the past 500 hundred years.
- In the twentieth century itself the population has increased four times.
- Nearly 80 million people are added each year.

DOUBLING TIME OF WORLD POPULATION

It took more than a million years for the human population to attain the one billion mark. But it took only 12 years for it to rise from 5 billion to 6 billion. There is a great variation among regions in doubling their population. Developed countries are taking more time to double their population as compared to developing countries. Most of the population growth is taking place in the developing world, where population is exploding.

SPATIAL PATTERN OF POPULATION CHANGE

The growth of population is low in developed countries as compared to developing countries. There is negative correlation between economic development and population growth. Even if the growth rate continues to decline, the total population grows each year. The infant mortality rate may have increased as has the death rate during childbirth.

IMPACT OF POPULATION CHANGE

A small increase in population is desirable in a growing economy. However, population growth beyond a certain level leads to problems. Of these the depletion of resources is the most serious. Population decline is also a matter of concern. It indicates that resources that had supported a population earlier are now insufficient to maintain the population. The deadly HIV/AIDS epidemics in Africa and some parts of the Commonwealth of Independent States (CIS) and Asia have pushed up death rates and reduced average life expectancy. This has slowed down population growth.

Population doubling in India

The annual population growth rate in India is 1.9 per cent. At this rate India's population of over 1 billion will double in 36 years. Some developed countries will take 318 years to double their population whereas some countries still do not show symptoms of doubling their population.

DEMOGRAPHIC TRANSITION

Demographic transition theory can be used to describe and predict the future population of any area. The theory tells us that population of any region changes from high births and high deaths to low births and low deaths as society progresses from rural agrarian and illiterate to urban industrial and literate society. These changes occur in stages which are collectively known as the **demographic cycle**

The **first stage** has high fertility and high mortality because people reproduce more to compensate for the deaths due to epidemics and variable food supply. The population growth is slow and most of the people are engaged in agriculture where large families are an asset. Life expectancy is low, people are mostly illiterate and have low levels of technology. Two hundred years ago all the countries of the world were in this stage. Fertility remains high in the beginning of **second stage** but it declines with time. This is accompanied by reduced mortality rate. Improvements in sanitation and health conditions lead to decline in mortality. Because of this gap the net addition to population is high. In the **last stage**, both fertility and mortality decline considerably. The population is either stable or grows slowly. The population becomes urbanised, literate and has high technical knowhow and deliberately controls the family size. This shows that human beings are extremely flexible and are able to adjust their fertility. In the present day, different countries are at different stages of demographic transition.

POPULATION CONTROL MEASURES

Family planning is the spacing or preventing the birth of children. Access to family planning services is a significant factor in limiting population growth and improving women's health. Propaganda, free availability of contraceptives and tax disincentives for large families are some of the measures which can help population control. Thomas Malthus in his theory (1793) stated that the number of people would increase faster than the food supply. Any further increase would result in a population crash caused by famine, disease and war. The preventive checks are better than the physical checks. For the sustainability of our resources, the world will have to control the rapid population increase

Population composition

People can be distinguished by their age, sex and their place of residence. Some of the other distinguishing attributes of the population are occupation, education and life expectancy.

SEX COMPOSITION

The number of women and men in a country is an important demographic characteristic. The ratio between the number of women and men in the population is called the Sex Ratio. In some countries it is calculated by using the formula:
Male Population / Female Population X 1000
or the number of males per thousand females.
In India, the sex ratio is worked out using the formula:
Female Population / Male Population X 1000
or the number of females per thousand males.

The sex ratio is an important information about the status of women in a country. In regions where gender discrimination is rampant, the sex ratio is bound to be unfavourable to women. Such areas are those where the practice of female foeticide, female infanticide and domestic violence against women are prevalent. One of the reasons could be lower socio-economic status of women in these areas. You must remember that more women in the population does not mean they have a better status. It could be that the men might have migrated to other areas for employment.

FactBox **Under construction Hydro Power Plant of 11th Five Year Plan:**

1. Parvati	–	Himachal Pradesh
2. Tista Stage	–	Sikkim
3. Seva	–	J & K
4. Subansiti Lower	–	Asom
5. Uri	–	J & K
6. Chamera	–	Himachal Pradesh
7. Tista Low Dam	–	West Bengal
8. Omkareshwar	–	Madhya Pradesh
9. Dulhasti	–	J & K
10. Nimmo – Bazgo	–	J & K
11. Chutak	–	J & K
12. Kishanganga	–	J & K
13. Pakal Kul	–	J & K
14. Dhauliganga	–	Uttarakhand
15. Khotli Bhel	–	Uttarakhand
16. Bav – II	–	Maharashtra
17. Puruliapss	–	West Bengal
18. Indira Sagar	–	Madhya Pradesh
19. Dibang	–	Arunchal Pradesh
20. Ranjit	–	Sikkim
21. Tipaimukh Dam	–	Manipur

NATURAL ADVANTAGE V/S SOCIAL DISADVANTAGE

Females have a biological advantage over males as they tend to be more resilient than males yet this advantage is cancelled out by the social disadvantages and discriminations that they face.

Population Composition

On an average, the world population reflects a sex ratio of 990 females per 1000 males. The highest sex ratio in the world has been recorded in Latvia which is 1187 females per 1000 males. In contrast, the lowest sex ratio occurs in U.A.E. which is 468 females per 1000 males. The world pattern of sex ratio does not exhibit variations in the developed regions of the world. The sex ratio is favourable for females in 139 countries of the world and unfavourable for them in the remaining 72 countries listed by the United Nations. In general, Asia has a low sex ratio. Countries like China, India, Saudi Arabia, Pakistan, Afghanistan have a lower sex ratio. On the other extreme is greater part of Europe (including Russia) where males are in minority. A deficit of males in the populations of many European countries is attributed to better status of women, and an excessively male-dominated out-migration to different parts of the world in the past.

Age Structure

Age structure represents the number of people of different age groups. This is an important indicator of population composition, since a large size of population in the age group of 15- 59 indicates a large working population. A greater proportion of population above 60 years represents an ageing population which requires more expenditure on health care facilities. Similarly high proportion of young population would mean that the region has a high birth rate and the population is youthful.

Age-Sex Pyramid

The age-sex structure of a population refers to the number of females and males in different age groups. A population pyramid is used to show the age-sex structure of the population. The shape of the population pyramid reflects the characteristics of the population.

Expanding Population

The age-sex pyramid here is a triangular shaped pyramid with a wide base and is typical of less developed countries(ex. Bangladesh, Mexico , Nigeria). These have larger populations in lower age groups due to high birth rates.

Constant Population

Here the age-sex pyramid is bell shaped and tapered towards the top. This shows birth and death rates are almost equal leading to a near constant population. Ex. Australia.

Declining Populations

Here the pyramid has a narrow base and a tapered top showing low birth and death rates. The population growth in developed countries is usually zero or negative.

Ageing Population

Population ageing is the process by which the share of the older population becomes proportionally larger. This is a new phenomenon of the twentieth century. In most of the developed countries of the world, population in higher age groups has increased due to increased life expectancy. With a reduction in birth rates, the proportion of children in the population has declined.

FACTBOX

- World Population Day was observed for the first time on 11 July, 1987
- The year in which world population reached 100 crores - 1804
- The day on which world population reached 600 crores - 12 October, 1999

RURAL URBAN COMPOSITION

The division of population into rural and urban is based on the residence. This division is necessary because rural and urban life styles differ from each other in terms of their livelihood and social conditions. The age-sex-occupational structure, density of population and level of development vary between rural and urban areas.

The criteria for differentiating rural and urban population varies from country to country. In general terms rural areas are those where people are engaged in primary activities and urban areas are those when majority of the working population is engaged in non-primary activities. The rural and urban differences in sex ratio in Canada and West European countries like Finland are just the opposite of those in African and Asian countries like Zimbabwe and Nepal respectively. In Western countries, males outnumber females in rural areas and females outnumber the males in urban areas. In countries like Nepal, Pakistan and India the case is reverse. The excess of females in urban areas of U.S.A., Canada and Europe is the result of influx of females from rural areas to avail of the vast job opportunities. Farming in these developed countries is also highly mechanised and remains largely a male occupation. By contrast the sex ratio in Asian urban areas remains male dominated due to the predominance of male migration. It is also worth noting that in countries like India, female participation in farming activity in rural area is fairly high. Shortage of housing, high cost of living, paucity of job opportunities and lack of security in cities, discourage women to migrate from rural to urban areas.

LITERACY

Proportion of literate population of a country in an indicator of its socio-economic development as it reveals the standard of living, social status of females, availability of educational facilities and policies of government. Level of economic development is both a cause and consequence of literacy. In India – literacy rate denotes the percentage of population above 7 years of age, who is able to read, write and have the ability to do arithmetic calculations with understanding.

Occupational Structure

The working population (i.e. women and men of the age group – 15 to 59) take part in various occupations ranging from agriculture, forestry, fishing, manufacturing construction, commercial transport, services, communication and other unclassified services. Agriculture, forestry, fishing and mining are classified as primary activities manufacturing as secondary, transport, communication and other services as tertiary and the jobs related to research and developing ideas as quaternary activities. The proportion of working population engaged in these four sectors is a good indicator of the levels of economic development of a nation. This is because only a developed economy with industries and infrastructure can accommodate more workers in the secondary, tertiary and quaternary sector. If the economy is still in the primitive stages, then the proportion of people engaged in primary activities world be high as it involves extraction of natural resources.

INDIAN POPULATION REACHED 100 CRORES ON 11, JUNE 2000.

Population Policy

Now you are aware of the problems created by rapid growth of population. To solve these problems and to attain national welfare, a population policy is essential. In India, it was in 1976 that population policy (Population control policy) was declared. Many schemes were also implemented for family planning and family welfare.

Need for Population Policy

We shall see why population policy is essential:

- To improve the economy of a country
- To maintain population suitable to the economy.
- To attain economic and social progress.
- To improve the standard of living.
- To improve education and health.
- To solve unemployment problem.

National Population Policy 2000- NPP 2000

This policy lays emphasis on health care of the people especially, that of women and children. Following are the aims of the new population policy.

- To meet the basic needs in public health sector.
- To ensure free and compulsory education to all children upto the age of 14.
- To reduce infant mortality rate below 30 in every 1000 live births.
- Popularise preventive measures against the communicable diseases
- To take steps for raising the age at marriage of women, above 20.

HUMAN DEVELOPMENT

Here we will discuss the concept of human development as it pertains to nations and communities.

GROWTH AND DEVELOPMENT

Both growth and development refer to changes over a period of time. The difference is that growth is quantitative and value neutral. It may have a positive or a negative sign. This means that the change may be either positive (showing an increase) or negative (indicating a decrease). Development means a qualitative change which is always value positive. This means that development cannot take place unless there is an increment or addition to the existing conditions. Development occurs when positive growth takes place. Yet, positive growth does not always lead to development. Development occurs when there is a positive change in quality. For example, if the population of a city grows from one lakh to two lakhs over a period of time, we say the city has grown.

However, if a facilities like housing, provision of basic services and other characteristics remain the same, then this growth has not been accompanied by development. For many decades, a country's level of development was measured only in terms of its economic growth. This meant that the bigger the economy of the country, the more developed it was considered, even though this growth did not really mean much change in the lives of most people. The idea that the quality of life people enjoy in a country, the opportunities they have and freedoms they enjoy, are important aspects of development, is not new.

These ideas were clearly spelt out for the first time in the late eighties and early nineties. The works of two South Asian economists, Mahbub-ul-Haq and Amartya Sen are important in this regard. The concept of human development was introduced by Dr Mahbub-ul-Haq. Dr Haq has described human development as development that enlarges people's choices and improves their lives. People are central to all development under this concept. These choices are not fixed but keep on changing. The basic goal of development is to create conditions where people can live meaningful lives. A meaningful life is not just a long one. It must be a life with some purpose. This means that people must be healthy, be able to develop their talents, participate in society and be free to achieve their goals.

A man of vision and compassion, Pakistani economist Dr Mahbub-ul-Haq created the Human Development Index in 1990. According to him, development is all about enlarging people's choices in order to lead long, healthy lives with dignity. The United Nations Development Programme has used his concept of human development to publish the Human Development Report annually since 1990. Dr Haq's flexibility of mind and ability to think out of the box can be illustrated from one of his speeches where he quoted Shaw saying, "'You see things that are, and ask why? I dream of things that never were, and ask why not?' Nobel Laureate Prof Amartya Sen saw an increase in freedom (or decrease in unfreedom) as the main objective of development. Interestingly, increasing freedoms is also one of the most effective ways of bringing about development. His work explores the role of social and political institutions and processes in increasing freedom.

Leading a long and healthy life, being able to gain knowledge and having enough means to be able to live a decent life are the most important aspects of human development. Therefore, access to resources, health and education are the key areas in human development. Suitable indicators have been developed to measure each of these aspects. Very often, people do not have the capability and freedom to make even basic choices. This may be due to their inability to acquire knowledge, their material poverty, social discrimination, inefficiency of institutions and other reasons. This prevents them from leading healthy lives, being able to get educated or to have the means to live a decent life. Building people's capabilities in the areas of health, education and access to resources is therefore, important in enlarging their choices. If people do not have capabilities in these areas, their choices also get limited.

CENSUS

Census is the collection, compilation, analysis and publication of different types of information related to the people living in a country in a given period.

THE FOUR PILLARS OF HUMAN DEVELOPMENT

The idea of human development is supported by the concepts of **equity, sustainability, productivity** and **empowerment**.

Equity refers to making equal access to opportunities available to everybody. The opportunities available to people must be equal irrespective of their gender, race, income and in the Indian case, caste. Yet this is very often not the case and happens in almost every society.

Sustainability means continuity in the availability of opportunities. To have sustainable human development, each generation must have the same opportunities. All environmental, financial and human resources must be used keeping in mind the future. Misuse of any of these resources will lead to fewer opportunities for future generations. **Each generation must ensure the availability of choices and opportunities to its future generations.**

Productivity here means human labour productivity or productivity in terms of human work. Such productivity must be constantly enriched by building capabilities in people. Ultimately, it is people who are the real wealth of nations. Therefore, efforts to increase their knowledge, or provide better health facilities ultimately leads to better work efficiency.

Empowerment means to have the power to make choices. Such power comes from increasing freedom and capability. Good governance and people-oriented policies are required to empower people. The empowerment of socially and economically disadvantaged groups is of special importance.

APPROACHES TO HUMAN DEVELOPMENT

There are many ways of looking at the problem of human development. Some of the important approaches are:
(a) The income approach;
(b) The welfare approach;
(c) Minimum needs approach; and
(d) Capabilities approach

i. ***Income Approach*** This is one of the oldest approaches to human development. Human development is seen as being inked to income. The idea is that the level of income reflects the level of freedom an individual enjoys. Higher the level of income, the higher is the level of human development.
ii. ***Welfare Approach*** This approach looks at human beings as beneficiaries or targets of all development activities. The approach argues for higher government expenditure on education, health, social secondary and amenities. People are not participants in development but only passive recipients. The government is responsible for increasing levels of human development by maximising expenditure on welfare.
iii. ***Basic Needs Approach*** This approach was initially proposed by the International Labour Organisation (ILO). Six basic needs i.e.: health, education, food, water supply, sanitation, and housing were identified. The question of human choices is ignored and the emphasis is on the provision of basic needs of defined sections.

iv. ***Capability Approach*** This approach is associated with Prof. Amartya Sen. Building human capabilities in the areas of health, education and access to resources is the key to increasing human development.

NTPC Power Points	
Project - State	**B. Gas Based**
Existing Singrauli – Uttar Pradesh Korba – Chhattisgarh Ramagundan – Andhra Pradesh Farakka – West Bengal Vinshyanchal – Madhya Pradesh Rihand – Uttar Pradesh Kahalgaon – Bihar Dadri (Coal) – Uttar Pradesh Talcher Thermal – Orissa Tanda – Uttar Pradesh Simhadri – Andhra Pradesh Badarpur – Delhi Sipat – II – Chhattisgarh	– Rajasthan Auraiya – Uttar Pradesh Kawas – Gujarat Dadri – Uttar Pradesh Jhanor - Gandhar – Anta Gujarat Rajiv Gandhi (Kayamkulam) – Kerala Faridabad – Haryana

MEASURING HUMAN DEVELOPMENT

The human development index (HDI) ranks the countries based on their performance in the key areas of health, education and access to resources. These rankings are based on a score between 0 to 1 that a country earns from its record in the key areas of human development. The indicator chosen to assess health is the life expectancy at birth. A higher life expectancy means that people have a greater chance of living longer and healthier lives. The adult literacy rate and the gross enrolment ratio represent access to knowledge.

The number of adults who are able to read and write and the number of children enrolled in schools show how easy or difficult it is to access knowledge in a particular country. Access to resources is measured in terms of purchasing power (in U.S. dollars). Each of these dimensions is given a weightage of 1/3. The human development index is a sum total of the weights assigned to all these dimensions. The closer a score is to one, the greater is the level of human development. Therefore, a score of 0.983 would be considered very high while 0.268 would mean a very low level of human development. The human development index measures **attainments** in human development. It reflects what has been achieved in the key areas of human development. Yet it is not the most reliable measure. This is because it does not say anything about the distribution. The human poverty index is related to the human development index. This index measures the **shortfall** in human development. It is a non-income measure.

The probability of not surviving till the age of 40, the adult illiteracy rate, the number of people who do not have access to clean water, and the number of small children who are underweight are all taken into account to show the shortfall in human development in any region. Often the human poverty index is more revealing than the human development index. Looking at both these measures of human development together gives an accurate picture of the human development situation in a country. The ways to measure human development are constantly being refined and newer ways of capturing different elements of human development are being researched. Researchers have found links between the level of corruption or political freedom in a particular region. There is also a discussion regarding a political freedom index and, a listing of the most corrupt countries. Can you think of other links to the level of human development? Since 1990, the United Nations Development Programme (UNDP) has been publishing the Human Development Report every year.

This report provides a rank-wise list of all member countries according to the level of human development. The Human Development index and the **Human Poverty index** are two important indices to measure human development used by the UNDP. Bhutan is the only country in the world to officially proclaim **the Gross National Happiness** (GNH) as the measure of the country's progress. Material progress and technological developments are approached more cautiously taking into consideration the possible harm they might bring to the environment or the other aspects of cultural and spiritual life of the Bhutanese. This simply means material progress cannot come at the cost of happiness. GNH encourages us to think of the spiritual, non-material and qualitative aspects of development.

INTERNATIONAL COMPARISONS

International comparisons of human development are interesting. Size of the territory and per capita income are not directly related to human development. Often smaller countries have done better than larger ones in human development. Similarly, relatively poorer nations have been ranked higher than richer neighbours in terms of human development. For example, Sri Lanka, Trinidad and Tobago have a higher rank than India in the human development index despite having smaller economies. Similarly, within India, Kerala performs much better than Punjab and Gujarat in human development despite having lower per capita income. Countries can be classified into three groups on the basis of the human development scores earned by them

High above 0.8 57	Medium between 0.5 up to 88 0.799
Low below 0.5 32	*Source: Human Development Report, 2005*

COUNTRIES WITH HIGH INDEX VALUE

Countries with high human development index are those which have a score of over 0.8. We Can notice that many of these countries have been the former imperial powers. The degree of social diversity in these countries is not very high. Many of the countries with a high human development score are located in Europe and represent the industrialised western world. Yet there are striking numbers of non-European countries also who have made it to this list. **Countries with Medium Index Value** Countries with medium levels of human development form the largest group. There are a total of 88 countries in this group. Most of these are countries which have emerged in the period after the Second World War. Some countries from this group were former colonies while many others have emerged after the break up of the erstwhile Soviet Union in 1990. Many of these countries have been rapidly improving their human development score by adopting more people-oriented policies and reducing social discrimination. Most of these countries have a much higher social diversity than the countries with higher human development scores. Many in this group have faced political instability and social uprisings at some point of time in their recent history.

Providing education and healthcare is an important government priority. Countries with higher human development are those where a lot of investment in the social sector has taken place. Altogether, a higher investment in people and good governance has set this group of countries apart from the others.

PrimaryActivities

Specialised Cultivations

Along with the traditional agricultures, some specialised agricultures are also practiced in the world. They are-

1. Viticulture: It is the export-oriented cultivation of grapes.
2. Pisciculture/Aquaculture: It is the trade oriented breeding of fish.
3. Sericulture: The practice of rearing silk worms, in which growing of mulberry trees is also included.
4. Horticulture: Large-scale production of various fruits for the export purposes.
5. Oliviculture: Trade oriented cultivation of olives.
6. Arboriculture: Cultivation of various types of trees and shrubs in which their conservation and expansion are also included.
7. Apiculture: Rearing of honeybees for the production of honey for trade purposes.
8. Floriculture: Trade oriented growing of various types of flowers.
9. Silviculture: Activity related to the conservation and development of forests.
10. Vegiculture: It is the primitive type of agriculture practiced by the early man of southeastern Asia.
11. Namery culture: A primitive agricultural practice, in which roots, tubers, fruits & flowers were gathered.
12. Oleryculture: Commercial cultivation of the vegetables grown on creepers.

13. Marl culture: Commercial production of ocean or sea organisms (shrimps, oysters etc.).
14. Horsiculture: Commercial rearing and breeding of good quality horses and mules.
15. Vermiculture: Rearing of earthworms for increasing agricultural production.
16. Moriculture: Agriculture of mulberry for silk work
17. Aeriponic: Plantation of trees, without surface, in air.
18. Pomology: Science of fruits

Human activities which generate income are known as *economic activities.* Economic activities are broadly grouped into primary, secondary, tertiary and quaternary activities. Primary activities are directly dependent on environment as these refer to utilisation of earth's resources such as land, water, vegetation, building materials and minerals. It, thus includes, hunting and gathering, pastoral activities, fishing, forestry, agriculture, and mining and quarrying. People engaged in primary activities are called **redcollar** workers due to the outdoor nature of their work.

HUNTING AND GATHERING

The earliest human beings depended on their immediate environment for their sustenance. They subsisted on:

(a) animals which they hunted; and

(b) the edible plants which they gathered from forests in the vicinity. Primitive societies depended on wild animals. People located in very cold and extremely hot climates survived on hunting. The people in the coastal areas still catch fish though fishing has experienced modernisation due to technological progress. Many species, now have become extinct or endangered due to illegalhunting (poaching). The early hunters used primitive tools made of stones, twigs or arrows so the number of animals killed was limited. Gathering and hunting are the oldest economic activity known. These are carried out at different levels with different orientations. Gathering is practised in regions with harsh climatic conditions. It often involves primitive societies, who extract, both plants and animals to satisfy their needs for food, shelter and clothing. This type of activity requires a small amount of capital investment and operates at very low level of technology. The yield per person is very low and little or no surplus is produced.

GATHERING IS PRACTISED IN:

a. high latitude zones which include northern Canada, northern Eurasia and southern Chile;
b. Low latitude zones such as the Amazon Basin, tropical Africa, Northern fringe of Australia and the interior parts of Southeast Asia. In modern times some gathering is market oriented and has become commercial. Gatherers collect valuable plants such as leaves, barks of trees and medicinal plants and after simple processing sell the products in the market. Gathering has little chance of becoming important at the global level. Products of such an activity cannot compete in the world market. Moreover, synthetic products often of better quality and at lower prices, have replaced many items supplied by the gatherers in tropical forests.

PASTORALISM

At some stage in history, with the realization that hunting is an unsustainable activity, human beings might have thought of domestication of animals. People living in different climatic conditions selected and domesticated animals found in those regions. Depending on the geographical factors, and technological development, animal rearing today is practised either at the subsistence or at the commercial level.

VARIOUS REVOLUTIONS

Green Revolution - Agriculture
White Revolution - Milk production
Blue Revolution – Fisheries
Pink Revolution - Lobsters production
Yellow Revolution - Oil seeds
Brown Revolution - Non-Conventional energy production
Red Revolution - Meat/ Tomato Production
Round Revolution - Potato production
Silver Revolution - Egg production
Golden Revolution - Fruits (Horticulture) Production
Rainbow Revolution - Comprehensive Agriculture Revolution [as set in the New Agricultural Policy].
Black Revolution - Mineral oil
Amrit Revolution - Interlinking of river
Sampark Revolution - Connecting major ports with four or six-lane roads under Golden Quadrilateral project

NOMADIC HERDING

Nomadic herding or pastoral nomadism is a primitive subsistence activity, in which the herders rely on animals for food, clothing, shelter, tools and transport. They move from one place to another along with their livestock, depending on the amount and quality of pastures and water. Each nomadic community occupies a well-identified territory as a matter of tradition. A wide variety of animals is kept in different regions. In tropical Africa, cattle are the most important livestock, while in Sahara and Asiatic deserts, sheep, goats and camel are reared. In the mountainous areas of Tibet and Andes, yak and llamas and in the Arctic and sub Arctic areas, reindeer are the most important animals. Pastoral nomadism is associated with three important regions. The core region extends from the Atlantic shores of North Africa eastwards across the Arabian peninsula into Mongolia and Central China.

The second region extends over the tundra region of Eurasia. In the southern hemisphere there are small areas in South-west Africa and on the island of Madagascar The process of migration from plain areas to pastures on mountains during summers and again from mountain pastures to plain areas during winters is known as *transhumance.* In mountain regions, such as Himalayas, Gujjars, Bakarwals, Gaddis and Bhotiyas migrate from plains to the mountains in summers and to the plains from the high altitude pastures in winters.

COMMERCIAL LIVESTOCK REARING

Unlike nomadic herding, commercial livestock rearing is more organised and capital intensive. Commercial livestock ranching is essentially associated with western cultures and is practiced on permanent ranches. These ranches cover large areas and are divided into a number of parcels, which are fenced to regulate the grazing. When the grass of one parcel is grazed, animals are moved to another parcel. The number of animals in a pasture is kept according to the carrying capacity of the pasture. This is a specialised activity in which only one type of animal is reared. Important animals include sheep, cattle, goats and horses. Products such as meat, wool, hides and skin are processed and packed scientifically and exported to different world markets.Rearing of animals in ranching is organised on a scientific basis. The main emphasis is on breeding, genetic improvement, disease control and health care of the animals. New Zealand, Australia, Argentina, Uruguay and United States of America are important countries where commercial livestock rearing is practised

AGRICULTURE

Agriculture is practised under multiple combinations of physical and socio-economic conditions, which gives rise to different types of agricultural systems. Based on methods of farming, different types of crops are grown and livestock raised. The following are the main agricultural systems.

MAJOR CROPS OF THE WORLD AND THEIR PRODUCER COUNTRIES

Rice -China, India, Indonesia, Bangladesh, Vietnam, Thailand
Wheat- China, India, USA, CIS, France, Canada.
Barley- Russia, Germany, Canada
Oat - Russia, Canada, USA
Maize- USA, China, Brazil, Mexico
Oilseed -USA, China, India
Soyabeen - USA, Brazil, China
Sugarcane - India, Brazil, Cuba, China
Sugarbeet - Ukraine, France, Germany, USA
Tea - India, China, Sri Lanka
Coffee - Brazil, Vietnam, Columbia
Cocoa - Ivory Coast, Costarica, Equatorl
Cotton - China, USA, CIS, India, Pakistan
Tobacco -China, USA, India, Brazil, CIS
Rubber - Thailand, Indonesia, Malaysia, India, China.

SUBSISTENCE AGRICULTURE

Subsistence agriculture is one in which the farming areas consume all, or nearly so, of the products locally grown. It can be grouped in two categories — Primitive Subsistence Agriculture and Intensive SubsistenceAgriculture.

Primitive Subsistence Agriculture

Primitive subsistence agriculture or shifting cultivation is widely practised by many tribes in the tropics, especially in Africa, south and central America and south east Asia The vegetation is usually cleared by fire, and the ashes add to the fertility of the soil. Shifting cultivation is thus, also called **slash and burn agriculture**. The cultivated patches are very small and cultivation is done with very primitive tools such as sticks and hoes. After sometime (3 to 5 years) the soil looses its fertility and the farmer shifts to another parts and clears other patch of the forest for cultivation. The farmer may return to the earlier patch after sometime. One of the major problems of shifting cultivation is that the cycle of *jhum* becomes less and less due to loss of fertility in different parcels. It is prevalent in tropical region in different names, e.g. **Jhuming** in North eastern states of India, **Milpa** in central America and Mexico and **Ladang** in Indonesia and Malaysia. ***Intensive Subsistence Agriculture*** This type of agriculture is largely found in densely populated regions of monsoon Asia.

Basically, there are two types of intensive subsistence agriculture.

(i) *Intensive subsistence agriculture dominated by wet paddy cultivation:* This type of agriculture is characterised by dominance of the rice crop. Land holdings are very small due to the high density of population. Farmers work with the help of family labour leading to intensive use of land. Use of machinery is limited and most of the agricultural operations are done by manual labour. Farm yard manure is used to maintain the fertility of the soil. In this type of agriculture, the yield per unit area is high but per labour productivity is low.

(ii) *Intensive subsidence agriculture dominated by crops other than paddy:* Due to the difference in relief, climate, soil and some of the other geographical factors, it is not practical to grow paddy in many parts of monsoon Asia. Wheat, soyabean, barley and sorghum are grown in northern China, Manchuria, North Korea and North Japan. In India wheat is grown in western parts of the Indo-Gangetic plains and millets are grown in dry parts of western and southern India. Most of the characteristics of this type of agriculture are similar to those dominated by wet paddy except that irrigation is often used. The Europeans colonised many parts in the world and they introduced some other forms of agriculture such as plantations which were mainly profit-oriented large scale production systems.

SHIFTING CULTIVATIONS IN INDIA

Jhum - North-eastern India
Vevar & Dahiyaar –BundelkhandRegion (M.P.)
Deepa -Baster District (M.P.)
Zara & Erka -Southern States
Batra -South-eastern Rajasthan
Podu - Andhra Pradesh
Kumari -Hilly region of the Western Ghats of Kerala
Kaman, Vinga &Dhavi - Orissa

PLANTATION AGRICULTURE

Plantation agriculture as mentioned above was introduced by the Europeans in colonies situated in the tropics. Some of the important plantation crops are tea, coffee, cocoa, rubber, cotton, oil palm, sugarcane, bananas and pineapples. The characteristic features of this type of farming are large estates or plantations, large capital investment, managerial and technical support, scientific methods of cultivation, single crop specialisation, cheap labour, and a good system of transportation which links the estates to the factories and markets for the export of the products. The French established cocoa and coffee plantations in west Africa. The British set up large tea gardens in India and Sri Lanka, rubber plantations in Malaysia and sugarcane and banana plantations in West Indies. Spanish and Americans invested heavily in coconut and sugarcane plantations in the Philippines. The Dutch once had monopoly over sugarcane plantation in Indonesia. Some coffee fazendas (large plantations) in Brazil are still managed by Europeans. Today, ownership of the majority of plantations has passed into the hands of the government or the nationals of the countries concerned.

The slopes of hills are used for tea plantations because of favourable geographical conditions.

Extensive Commercial Grain Cultivation Commercial grain cultivation is practised in the interior parts of semi-arid lands of the midlatitudes. Wheat is the principal crop, though other crops like corn, barley, oats and rye are also grown. The size of the farm is very large, therefore entire operations of cultivation from ploughing to harvesting are mechanised. This type of agriculture is best developed in Eurasian steppes, the Canadian and American Prairies, the Pampas of Argentina, the Velds of South Africa, the Australian Downs and the Canterbury Plains of New Zealand.

Mixed Farming

This form of agriculture is found in the highly developed parts of the world, e.g. North-western Europe, Eastern North America, parts of Eurasia and the temperate latitudes of Southern continents. Mixed farms are moderate in size and usually the crops associated with it are wheat, barley, oats, rye, maize, fodder and root crops.

Fodder crops are an important component of mixed farming. Crop rotation and intercropping play an important role in maintaining soil fertility. Equal emphasis is laid on crop cultivation and animal husbandry. Animals like cattle, sheep, pigs and poultry provide the main income along with crops. Mixed farming is characterised by high capital expenditure on farm machinery and building, extensive use of chemical fertilizers and green manures and also by the skill and expertise of the farmers.

CLASSIFICATION OF VEGETATION

- **Tropophyte:** Forest and grassland vegetation of the tropical belt.
- **Hydrophyte:** Vegetation growing on the surface of water bodies.
- **Hygrophyte:** Vegetation found in the areas of high humidity.
- **Xerophyte:** Vegetation found in the tropical deserts.
- **Mesophyte:** Temperate taiga vegetation
- **Cryophyte:** Tundra vegetation like lichen and algae.
- **Halophyte:** Vegetation of saline soil like mangroves.
- **Lithophyte:** Vegetation growing on hard rocks.
- **Pyrophyte:** Fire resistant vegetation (found in Savanna region).

DAIRY FARMING

Dairy is the most advanced and efficient type of rearing of milch animals. It is highly capital intensive. Animal sheds, storage facilities for fodder, feeding and milching machines add to the cost of dairy farming. Special emphasis is laid on cattle breeding, health care and veterinary services. It is highly labour intensive as it involves rigorous care in feeding and milching. There is no off season during the year as in the case of crop raising. It is practised mainly near urban and industrial centres which provide neighbourhood market for fresh milk and dairy products. The development of transportation, refrigeration, pasteurisation and other preservation processes have increased the duration of storage of various dairy products. There are three main regions of commercial dairy farming. The largest is North Western Europe the second is Canada and the third belt includes South Eastern Australia, New Zealand and Tasmania

MEDITERRANEAN AGRICULTURE

Mediterranean agriculture is highly specialized commercial agriculture. It is practised in the countries on either side of the Mediterranean sea in Europe and in north Africa from Tunisia to Atlantic coast, southern California, central Chile, south western parts of South Africa and south and south western parts of Australia. This region is an important supplier of citrus fruits. **Viticulture** or grape cultivation is a speciality of the Mediterranean region. Best quality wines in the world with distinctive flavours are produced from high quality grapes in various countries of this region. The inferior grapes are dried into raisins and currants. This region also produces olives and figs. The advantage of Mediterranean agriculture is that more valuable crops such as fruits and vegetables are grown in winters when there is great demand in European and North American markets.

MARKET GARDENING AND HORTICULTURE

Market gardening and horticulture specialize in the cultivation of high value crops such as vegetables, fruits and flowers, solely for the urban markets. Farms are small and are located where there are good transportation links with the urban centre where high income group of consumers is located. It is both labour and capital intensive and lays emphasis on the use of irrigation, HYV seeds, fertilisers, insecticides, greenhouses and artificial heating in colder regions. This type of agriculture is well developed in densely populated industrial districts of north west Europe, north eastern United States of America and the Mediterranean regions. The Netherlands specialises in growing flowers and horticultural crops especially tulips, which are flown to all major cities of Europe.

The regions where farmers specialise in vegetables only, the farming is know as **truck farming**. The distance of truck farms from the market is governed by the distance that a truck can cover overnight, hence the name truck farming. In addition to market gardening, a modern development in the industrial regions of Western Europe and North America is factory farming. Livestock, particularly poultry and cattle rearing, is done in stalls and pens, fed on manufactured feedstuff and carefully supervised against diseases. This requires heavy capital investment in terms of building, machinery for various operations, veterinary services and heating and lighting. One of the important features of poultry farming and cattle rearing is breed selection and scientific breeding. Types of farming can also be categorized according to the farming organisation. Farming organisation is affected by the way in which farmers own their farms and various policies of the government which help to run these farms.

Co-operative Farming

A group of farmers form a co-operative society by pooling in their resources voluntarily for more efficient and profitable farming. Individual farms remain intact and farming is a matter of cooperative initiative. Co-operative societies help farmers, to procure all important inputs of farming, sell the products at the most favourable terms and help in processing of quality products at cheaper rates. Co-operative movement originated over a century ago and has been successful in many western European countries like Denmark, Netherlands, Belgium, Sweden, Italy etc. In Denmark, the movement has been so successful that practically every farmer is a member of aco-operative.

Collective Farming

The basic principle behind this types of farming is based on social ownership of the means of production and collective labour. Collective farming or the model of **Kolkhoz** was introduced in erstwhile Soviet Union to improve upon the inefficiency of the previous methods of agriculture and to boost agricultural production for self-sufficiency. The farmers used to pool in all their resources like land, livestock and labour. However, they were allowed to retain very small plots to grow crops in order to meet their daily requirements. Yearly targets were set by the government and the produce was also sold to the state at fixed prices.

Produce in excess of the fixed amount was distributed among the members or sold in the market. The farmers had to pay taxes on the farm produces, hired machinery etc. Members were paid according to the nature of the work allotted to them by the farm management. Exceptional work was rewarded in cash or kind. This type of farming was introduced in former Soviet Union under the socialist regime which was adopted by the socialist countries. After its collapse, these have already been modified.

AGRICULTURAL PRACTICES AND TECHNIQUES

1. **Fallow:** The soil loses its fertility due to continuous cultivation. Therefore, the land is left fallow from time to time for some period, normally 3-4 years, so that it may regain its natural fertility.
2. **Crop Rotation:** This practice is followed to avoid the land from being left fallow or to reduce the duration ofleaving the land fallow. In it, various crops are cultivated in rotation so that the fertility of land can be maintained for a longer period and the land may not become deficient in any particular crop nutrient. The most common crops grown in crop rotation are leguminous plants, which fix the atmospheric nitrogen naturally.
3. **Mixed Cropping:** In this practice, two or three crops are simultaneously grown on an agricultural land so that the nutrients utilized by one crop can be replaced to some extent by the other crop/crops. In this type of agriculture, the early maturing crops are harvested first. This type of agriculture saves the farmers from the uncertainties and crop failures to a large extent. The ratio of crops to be mixed varies according to the methods applied and the local needs.
4. **Two-Cropping Agriculture**: In it, two crops are cultivated in rotation in a year. It is practiced in those areas where there is adequate rainfall or proper facility of irrigation. Its main aim is to maintain the fertility of the soil. Therefore, the second crop grown is, normally, the nitrogen fixing leguminous crop.
5. **Multi-cropping Agriculture**: Due to availability of early maturing varieties of crops and better water management techniques, now-a-days it is becoming common to cultivate three crops in a year. This type of agriculture is called multi-cropping agriculture. As the agricultural practices are getting advanced, farmers are attracted towards the multi crop rotation practices.
6. **Relay Cropping**: When a new crop is sown, while the ripening crop is still standing in the field, it is termed as relay cropping.
7. **Crop-Productivity:** Crop productivity means the amount of production of crop per hectare or per worker. In the areas of extensive agriculture, per worker productivity is high whereas in the areas of intensive agriculture per hectare productivity is high. But, India is lagging behind in both the respects, as the agricultural practices have not developed sufficiently. Moreover, per worker and per hectare productivity is high in only the Green revolution affected areas. Crop productivity depends both on the physical as well as non-physical factors. The physical or geographical factors

include climate, soil, relief features and slope, while on the other hand, the non-geographical factors include the institutional, structural, political and administrative aspects. In fact, crop productivity is a technical term in which emphasis is on higher productivity irrespective of the cost incurred.

8. **Agricultural Efficiency**: In it, profitability is also included along with the productivity. In other words, it is concerned with what maximum quantity is produced in minimum time and at what price it is sold. So, it may be possible that the states with high crop productivity may register a low efficiency.
9. **Crop Intensity:** The arable land can hardly be stretched further in the countries like India. Therefore, it is essential to obtain more than one crop from the land in a year. The optimum agricultural use of a land is termed as crop intensity.

MINING

The discovery of minerals in the history of human development, is reflected in many stages in terms of copper age, bronze age and iron age. The use of minerals in ancient times was largely confined to the making of tools, utensils and weapons. The actual development of mining began with the industrial revolution and its importance is continuously increasing.

The profitability of mining operations thus, depends on two main factors:

(i) Physical factors include the size, grade and the mode of occurrence of the deposits.
(ii) Economic factors such as the demand for the mineral, technology available and used, capital to develop infrastructure and the labour and transport costs.

METHODS OF MINING

Depending on the mode of occurrence and the nature of the ore, mining is of two types: surface and underground mining. The surface mining also known as *open-cast* mining is the easiest and the cheapest way of mining minerals that occur close to the surface. Overhead costs such as safety precautions and equipment is relatively low in this method. The output is both large and rapid.

When the ore lies deep below the surface, **underground mining method** (shaft method) has to be used. In this method, vertical shafts have to be sunk, from where underground galleries radiate to reach the minerals. Minerals are extracted and transported to the surface through these passages. It requires specially designed lifts, drills, haulage vehicles, ventilation system for safety and efficient movement of people and material. This method is risky. Poisonous gases, fires, floods and caving in lead to fatal accidents. Have you ever read about mine fires and flooding of coal mines in India? The developed economies are retreating from mining, processing and refining stages of production due to high labour costs, while the developing countries with large labour force and striving for higher standard of living are becoming more important. Several countries of Africa and few of south America and Asia have over fifty per cent of the earnings from minerals alone.

SECONDARY ACTIVITIES

All economic activities namely primary, secondary, tertiary and quaternary, revolve around obtaining and utilising resources necessary for survival. Secondary activities add value to natural resources by *transforming* raw materials into valuable products. Cotton in the boll has limited use but after it is transformed into yarn, becomes more valuable and can be used for making clothes. Iron ore, cannot be used; directly from the mines, but after being converted into steel it gets its value and can be used for making many valuable machines, tools, etc. The same is true of most of the materials from the farm, forest, mine and the sea. Secondary activities, therefore, are concerned with manufacturing, processing and construction (infrastructure) industries.

MANUFACTURING

Manufacturing involves a full array of production from handicrafts to moulding iron and steel and stamping out plastic toys to assembling delicate computer components or space vehicles. In each of these processes, the common characteristics are the application of power, mass production of identical products and specialised labour in factory settings for the production of standardised commodities. Manufacturing may be done with modern power and machinery or it may still be very primitive. Most of the Third World countries still 'manufacture' in the literal sense of the term. It is difficult to present a full picture of all the manufacturers in these countries. More emphasis is given to the kind of 'industrial' activity which involves less complicated systems of production.

Characteristics of Modern Large Scale Manufacturing

Modern large scale manufacturing has the following characteristics:

Specialisation of Skills/Methods of Production

Under the 'craft' method factories produce only a few pieces which are made-to-order. So the costs are high. On the other hand, mass production involves production of large quantities of standardised parts by each worker performing only one task repeatedly.

'Manufacturing' Industry and 'Manufacturing Industry'

It is essentially a process which involves *transforming raw materials into finished goods of higher value for sale in local or distant markets*. Conceptually, an industry is a geographically located manufacturing unit maintaining books of accounts and, records under a management system. As the term *industry* is comprehensive, it is also used as synonymous with 'manufacturing' When one uses terms like 'steel industry' and 'chemical industry' one thinks of *factories* and *processes.* But there are many secondary activities which are not carried on in factories such as what is now called the 'entertainment industry' and Tourism industry, etc. So for clarity the longer expression 'manufacturing industry' is used.

Mechanisation

Mechanisation refers to using gadgets which accomplish tasks. Automation (without aid of human thinking during the manufacturing process) is the advanced stage of mechanisation. Automatic factories with feedback and closedloop computer control systems where machines are developed to ‘think’, have sprung up all over the world.

Technological Innovation

Technological innovations through research and development strategy are an important aspect of modern manufacturing for quality control, eliminating waste and inefficiency, and combating pollution.

Organisational Structure and Stratification

Modern manufacturing is characterised by:
(i) a complex machine technology
(ii) extreme specialisation and division of labour for producing more goods with less effort, and low costs
(iii) vast capital (iv) large organizations (v) executive bureaucracy.

Uneven Geographic Distribution

Major concentrations of modern manufacturing have flourished in a few number of places. These cover less than 10 per cent of the world’s land area. These nations have become the centres of economic and political power. However, in terms of the total area covered, manufacturing sites are much less conspicuous and concentrated on much smaller areas than that of agriculture due to greater intensity of processes. For example, 2.5 sq km of the American corn belt usually includes about four large farms employing about 10-20 workers supporting 50-100 persons. But this same area could contain several large integrated factories and employ thousands of workers.

Why do Large-scale Industries choose different locations?

Industries maximise profits by reducing costs. Therefore, industries should be located at points where the production costs are minimum. Some of the factors influencing industrial locations are as under:

Access to Market

The existence of a market for manufactured goods is the most important factor in the location of industries. ‘Market’ means people who have a demand for these goods and also have the purchasing power (ability to purchase) to be able to purchase from the sellers at a place. Remote areas inhabited by a few people offer small markets. The developed regions of Europe, North America, Japan and Australia provide large global markets as the purchasing power of the people is very high. The densely populated regions of South and South-east Asia also provide large markets. Some industries, such as aircraft manufacturing, have a global market. The arms industry also has global markets.

Access to Raw Material

Raw material used by industries should be cheap and easy to transport. Industries based on cheap, bulky and weight-losing material (ores) are located close to the sources of raw material such as steel, sugar, and cement industries. Perishability is a vital factor for the industry to be located closer to the source of the raw material. Agro-processing and dairy products are processed close to the sources of farm produce or milk supply respectively.

Access to Labour Supply

Labour supply is an important factor in the location of industries. Some types of manufacturing still require skilled labour. Increasing mechanisation, automation and flexibility of industrial processes have reduced the dependence of industry upon the labours.

Access to Sources of Energy

Industries which use more power are located close to the source of the energy supply such as the aluminium industry. Earlier coal was the main source of energy, today hydroelectricity and petroleum are also important sources of energy for many industries.

Access to Transportation and Communication Facilities

Speedy and efficient transport facilities to carry raw materials to the factory and to move finished goods to the market are essential for the development of industries. The cost of transport plays an important role in the location of industrial units. Western Europe and eastern North America have a highly developed transport system which has always induced the concentration of industries in these areas. Modern industry is inseparably tied to transportation systems. Improvements in transportation led to integrated economic development and regional specialisation of manufacturing. Communication is also an important need for industries for the exchange and management of information.

Government Policy

Governments adopt ‘regional policies’ to promote ‘balanced’ economic development and hence set up industries in particular areas.

Access to Agglomeration Economies/ Links between Industries

Many industries benefit from nearness to a leader-industry and other industries. These benefits are termed as agglomeration economies. Savings are derived from the linkages which exist between different industries. These factors operate together to determine industrial location.

Foot Loose Industries

Foot loose industries can be located in a wide variety of places. They are not dependent on any specific raw material, weight losing or otherwise. They largely depend on component parts which can be obtained anywhere. They produce in small quantity and also employ a small labour force. These are generally not polluting industries. The important factor in their location is accessibility by road network.

COUNTRY	INDUSTRIAL CENTRES	INDUSTRY
U.S.A. Canada Britain France Germany Russia Ukraine Netherlands Denmark Italy Sweden	Pittsburgh (Steel Capital of the World) Los Angels (Hollywood) Chicago Detroit Bermingham San-Francisco (Silicon Valley) Seattle (Most important industrial region of North America) Montreal Quebec Ottawa Hamilton (Bermingham of Canada) Toronto Manchester Liverpool Bredford London Derbishire Paris Champagne and Bordeaux Lyon village Loraine-Saar region Dartmund Frankfurt Moscow and Gorki Magntigorsk Leningrad (St Petersburg) Moscow-Ivanovo (Manchester of Russia) Krivoy Rog-Rostogo Rotterdam	Iron & Steel Film and Air-crafts Meat Processing Automobiles Iron & Steel Oil refineries, computer & Technology industries & Ship building Lumbering, Aluminium Smelting Ships and Aircrafts Marine engineering and ship building Paper industry Iron & Steel, Engineering Engineering and Automobiles Cotton textile Ship-building and oil refining Woollen textile Engineering and transport Woollen textile Aircraft and transport Wine and liquor Iron & Steel Iron & Steel Iron & Steel, Chemical Engineering & Transport Iron & Steel and Chemicals Iron & Steel and Oil refining Textile, Chemicals and Paper Cotton textile Iron & Steel and Heavy machinery Marine Engineering and Ship-building Diamond polishing Dairy industry

Brazil	Amsterdam Copenhagen Milan (Manchester of Italy) Turin (Detroit of Italy) Stockholm SaoPoalo	Silk textile Autombiles Ship-building Textile & Coffee industry

CLASSIFICATION OF MANUFACTURING INDUSTRIES

Manufacturing industries are classified on the basis of their size, inputs/raw materials, output/products and ownership

INDUSTRIES BASED ON SIZE

The amount of capital invested, number of workers employed and volume of production determine the size of industry. Accordingly, industries may be classified into household or cottage, small-scale and large-scale.

HOUSEHOLD INDUSTRIES OR COTTAGE MANUFACTURING

It is the smallest manufacturing unit. The artisans use local raw materials and simple tools to produce everyday goods in their homes with the help of their family members or parttime labour. Finished products may be for consumption in the same household or, for sale in local (village) markets, or, for barter. Capital and transportation do not wield much influence as this type of manufacturing has low commercial significance and most of the tools are devised locally. Some common everyday products produced in this sector of manufacturing include foodstuffs, fabrics, mats, containers, tools, furniture, shoes, and figurines from wood lot and forest, shoes, thongs and other articles from leather; pottery and bricks from clays and stones. Goldsmiths make jewellery of gold, silver and bronze. Some artefacts and crafts are made out of bamboo, wood obtained locally from the forests.

SMALL SCALE MANUFACTURING

Small scale manufacturing is distinguished from household industries by its production techniques and place of manufacture (a workshop outside the home/cottage of the producer). This type of manufacturing uses local raw material, simple power-driven machines and semi-skilled labour. It provides employment and raises local purchasing power. Therefore, countries like India, China, Indonesia and Brazil, etc. have developed labour-intensive small scale manufacturing in order to provide employment to their population. Large scale manufacturing involves a large market, various raw materials, enormous energy, specialised workers, advanced technology, assembly-line mass production and large capital. This kind of manufacturing developed in the last 200 years, in the United Kingdom, north-eastern U.S.A. and Europe. Now it has diffused to almost all over the world. On the basis of the system of large scale manufacturing, the world's major industrial regions may be grouped under two broad types, namely

(i) traditional large-scale industrial regions which are thickly clustered in a few more developed countries.

(ii) high-technology large scale industrial regions which have diffused to less developed countries.

INDUSTRIES BASED ON INPUTS/RAW MATERIALS

On the basis of the raw materials used, the industries are classified as:

(a) agro-based; (b) mineral based;
(c) chemical based; (d) forest based: and
(e) animal based.

(a) *Agro based Industries*

Agro processing involves the processing of raw materials from the field and the farm into finished products for rural and urban markets. Major agro-processing industries are food processing, sugar, pickles, fruits juices, beverages (tea, coffee and cocoa), spices and oils fats and textiles (cotton, jute, silk), rubber, etc.

Food Processing

Agro processing includes canning, producing cream, fruit processing and confectionery. While some preserving techniques, such as drying, fermenting and pickling, have been known since ancient times, these had limited pplications to cater to the pre-Industrial Revolution demands.Agri-business is commercial farming on an industrial scale often financed by business whose main interests lie outside agriculture, for example, large corporations in tea plantation business. Agri-business farms are mechanised, large in size, highly structured, reliant on chemicals, and may be described as 'agro-factories'.

(b) *Mineral based Industries*

These industries use minerals as a raw material. Some industries use ferrous metallic minerals which contain ferrous (iron), such as iron and steel industries but some use non-ferrous metallic minerals, such as aluminium, copper and jewellery industries. Many industries use non-metallic minerals such as cement and pottery industries.

(c) *Chemical based Industries*

Such industries use natural chemical minerals, e.g. mineral-oil (petroleum) is used in petrochemical industry. Salts, sulphur and potash industries also use natural minerals. Chemical industries are also based on raw materials obtained from wood and coal. Synthetic fibre, plastic, etc. are other examples of chemical based industries.

(d) Forest based Raw Material using Industries

The forests provide many major and minor products which are used as raw material. Timber for furniture industry, wood, bamboo and grass for paper industry, lac for lac industries come from forests.

INDUSTRIES BASED ON OWNERSHIP

(a) Public Sector Industries are owned and managed by governments. In India, there were a number of Public Sector Undertakings (PSUs). Socialist countries
have many state owned industries. Mixed economies have both Public and Private sector enterprises.

(b) Private Sector Industries are owned by individual investors. These are managed by private organisations. In capitalist countries, industries are generally owned privately.

(c) Joint Sector Industries are managed by joint stock companies or sometimes the private and public sectors together establish and manage the industries

TRADITIONAL LARGE-SCALE INDUSTRIAL REGIONS

These are based on heavy industry, often located near coal-fields and engaged in metal smelting, heavy engineering, chemical manufacture or textile production. These industries are now known as smokestack industries. Traditional industrial regions can be recognised by:

• High proportion of employment in manufacturing industry. High-density housing, often of inferior type, and poor services. Unattractive environment, for example, pollution, waste heaps, and so on.

• Problems of unemployment, emigration and derelict land areas caused by closure of factories because of a worldwide fall in demand.

The Ruhr Coal-field, Germany

This has been one of the major industrial regions of Europe for a long time. Coal and iron and steel formed the basis of the economy, but as the demand for coal declined, the industry started shrinking. Even after the iron ore was exhausted, the industry remained, using imported ore brought by waterways to the Ruhr. The Ruhr region is responsible for 80 percent of Germany's total steel production.

(e) Animal based Industries

Leather for leather industry and wool for woollen textiles are obtained from animals. Besides, ivory is also obtained from elephant's tusks.

INDUSTRIES BASED ON OUTPUT/PRODUCT

You have seen some machines and tools made of iron or steel. The raw material for such machines and tools is iron and steel. Which is itself an industry. The industry whose products are used to make other goods by using them as raw materials are basic industries. Iron/steel machines for textile industry clothes for use by consumers. The consumer goods industries produced goods which are consumed by consumers directly. For example, industries producing breads and biscuits, tea, soaps and toiletries, paper for writing, televisions, etc. are consumer goods or non-basic industries.

Changes in the industrial structure have led to the decay of some areas, and there are problems of industrial waste and pollution. The future prosperity of the Ruhr is based less on the products of coal and steel, for which it was initially famous, and more on the new industries like the huge Opel car assembly plant, new chemical plants, universities. Outof- town shopping centres have appeared resulting in a 'New Ruhr' landscape.

FACTBOX **LINES ON THE MAP**

Isohypes: The lines joining the points of equal elevation or height.
Isobath: The lines joining the points of equal depth of sea – water.
Isobar: The lines joining the points of equal atmospheric pressure.
Isobathytherm: The lines joining the ocean regions having equal temperature.
Isodopane: Lines of equal transportation costs.
Isogeotherm: The isotherms under the surface of the earth.
Isohaline: The lines joining the ocean regions of equal salinity.
Isohel: The lines joining the points of equal period of insolation.
Isohytes: The lines joining the regions receiving equal precipitation.
Isonif: The lines joining the regions of equal snow.
Isoneph: The lines joining the region of equal average cloud overcast.
Isophyte: he lines joining the points of equal height vegetation.
Iso – seismal: The lines joining the points of equal earthquake intensity.
Isothern: The lines joining the points of equal temperature reduced to sea – level.
Isonomal: The lines showing the equal thermal anomaly.
Isocline: The lines of equal mahnetic dip.
Isogloss: The lnes separating linguistic areas of a region.
Isopract: A specialized chart prepared for population study purpose.
Isoganic Line: Line of similar magnetic dip.
Agonic Line: Line of zero magnetic dip.
Loxodrum or Rhumb Line: The line of equal magnetic dip at the Mercater projection.
Plumb Line: The line joining the surface and the center of the earth.
Iso – stasy: Equilibrium state or balance on earth surface which are found between the light rock materials on the earth and the heavy rock materials inside the earth.
Isotach: The line in the weather maps, showing the points of equal wind velocity.
Isobront: The line joining the regions of equal thunder – storms.

CONCEPT OF HIGH TECHNOLOGY INDUSTRY

High technology, or simply high-tech, is the latest generation of manufacturing activities. It is best understood as the application of intensive research and development (R and D) efforts leading to the manufacture of products of an advanced scientific and engineering character. Professional (white collar) workers make up a large share of the total workforce. These highly skilled specialists greatly outnumber the actual production (blue collar) workers. Robotics on the assembly line, computer-aided design (CAD) and manufacturing, electronic controls of smelting and refining processes, and the constant development of new chemical and pharmaceutical products are notable examples of a high-tech industry.

Neatly spaced, low, modern, dispersed, office-plant-lab buildings rather than massive assembly structures, factories and storage areas mark the high-tech industrial landscape. Planned business parks for high-tech start-ups have become part of regional and local development schemes. High-tech industries which are regionally concentrated, self-sustained and highly specialised are called technopolies. The Silicon Valley near San Francisco and Silicon Forest near Seattle are examples of technopolies. Manufacturing contributes significantly to the world economy. Iron and steel, textiles, automobiles, petrochemicals and electronics are some of the world's most important manufacturing industries.

IRON AND STEEL INDUSTRY

The iron and steel industry forms the base of all other industries and, therefore, it is called a basic industry. It is basic because it provides raw material for other industries such as machine tools used for further production. It may also be called a heavy industry because it uses large quantities of bulky raw materials and its products are also heavy. Iron is extracted from iron ore by smelting in a blast furnace with carbon (coke) and limestone. The molten iron is cooled and moulded to form pig iron which is used for converting into steel by adding strengthening materials like manganese. The large integrated steel industry is traditionally located close to the sources of raw materials – iron ore, coal, manganese and limestone – or at places where these could be easily brought, e.g. near ports. But in mini steel mills access to markets is more important than inputs. These are less expensive to build and operate and can be located near markets because of the abundance of scrap metal, which is the main input. Traditionally, most of the steel was produced at large integrated plants, but mini mills are limited to just one-step process – steel making – and are gaining ground.

Distribution: The industry is one of the most complex and capital-intensive industries and is concentrated in the advanced countries of North America, Europe and Asia. In U.S.A, most of the production comes from the north Appalachian region (Pittsburgh), Great Lake region (Chicago-Gary, Erie, Cleveland, Lorain, Buffalo and Duluth) and the Atlantic Coast (Sparrows Point and Morisville). The industry has also moved towards the southern state of Alabama. Pittsburg area is now losing ground. It has now become the "rust bowl" of U.S.A. In Europe, U.K., Germany, France, Belgium, Luxembourgh, the Netherlands and Russia are the leading producers. The important steel centres are Scun Thorpe, Port Talbot, Birmingham and Sheffield in the U.K.; Duisburg, Dortmund, Dusseldorf and Essen in Germany; Le Creusot and St. Ettienne in France; and Moscow, St. Petersburgh, Lipetsk, Tula, in Russia and Krivoi Rog, and Donetsk in Ukraine. In Asia, the important centres include Nagasaki and Tokyo-Yokohama in Japan; Shanghai, Tienstin and Wuhan in China; and Jamshedpur, Kulti-Burnpur, Durgapur, Rourkela, Bhilai, Bokaro, Salem, Visakhapatnam and Bhadravati in India. Consult your atlas to locate these places/ centres.

Country	City	Industry
Argentina	Rio-de-Janeiro	Textile and Coffee industries
	Buenos Aires	Ship-building
	La Plata	Aircrafts, Chemicals and Iron and
Chile	ValPerazo	Steel
		Oil refining, Petro-chemicals and
	Santiago	wine
Venezuela	Maracaibo	and liquor
Morocco	Casablanca	Wine and liquor
Egypt	Cairo and Alexandria	Oil refining
Japan	Nagoya (Detroit of Japan)	Chemical industry
	Osaka (Manchester of Japan)	Cotton textile
	Kobe and Kyoto	Aircraft, Automobile and machinery
	Nagasaki	Ships, Iron and Steel and Textile
		Ship-building, Iron & Steel and
	Tokyo	Textile
China	Shanghai	Iron & Steel, Ships building and
	Wuhan	Machinery
	Beijing	Engineering and Textile
	Anshan-Mukden (Pittsburgh of	Textile and machinery
	China)	Textile, machinery, ships and Iron
		&Steel
		Textile and machinery
		Iron & Steel

COTTON TEXTILE INDUSTRY

Cotton textile industry has three sub-sectors i.e. handloom, powerloom and mill sectors. Handloom sector is labour-intensive and provides employment to semi-skilled workers. It requires small capital investment. This sector involves spinning, weaving and finishing of the fabrics. The powerloom sector introduces machines and becomes less labour intensive and the volume of production increases. Cotton textile mill sector is highly capital intensive and produces fine clothes in bulk.

Cotton textile manufacturing requires good quality cotton as raw material. India, China, U.S.A, Pakistan, Uzbekistan, Egypt produce more than half of the world's raw cotton. The U.K, NW European countries and Japan also produce cotton textile made from imported yarn. Europe alone accounts for nearly half of the world's cotton imports. The industry has to face very stiff competition with synthetic fibres hence it has now shown a declining trend in many countries. With the scientific advancement and technological improvements the structure of industries changes. For example, Germany recorded constant growth in cotton textile industry since Second World War till the seventies but now it has declined. It has shifted to less developed countries where labour costs are low.

TERTIARY AND QUATERNARY ACTIVITIES

There are many professionals who provide their services against payment of their fee. Thus, all types of services are special skills provided in exchange of payments. Health, education, law, governance and recreation etc. require professional skills. These services require other theoretical knowledge and practical training. Tertiary activities are related to the service sector. Manpower is an important component of the service sector as most of the tertiary activities are performed by skilled labour, professionally trained experts and consultants. In the initial stages of economic development, larger proportion of people worked in the primary sector. In a developed economy, the majority of workers get employment in tertiary activity and a moderate proportion is employed in the secondary sector. Tertiary activities include both production and exchange.

The production involves the 'provision' of services that are 'consumed'. The output is indirectly measured in terms of wages and salaries. Exchange, involves trade, transport and communication facilities that are used to overcome distance. Tertiary activities, therefore, involve the commercial output of services rather than the production of tangible goods. They are not directly involved in the processing of physical raw materials. Common examples are the work of a plumber, electrician, technician, launderer, barber, shopkeeper, driver, cashier, teacher, doctor, lawyer and publisher etc. The main difference between secondary activities and tertiary activities is that the expertise provided by services relies more heavily on specialised skills, experience and knowledge of the workers rather than on the production techniques, machinery and factory processes.

TYPES OF TERTIARY ACTIVITIES

Trade, transport, communication and services are some of the tertiary activities.

Trade and commerce

Trade is essentially **buying** and **selling** of items produced elsewhere. All the services in retail and wholesale trading or commerce are specifically intended for profit.

TRANSPORT

Transport is a service or facility by which people, materials and manufactured goods are physically carried from one location to another. It is an organised industry created to satisfy man's basic need of mobility. Modern society requires speedy and efficient transport systems to assist in the production, distribution and consumption of goods. As transport systems develop, different places are linked together to form a network. Networks are made up of nodes and links. A node is the meeting point of two or more routes, a point of origin, a point of destination or any sizeable town along a route, Every road that joins two nodes is called a link. A developed network has many links, which means that places are well-connected.

Factors Affecting Transport

Demand

for transport is influenced by the size of population. The larger the population size, the greater is the demand for transport.

ROUTES

depend on: location of cities, towns, villages, industrial centres and raw materials, pattern of trade between them, nature of the landscape between them, type of climate, and funds available for overcoming obstacles along the length of the route.

Communication

Communication services involve the transmission of **words** and **messages, facts** and **ideas.** Where the transport network is efficient, communications are easily disseminated. Certain developments, such as mobile telephony and satellites, have made communications independent of transport.

Telecommunications

The use of telecommunications is linked to the development of modern technology. It has revolutionised communications because of the speed with which messages are sent. The time reduced is from weeks to minutes. Besides, the recent advancements like mobile telephony have made communications direct and instantaneous at any time and from anywhere

SERVICES

Services occur at many different levels. Some are geared to industry, some to people, and some to both industry and people, e.g. the transport systems. Low-order services, such as grocery shops and laundries, are more common and widespread than high-order services or more specialised ones like those of accountants, consultants and physicians. Many services have now been regulated. Making and maintaining highways and bridges, maintaining fire fighting departments and supplying or supervising education and customer - care are among the important services most often supervised or performed by governments or companies.

PEOPLE ENGAGED IN TERTIARY ACTIVITIES

Today most people are service workers. Services are provided in all societies. But in more developed countries a higher percentage of workers is employed in provision of services in contrast to less than 10 per cent in the less developed countries. In U.S.A. over 75 per cent of workers are engaged in services. The trend in employment in this sector has been increasing while it has remained unchanged or decreasing in the primary and secondary activities.

SOME SELECTED EXAMPLES

Tourism

Tourism is travel undertaken for purposes of recreation rather than business. It has become the world's single largest tertiary activity in total registered jobs (250 million) and total revenue (40 per cent of the total GDP). Besides, many local persons, are employed to provide services like accommodation, meals, transport, entertainment and special shops serving the tourists.

Tourism fosters the growth of infrastructure industries, retail trading, and craft industries (souvenirs). In some regions, tourism is seasonal because the vacation period is dependent on favourable weather conditions, but many regions attract visitors all the year round.

Tourist Regions

The warmer places around the Mediterranean Coast and the West Coast of India are some of the popular tourist destinations in the world. Others include winter sports regions, found mainly in mountainous areas, and various scenic landscapes and national parks, which are scattered. Historic towns also attract tourists, because of the monument, heritage sites and cultural activities.

Factors Affecting Tourism

Demand **:** Since the last century, the demand for holidays has increased rapidly. Improvements in the standard of living and increased leisure time, permit many more people to go on holidays for leisure. *Transport* **:** The opening-up of tourist areas has been aided by improvement in transport facilities. Travel is easier by car, with better road systems. More significant in recent years has been the expansion in air transport. For example, air travel allows one to travel anywhere in the world in a few hours of flyingtime from their homes. The advent of package holidays has reduced the costs.

FactBox **International Boundaries**

Durand Line: The boundary between Pakistan and Afghanistan, determined by Sir Motiger Durand of Britain. Afghanistan does not recognize it as the international frontier.
McMahon Line: This boundary between India and China, was determined by Sir McMahon (Britain) through a treaty, in 1914. Its length is 700 miles.
Radcliff Line: It is the boundary between India and Pakistan. It was determined by Sir Radcliff on the 15, August 1947.
Hindenberg Line: It is the boundary between Germany and Poland, determined during the First World War
Mannerhein Line: The frontier between Russia and Finland.
Maginot Line: The frontier between Germany and France.
17th Parallel: The boundary between North and South Vietnam.
24th Parallel: It is near Kachcha, and considered as the boundary between India and Pakistan, but India does not accept it.
38th Parallel: The boundary between the North and the South Koreas.
141^{0} W Longitude: The frontier between Alaska (USA) and Canada
49th Parallel: The boundary line between the USA and Canada.
Odernisse Line: The frontier between the former Germany and Poland.
Seigfriend Line: The frontier constructed by Germany in the forms of walls, minarets and army posts between France and former Germany before the World War – II.

Tourist Attractions

Climate: Most people from colder regions expect to have warm, sunny weather for beach holidays. This is one of the main reasons for the importance of tourism in Southern Europe and the Mediterranean lands. The Mediterranean climate offers almost consistently higher temperatures, than in other parts of Europe, long hours of sunshine and low rainfall throughout the peak holiday season. People taking winter holidays have specific climatic requirements, either higher temperatures than their own homelands, or snow cover suitable for skiing.

Landscape: Many people like to spend their holidays in an attractive environment, which often means mountains, lakes, spectacular sea coasts and landscapes not completely altered by man. *History and Art:* The history and art of an area have potential attractiveness. People visit ancient or picturesque towns and archaeological sites, and enjoy exploring castles, palaces and churches. *Culture and Economy:* These attract tourists with a penchant for experiencing ethnic and local customs. Besides, if a region provides for the needs of tourists at a cheap cost, it is likely to become very popular. Home-stay has emerged as a profitable business such as *heritage homes* in Goa, Madikere and Coorg in Karnataka.

Medical Services for Overseas Patients in India

About 55,000 patients from U.S.A. visited India in 2005 for treatment. This is still a small number compared with the millions of surgeries performed each year in the U.S. healthcare system. India has emerged as the leading country of medical tourism in the world. World class hospitals located in metropolitan cities cater to patients all over the world. Medical tourism brings abundant benefits to developing countries like India, Thailand, Singapore and Malaysia. Beyond medical tourism, is the trend of outsourcing of medical tests and data interpretation. Hospitals in India, Switzerland and Australia have been performing certain medical services – ranging from reading radiology images, to interpreting Magnetic Resonance Images (MRIs) and ultrasound tests. Outsourcing holds tremendous advantages for patients, if it is focused on improving quality or providing specialised care.

Medical Tourism

When medical treatment is combined with international tourism activity, it lends itself to what is commonly known as medical tourism.

QUATERNARY ACTIVITIES

What do a CEO of an MNC in Copenhagen, at New York and a medical transcriptionist at Bangalore have in common? All these people work in a segment of the service sector that is knowledge oriented. This sector can be divided into quaternary and quinary activities. Quaternary activities involve some of the following: the collection, production and dissemination of information or even the production of information. Quaternary activities centre around research, development and may be seen as an advanced form of services involving specialised knowledge and technical skills.

THE QUATERNARY SECTOR

The Quaternary Sector along with the Tertiary Sector has replaced most of the primary and secondary employment as the basis for economic growth. Over half of all workers In developed economies are in the 'Knowledge Sector' and there has been a very high growth in demand for and consumption of information based services from mutual fund managers to tax consultants, software developers and statisticians. Personnel working in office buildings, elementary schools and university classrooms, hospitals and doctors' offices, theatres, accounting and brokerage firms all belong to this category of services. Like some of the tertiary functions, quaternary activities can also be outsourced. They are not tied to resources, affected by the environment, or necessarily localised by market.

QUINARY ACTIVITIES

The highest level of decision makers or policy makers perform quinary activities. These are subtly different from the knowledge based industries that the quinary sector in general deals with. Quinary activities are services that focus on the creation, re-arrangement and interpretation of new and existing ideas; data interpretation and the use and evaluation of new technologies. Often referred to as **'gold collar'** professions, they represent another subdivision of the tertiary sector representing special and highly paid skills of senior business executives, government officials, research scientists, financial and legal consultants, etc. Their importance in the structure of advanced economies far outweighs their numbers. Outsourcing has resulted in the opening up of a large number of call centres in India, China, Eastern Europe, Israel, Philippines and Costa Rica. It has created new jobs in these countries. Outsourcing is coming to those countries where cheap and skilled workers are available.

These are also out-migrating countries. With the work available though outsourcing, the migration in these countries may come down. Outsourcing countries are facing resistance from job-seeking youths in their respective countries. The comparative advantage is the main reason for continuing outsourcing. New trends in quinary services include knowledge processing outsourcing (KPO) and 'home shoring', the latter as an alternative to outsourcing. The KPO industry is distinct from Business Process Outsourcing (BPO) as it involves highly skilled workers. It is information driven knowledge outsourcing. KPO enables companies to create additional business opportunities. Examples of KPOs include research and development (R and D) activities, e-learning, business research, intellectual property (IP) research, legal profession and the banking sector.

TRANSPORT AND COMMUNICATION

Transport, communication and trade establish links between producing centres and consuming centres. The system of mass production and exchange is complex. Each region produces the items for which it is best suited. Trade or the exchange of such commodities relies on transportation and communication. Transport provides the network of links and carriers through which trade takes place.

TRANSPORT

Transport is a service or facility for the carriage of persons and goods from one place to the other using humans, animals and different kinds of vehicles. Such movements take place over land, water and air. Roads and railways form part of land transport; while shipping and waterways and airways are the other two modes. Pipelines carry materials like petroleum, natural gas, and ores in liquidified form. Moreover, transportation is an organized service industry created to satisfy the basic needs of society. It includes transport arteries, vehicles to carry people and goods, and the organisation to maintain arteries, and to handle loading, unloading and delivery. Every nation as developed various kinds of transportation for defence purposes. Assured and speedy transportation, along with efficient communication, promote cooperation and unity among scattered peoples.

MODES OF TRANSPORTATION

The principal modes of world transportation, as already mentioned are **land, water, air** and **pipelines.** International movement of goods is handled by ocean freighters. Road transport is cheaper and faster over short distances and for door-todoor services. Railways are most suited for large volumes of bulky materials over long distances within a country. High-value, light and perishable goods are best moved by airways.

Land Transport

Most of the movement of goods and services takes place over land. Perhaps the first public railway line was opened in 1825 between Stockton and Darlington in northern England and then onwards, railways became the most popular and fastest form of transport in the nineteenth century. In the densely populated districts of India and China, overland transport still takes place by human porters or carts drawn or pushed by humans.

Roads

Road transport is the most economical for short distances compared to railways. Freight transport by road is gaining importance because it offers door-to-door service. Roads play a vital role in a nation's trade and commerce and for promoting tourism.

Length of the Roads Sl. Countries For every No. 100 km2 area

1. India 105	2. Japan 327
3. France 164	4. U.K. 162
5. U.S.A. 67	6. Spain 68
7. Sri Lanka 151	

Source : Encyclopedia Britannica.

Traffic Flows: Traffic on roads has increased dramatically in recent years. When the road network cannot cope with the demands of traffic, congestion occurs. City roads suffer from chronic traffic congestion. Peaks (high points) and troughs (low points) of traffic flow can be seen on roads at particular times of the day, for example, peaks occurring during the rush hour before and after work. Most of the cities in the world have been facing the problem of congestion.

HIGHWAYS

Highways are metalled roads connecting distant places. They are constructed in a manner for unobstructed vehicular movement. As such these are 80 m wide, with separate traffic lanes, bridges, flyovers and dual carriageways to facilitate uninterrupted traffic flow. In developed countries, every city and port town is linked through highways.

Border Roads

Roads laid along international boundaries are called border roads. They play an important role in integrating people in remote areas with major cities and providing defence. Almost all countries have such roads to transport goods to border villages and military camps.

Railways

Railways are a mode of land transport for bulky goods and passengers over long distances. The railway gauges vary in different countries and are roughly classified as broad (more than 1.5 m), standard (1.44 m), metre gauge (1 m) and smaller gauges.

***Total Length of Railways in Selected Countries* (in 100 sq km)**

1. U.S.A. 278.3	2. Russia 160.8
3. India 144.7	4. Canada 93.5
5. Germany 90.8	6. China 70.1
7. Australia 40.0	8. U.K. 37.9
9. France 34.5	10. Brazil 30.1

SOURCE: ENCYCLOPAEDIA BRITANICA

Sobriquets of Places (World)

Sobriquet – Place

The Queen of Adriatic – Venice (Italy)
The Island of Clove – Zanzibar
The City of Seven Hills – Rome
The Eternal city – Rome
The Gift of Nile – Egypt
The Gateways of Tears – Bab – el – andeb
The Forbidden City – Lhasa (Tibet)
The Land of Thunder Bolt – Bhutan
The city of Sky – scrapers – New York
The Empire City – New York
The Dark Continent – Africa
The City of Golden Gate – San Francisso (USA)
The Quaker City – Philadelphia (USA)
The pearl of Antilles – Cuba
The Sugar Bowl of the World – Cuba
The Land of White Elephants – Thailand

The Land of Thousand Lakes – Fingland
The Land of Rising Sun – Japan
The Land of Mid – night Sun – Norway
The Land of Morning Calms – Korea
The Land of Golden Pagoda – Myanmar
The Land of Kangaroos – Australia
The Britain of South – New Zealand
The Key of Mediterranean – Strait of Gibraltar
The Island of Pearls– Bahrain
The Sacred Land – Jerusalem
The Herring Pond – Atlantic Ocean
The Roof of the World – The plateau of Pamir
The Sickman of Europe – Turkey
The Battle Ground of Europe – Belgium
The play Ground of Europe – Switzerland
The City of Golden Minarets – Oxford
The Sorrow of China – Hwang Ho
The Yellow River – Hwang Ho
The Bread Basket of the World – Praines (N America)
The most Isolated Island of the World – Trista de Cunha (Atlantic Ocean)
The City of Golden Temple– Amritsar
The Land of Five Rivers – Punjab
The Blue Mountains – Nilgiri hills
The Sorrow of Bengal – R. Damodar
The Gateway of India – Mumbai
The Garden City of India – Bangalore
The City of Palaces – Kolkata
The Queen of Arabian Sea – Cochin
The Venice of East – Cochin
The Pink City – Jaipur
The Spice Garden of India – Kerala
The Switzerland of India – Kashmir
Te Diamond Harbour – Kolkata
The City of Seven Islands – Mumbai
The Twin Cities – Hyderabad – Secunderabad
The City of Lakes – Srinagar
The City of Temples and Banks (Ghats) – Varanasi
The City of Nawabs – Lucknow
The Backbone of Economy of Northern India – R. Ganga
The Sorrow of Bihar – R. Kosi
The Scotland of East – Meghalaya
The Hollywood of India – Mumbai

The Steel City – Jamshedpur
The Queen of Chhotanagpur – Netarhat (Jharkhand)
The Queen of Mountains – Mussoorie
The Child of Sea – Lakshadweep
The Kashmir of South – Kerala
The Manchester of India – Ahmedabad
The Paris of India – Jaipur
The Pittsberg of India – Jamshedpur
The Adobe of God – Allahabad
The Manchester of North India – Kanpur
The Heart of India – Delhi
The Southern Ganga – R. Godavari
The City of Festivals – Madurai
The Pearl of Karnataka – Mysore
The Baskets of Fruits – Himachal Pradesh
The Thermopalli of Rajasthan – Haldi Ghati
The Paris of East – Jaipur
The Pride of Rajasthan– Chittorgarh
The Gateway of Rajasthan – Bharatpur
The Mini – Switzerland of India – Khojjiyar (Chamba valley, Himachal Prades)

Europe has one of the most dense rail networks in the world. Channel Tunnel, operated by Euro Tunnel Group through England, connects London with Paris. Trans-continental railway lines have now lost their importance to quicker and more flexible transport systems of airways and roadways. In Russia, railways account for about 90 per cent of the country's total transport with a very dense network west of the Urals. Africa continent, despite being the second largest, has only 40,000 km of railways with South Africa alone accounting for 18,000 km due to the concentration of gold, diamond and copper mining activities. The important routes of the continent are:
(i) the Benguela Railway through Angola to Katanga-Zambia Copper Belt;
(ii) the Tanzania Railway from the Zambian Copper Belt to Dar-es-Salaam on the coast;
(iii) the Railway through Botswana and Zimbabwe linking the landlocked states to the South African network; and
(iv) the Blue Train from Cape Town to Pretoria in the Republic of South Africa.

Trans–Continental Railways

Trans–continental railways run across the continent and link its two ends. They were constructed for economic and political reasons to facilitate long runs in different directions. The following are the most important of these:

TRANS–SIBERIAN RAILWAY

This is a trans–siberian Railways major rail route of Russia runs from St. Petersburg in the west to Vladivostok on the Pacific Coast in the east passing through Moscow, Ufa, Novosibirsk, Irkutsk, Chita and Khabarovsk. It is the most important route in Asia and the longest (9,332 km) double-tracked and electrified trans– continental railway in the world. It has helped in opening up its Asian region to West European markets. It runs across the Ural Mountains Ob and Yenisei rivers Chita is an important agro-centre and Irkutsk, a fur centre. There are connecting links to the south, namely, to Odessa (Ukraine), Baku on the Caspian Coast, Tashkent (Uzbekistan), Ulan Bator (Mongolia), and Shenyang (Mukden) and Beijing in China.

Trans–Canadian Railways

This 7,050 km long rail-line in Canada runs from Halifax in the east to Vancouver on the Pacific Coast passing through Montreal, Ottawa, Winnipeg and Calgary It was constructed in 1886, initially as part of an agreement to make British Columbia on the west coast join the Federation of States. Later on, it gained economic significance because it connected the Quebec-Montreal Industrial Region with the wheat belt of the Prairie Region and the Coniferous Forest region in the north. Thus each of these regions became complementary to the other. A loop line from Winnipeg to Thunder Bay (Lake Superior) connects this rail-line with one of the important waterways of the world. This line is the economic artery of Canada. Wheat and meat are the important exports on this route.

The Union and Pacific Railway

This rail-line connects New York on the Atlantic Coast to San Francisco on the Pacific Coast passing through Cleveland, Chicago, Omaha, Evans, Ogden and Sacramento. The most valuable exports on this route are ores, grain, paper, chemicals and machinery.

The Australian Trans–Continental Railway

This rail-line runs west-east across the southern part of the continent from Perth on the west coast, to Sydney on the east coast. Passing through Kalgoorlie, Broken Hill and Port Augusta Another major north-south line connects Adelaide and Alice Spring and to be joined further to the Darwin–Birdum line.

The Orient Express

This line runs from Paris to Istanbul passing through Strasbourg, Munich, Vienna, Budapest and Belgrade. The journey time from London to Istanbul by this Express is now reduced to 96 hours as against 10 days by the sea-route. The chief exports on this rail-route are cheese, bacon, oats, wine, fruits, and machinery. There is a proposal to build a Trans–Asiatic Railway linking Istanbul with Bangkok via Iran, Pakistan, India, Bangladesh and Myanmar.

WATER TRANSPORT

One of the great advantages of water transportation is that it does not require route construction. The oceans are linked with each other and are negotiable with ships of various sizes. All that is needed is to provide port facilities at the two ends. It is much cheaper because the friction of water is far less than that of land. The energy cost of water transportation is lower. Water transport is divided into sea routes and inland waterways.

The oceans offer a smooth highway traversable in all directions with no maintenance costs. Its transformation into a routeway by sea-going vessels is an important development in human adaptation to the physical environment. Compared to land and air, ocean transport is a cheaper means of haulage (carrying of load) of bulky material over long distances from one continent to another. Modern passenger liners (ships) and cargo ships are equipped with radar, wireless and other navigation aids. The development of refrigerated chambers for perishable goods, tankers and specialised ships has also improved cargo transport. The use of containers has made cargo handling at the world's major ports easier.

Important Sea Routes

Some important routes have been discussed in the following pages.

The Northern Atlantic Sea Route

This links North-eastern U.S.A. and Northwestern Europe, the two industrially developed regions of the world. The foreign trade over this route is greater than that of the rest of the world combined. One fourth of the world's foreign trade moves on this route. It is, therefore, the busiest in the world and otherwise, called the Big Trunk Route. Both the coasts have highly advanced ports and harbour facilities. Find out some of the important ports on the coast of U.S.A. and Western Europe in your atlas.

The Mediterranean–Indian Ocean Sea Route

This sea route passes through the heart of the Old World and serves more countries and people than any other route. Port Said, Aden, Mumbai, Colombo and Singapore are some of the important ports on this route. The construction of Suez canal has greatly reduced the distance and time as compared to the earlier route through the Cape of Good Hope. This trade route connects the highly industrialised Western European region with West Africa, South Africa, South-east Asia and the commercial agriculture and livestock economies of Australia and New Zealand. Before the construction of the Suez Canal this was the route connecting Liverpool and Colombo which was 6,400 km longer than the Suez Canal route. The volume of trade and traffic between both East and West Africa is on the increase due to the development of the rich natural resources such as gold, diamond, copper, tin, groundnut, oil palm, coffee and fruits.

The Cape of Good Hope Sea Route

This sea route is another important one across the Atlantic Ocean which connects West European and West African countries with Brazil, Argentina and Uruguay in South America. The traffic is far less on this route compared to that of the North Atlantic Route because of the limited development and population in South America and Africa. Only southeastern Brazil and Plata estuary and parts of South Africa have large-scale industries. There is also little traffic on the route between Rio de Janeiro and Cape Town because both South America and Africa have similar products and resources. Trade across the vast North Pacific Ocean moves by several routes which converge at Honolulu. The direct route on the Great Circle links Vancouver and Yokohama and reduces the travelling distance (2,480 km) by half.

The North Pacific Sea Route

This sea route links the ports on the west-coast of North America with those of Asia. These are Vancouver, Seattle, Portland, San Francisco and Los Angeles on the American side and Yokohama, Kobe, Shanghai, Hong Kong, Manila and Singapore on the Asian side.

The South Pacific Sea Route

This sea route connects Western Europe and North America with Australia, New Zealand and the scattered Pacific islands via the Panama Canal. This route is also used for reaching Hong Kong, Philippines and Indonesia. The distance covered between Panama and Sydney is 12,000 km. Honolulu is an important port on this route.

COASTAL SHIPPING

It is obvious that water transport is a cheaper mode. While oceanic routes connect different countries, coastal shipping is a convenient mode of transportation with long coastlines, e.g. U.S.A, China and India. Shenzhen States in Europe are most suitably placed for coastal shipping connecting one member's coast with the other. If properly developed, coastal shipping can reduce the congestion on the land routes.

Shipping Canals

The Suez and the Panama Canals are two vital man-made navigation canals or waterways which serve as gateways of commerce for both the eastern and western worlds.

The Suez Canal

This canal had been constructed in 1869 in Egypt between Port Said in the north and Port Suez in the south linking the Mediterranean Sea and the Red Sea. It gives Europe a new gateway to the Indian Ocean

The Panama Canal

This canal connects the Atlantic Ocean in the east to the Pacific Ocean in the west. It has been constructed across the Panama Isthmus between Panama City and Colon by the U.S. government

OLD AND NEW NAMES OF COUNTRIES AND CITIES

New Name – Old Name	New Name – Old Name
Japan – Nippon	Ho Chi Minh City – Saogan
Surinam – Dutch Guyana	Hawaii Island – Sandwich Island
Iran – Persia	Iraq – Messopotamia
Malawi – Nyasaland	Lesotho – Vasutoland
Ghana – Gold Coast	Ethiopia – Abyssinia
Thailand – Siam	Taiwan – Formosa
Kozhikode – Calicut	St Petersburg – Leningrad
Chennai – Madras	Combodia – Campuchia, Khamer
Djibouti – French Somaliland	Zambia – North Rhodesia
Zimbabwe – South Rhodesia	Istanbul – Constantinople
Varanasi – Banaras, Kashi	Allahabad – Prayagraj (Prayag)
Zaire – Republic of Congo	Malagasy – Madagascar
Myanmar – Burma	Java – Suvarnadweep and Yavodweep
Patna – Pataliputra	Bangladesh – East Pakistan
Malaysia – Malaya	Harare – Salisbury

INLAND WATERWAYS

Rivers, canals, lakes and coastal areas have been important waterways since time immemorial. Boats and steamers are used as means of transport for cargo and passengers. The development of inland waterways is dependent on the **navigability** width and depth of the channel, continuity in the **water flow**, and **transport technology** in use. Rivers are the only means of transport in dense forests. Very heavy cargo like coal, cement, timber and metallic ores can be transported through inland waterways. In ancient times, riverways were the main highways of transportation as in the case of India. But they lost importance because of competition from railways, lack of water due to diversion for irrigation, and their poor maintenance.

The significance of rivers as inland waterways for domestic and international transport and trade has been recognized throughout the developed world. Despite inherent limitations, many rivers have been modified to enhance their navigability by dredging, stabilising river banks, and building dams and barrages for regulating the flow of water. The following river waterways are some of the world's important highways of commerce.

The Rhine Waterways

The Rhine flows through Germany and the Netherlands. It is navigable for 700 km from Rotterdam**,** at its mouth in the Netherlands to **Basel** in Switzerland. Ocean-going vessels can reach up to Cologne. The Ruhr river joins the Rhine from the east. It flows through a rich coalfield and the whole basin has become a prosperous manufacturing area. Dusseldorf is the Rhine port for this region. Huge tonnage moves along the stretch south of the Ruhr. This waterway is the world's most heavily used. Each year more than 20,000 ocean-going ships and 2,00,000 inland vessels exchange their cargoes. It connects the industrial areas of Switzerland, Germany, France, Belgium and the Netherlands with the North Atlantic Sea Route.

The Danube Waterway

This important inland waterway serves Eastern Europe. The Danube river rises in the Black Forest and flows eastwards through many countries. It is navigable up to Taurna Severin. The chief export items are wheat, maize, timber, and machinery.

The Volga Waterway

Russia has a large number of developed waterways, of which the Volga is one of the most important. It provides a navigable waterway of 11,200 km and drains into the Caspian Sea. The Volga-Moscow Canal connects it with the Moscow region and the Volga-Don Canal with the Black Sea.

The Great Lakes of North America Superior, Huron Erie and Ontario are connected by Soo Canal and Welland Canal to form an inland waterway. The estuary of St. Lawrence River, along with the Great Lakes, forms a unique commercial waterway in the northern part of North America. The ports on this route like Duluth and Buffalo are equipped with all facilities of ocean ports. As such large oceangoing vessels are able to navigate up the river operations require elaborate infrastructure like hangars, landing, fuelling, and maintenance facilities for the aircrafts. The construction of airports is also very expensive and has developed more in highly industrialised countries where there is a large volume of traffic. At present no place in the world is more than 35 hours away. This startling fact has been made possible due to people who build and fly airplanes. Travel by air can now be measured by hours and minutes instead of years and months. Frequent air services are available to many parts of the world. Although, U.K. pioneered the use of commercial jet transport, U.S.A. developed largely post-War international civil aviation. Today, more than 250 commercial airlines offer regular services to different parts of the world. Recent developments can change the future course of air transport. Supersonic aircraft, cover the distance between London and New York within three and a half hours.

INTER-CONTINENTAL AIR ROUTES

In the Northern Hemisphere, there is a distinct east-west belt of inter-continental air routes. Dense network exists in Eastern U.S.A., Western Europe and Southeast Asia. U.S.A. alone accounts for 60 per cent of the airways of the world. New York, London, Paris, Amsterdam, Frankfurt Rome, Moscow, Karachi, New Delhi, Mumbai, Bangkok, Singapore, Tokyo, San Francisco, Los Angeles and Chicago are the nodal points where air routes converge or radiate to all continents. Africa, Asiatic part of Russia and South America lack air services. There are limited air services between 10-35 latitudes in the Southern hemisphere due to sparser population, limited landmass and economic development.

PIPELINES

Pipelines are used extensively to transport liquids and gases such as water, petroleum and natural gas for an uninterrupted flow. Water supplied through pipelines is familiar to all. Cooking gas or LPG is supplied through deep inside the continent to Montreal**.** But here goods have to be trans-shipped to smaller vessels due to the presence of rapids. Canals have been constructed up to 3.5 m deep to avoid these.

The Mississippi Waterways

The Mississippi-Ohio waterway connects the interior part of U.S.A. with the Gulf of Mexico in the south. Large steamers can go through this route up to Minneapolis.

AIR TRANSPORT

Air transport is the fastest means of transportation, but it is very costly. Being fast, it is preferred by passengers for long-distance travel. Valuable cargo can be moved rapidly on a world-wide scale. It is often the only means to reach inaccessible areas. Air transport has brought about a connectivity revolution in he world. The frictions created by mountainous snow fields or inhospitable desert terrains have been overcome. The accessibility has increased. The airplane brings varied articles to the Eskimos in Northern Canada unhindered by the frozen ground. In the Himalayan region, the routes are often obstructed due to landslides, avalanches or heavy snow fall. At such times, air travel is the only alternative to reach a place. Airways also have great strategic importance. The air strikes by U.S. and British forces in Iraq bears testimony to this fact. The airways network is expanding very fast.

COMMUNICATIONS

Human beings have used different methods long-distance communications of which the telegraph and the telephone were important. The telegraph was instrumental in the colonisation of the American West. During the early and mid-twentieth century, the American Telegraph and Telephone Company (AT&T) enjoyed a monopoly over U.S.A.'s telephone industry. In fact, the telephone became a critical factor in the urbanisation of America. Firms centralised their functioning at city headquarters and located their branch offices in smaller towns. Even today, the telephone is the most commonly used mode. In developing countries, the use of cell phones, made possible by satellites, is important for rural connectivity. Today there is a phenomenal pace of development. The first major breakthrough is the use of optic fiber cables (OFC). Faced with mounting competition, telephone companies all over the world soon upgraded their copper cable systems to include optic fiber cables. These allow large quantities of data to be transmitted rapidly, securely, and are virtually error-free. With the digitisation of information in the 1990s, telecommunication slowly merged with computers to form integrated networks termed as Internet.

SATELLITE COMMUNICATION

Today Internet is the largest electronic network on the planet connecting about 1,000 million people in more than 100 countries. Satellites touch human lives in many ways. Every time you use a cell phone to call a friend, send an SMS or watch a popular programme on cable television. You are using satellite communication. Communication through satellites emerged as a new area in communication technology since the 1970s after U.S.A. and former U.S.S.R. pioneered space research.

Artificial satellites, now, are successfully deployed in the earth's orbit to connect even the remote corners of the globe with limited onsite verification. These have rendered the unit cost and time of communication invariant in terms of distance. This means it costs the same to communicate over 500 km as it does over 5,000 km via satellite India has also made great strides in satellite development. Aryabhatt was launched on 19 April 1979, Bhaskar-I in 1979 and Rohini in 1980. On 18 June 1981, APPLE (Arian Passenger Payload Experiment) was launched through Arian rocket. Bhaskar, Challenger and INSAT I-B have made longdistance communication, television and radio very effective. Today weather forecasting through television is a boon.

INDIA

City – River	City – River
Agra – Yamuna	Ahmadabad – Sabarmati
Allahabad – Confluence of Ganga & Yamuna	Kolkata – Hugli
Guwahati – Brahmaputra	aridwar – Ganga
Madurai – Vaigai	Nasik – Godavari
Panji – Mandavi	Ujjain – Kshipra
Sri Nagar – Jhelum	Surat – Tapti / Tapi
Ayodhya – Sarayu (Ghaghra)	Pandharpur – Bhima
Dibrugarh – Brahmaputra	Srirangapattanam – Kaveri
Vijaywada – Krishna	Delhi – Yamuna
Badrinath – Alaknanda	Lucknow – Gomati
Varanasi – Ganga	Ajmer – Luni
Kanpur – Ganga	Cuttack – Mahanadi

CYBER SPACE – INTERNET

Cyberspace is the world of electronic computerised space. It is encompassed by the Internet such as the World Wide Web (www). In simple words, it is the electronic digital world for communicating or accessing information over computer networks without physical movement of the sender and the receiver... It is also referred to as the Internet. Cyberspace exists everywhere. It may be in an office, sailing boat, flying plane and virtually anywhere. The speed at which this electronic network has spread is unprecedented in human history. There were less than 50 million Internet users in 1995, about 400 million in 2000 A.D. and over one billion in 2005. The next billion users are to be added by 2010. In the last five years there has been a shift among global users from U.S.A. to the developing countries. The percentage share of U.S.A. has dropped from 66 in 1995 to only 25 in 2005. Now the majority of the world's users are in U.S.A., U.K., Germany, Japan, China and India.

As billions use the Internet each year, cyberspace will expand the contemporary economic and social space of humans through e-mail, e-commerce, e-learning and e-governance. Internet together with fax, television and radio will be accessible to more and more people cutting across place and time. It is these modern communication systems, more than transportation, that has made the concept of global village a reality.

INTERNATIONAL TRADE

You are already familiar with the term "trade" as a tertiary activity which you have studied in Chapter 7 of this book. You know that trade means the voluntary exchange of goods and services. Two parties are required to trade. One person sells and the other purchases. In certain places, people barter their goods. For both the parties trade is mutually beneficial. Trade may be conducted at two levels: international and national. International trade is the exchange of goods and services among countries across national boundaries. Countries need to trade to obtain commodities, they cannot produce themselves or they can purchase elsewhere at a lower price. The initial form of trade in primitive societies was the **barter system**, where direct exchange of goods took place. In this system if you were a potter and were in need of a plumber, you would have to look for a plumber who would be in need of pots and you could exchange your pots for his plumbing service.

Every January after the harvest season Jon Beel Mela takes place in Jagiroad, 35 km away from Guwahati and it is possibly the only fair In India, where barter system is still alive. A big market is organised during this fair and people from various tribes and communities exchange their products. The difficulties of barter system were overcome by the introduction of money. In the olden times, before paper and coin currency came into being, rare objects with very high intrinsic value served as money, like, flintstones, obsidian, *cowrie* shells, tiger'spaws, whale's teeth, dogs teeth, skins, furs, cattle, rice, peppercorns, salt, small tools, copper, silver and gold. The word salary comes from the Latin word *Salarium* which means payment by salt. As in those times producing salt from sea water was unknown and could only be made from rock salt which was rare and expensive. That is why it became a mode of payment.

HISTORY OF INTERNATIONAL TRADE

In ancient times, transporting goods over long distances was risky, hence trade was restricted to local markets. People then spent most of their resources on basic necessities – food and clothes. Only the rich people bought jewellery, costly dresses and this resulted in trade of luxury items. The Silk Route is an early example of long distance trade connecting Rome to China – along the 6,000 km route. The traders transported Chinese silk, Roman wool and precious metals and many other high value commodities from intermediate points in India, Persia and Central Asia.

After the disintegration of the Roman Empire, European commerce grew during twelfth and thirteenth century with the development of ocean going warships trade between Europe and Asia grew and the Americas were discovered. Fifteenth century onwards, the European colonialism began and along with trade of exotic commodities, a new form of trade emerged which was called **slave trade.**

The Portuguese, Dutch, Spaniards, and British captured African natives and forcefully transported them to the newly discovered Americas for their labour in the plantations. Slave trade was a lucrative business for more than two hundred years till it was abolished in Denmark in 1792, Great Britain in 1807 and United States in 1808. During the postwar period, organisations like General Agreement for Tariffs and Trade (which later became the World Trade Organisation), helped in reducing tariff.

International trade is the result of specialization in production**.** It benefits the world economy if different countries practise specialisation and division of labour in the production of commodities or provision of services. Each kind of specialisation can give rise to trade. Thus, international trade is based on the principle of comparative advantage, complimentarity and transferability of goods and services and in principle, should be mutually beneficial to the trading partners. In modern times, trade is the basis of the world's economic organisation and is related to the foreign policy of nations. With well developed transportation and communication systems, no country is willing to forego the benefits derived from participation in international trade.

Basis of International Trade

i. *Difference in national resources:* The world's national resources are unevenly distributed because of differences in their physical make up i.e. geology, relief soil and climate.

a. *Geological structure:* It determines the mineral resource base and topographical differences ensure diversity of crops and animals raised. Lowlands have greater agricultural potential. Mountains attract tourists and promote tourism.

b. *Mineral resources:* They are unevenly distributed the world over. The availability of mineral resources provides the basis for industrial development.

c. *Climate:* It influences the type of flora and fauna that can survive in a given region. It also ensures diversity in the range of various products, e.g. wool production can take place in cold regions, bananas, rubber and cocoa can grow in tropical regions.

ii. *Population factors*: The size, distribution and diversity of people between countries affect the type and volume of goods traded.

a. *Cultural factors:* Distinctive forms of art and craft develop in certain cultures which are valued the world over, e.g. China produces the finest porcelains and brocades. Carpets of Iran are famous while North African leather work and Indonesian batik cloth are prized handicrafts.

b. *Size of population:* Densely populated countries have large volume of internal trade but little external trade because most of the agricultural and industrial production is consumed in the local markets. Standard of living of the population determines the demand for better quality imported products because with low standard of living only a few people can afford to buy costly imported goods.

iii. *Stage of economic development:* At different stages of economic development of countries, the nature of items traded undergo changes. In agriculturally important countries, agro products are exchanged for manufactured goods whereas industrialised nations export machinery and finished products and import food grains and other raw materials.

iv. *Extent of foreign investment:* Foreign investment can boost trade in developing countries which lack in capital required for the development of mining, oil drilling, heavy engineering, lumbering and plantation agriculture. By developing such capital intensive industries in developing countries, the industrial nations ensure import of food stuffs, minerals and create markets for their finished products. This entire cycle steps up the volume of trade between nations.

v. *Transport:* In olden times, lack of adequate and efficient means of transport restricted trade to local areas. Only high value items, e.g. gems, silk and spices were traded over long distances. With expansions of rail, ocean and air transport, better means of refrigeration and preservation, trade has experienced spatial expansion.

Important Aspects of International Trade

International trade has three very important aspects. These are volume, sectoral composition and direction of trade.

Volume of Trade

The actual tonnage of goods traded makes up the volume. However, services traded cannot be measured in tonnage. Therefore, the **total value** of goods and services traded is considered to be the volume of trade. The total volume of world trade has been steadily rising over the past decades

TRIBUTORIES OF GANGA

Tributories	Meeting Place
Alkananda + Dhaulaganga	Vishnu Prayag
Alkananda + Mandakini	Nand Prayag
Alkananda + Pindar	Karna Prayag
Alkananda + Vasukiganga	Rudra Prayag
Alkananda + Bhagirathi	Dev Prayag
Ganga + Yamuna + Saraswati	Prayag (Allahabad)

COMPOSITION OF TRADE

The nature of goods and services imported and exported by countries have undergone changes during the last century. Trade of primary products was dominant in the beginning of the last century. Later manufactured goods gained prominence and currently, though the manufacturing sector commands the bulk of the global trade, service sector which includes travel, transportation and other commercial services have been showing an upward trend.

Machinery and transport equipment, fuel and mining products, office and telecom equipment, chemicals, automobile parts, agricultural products, iron and steel, clothing and textiles make up the major items of merchandise which are traded over the world. Trade in the service sector is quite different from trade in the products of primary and manufacturing sectors as the services can be expanded infinitely, consumed by many, are weightless and once produced, can be easily replicated and thus, are capable of generating more profit than producing goods. There are four different ways through which services can be supplied.

1. Commercial services excluding travel and construction services.
2. Travel
3. Construction services
4. Labour flow

Direction of Trade

Historically, the developing countries of the present used to export valuable goods and artefacts, etc. which were exported to European countries. During the nineteenth century there was a reversal in the direction of trade. European countries started exporting manufactured goods for exchange of foodstuffs and raw materials from their colonies. Europe and U.S.A. emerged as major trade partners in the world and were leaders in the trade of manufactured goods. Japan at that time was also the third important trading country. The world trade pattern underwent a drastic change during the second half of the twentieth century. Europe lost its colonies while India, China and other developing countries started competing with developed countries. The nature of the goods traded has also changed.

Balance of Trade

Balance of trade records the volume of goods and services imported as well as exported by a country to other countries. If the value of imports is more than the value of a country's exports, the country has negative or unfavourable balance of trade. If the value of exports is more than the value of imports, then the country has a positive or favourable balance of trade. Balance of trade and balance of payments have serious implications for a country's economy. A negative balance would mean that the country spends more on buying goods than it can earn by selling its goods. This would ultimately lead to exhaustion of its financial reserves.

TYPES OF INTERNATIONAL TRADE

International trade may be categorised into two types:

a) Bilateral trade: Bilateral trade is done by two countries with each other. They enter into agreement to trade specified commodities amongst them. For example, country A may agree to trade some raw material with agreement to purchase some other specified item to country B or vice versa.

b) Multi-lateral trade: As the term suggests multi-lateral trade is conducted with many trading countries. The same country can trade with a number of other countries. The country may also grant the status of the "Most Favoured Nation" (MFN) on some of the trading partners.

CASE FOR FREE TRADE

The act of opening up economies for trading is known as free trade or trade liberalisation. This is done by bringing down trade barriers like tariffs. Trade liberalisation allows goods and services from everywhere to compete with domestic products and services. Globalisation along with free trade can adversely affect the economies of developing countries by not giving equal playing field by imposing conditions which are unfavourable. With the development of transport and communication systems goods and services can travel faster and farther than ever before. But free trade should not only let rich countries enter the markets, but allow the developed countries to keep their own markets protected from foreign products. Countries also need to be cautious about **dumped goods;** as along with free trade dumped goods of cheaper prices can harm the domestic producers.

DUMPING

The practice of selling a commodity in two countries at a price that differs for reasons not related to costs is called dumping.

World Trade Organisation

In1948, to liberalise the world from high customs tariffs and various other types of restrictions, General Agreement for Tariffs and Trade (GATT) was formed by some countries. In 1994, it was decided by the member countries to set up a permanent institution for looking after the promotion of free and fair trade amongst nation and the GATT was transformed into the World Trade Organisation from 1st January 1995. WTO is the only international organization dealing with the global rules of trade between nations. It sets the rules for the global trading system and resolves disputes between its member nations. WTO also covers trade in services, such as telecommunication and banking, and others issues such as intellectual rights. The WTO has however been criticised and opposed by those who are worried about the effects of free trade and economic globalisation. It is argued that free trade does not make ordinary people's lives more prosperous.

It is actually widening the gulf between rich and poor by making rich countries more rich. This is because the influential nations in the WTO focus on their own commercial interests. Moreover, many developed countries have not fully opened their markets to products from developing countries. It is also argued that issues of health, worker's rights, child labour and environment are ignored. WTO Headquarters are located in Geneva, Switzerland. 149 countries were members of WTO as on December 2005. India has been one of the founder member of WTO.

REGIONAL TRADE BLOCS

Regional Trade Blocs have come up in order to encourage trade between countries with geographical proximity, similarity and complementarities in trading items and to curb restrictions on trade of the developing world. Today, 120 regional trade blocs generate 52 per cent of the world trade. These trading blocs developed as a response to the failure of the global organisations to speed up intra-regional trade. Though, these regional blocs remove trade tariffs within the member nations and encourage free trade, in the future it could get increasingly difficult for free trade to take place between different trading blocs.

Major Regional Trade Regional Blocs

ASEAN (Association of South East Asian Nations), Jakarta, Indonesia
CIS (Commonwealth of Independent States), Minsk, Belarus
EU (European Union) , Brussels, Belgium
LAIA (Latin American Integration Association), Montevideo, Uruguay
NAFTA (North American Free Trade Association) Vienna, Austria
OPEC (Organization of Petroleum Exporting Countries)
SAFTA (South Asian Free Trade Agreement)

GATEWAYS OF INTERNATIONAL TRADE

PORTS

The chief gateways of the world of international trade are the harbours and ports. Cargoes and travellers pass from one part of the world to another through these ports. The ports provide facilities of docking, loading, unloading and the storage facilities for cargo. In order to provide these facilities, the port authorities make arrangements for maintaining navigable channels, arranging tugs and barges, and providing labour and managerial services. The importance of a port is judged by the size of cargo and the number of ships handled. The quantity of cargo handled by a port is an indicator of the level of development of its hinterland.

TYPES OF PORT

Generally, ports are classified according to the types of traffic which they handle. Types of port according to cargo handled:

(i) *Industrial Ports:* These ports specialise in bulk cargo-like grain, sugar, ore, oil, chemicals and similar materials.
(ii) *Commercial Ports:* These ports handle general cargo-packaged products and manufactured good. These ports also handle passenger traffic.

(iii) *Comprehensive Ports:* Such ports handle bulk and general cargo in large volumes.

TYPES OF PORT ON THE BASIS OF LOCATION:

(i) *Inland Ports:* These ports are located away from the sea coast. They are linked to the sea through a river or a canal. Such ports are accessible to flat bottom ships or barges. For example, Manchester is linked with a canal; Memphis is located on the river Mississippi; Rhine has several ports like Mannheim and Duisburg; and Kolkata is located on the river Hoogli, a branch of the river Ganga.

(ii) *Out Ports:* These are deep water ports built away from the actual ports. These serve the parent ports by receiving those ships which are unable to approach them due to their large size. Classic combination, for example, is Athens and its out port Piraeus in Greece. Types of port on the basis of specialized functions:

(i) *Oil Ports:* These ports deal in the processing and shipping of oil. Some of these are tanker ports and some are refinery ports. Maracaibo in Venezuela, Esskhira in Tunisia, Tripoli in Lebanon are tanker ports. Abadan on the Gulf of Persia is a refinery port.

(ii) *Ports of Call:* These are the ports which originally developed as calling points on main sea routes where ships used to anchor for refuelling, watering and taking food items. Later on, they developed into commercial ports. Aden, Honolulu and Singapore are good examples.

(iii) *Packet Station:* These are also known as *ferry ports.* These packet stations are exclusively concerned with the transportation of passengers and mail across water bodies covering short distances. These stations occur in pairs located in such a way that they face each other across the water body, e.g. Dover in England and Calais in France across the English Channel.

(iv) *Entrepot Ports:* These are collection centres where the goods are brought from different countries for export. Singapore is an entrepot for Asia. Rotterdam for Europe, and Copenhagen for the Baltic region.

(v) *Naval Ports:* These are ports which have only strategic importance. These ports serve warships and have repair workshops for them. Kochi and Karwar are examples of such ports in India.

HUMAN SETTLEMENTS

CLASSIFICATION OF SETTLEMENTS RURAL URBAN DICHOTOMY

It is widely accepted that settlements can be differentiated in terms of rural and urban, but there is no consensus on what exactly defines a village or a town. Although population size is an important criterion, it is not a universal criterion since many villages in densely populated countries of India and China have population exceeding that of some towns of Western Europe and United States.

At one time, people living in villages pursued agriculture or other primary activities, but presently in developed countries, large sections of urban populations prefer to live in villages even though they work in the city. The basic difference between towns and villages is that in towns the main occupation of the people is related to secondary and tertiary sectors, while in the villages most of the people are engaged in primary occupations such as agriculture, fishing, lumbering, mining, animal husbandry, etc.

Sub Urbanisation

It is a new trend of people moving away from congested urban areas to cleaner areas outside the city in search of a better quality of living. Important suburbs develop around major cities and everyday thousands of people commute from their homes in the sub urbs to their work places in the city.

Differentiations between rural and urban on the basis of functions are more meaningful even though there is no uniformity in the hierarchy of the functions provided by rural and urban settlements. Petrol pumps are considered as a lower order function in the United States while it is an urban function in India. Even within a country, rating of functions may vary according to the regional economy. Facilities available in the villages of developed countries may be considered rare in villages of developing and less developed countries. The census of India, 1991 defines urban settlements as “All places which have municipality, corporation, cantonment board or notified town area committee and have a minimum population of 5000 persons, at least 75 per cent of male workers are engaged in non-agricultural pursuits and a density of population of at least 400 persons per square kilometers are urban.

TYPES AND PATTERNS OF SETTLEMENTS

Settlements may also be classified by their shape, patterns types. The major types classified by shape are:

i. *Compact or Nucleated settlements:* These settlements are those in which large number of houses are built very close to each other. Such settlements develop along river valleys and in fertile plains. Communities are closely knit and share common occupations.
ii. *Dispersed Settlements:* In these settlements, houses are spaced far apart and often interspersed with fields. A cultural feature such as a place of worship or a market, binds the settlement together.

Rural settlements are most closely and directly related to land. They are dominated by primary activities such as agriculture, animal husbandary, fishing etc. The settlements size is relatively small.

Usually rural settlements are located near water bodies such as rivers, lakes, and springs where water can be easily obtained. Sometimes the need for water drives people to settle in otherwise disadvantaged sites such as islands surrounded by swamps or low lying river banks. Most water based 'wet point' settlements have many advantages such as water drinking, cooking and washing. Rivers and lakes can be used to irrigate farm land. Water bodies also have fish which can be caught for diet and navigable rivers and lakes can be used for transportation.

Land

People choose to settle near fertile lands suitable for agriculture. In Europe villages grew up near rolling country avoiding swampy, low lying land while people in south east Asia chose to live near low lying river valleys and coastal plains suited for wet rice cultivation. Early settlers chose plain areas with fertile soils.

Upland

Upland which is not prone to flooding was chosen to prevent damage to houses and loss of life. Thus, in low lying river basins people chose to settle on terraces and levees which are "dry points". In tropical countries people build their houses on stilts near marshy lands to protect themselves from flood, insects and animal pests.

Building Material

The availability of building materials- wood, stone near settlements is another advantage. Early villages were built in forest clearings where wood was plentiful.

'NATIONAL RIVER' STATUS FOR GANGA

The Union Government on Nov, 2008 decided to declare the Ganga as 'National River' and set up a high – power Ganga River Basin Authority to stop its pollution a degradation. The Authority will be chaired by the prime minister and will have its members chief ministers of the states though which the Ganga flows.

DEFENCE

During the times of political instability, war, hostility of neighbouring groups villages were built on defensive hills and islands. In Nigeria, upstanding inselbergs formed good defensive sites. In India most of the forts are located on higher grounds or hills.

Planned Settlements

Sites that are not spontaneously chosen by villagers themselves, planned settlements are constructed by governments by providing shelter, water and other infrastructures on acquired lands. The scheme of villagisation in Ethiopia and the canal colonies in Indira Gandhi canal command area in India are some good examples.

Rural Settlement Patterns

Patterns of rural settlements reflect the way the houses are sited in relation to each other. The site of the village, the surrounding topography and terrain influence the shape and size of a village. Rural settlements may be classified on the basis of a number of criteria:

(i) *On the basis of setting:* The main types are plain villages, plateau villages, coastal villages, forest villages and desert villages.
(ii) *On the basis of functions:* There may be farming villages, fishermen's villages, lumberjack villages, pastoral villages etc.
(iii) *On the basis of forms or shapes of the settlements:* These may be a number of geometrical forms and shapes such as Linear, rectangular, circular star like, T-shaped village, double village, cross-shaped village etc.

a. *Linear pattern:* In such settlements houses are located along a road, railway line, river, canal edge of a valley or along a levee.
b. *Rectangular pattern:* Such patterns of rural settlements are found in plain areas or wide inter montane valleys. The roads are rectangular and cut each other at right angles. In loess areas of China, cave dwellings were important and African Savanna's building materials were mud bricks and the Eskimos, in polar regions, use ice blocks to construct igloos.
c. *Circular pattern*: Circular villages develop around lakes, tanks and sometimes the village is planned in such a way that the central part remains open and is used for keeping the animals to protect them from wild animals.
d. *Star like pattern:* Where several roads converge, star shaped settlements develop by the houses built along the roads.
e. *T-shaped, Y-shaped, Cross-shaped or crucifor m settlements:* T –shaped settlements develop at tri-junctions of the roads ( ) while –shaped settlements emerge as the places where two roads converge on the third one and houses are built along these roads. Cruciform settlements develop on the cross-roads and houses extend in all the four direction.
f. Double village: These settlements extend on both sides of a river where there is a bridge or a ferry.

PROBLEMS OF RURAL SETTLEMENTS

Rural settlements in the developing countries are large in number and poorly equipped with infrastructure. They represent a great challenge and opportunity for planners. Supply of water to rural settlements in developing countries is not adequate. People in villages, particularly in mountainous and arid areas have to walk long distances to fetch drinking water. Water borne diseases such as cholera and jaundice tend to be a common problem. The countries of South Asia face conditions of drought and flood very often. Crop cultivation sequences, in the absence of irrigation, also suffer. The general absence of toilet and garbage disposal facilities cause health related problems. The design and use of building materials of houses vary from one ecological region to another. The houses made up of mud, wood and thatch, remain susceptible to damage during heavy rains and floods, and require proper maintenance every year. Most house designs are typically deficient in proper ventilation. Besides, the design of a house includes the animal shed along with its fodderstore within it. This is purposely done to keep the domestic animals and their food properly protected from wild animals. Unmetalled roads and lack of modern communication network creates a unique problem. During rainy season, the settlements remain cut off and pose serious difficulties in providing emergency services. It is also difficult to provide adequate health and educational infrastructure for their large rural population. The problem is particularly serious where proper villagisation has not taken place and houses are scattered over a large area.

URBAN SETTLEMENTS

Rapid urban growth is a recent phenomenon. Until recent times, few settlements reached the population size of more than a few thousand inhabitants. The first urban settlement to reach a population of one million was the city of London by around. A.D. 1810 By 1982 approximately 175 cities in the world had crossed the one million population mark. Presently 48 per cent of the world's population lives in urban settlements compared to only 3 per cent in the year 1800

POPULATION SIZE

It is an important criteria used by most countries to define urban areas. The lower limit of the population size for a settlement to be designated as urban is 1,500 in Colombia, 2,000 in Argentina and Portugal, 2,500 in U.S.A. and Thailand, 5,000 in India and 30,000 in Japan. Besides the size of population, density of 400 persons per sq km and share of non-agricultural workers are taken into consideration in India. Countries with low density of population may choose a lower number as the cut-off figure compared to densely populated countries. In Denmark, Sweden and Finland, all places with a population size of 250 persons are called urban. The minimum population for a city is 300 in Iceland, whereas in Canada and Venezuela, it is 1,000 persons.

CLASSIFICATION OF URBAN SETTLEMENTS

The definition of urban areas varies from one country to another. Some of the common basis of classification are size of population, occupational structure and administrative setup.

Occupational Structure

In some countries, such as India, the major economic activities in addition to the size of the population in designating a settlement as urban are also taken as a criterion. Similarly, in Italy, a settlement is called urban, if more than 50 per cent of its economically productive population is engaged in non-agricultural pursuits. India has set this criterion at 75 per cent.

Administration

The administrative setup is a criterion for classifying a settlement as urban in some countries. For example, in India, a settlement of any size is classified as urban, if it has a municipality, Cantonment Board or Notified Area Council. Similarly, in Latin American countries, such as Brazil and Bolivia, any administrative centre is considered urban irrespective of its population size.

Location

Location of urban centres is examined with reference to their function. For example, the sitting requirements of a holiday resort are quite different from that of an industrial town, a military centre or a seaport. Strategic towns require sites offering natural defence; mining towns require the presence of economically valuable minerals; industrial towns generally need local energy supplies or raw materials; tourist centres require attractive scenery, or a marine beach, a spring with medicinal water or historical relics, ports require a harbour etc. Locations of the earliest urban settlements were based on the availability of water, building materials and fertile land. Today, while these considerations still remain valid, modern technology plays a significant role in locating urban settlements far away from the source of these materials. Piped water can be supplied to a distant settlement, building material can be transported from long distances. Apart from site, the situation plays an important role in the expansion of towns. The urban centres which are located close to an important trade route have experienced rapid development.

Administrative Towns

National capitals, which house the administrative offices of central governments, such as New Delhi, Canberra, Beijing, Addis Ababa, Washington D.C., and London etc. are called administrative towns. Provincial (sub-national) towns can also have administrative functions, for example, Victoria (British Columbia), Albany (New York), Chennai (Tamil Nadu).

FUNCTIONS OF URBAN CENTRES

The earliest towns were centres of administration, trade, industry, defence and religious importance. The significance of defence and religion as differentiating functions has declined in general, but other functions have entered the list. Today, several new functions, such as, recreational, residential, transport, mining, manufacturing and most recently activities related to information technology are carried on in specialised towns. Some of these functions do not necessarily require the urban centre to have any fundamental relationship with their neighbouring rural areas. In spite of towns performing multiple functions we refer to their dominant function. For example, we think of Sheffield as an industrial city, London as a port city, Chandigarh as an administrative city and so on. Large cities have a rather greater diversity of functions. Besides, all cities are dynamic and over a period of time may develop new functions. Most of the early nineteenth-century fishing ports in England have now developed tourism. Many of the old market towns are now known for manufacturing activities. Towns and cities are classified into the following categories.

Trading and Commercial Towns

Agricultural market towns, such as, Winnipeg and Kansas city; banking and financial centres like Frankfurt and Amsterdam; large inland centres like Manchester and St Louis; and transport nodes such as, Lahore, Baghdad and Agra have been important trading centres.

Cultural Towns

Places of pilgrimage, such as Jerusalem, Mecca, Jagannath Puri and Varanasi etc. are considered cultural towns. These urban centres are of great religious importance. Additional functions which the cities perform are health and recreation (Miami and Panaji), industrial (Pittsburgh and Jamshedpur), mining and quarrying (Broken Hill and Dhanbad) and transport (Singapore and Mughal Sarai). Urbanisation means the increase in the proportion population of a country who live in urban areas. The most important cause of urbanisation is rural-urban migration. During the late 1990s some 20 to 30 million people were leaving the countryside every year and moving into towns and cities. Developed countries experienced rapid urbanization during the nineteenth century. Developing counties experienced rapid urbanization during the second half of the twentieth century.

CLASSIFICATION OF TOWNS ON THE BASIS OF FORMS

An urban settlement may be linear, square, star or crescent shaped. In fact, the form of the settlement, architecture and style of buildings and other structures are an outcome of its historical and cultural traditions. Towns and cities of developed and developing countries reflect marked differences in planning and development. While most cities n developed countries are planned, most urban settlements of developing countries have evolved historically with irregular shapes. For example, Chandigarh and Canberra are planned cities, while smaller town in India have evolved historically from walled cities to large urban sprawls.

Addis Ababa (The New Flower)

The name of Ethiopian capital Addis Ababa, as the name indicates (*Addis*-New, *Ababa*-Flower) is a 'new' city which was established in 1878. The whole city is located on a hill-valley topography. The road pattern bears the influence of the local topography. The roads radiate from the govt headquarters Piazza, Arat and Amist Kilo roundabouts. Mercato has markets which grew with time and is supposed to be the largest market between Cairo and Johannesburg. A multi-faculty university, a medical college, a number of good schools make Addis Ababa an educational centre. It is also the terminal station for the Djibouti-Addis Ababa rail route. Bole airport is a relatively new airport. The city has witnessed rapid growth because of its multifunctional nature and being a large nodal centre located in the centre of Ethiopia.

Canberra

Canberra was planned as the capital of Australia in 1912 by American landscape architect, Walter Burley Griffin. He had envisaged a garden city for about 25,000 people taking into account the natural features of the landscape. There were to be five main centres, each with separate city functions. During the last few decades, the city has expanded to accommodate several satellite towns, which have their own centres. The city has wide-open spaces and many parks and gardens.

Types of Urban Settlements

Depending on the size and the services available and functions rendered, urban centres are designated as town, city, million city, conurbation, megalopolis.

Town

The concept of 'town' can best be understood with reference to 'village'. Population size is not the only criterion. Functional contrasts between towns and villages may not always be clearcut, but specific functions such as, manufacturing, retail and wholesale trade, and professional services exist in towns.

CITY

A city may be regarded as a leading town, which has outstripped its local or regional rivals. In the words of Lewis Mumford,“ the city is in fact the physical form of the highest and most complex type of associative life”. Cities are much larger than towns and have a greater number of economic functions. They tend to have transport terminals, major financial institutions and regional administrative offices. When the population crosses the one million mark it is designated as a million city.

Conurbation

The term conurbation was coined by Patrick Geddes in 1915 and applied to a large area of urban development that resulted from the merging of originally separate towns or cities. Greater London, Manchester, Chicago and Tokyo are examples.

Megalopolis

This Greek word meaning “great city”, was popularised by Jean Gottman (1957) and as union of conurbations. The urban landscape stretching from Boston in the north to south of Washington in U.S.A. is the best known example of a megalopolis.

Million City

The number of million cities in the world has been increasing as never before. London reached the million mark in 1800, followed by Paris in 1850, New York in 1860, and by 1950 there were around 80 such cities. The rate of increase in the number of million cities has been three-fold in every three decades – around 160 in 1975 to around 438 in 2005.

Distribution of Mega Cities

A mega city or megalopolis is a general term for cities together with their suburbs with a population of more than 10 million people. New York was the first to attain the status of a mega city by 1950 with a total population of about 12.5 million. The number of mega cities is now 25. The number of mega cities has increased in the developing countries during the last 50 years vis-à-vis the developed countries.

Problems of Human Settlements in Developing Countries

The settlements in developing countries, suffer from various problems, such as unsustainable concentration of population, congested housing and streets, lack of drinking water facilities. They also lack infrastructure such as, electricity, sewage disposal, health and education facilities. Rural/Urban Problems

Source: www.citypopulation.de/World.html

Mega Cities of the World (as on 28. 01. 2006)
Sl. Name of Country Population of the City (in millions)

1. Tokyo Japan 34.2
2. Mexico city Mexico 22.8
3. Seoul South Korea 22.3
4. New York U.S.A. 21.9
5. Sao Paulo Brazil 20.2
6. Mumbai India 19.9
7. Delhi India 19.7
8. Shanghai China 18.2
9. Los Angeles U.S.A. 18.0
10. Osaka Japan 16.8
11. Jakarta Indonesia 16.6
12. Kolkata India 15.7
13. Cairo Egypt 15.6
14. Manila Philippines 15.0
15. Karachi Pakistan 14.3
16. Moscow Russia 13.8
17. Buenos Aires Argentina 13.5
18. Dhaka Bangladesh 13.3
19. Rio de Janeiro Brazil 12.2
20. Beijing China 12.1
21. London G. Britain 12.0
22. Tehran Iran 11.9
23. Istanbul Turkey 11.5
24. Lagos Nigeria 11.1
25. Shenzhen China 10.7

People flock to cities to avail of employment opportunities and civic amenities. Since most cities in developing countries are unplanned, it creates severe congestion. Shortage of housing, vertical expansion and growth of slums are characteristic features of modern cities of developing countries. In many cities an increasing proportion of the population lives in substandard housing, e.g. slums and squatter settlements. In most million plus cities in India, one in four inhabitants lives in illegal settlements, which are growing twice as fast as the rest of the cities. Even in the Asia Pacific countries, around 60 per cent of the urban population lives in squatter settlements.

The decreasing employment opportunities in the rural as well as smaller urban areas of the developing countries consistently push the population to the urban areas. The enormous migrant population generates a pool of unskilled and semi-skilled labour force, which is already saturated in urban areas.

Environmental Problems

The large urban population in developing countries not only uses but also disposes off a huge quantity of water and all types of waste materials. Many cities of the developing countries even find it extremely difficult to provide the minimum required quantity of potable water and water for domestic and industrial uses. An improper sewerage system creates unhealthy conditions. Massive use of traditional fuel in the domestic as well as the industrial sector severely pollutes the air. The domestic and industrial wastes are either let into the general sewerages or dumped without treatment at unspecified locations. Huge concrete structures erected to accommodate the population and economic play a very conducive role to create heat islands.

Urban Strategy

The United Nations Development Programme (UNDP) has outlined these priorities as part of its ‘Urban Strategy’. What is a Healthy City?

World Health Organisation (WHO) suggests that, among other things, a 'healthy city' must have: A 'Clean' and 'Safe' environment. Meets the 'Basic Needs' of 'All' its inhabitants. Involves the 'Community' in local government. Provides easily accessible 'Health' service. *Increasing 'Shelter' for the urban poor. Provision of basic urban services such as 'Education', 'Primary Health care', 'Clean Water and Sanitation'. Improving women's access to 'Basic Services' and government facilities. Upgrading 'Energy' use and alternative 'Transport' systems. Reducing 'Air Pollution'*.

INDIA PHYSICAL

The mainland of India, extends from Kashmir in the north to Kanniya kumari in the south and Arunachal Pradesh in the east to Gujarat in the west. India's territorial limit further extends towards the sea upto 12 nautical miles (about 21.9 km) from the coast. Statute mile = 63,360 inches Nautical mile = 72,960 inches 1 Statute mile = about 1.6 km (1.584 km) 1 Nautical mile = about 1.8 km (1.852 km) Our southern boundary extends upto 6°45' N latitude in the Bay of Bengal. Let us try to analyse the implications of having such a vast longitudinal and latitudinal extent. If you work out the latitudinal and longitudinal extent of India, they 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. 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. 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). 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.
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.

The earth and its landforms that we see today have evolved over a very long time. Current estimation shows that the earth is approximately 460 million years old. Over these long years, it has undergone many changes brought about primarily by the endogenic and exogenic forces. These forces have played a significant role in giving shape to various surface and subsurface features of the earth. You have already studied about the Plate Tectonics and the movement of the Earth's plates. You know that the Indian plate was to the south of the equator millions of years ago. You also know that it was much larger in size and the Australian plate was a part of it. Over millions of years, this plate broke into many parts and the Australian plate moved towards the southeastern direction and the Indian plate to the north. This northward movement of the Indian plate is still 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? 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. These geological regions broadly follow the physical features:

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

THE PENINSULAR BLOCK

The northern boundary of the Peninsular Block may be taken as an irregular line running from Kachchh 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, the Karbi Anglong and the Meghalaya Plateau in the northeast and Rajasthan in the west are also extensions of this block. The northeastern parts are separated by the Malda fault in West Bengal from the Chotanagpur plateau. In Rajasthan, the desert and other desert–like features overlay this block. The Peninsula is formed essentially by a great complex of very ancient gneisses and granites, which constitutes a major part of it. 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. 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 river valleys here are shallow with low gradients. You are aware of the method of calculating the gradient as a part of your study of the book *Practical Work in Geography– Part I*(2006). Can you calculate the gradient of the Himalayan and the Peninsular rivers and draw the comparisons? Most of the east flowing rivers form deltas before entering into the Bay of Bengal. The deltas formed by the Mahanadi, the Krishna, the Kaveri and the Godavari are important examples.

THE HIMALAYAS AND OTHER PENINSULAR MOUNTAINS

The Himalayas along with other peninsular mountains are young, weak and flexible in their geological structure unlike the rigid and stable Peninsular Block. Consequently, they are still subjected to the interplay of exogenic and endogenic forces, resulting in the development of faults, folds and thrust plains. These mountains are tectonic in origin, dissected by fast-flowing rivers which are in their youthful stage. 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. Originally, 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. It is evident from the above discussion that there are significant variations among the different regions of India in terms of their geological structure, which has far-reaching impact upon other related aspects. Variations in the physiography and relief are important among these. The relief and physiography of India has been greatly influenced by the geological and geomorphological processes active in the Indian subcontinent.

PHYSIOGRAPHY

'Physiography' of an area is the outcome of structure, process and the stage of development. The land of India is characterized by great diversity in its physical features. The north has a vast expanse of rugge topography consisting of a series of mountain ranges with varied peaks, beautiful valleys and deep gorges. The south consists of stable table land with highly dissected plateaus, denuded rocks and developed series of scarps. In between these two lies the vast north Indian plain.Based on these macro variations, India can be divided into the following physiographic divisions:

(i) The Northern and Northeastern Mountains
(ii) The Northern Plain
(iii) The Peninsular Plateau
(iv) The Indian Desert
(v) The Coastal Plains
(vi) The Islands.

THE NORTH AND NORTHEASTERN MOUNTAINS

The North and Northeastern Mountains consist of the Himalayas and the Northeastern hills. 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. The general orientation of these ranges is from northwest to the southeast direction in the northwestern part of India. Himalayas in the Darjiling and Sikkim regions lie in an eastwest direction, while in Arunachal Pradesh they are from southwest to the northwest direction. In Nagaland, Manipur and Mizoram, they are in the northsouth direction. The approximate length of the Great Himalayan range, also known as the central axial range, is 2,500 km from east to west, and their width varies between 160-400 km from north to south. It is also evident from the map that the Himalayas stand almost like a strong and long wall between the Indian subcontinent and the Central and East Asian countries. Himalayas are not only the physical barrier, they are also a climatic, drainage and cultural divide. Can you identify the impact of Himalayas on the geoenvironment of the countries of South Asia? Can you find some other examples of similar geoenvironmental divide in the world? There are large-scale regional variations within the Himalayas. On the basis of relief, alignment of ranges and other geomorphological features, 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

It comprise a series of ranges such as the Karakoram, Ladakh, Zaskar and Pir Panjal. The northeastern part of the Kashmir Himalayas is a cold desert, which lies between the Greater Himalayas and the Karakoram ranges. Between the Great Himalayas and the Pir Panjal range, lies the world famous valley of Kashmir and the famous Dal Lake. Important glaciers of South Asia such as the Baltoro and Siachen are also found in this region. The Kashmir Himalayas are also famous for Karewa formations, which are useful for the cultivation of *Zafan*, a local variety of saffron. Some of the important passes of the region are Zoji La on the Great Himalayas, Banihal on the Pir Panjal, Photu La on the Zaskar and Khardung La on the Ladakh range. Some of the important fresh lakes such as Dal and Wular and salt water lakes such as Pangong Tso and Tso Moriri are also in this region. This region is drained by the river Indus, and its tributaries such as the Jhelum and the Chenab. The Kashmir and northwestern Himalayas are well-known for their scenic beauty and picturesque landscape.

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, etc. are also located here and large number of pilgrims visit these places every year. Srinagar, capital city of the state of Jammu and Kashmir is located on the banks of Jhelum river. Dal Lake in Srinagar presents an interesting physical feature. Jhelum in the valley of Kashmir is still in its youth stage and yet forms meanders – a typical feature associated with the mature stage in the evolution of fluvial land form. Karewas are the thick deposits of glacial clay and other materials embedded with moraines.

AN INTERESTING FACT

In Kashmir Valley, the meanders in Jhelum river are caused by the local base level provided by the erstwhile larger lake of which the present Dal Lake is a small part.

The southernmost part of this region consists of longitudinal valleys known as ‘duns’. Jammu dun and Pathankot dun are important examples. *The Himachal and Uttaranchal Himalayas* This part lies approximately between the Ravi in the west and the Kali (a tributary of Ghaghara) in the east. It is drained by two major river systems of India, i.e. the Indus and the Ganga. Tributaries of the Indus include the river Ravi, the Beas and the Satluj, and the tributaries of Ganga flowing through this region include the Yamuna and the Ghaghara. The northernmost part of the Himachal Himalayas is an extension of the Ladakh cold desert, which lies in the Spiti subdivision of district Lahul and Spiti. All the three ranges of Himalayas are prominent in this section also. These are the Great Himalayan range, the Lesser Himalayas (which is locally known as Dhaoladhar in Himachal Pradesh and Nagtibha in Uttaranchal) and the Shiwalik range from the North to the South. In this section of Lesser Himalayas, the altitude between 1,000-2,000 m specially attracted to the British colonial administration, and subsequently, some of 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. were developed in this region.

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 Chandigarh-Kalka dun, Nalagarh dun, Dehra Dun, Harike dun and the Kota dun, etc. *Dehra Dun* is the largest of all the duns with an approximate length of 35-45 km and a width of 22-25 km. In the Great Himalayan range, the valleys are mostly inhabited by the Bhotia’s. These are nomadic groups who migrate to ‘Bugyals’ (the summer glasslands in the higher reaches) during summer months and return to the valleys during winters. The famous ‘Valley of flowers’ is also situated in this region. The places of pilgrimage such as the Gangotri, Yamunotri, Kedarnath, Badrinath and Hemkund Sahib are also situated in this part.

The region is also known to have five famous Prayags (river confluences) as mentiond in Chapter 3 of this book. Can you name some other famous *prayags* in other parts of the country? *The Darjiling and Sikkim Himalayas* They are flanked by Nepal Himalayas in the west and Bhutan Himalayas in the east. It is relatively small but is a most significant part of the Himalayas. Known for its fast-flowing rivers such as Tista, it is a region of high mountain peaks like Kanchenjunga (Kanchengiri), and deep valleys. The higher reaches of this region are inhabited by Lepcha tribes while the southern part, particularly the Darjiling Himalayas, has a mixed population of Nepalis, Bengalis and tribals from Central India. The British, taking advantage of the physical conditions such as moderate slope, thick soil cover with high organic content, well distributed rainfall throughout the year and mild winters, introduced tea plantations in this region. As compared to the other sections of the Himalayas, these along with the Arunachal Himalayas are conspicuous by the absence of the Shiwalik formations.

In place of the Shiwaliks here, the 'duar formations' are important, which have also been used for the development of tea gardens. Sikkim and Darjiling Himalayas are also known for their scenic beauty and rich flora and fauna, particularly various types of orchids.

The Arunachal Himalayas These extend from the east of the Bhutan Himalayas up to the Diphu pass in the east. The general direction of the mountain range is from southwest to northeast. Some of the important mountain peaks of the region are Kangtu and Namcha Barwa. These ranges are dissected by fast-flowing rivers from the north to the south, forming deep gorges. Bhramaputra 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. These are perennial with the high rate of fall, thus, having the highest hydro-electric power potential in the country. An important aspect of the Arunachal Himalayas is the numerous ethnic tribal community inhabiting in these areas. Some of the prominent ones from west to east 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. This region is rich in biodiversity which has been preserved by the indigenous communities. Due to rugged topography, the inter-valley transportation linkages are nominal. Hence, most of the interactions are carried through the duar region along the Arunachal-Assam border. *The Eastern Hills and Mountains* 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. These are low hills, inhabited by numerous tribal groups practising Jhum cultivation. Most of these ranges are separated from each other by numerous small rivers. The Barak is an important river in Manipur and Mizoram. 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.

Mizoram which is also known as the 'Molassis basin' which is made up of soft unconsolidated deposits. Most of the rivers in Nagaland form the tributary of the Brahmaputra. While two rivers of Mizoram and Manipur are the tributaries of the Barak river, which in turn is the tributary of Meghna; the rivers in the eastern part of Manipur are the tributaries of Chindwin, which in turn is a tributary of the Irrawady of Myanmar.

THE SHIWALIK

The word *shiwalik* has its origin in the geological formation found in and around a place called Sivawala near Dehra Dun which was once a headquarter of the Imperial Survey and which subsequently established its permanent headquarters at Dehra Dun.

THE NORTHERN PLAINS

The northern plains are formed by the alluvial deposits brought by the rivers – the Indus, the Ganga and the Brahmaputra. These plains extend approximately 3,200 km from the east to the west. The average width of these plains varies between 150-300 km. The maximum depth of alluvium deposits varies between 1,000-2,000 m. From the north to the south, these can be divided into three major zones: the *Bhabar*, the *Tarai* and the alluvial plains. The alluvial plains can be further divided into the *Khadar* and the *Bhangar*. *Bhabar* is a narrow belt ranging between 8-10 km parallel to the Shiwalik foothills at the break-up of the slope. As a result of this, the streams and rivers coming from the mountains deposit heavy materials of rocks and boulders, and at times, disappear in this zone. 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, thereby, creating marshy and swampy conditions known as the *Tarai*. This has a luxurious growth of natural vegetation and houses a varied wild life. The south of *Tarai* is a belt consisting of old and new alluvial deposits known as the *Bhangar* and *Khadar* respectively. These plains have characteristic features of mature stage of fluvial erosional and depositional landforms such as sand bars, meanders, oxbow lakes and braided channels. The Brahmaputra plains are known for their riverine islands and sand bars. Most of these areas are subjected to periodic floods and shifting river courses forming braided streams. The mouths of these mighty rivers also form some of the largest deltas of the world, for example, the famous Sunderbans delta. Otherwise, this is a featureless plain with a general elevation of 50-150 m above the mean sea level. The states of Haryana and Delhi form a water divide between the Indus and the Ganga river systems. As opposed to this, the Brahmaputra river flows from the northeast to the southwest direction before it takes an almost 90° southward turn at Dhubri before it enters into Bangladesh. These river valley plains have a fertile alluvial soil cover which supports a variety of crops like wheat, rice, sugarcane and jute, and hence, supports a large population.

THE PENINSULAR PLATEAU

Rising from the height of 150 m above the river plains up to an elevation of 600-900 m is the irregular triangle known as the Peninsular plateau. 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. However, an extension of this is also seen in the northeast, in the form of Shillong and Karbi-Anglong plateau. 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. This is one of the oldest and the most stable landmass of India. The general elevation of the plateau is from the west to the east, which is also proved by the pattern of the flow of rivers. Name some rivers of the Peninsular plateau which have their confluence in the Bay of Bengal and the Arabian sea and mention some landforms which are typical to the east flowing rivers but are absent in the west flowing rivers. 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. The western and northwestern part of the plateau has an emphatic presence of black soil. This Peninsular plateau has undergone recurrent phases of upliftment and submergence accompanied by crustal faulting and fractures. (The Bhima fault needs special mention, because of its recurrent seismic activities). These spatial variations have brought in elements of diversity in the relief of the Peninsular plateau. 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

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. 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. 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. '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. 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. Some of the important ranges include the Javadi hills, the Palconda range, the Nallamala hills, the Mahendragiri hills, etc.

The Eastern and the Western Ghats meet each other at the Nilgiri hills. *The Central Highlands* They are bounded to the west by the Aravali range. 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. This forms the northernmost boundary of the Deccan plateau. It is a classic example of the relict mountains which are highly denuded and form discontinuous ranges. The extension of the Peninsular plateau can be seen as far as Jaisalmer in the West, where it has been covered by the longitudinal sand ridges and crescent-shaped sand dunes called *barchans*. 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.

The general elevation of the Central Highlands ranges between 700-1,000 m above the mean sea level and it slopes towards the north and northeastern directions. Most of the tributaries of the river Yamuna have their origin in the Vindhyan and Kaimur ranges. Banas is the only significant tributary of the river Chambal that originates from the Aravalli in the west. 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

In fact it is an extension of the main Peninsular plateau. 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. Today, 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. An extension of this is also seen in the Karbi Anglong hills of Assam. Similar to the Chotanagpur plateau, the Meghalaya plateau is also rich in mineral resources like coal, iron ore, sillimanite, limestone and uranium. This area receives maximum rainfall from the south west monsoon. As a result, the Meghalaya plateau has a highly eroded surface. Cherrapunji displays a bare rocky surface devoid of any permanent vegetation cover.

The Indian Desert

To the northwest of the Aravali hills lies the Great Indian desert. It is a land of undulating topography dotted with longitudinal dunes and *barchans*. This region receives low rainfall below 150 mm per year; hence, it has arid climate with low vegetation cover. It is because of these characteristic features that this is also known as *Marusthali*.

It is believed that Kathiawar coast in Gujarat, Konkan coast in Maharashtra, Goan coast and Malabar coast in Karnataka and Kerala respectively. The western coastal plains are narrow in the middle and get broader towards north and south. The rivers flowing through this coastal plain do not form any delta. The Malabar coast has got certain distinguishing features in the form of *'Kayals'* (backwaters), which are used for fishing, inland navigation and also due to its special attraction for tourists. Every year the famous *Nehru Trophy Vallamkali* (boat race) is held in *Punnamada Kayal* in Kerala. As compared to the western coastal plain, the eastern coastal plain is broader and is an example of an emergent coast. There are welldeveloped deltas here, formed by the rivers flowing eastward in to the Bay of Bengal. These include the deltas of the Mahanadi, the Godavari, the Krishna and the Kaveri. Because of its emergent nature, it has less number of ports and harbours. The continental shelf extends up to 500 km into the sea, which makes it difficult for the development of good ports and harbours. Name some ports on the eastern coast.

THE ISLANDS

There are two major island groups in India – one in the Bay of Bengal and the other in the Arabian Sea. The Bay of Bengal island groups consist of about 572 islands/islets. These are situated roughly between 6°N-14°N and 92°E - 94°E. The two principal groups of islets include the Ritchie's archipelago and the Labrynth island. The entire group of island is during the Mesozoic era, this region was under the sea. 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 woodfossils is estimated to be 180 million years). Though the underlying rock structure of the desert is an extension of the Peninsular plateau, yet, due to extreme arid conditions, its surface features have been carved by physical weathering and wind actions. Some of the well pronounced desert land features present here are mushroom rocks, shifting dunes and oasis (mostly in its southern part). On the basis of the orientation, the desert can be divided into two parts: the northern part is sloping towards Sindh and the southern towards the Rann of Kachchh. Most of the rivers in this region are ephemeral. The Luni river flowing in the southern part of the desert is of some significance. Low precipitation and high evaporation makes it a water deficit region. There are some streams which disappear after flowing for some distance and present a typical case of inland drainage by joining a lake or playa. The lakes and the playas have brackish water which is the main source of obtaining salt.

THE COASTAL PLAINS

You have already read that India has a long coastline. On the basis of the location and active geomorphological processes, it can be broadly divided into two:
(i) the western coastal plains; (ii) the eastern coastal plains.

The western coastal plains are an example of submerged coastal plain. It is believed that the city of Dwaraka which was once a part of the Indian mainland situated along the west coast is submerged under water. Because of this submergence it is a narrow belt and provides natural conditions for the development of ports and harbours. Kandla, Mazagaon, JLN port Navha Sheva, Marmagao, Mangalore, Cochin, etc. are some of the important natural ports located along the west coast. Extending from the Gujarat coast in the north to the Kerala coast in the south, the western coast may be divided into following divisions – the Kachchh and divided into two broad categories – the Andaman in the north and the Nicobar in the south. They are separated by a water body which is called the Ten degree channel. It is believed that these islands are an elevated portion of submarine mountains. However, some smaller islands are volcanic in origin. *Barren island,* the only active volcano in India is also situated in the Nicobar islands. 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). The coastal line has some coral deposits, and beautiful beaches. These islands receive convectional rainfall and have an equatorial type of vegetation. The islands of the Arabian sea include Lakshadweep and Minicoy. These are scattered between 8°N-12°N and 71°E -74°E longitude. These islands are located at a distance of 280 km-480 km off the Kerala coast. The entire island group is built of coral deposits.

There are approximately 36 islands of which 11 are inhabited. *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. On 26 December 2004, the Andaman and Nicobar islands experienced one of the most devasting natural calamity. You have observed water flowing through the rivers, *nalas* and even channels during rainy season which drain the excess water. Had these channels not been there, large-scale flooding would have occurred. Wherever channels are ill-defined or choked, flooding is a common phenomenon. The flow of water through well-defined channels is known as 'drainage' and 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.

A river drains the water collected from a specific area, which is called its 'catchment area'. An area drained by a river and its tributaries is called a drainage basin. 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. River basins and watersheds are marked by unity. What happens in one part of the basin or watershed directly affects the other parts and the unit as a whole. That is why, 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 each other through the Delhi ridge, the Aravalis and the Sahyadris (water divide is shown by a line in Figure 3.1). Nearly 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 while 23 per cent 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. (Appendix III).
(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. Many rivers have their sources in the Himalayas and discharge their waters either in the Bay of Bengal or in the Arabian Sea. Identify these rivers of North India. Large rivers flowing on the Peninsular plateau have their origin in the Western Ghats and discharge their waters in the Bay of Bengal. Identify these rivers of the South India. The Narmada and Tapi are two large rivers which are exceptions. They along with many small rivers discharge their waters in the Arabian Sea. Name these rivers of the western coastal region from the Konkan to the Malabar coast. On the basis of the mode of origin, nature and characteristics, the Indian drainage may also be classified into the Himalayan drainage and the Peninsular drainage. Although it has the problem of including the Chambal, the Betwa, the Son, etc. which are much older in age and origin than other rivers that have their origin in the Himalayas, it is the most accepted basis of classification.

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'**.

DRAINAGE SYSTEMS OF INDIA

Indian drainage system consists of a large number of small and big rivers. It is the outcome of the evolutionary process of the three major physiographic units and the nature and characteristics of precipitation.

THE HIMALAYAN DRAINAGE

The Himalayan drainage system has evolved through a long geological history. It mainly includes the Ganga, the Indus and the Brahmaputra river basins. Since these are fed both by melting of snow and precipitation, rivers of this system are perennial. These rivers pass through the giant gorges carved out by the erosional activity carried on simultaneously with the uplift of the Himalayas. Besides deep gorges, these rivers also form V-shaped valleys, rapids and waterfalls in their mountainous course. While entering the plains, they form depositional features like flat valleys, ox-bow lakes, flood plains, braided channels, and deltas near the river mouth. In the Himalayan reaches, the course of these rivers is highly tortous, but over the plains they display a strong meandering tendency and shift their courses frequently. River Kosi, also know as the 'sorrow of Bihar', has been notorious for frequently changing its course. The Kosi brings huge quantity of sediments from its upper reaches and deposits it in the plains. The course gets blocked, and consequently, the river changes its course.

EVOLUTION OF THE HIMALAYAN DRAINAGE

There are difference of opinion about the evolution of the Himalayan rivers. However, 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. The remarkable continuity of the Shiwalik and its lacustrine origin and alluvial deposits consisting of sands, silt, clay, boulders and conglomerates support this viewpoint. It is opined that 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 downthrusting 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 SYSTEMS OF THE HIMALAYAN DRAINAGE

The Himalayan drainage consists of several river systems but the following are the major river systems:

THE INDUS SYSTEM

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). The Indus also known as the Sindhu, is the westernmost of the Himalayan rivers in India. 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. 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. It cuts across the Ladakh range, forming a spectacular gorge near Gilgit in Jammu and Kashmir. It enters into Pakistan near Chillar in the Dardistan region. The Indus receives a number of Himalayan tributaries such as the Shyok, the Gilgit, the Zaskar, the Hunza, the Nubra, the Shigar, the Gasting and the Dras. It finally emerges out of the hills near Attock where it receives the Kabul river on its right bank. 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. 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 Jhelum, an important tributary of the Indus, rises from a spring at Verinag situated at the foot of the Pir Panjal in the south-eastern part of the valley of Kashmir. It flows through Srinagar and the Wular lake before entering Pakistan through a deep narrow gorge. It joins the Chenab near Jhang in Pakistan. The Chenab is the largest tributary of the Indus. It is formed by two streams, the Chandra and the Bhaga, which join at Tandi near Keylong in Himachal Pradesh. Hence, it is also known as Chandrabhaga. The river flows for 1,180 km before entering into Pakistan. The Ravi is another important tributary of the Indus.

It rises west of the Rohtang pass in the Kullu hills of Himachal Pradesh and flows through the Chamba valley of the state. Before entering Pakistan and joining the Chenab near Sarai Sidhu, it drains the area lying between the southeastern part of the Pir Panjal and the Dhauladhar ranges. The Beas is another important tributary of the Indus, originating from the Beas Kund near the Rohtang Pass at an elevation of 4,000 m above the mean sea level. The river flows through the Kullu valley and forms gorges at Kati and Largi in the Dhaoladhar range. It enters the Punjab plains where it meets the Satluj near Harike. The Satluj originates in the Rakas lake near Mansarovar at an altitude of 4,555 m in Tibet where it is known as Langchen Khambab. It flows almost parallel to the Indus for about 400 km before entering India, and comes out of a gorge at Rupar. It passes through the Shipki La on the Himalayan ranges and enters the Punjab plains. It is an antecedent river. It is a very important tributary as it feeds the canal system of the Bhakra Nangal project.

THE GANGA SYSTEM

The Ganga is the most important river of India both from the point of view of its basin and cultural significance. It rises in the Gangotri glacier near Gaumukh (3,900 m) in the Uttarkashi district of Uttaranchal. Here, it is known as the Bhagirathi. It cuts through the Central and the Lesser Himalayas in narrow gorges. At Devprayag, the Bhagirathi meets the Alaknanda; hereafter, it is known as the Ganga. 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. The other tributaries of Alaknanda such as the Pindar join it at Karna Prayag while Mandakini or Kali Ganga meets it at Rudra Prayag. 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 Uttaranchal (110 km) and Uttar Pradesh (1,450 km), Bihar (445 km) and West Bengal (520 km). The Ganga basin covers about 8.6 lakh sq. km area in India alone. 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. The Son is its major right bank tributary. The important left bank tributaries are the Ramganga, the Gomati, the Ghaghara, the Gandak, the Kosi and the Mahanada. The river finally discharges itself into the Bay of Bengal near the Sagar Island. The Yamuna, the western most and the longest tributary of the Ganga, has its source in the Yamunotri glacier on the western slopes of Banderpunch range. It joins the Ganga at Prayag (Allahabad). It is joined by the Chambal, the Sind, the Betwa and the Ken on its right bank which originates from the Peninsular plateau while the Hindan, the Rind, the Sengar, the Varuna, etc. join it on its left bank. Much of its water feeds the western and eastern Yamuna and the Agra canals for irrigation purposes. Name the states which are drained by the river Yamuna.

The Chambal rises near Mhow in the Malwa plateau of Madhya Pradesh and flows northwards through a gorge up wards of Kota in Rajasthan, where the Gandhisagar dam has been constructed. From Kota, it traverses down to Bundi, Sawai Madhopur and Dholpur, and finally joins the Yamuna. The Chambal is famous for its badland topography called the Chambal ravines. The Gandak comprises two streams, namely Kaligandak and Trishulganga. It rises in the Nepal Himalayas between the Dhaulagiri and Mount Everest and drains the central part of Nepal. It enters the Ganga plain in Champaran district of Bihar and joins the Ganga at Sonpur near Patna. The Ghaghara originates in the glaciers o Mapchachungo. After collecting the waters of its tributaries – Tila, Seti and Beri, it comes out of the mountain, cutting a deep gorge at Shishapani. The river Sarda (Kali or Kali Ganga) joins it in the plain before it finally meets the Ganga at Chhapra. The Kosi is an antecedent river with its source to the north of Mount Everest in Tibet, where its main stream Arun rises. After crossing the Central Himalayas in Nepal, it is joined by the Son Kosi from the West and the Tamur Kosi from the east. It forms Sapt Kosi after uniting with the river Arun.

The Ramganga is comparatively a small river rising in the Garhwal hills near Gairsain. It changes its course to the southwest direction after crossing the Shiwalik and enters into the plains of Uttar Pradesh near Najibabad. Finally, it joins the Ganga near Kannauj. The Damodar occupies the eastern margins of the Chotanagpur Plateau where it flows through a rift valley and finally joins the Hugli. The Barakar is its main tributary. Once known as the ‘sorrow of Bengal’, the Damodar has been now tamed by the Damodar Valley corporation, a multipurpose project. The Sarda or Saryu river rises in the Milan glacier in the Nepal Himalayas where it is known as the Goriganga. Along the Indo-Nepal border, it is called Kali or Chauk, where it joins the Ghaghara. The Mahananda is another important tributary of the Ganga rising in the Darjiling hills. It joins the Ganga as its last left bank tributary in West Bengal. The Son is a large south bank tributary of the Ganga, originating in the Amarkantak plateau. After forming a series of waterfalls at the edge of the plateau, it reaches Arrah, west of Patna, to join the Ganga.

THE BRAHMAPUTRA SYSTEM

The Brahmaputra, one of the largest rivers of the world, has its origin in the Chemayungdung glacier of the Kailash range near the Mansarovar lake. 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.’ The Rango Tsangpo is the major right bank tributary of this river in Tibet. It emerges as a turbulent and dynamic river after carving out a deep gorge in the Central Himalayas near Namcha Barwa (7,755 m). The river emerges from the foothills under the name of Siang or Dihang. It enters India west of Sadiya town in Arunachal Pradesh. Flowing southwest, it receives its main left bank tributaries, viz., Dibang or Sikang and Lohit; thereafter, it is known as the Brahmaputra. The Brahmaputra receives numerous tributaries in its 750 km long journey through the Assam valley.

Its major left bank tributaries are the Burhi Dihing, Dhansari (South) and Kalang whereas the important right bank tributaries are the Subansiri, Kameng, Manas and Sankosh. The Subansiri which has its origin in Tibet, is an antecedent river. 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. 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. 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

The Peninsular drainage system is older than the Himalayan one. This is evident from the broad, largely-graded shallow valleys, and the maturity of the rivers. 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. Most of the major Peninsular rivers except Narmada and Tapi flow from west to east. 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. Peninsular rivers are characterised by fixed course, absence of meanders and nonperennial flow of water. 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.

River Systems of the Peninsular Drainage

There are a large number of river systems in the Peninsular drainage. A brief account of the major Peninsular river systems is given below: The Mahanadi rises near Sihawa in Raipur district of Chhattisgarh and runs through Orissa to discharge its water into the Bay of Bengal. It is 851 km long and its catchment area spreads over 1.42 lakh sq. km. Some navigation is carried on in the lower course of this river. Fifty three per cent of the drainage basin of this river lies in Madhya Pradesh and Chhattisgarh, while 47 per cent lies in Orissa. The Godavari is the largest Peninsular river system. It is also called the Dakshin Ganga. It rises in the Nasik district of Maharashtra and discharges its water into the Bay of Bengal. Its tributaries run through the states of Maharashtra, Madhya Pradesh, Chhattisgarh, Orissa and Andhra Pradesh. It is 1,465 km long with a catchment area spreading over 3.13 lakh sq. km 49 per cent of this, lies in Maharashtra, 20 per cent in Madhya Pradesh and Chhattisgarh, and the rest in Andhra Pradesh. The Penganga, the Indravati, the Pranhita, and the Manjra are its principal tributaries. The Godavari is subjected to heavy floods in its lower reaches to the south of Polavaram, where it forms a picturesque gorge. It is navigable only in the deltaic stretch. The river after Rajamundri splits into several branches forming a large delta.

The Krishna is the second largest eastflowing Peninsular river which rises near Mahabaleshwar in Sahyadri. Its total length is 1,401 km. The Koyna, the Tungbhadra and the Bhima are its major tributaries. Of the total catchment area of the Krishna, 27 per cent lies in Maharashtra, 44 per cent in Karnataka and 29 per cent in Andhra Pradesh. The Kaveri rises in Brahmagiri hills (1,341m) of Kogadu district in Karnataka. Its length is 800 km and it drains an area of 81,155 sq. km. Since the upper catchment area receives rainfall during the southwest monsoon season (summer) and the lower part during the northeast monsoon season (winter), the river carries water throughout the year with comparatively less fluctuation than the other Peninsular rivers. About 3 per cent of the Kaveri basin falls in Kerala, 41 per cent in Karnataka and 56 per cent in Tamil Nadu. Its important tributaries are the Kabini, the Bhavani and the Amravati. The Narmada originates on the western flank of the Amarkantak plateau at a height of about 1,057 m. Flowing in a rift valley between the Satpura in the south and the Vindhyan range . It is Sharavati river on which the Gersoppa (Jog) fall is found. Goa has two important rivers which can be mentioned here. One is Mandovi and the other is Juari. You can locate them on the map. Kerala has a narrow coastline. The longest river of Kerala, Bharathapuzha rises near Annamalai hills. It is also known as Ponnani. It drains an area of 5,397 sq. km. Compare its catchment area with that of the Sharavati river of Karnataka. The Periyar is the second largest river of Kerala. Its catchment area is 5,243 sq. km. You can see that there is a marginal difference in the catchment area of the Bhartapuzha and the Periyar rivers. Another river of Kerala worth mentioning is the Pamba river which falls in the Vemobanad lake after traversing a course of 177 km.

WEST FLOWING SMALL RIVERS

River - Catchment area sq. km

Sabarmati - 21,674

Mahi - 34,842

Dhandhar - 2,770

Kalinadi - 5,179

Sharavati - 2,029

Bharathapuzha - 5,397

Periyar - 5,243

SMALL RIVERS FLOWING TOWARDS THE EAST

There are a large number of rivers flowing towards the east along with their tributaries. There are small rivers which join the Bay of Bengal, though small, these are important in their own right. The Subarnrekha, the Baitarni, the Brahmani, the Vamsadhara, the Penner, the Palar and the Vaigai are important rivers.

EAST FLOWING SMALL RIVERS

River - Catchment area sq. km

Subarnarekha 19,296

Baitarni 12,789

Brahmani 39,033

Penner 55,213

Palar 17,870

in the north, Narmada forms a picturesque gorge in marble rocks and Dhuandhar waterfall near Jabalpur. After flowing a distance of about 1,312 km, it meets the Arabian sea south of Bharuch, forming a broad 27 km long estuary. Its catchment area is about 98,796 sq. km. The Sardar Sarovar Project has been constructed on this river. The Tapi is the other important westward flowing river. It originates from Multai in the Betul district of Madhya Pradesh. It is 724 km long and drains an area of 65,145 sq. km. Nearly 79 per cent of its basin lies in Maharashtra, 15 per cent in Madhya Pradesh and the remaining 6 per cent in Gujarat. Luni is the largest river system of Rajasthan, west of Aravali. It originates near Pushkar in two branches, i.e. the Saraswati and the Sabarmati, which join with each other at Govindgarh. From here, the river comes out of Aravali and is known as Luni. It flows towards the west till Telwara and then takes a southwest direction to join the Rann of Kuchchh. The entire river system is ephemeral.

SMALLER RIVERS FLOWING TOWARDS THE WEST

The rivers flowing towards the Arabian sea have short courses. Why do they have short courses? Find out the smaller rivers of Gujarat. The Shetruniji is one such river which rises near Dalkahwa in Amreli district. The Bhadra originates near Aniali village in Rajkot district. The Dhadhar rises near Ghantar village in Panchmahal district. Sabarmati and Mahi are the two famous rivers of Gujarat. Find out the places of confluence of these rivers. Find out some important west flowing rivers of Maharashtra.

The Vaitarna rises from the Trimbak hills in Nasik district at an elevation of 670 m. The Kalinadi rises from Belgaum district and falls in the Karwar Bay. The source of Bedti river lies in Hubli Dharwar and traverses a course of 161 km. The Sharavati is another important river in Karnataka flowing towards the west. The Sharavati originates in Shimoga district of Karnataka and drains a catchment area of 2,209 sq. km.

RIVER REGIMES

Quantity of water flowing in a river channel is not the same throughout the year. It varies from season to season. The pattern of flow of water in a river channel over a year is known as its regime. 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. The rivers of South India do not originate from glaciers and their flow pattern witnesses fluctuations. 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. 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). 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.

There are striking differences in the river regimes in the eastern and the western parts of the Ganga Basin. 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. The two Peninsular rivers display interesting differences in their regimes compared to the Himalayan rivers. The Narmada has a very low volume of discharge from January to July but it suddenly rises in August when the maximum flow is attained. The fall in October is as spectacular as the rise in August. The flow of water in the Narmada, as recorded at Garudeshwar, shows that the maximum flow is of the order of 2,300 cusecs, while the minimum flow is only 15 cusecs. The Godavari has the minimum discharge in May, and the maximum in July-August. After August, there is a sharp fall in water flow although the volume of flow in October and November is higher than that in any of the months from January to May. The mean maximum discharge of the Godavari at Polavaram is 3,200 cusecs while the mean minimum flow is only 50 cusecs.

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

CLIMATE, VEGETATION AND SOIL

There are variations in weather conditions during different seasons. These changes occur due to the changes in the elements of weather (temperature, pressure, wind direction and velocity, humidity and precipitation, etc.). Weather is the momentary state of the atmosphere while climate refers to the average of the weather conditions over a longer period of time. Weather changes quickly, may be within a day or week but climate changes imperceptively and may be noted after 50 years or even more. Monsoon connotes the climate associated with seasonal reversal in the direction of winds. India has hot monsoonal climate which is the prevalent climate in south and southeast Asia.

THE MONSOON CLIMATE

The monsoon regime emphasises the unity of India with the rest of southeast Asian region. 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. For example, 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. The climate of India has many regional variations expressed in the pattern of winds, temperature and rainfall, rhythm of seasons and the degree of wetness or dryness. These regional diversities may be described as sub-types of monsoon climate. Let us take a closer look at these regional variations in temperature, winds and rainfall.

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. 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. On a December night, temperature in Drass (Jammu and Kashmir) may drop down to minus 45°C while Tiruvanantapuram or Chennai on the same night records 20°C or 22°C. These examples confirm that there are seasonal variations in temperature from place to place and from region to region in India. Not only this, if we take only a single place and record the temperature for just one day, variations are no less striking. 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 upto 15°-20°C.

CLIMATE

While snowfall occurs in the Himalayas, it only rains over the rest of the country. Similarly, variations are noticeable not only in the type of precipitation but also in its amount. While Cherrapunji and Mawsynram in 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. 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. While the annual precipitation is less than 10 cm in the northwest Himalayas and the western deserts, it exceeds 400 cm in Meghalaya. 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. 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. In spite of these differences and variations, the climate of India is monsoonal in rhythm and character.

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 : You already know the latitudinal and longitudinal extent of the land of India. You also know that 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 :* The lofty Himalayas in the north along with its extensions act as an effective climatic divide. The towering mountain chain provides an invincible shield to protect the subcontinent from the cold northern winds. These cold and chilly winds originate near the Arctic circle and blow across central and eastern Asia. The Himalayas also trap the monsoon winds, forcing them to shed their moisture within the subcontinent. *Distribution of Land and Water :* India is flanked by the Indian Ocean on three sides in the south and girdled by a high and continuous mountain-wall in the north. 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. On the other hand, the seasonal contrasts in weather at places in the interior of the country such as Delhi, Kanpur and Amritsar affect the entire sphere of life. *Altitude :* Temperature decreases with height. Due to thin air, places in the mountains are cooler than places on the plains. For example, Agra and Darjiling are located on the same latitude, but temperature of January in Agra is 16°C whereas it is only 4°C in Darjiling. *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 favourable 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 : In winter months, the weather conditions over India are generally influenced by the distribution of pressure in Central and Western Asia. A high pressure centre in the region lying to the north of the Himalayas develops during winter. 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. The surface winds blowing out of the high pressure centre over Central Asia reach India in the form of a dry continental air mass. These continental winds come in contact with trade winds over northwestern India. The position of this contact zone is not, however, stable. Occasionally, it may shift its position as far 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* 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, 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. All of Western and Central Asia remains under the influence of westerly winds along the altitude of 9-13 km from west to east. 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. Tibetan highlands act as a barrier in the path of these jet streams. As a result, jet streams get bifurcated. One of its branches blows to the north of the Tibetan highlands, while the southern branch blows in an eastward direction, south of the Himalayas. It has its mean position at 25°N in February at 200-300 mb level. It is believed that this southern branch of the jet stream exercises an important influence on the winter weather in India. *Western Cyclonic Disturbance and Tropical Cyclones :* The western cyclonic disturbances which enter the Indian subcontinent from the west and the northwest during the winter months, originate over the Mediterranean Sea and are brought into India by the westerly jet stream. An increase in the prevailing night temperature generally indicates an advance in the arrival of these cyclones disturbances. 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. Most of these cyclones are very destructive due to high wind velocity and torrential rain that accompanies it.

MECHANISM OF WEATHER IN THE SUMMER SEASON

Surface Pressure and Winds : As the summer sets in and the sun shifts northwards, the wind circulation over the subcontinent undergoes a complete reversal at both, the lower as well as the upper levels. 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. By this time, the westerly jet stream withdraws from the Indian region. In fact, meteorologists have found an interrelationship between the northward shift of the equatorial trough (ITCZ) and the withdrawal of the westerly jet stream from over the North Indian Plain. 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. The maritime tropical airmass (mT) from the southern hemisphere, after crossing the equator, rushes to the low pressure area in the general southwesterly direction. It is this moist air current which is popularly known as the southwest monsoon. *Jet Streams and Upper Air Circulation :* The pattern of pressure and winds as mentioned above is formed only at the level of the troposphere. An easterly jet stream flows over the southern part of the Peninsula in June, and has a maximum speed of 90 km per hour. In August, it is confined to 15oN latitude, and in September up to 22o N latitudes. The easterlies normally do not extend to the north of 30o N latitude in the upper atmosphere. *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 tracks of these depressions are the areas of highest rainfall in India. The frequency at which these depressions visit India, their direction and intensity, all go a long way in determining the rainfall pattern during the southwest monsoon period.

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 thrmal 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.

THE NATURE OF INDIAN MONSOON

Monsoon is a familiar though a little known climatic phenomenon. Despite the observations spread over centuries, the monsoon continues to puzzle the scientists. Many attempts have been made to discover the exact nature and causation of monsoon, but so far, no single theory has been able to explain the monsoon fully. A real breakthrough has come recently when it was studied at the global rather than at regional level. Systematic studies of the causes of rainfall in the South Asian region help to understand the causes and salient features of the monsoon, particularly some of its important aspects, such as:

(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

Towards the end of the nineteenth century, it was believed that 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. 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. This causes the formation of an intense low pressure in the northwestern part of the subcontinent. Since the pressure in the Indian Ocean in the south of the landmass is high as water gets heated The shift in the position of the ITCZ is also related to the phenomenon of the withdrawal of the westerly jet stream from its position over the north Indian plain, south of the Himalayas.

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 mid- July, southwest monsoon engulfs the entire subcontinent

Rain-bearing Systems and Rainfall Distribution

There seem to be two rain-bearing systems in India. First originate in the Bay of Bengal causing rainfall over the plains of north India. Second is the Arabian Sea current of the southwest monsoon which brings rain to the west coast of India. Much of the rainfall along the Western Ghats is orographic as the moist air is obstructed and forced to rise along the Ghats. The intensity of rainfall over the west coast of India is, however, related to two factors:
(i) The offshore meteorological conditions.
(ii) The position of the equatorial jet stream along the eastern coast of Africa.

EI-Nino and the Indian Monsoon

EI-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. EI-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 EI-Nino means 'Child Christ' because this current appears around Christmas in December. December is a summer month in Peru (Southern Hemisphere). EI-Nino is used in India for forecasting long range monsoon rainfall. In 1990-91, there was a wild EI-Nino event and the onset of southwest monsoon was delayed over most parts of the country ranging from five to twelve days. Slowly, the low pressure cell attracts the southeast trades across the Equator. These conditions help in the northward shift in the position of the ITCZ. The southwest monsoon may thus, be seen as a continuation of the southeast trades deflected towards the Indian subcontinent after crossing the Equator. These winds cross the Equator between 40°E and 60°E longitudes.

The frequency of the tropical depressions originating from the Bay of Bengal varies from year to year. Their paths over India are mainly determined by the position of ITCZ which is generally termed as the monsoon trough. As the axis of the monsoon trough oscillates, there are fluctuations in the track and direction of these depressions, and the intensity and the amount of rainfall vary from year to year. The rain which comes in spells, displays a declining trend from west to east over the west coast, and from the southeast towards the northwest over the North Indian Plain and the northern part of the Peninsula.

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: Usually, the cold weather season sets in by mid-November in northern India. December and January are the coldest months in the northern plain. The mean daily temperature remains below 21°C over most parts of northern India. 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.

Understanding the Monsoon

Attempts have been made to understand the nature and mechanism of the monsoon on the basis of data collected on land, oceans and in the upper atmosphere. The intensity of southwest monsoon winds of southern oscillation can be measured, among others, by measuring the difference in pressure between Tahiti (roughly 20°S and 140°W) in French Polynesia in East Pacific and port Darwin (12°30'S and 131°E) in northern Australia. Indian Meteorological Department (IMD) can forecast the possible behaviour of monsoons on the basis of 16 indicators. The Peninsular region of India, however, does not have any well-defined cold weather season. There is hardly any seasonal change in the distribution pattern of the temperature in coastal areas because of moderating influence of the sea and the proximity to equator. For example, the mean maximum temperature for January at Thiruvanantapuram is as high as 31°C, and for June, it is 29.5°C. Temperatures at the hills of Western Ghats remain comparatively low. *Pressure and Winds:* By the end of December (22nd December), the sun shines vertically over the Tropic of Capricorn in the southern hemisphere. The weather in this season is characterised by feeble high pressure conditions over the northern plain. In south India, the air pressure is slightly lower. The isobars of 1019 mb and 1013 mb pass through northwest India and far south, respectively. 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. 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. During the winters, the weather in India is pleasant. 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. On their way, the moisture content gets augmented from the Caspian Sea in the north and the Persian Gulf in the south. What is the role of Westerly Jet Streams in steering these depressions in India? *Rainfall:* Winter monsoons do not cause rainfall as they move from land to the sea. It is because firstly, they have little humidity; and 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 meagre, 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. The average winter rainfall in Delhi is around 53 mm. In Punjab and Bihar, rainfall remains between 25 mm and 18 mm respectively.

(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 southeast Kerala.

THE HOT WEATHER SEASON

Temperature: With the apparent northward movement of the sun towards the Tropic of Cancer in March, temperatures start rising in north India. April, May and June are the months of summer in north India. In most parts of India, temperatures recorded are between 30°-32°C. 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. In May, the heat belt moves further north, and in the north-western part of India, temperatures around 48°C are not uncommon (Figure 4.8). The hot weather season in south India is mild and not so intense as found in north India. The Peninsular situation of south India with moderating effect of the oceans keeps the temperatures lower than that prevailing in north India. So, temperatures remain between 26°C and 32°C. Due to altitude, the temperatures in the hills of Western Ghats remain below 25°C. In the coastal regions, the north-south extent of isotherms parallel to the coast confirms that temperature does not decrease from north to south rather it increases from the coast to the interior. The mean daily minimum temperature during the summer months also remains quite high and rarely goes below 26°C.

Pressure and Winds:

The summer months are a period of excessive heat and falling air pressure in the northern half of the country. Because of the heating of the subcontinent, the ITCZ moves northwards occupying a position centred at 25°N in July. 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. 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. They are easterly or southeasterly over north Bengal and Bihar. It has been discussed earlier that these currents of southwesterly monsoon are in reality 'displaced' equatorial westerlies. The influx of these winds by mid-June brings about a change in the weather towards the rainy season. 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. Dust storms in the evening are very common during May in Punjab, Haryana, Eastern Rajasthan and Uttar Pradesh.

These temporary storms bring a welcome respite from the oppressing heat since they bring with them light rains and a pleasant cool breeze. Occasionally, the moisture-laden winds are attracted towards the periphery of the trough. A sudden contact between dry and moist air masses gives rise to local storms of great intensity. 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*. These showers are useful for tea, jute and rice cultivation. In Assam, these storms are known as *"Bardoli Chheerha"*.

(iv) *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

As a result of rapid increase of temperature in May over the northwestern plains, the low pressure conditions over there get further intensified. By early June, they are powerful enough to attract the trade winds of Southern Hemisphere coming from the Indian Ocean. These southeast trade winds cross the equator and enter the Bay of Bengal and the Arabian Sea, only to be caught up in the air circulation over India. Passing over the equatorial warm currents, they bring with them moisture in abundance. After crossing the equator, they follow a southwesterly direction. That is why they are known as southwest monsoons. The rain in the southwest monsoon season begins rather abruptly. One result of the first rain is that it brings down the temperature substantially. This sudden onset of the moisture-laden winds associated with violent thunder and lightening, is often termed as the "break" or "burst" of the monsoons. The monsoon may burst in the first week of June in the coastal areas of Kerala, Karnataka, Goa and Maharashtra while in the interior parts of the country, it may be delayed to the first week of July. The day temperature registers a decline of 5°C to 8°C between mid- June and mid-July. As these winds approach the land, their southwesterly direction is modified by the relief and thermal low pressure over the northwest India. 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 from 900-1200 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. This reduces humidity in the winds. As a result, these winds cause little rainfall east of the Western Ghats. This region of low rainfall is known as the rain-shadow area. Find out the rainfall at Kozhikode, Mangalore, Pune and Bangalore and note the difference

(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 Aravallis, 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, The Bay of Bengal branch strikes the coast of Myanmar and part of southeast Bangladesh. But the Arakan Hills along the coast of Myanmar deflect a big portion of this branch towards the Indian subcontinent. 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 rainshadow 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 northeastern 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.
(ix) 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

The months of October and November are known for retreating monsoons. By the end of September, the southwest monsoon becomes weak as the low pressure trough of the Ganga plain starts moving southward in response to the southward march of the sun. The monsoon retreats from the western Rajasthan by the first week of September. It withdraws from Rajasthan, Gujarat, Western Ganga plain and the Central Highlands by the end of the month. 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. By the middle of December, the centre of low pressure is completely removed from the Peninsula. The retreating southwest monsoon season is marked by clear skies and rise in temperature. 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'. In the second half of October, the mercury begins to fall rapidly, particularly in northern India. The weather in the retreating monsoon is dry in north India but it is associated with rain in the eastern part of the Peninsula. Here, October and November are the rainiest months of the year. 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. These tropical cyclones are very destructive. The thickly populated deltas of the Godavari, Krishna and Kaveri are their preferred targets. Every year cyclones bring disaster here. A few cyclonic storms also strike the coast of West Bengal, Bangladesh and Myanmar. A bulk of the rainfall of the Coromondal coast is derived from these depressions and cyclones. Such cyclonic storms are less frequent in the Arabian Sea.

TRADITIONAL INDIAN SEASONS

In the Indian tradition, a year is divided into six two-monthly seasons. This cycle of seasons, which the common people in north and central India follow is based on their practical experience and age-old perception of weather phenomena. However, this system does not match with the seasons of south India where there is little variation in the seasons. *Seasons Months Months (According to the (According to the Indian Calendar) Indian Calendar)* asanta 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 50

DISTRIBUTION OF RAINFALL

The average annual rainfall in India is about 125 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 then 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 Orissa, 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.

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. Standard Deviation Mean 100 where C.V. is the coefficient of variation. The values of coefficient of variation show the change from the mean values of rainfall. The actual rainfall in some places deviates from 20-50 per cent. The values of coefficient of variation show variability of rainfall in India. A variability of less than 25 per cent exists on the western coasts, Western Ghats, northeastern Peninsula, eastern plains of the Ganga, northeastern India, Uttaranchal and Himachal Pradesh and south-western part of Jammu and Kashmir. These areas have an annual rainfall of over 100 cm. 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. 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. A climatic region has a homogeneous climatic condition which is the result of a combination of factors. Temperature and rainfall are two important elements which are considered to be decisive in all the schemes of climatic classification. The classification of climate, however, is a complex exercise. There are different schemes of classification of climate. 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 (rain forest despite a dry monsoon season), w (dry season in winter), h (dry and hot), c (less than four months with mean temperature over 10°C), and 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 per cent 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 threashold 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

Climate has 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. Now you might have read or heard the debate on global warming. Besides the natural causes, human activities such as large scale industrialisation and presence of polluting gas in the atmosphere are also important factors responsible for global warming. You might have heard about the “green house effect” while discussing global warming. The temperature of the world is significantly increasing. Carbon dioxide produced by human activities is a major source of concern. This gas, released to the atmosphere in large quantities by burning of fossil fuel, is increasing gradually.

Other gases like methane, chlorofluorocarbons, and nitrous oxide which are present in much smaller concentrations in the atmosphere, together with carbon dioxide are known as green house gases. These gases are better absorbers of long wave radiations than carbon dioxide, and so, are more effective at enhancing the green house effect. These gases have been contributing to global warming. It is said that due to global warming the polar ice caps and mountain glaciers would melt and the amount of water in the oceans would increase. The mean annual surface temperature of the earth in the past 150 years has increased. It is projected that by the year 2,100, global temperature will warm about 2°C. This rise in temperature will accompany many other changes: one of these is a rise in sea level, as glacier and sea ice melt in response to warming. According to the current prediction, on an average, the sea level will rise 48 cm by the end of twenty first century. This would increase the incidence of annual flooding. Climatic change would promote insect-borne diseases like malaria, and lead to shift in climatic boundaries, making some regions wetter and others drier. Agricultural pattern would shift and human population as well as the ecosystem would experience change.

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 Uttaranchal

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. India is a land of great variety of natural vegetation. 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 cactii, 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

These forests are found in the western slope of the Western Ghats, hills of the northeastern region and the Andaman and Nicobar Islands. They are found in warm and humid areas with an annual precipitation of over 200 cm and mean annual temperature above 22ºC. 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. In these forests, trees reach great heights up to 60 m or above.

There is no definite time for trees to shed their leaves, flowering and fruition. As such these forests appear green all the year round. Species found in these forests include rosewood, mahogony, aini, ebony, etc. The semi evergreen forests are found in the less rainy parts of these regions. Such forests have a mixture of evergreen and moist deciduous trees. The undergrowing climbers provide an evergreen character to these forests. Main species are white cedar, hollock and kail. The British were aware of the economic value of the forests in India, hence, large scale exploitation of these forests was started. The structure of forests was also changed. The oak forests in Garhwal and Kumaon were replaced by pine (chirs) which was needed to lay railway lines. Forests were also cleared for introducing plantations of tea, rubber and coffee. The British also used timber for construction activities as it acts as an insulator of heat. The protectional use of forests was, thus, replaced by commercial use.

Tropical Deciduous Forests

These are the most widespread forests in India. They are also called the monsoon forests. They spread over regions which receive rainfall between 70-200 cm. On the basis of the availability of water, these forests are further divided into moist and dry deciduous. *The Moist deciduous forests* are more pronounced in the regions which record rainfall between 100-200 cm. These forests are found in the northeastern states along the foothills of Himalayas, eastern slopes of the Western Ghats and Orissa. Teak, *sal, shisham, hurra, mahua, amla, semul, kusum,* and sandalwood etc. are the main species of these forests. *Dry deciduous forest* covers vast areas of the country, where rainfall ranges between 70 -100 cm. On the wetter margins, it has a transition to the moist deciduous, while on the drier margins to thorn forests. These forests are found in rainier areas of the Peninsula and the plains of Uttar Pradesh and Bihar. In the higher rainfall regions of the Peninsular plateau and the northern Indian plain, these forests have a parkland landscape with open stretches in which teak and other trees interspersed with patches of grass are common. 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

Tropical thorn forests occur in the areas which receive rainfall less than 50 cm. These consist of a variety of grasses and shrubs. It includes semi-arid areas of south west Punjab, Haryana, Rajasthan, Gujarat, Madhya Pradesh and Uttar Pradesh. In these forests, plants remain leafless for most part of the year and give an expression of scrub vegetation. Important species found are *babool, ber*, and wild date palm, *khair, neem, khejri, palas*, etc. Tussocky grass grows upto a height of 2 m as the under growth.

MONTANE FORESTS

In mountainous areas, the decrease in temperature with increasing altitude leads to a corresponding change in natural vegetation. Mountain forests can be classified into two types, the northern mountain forests and the southern mountain forests. The Himalayan ranges show a succession of vegetation from the tropical to the tundra, which change in with the altitude. Deciduous forests are found in the foothills of the Himalayas. It is succeeded by the wet temperate type of forests between an altitude of 1,000-2,000 m. In the higher hill ranges of northeastern India, hilly areas of West Bengal and Uttaranchal, evergreen broad leaf trees such as oak and chestnut are predominant. Between 1,500-1,750 m, pine forests are also well-developed in this zone, with Chir Pine as a very useful commercial tree. Deodar, a highly valued endemic species grows mainly in the western part of the Himalayan range.

Deodar is a durable wood mainly used in construction activity. Similarly, the *chinar* and the walnut, which sustain the famous Kashmir handicrafts, belong to this zone. Blue pine and spruce appear at altitudes of 2,225-3,048 m. At many places in this zone, temperate grasslands are also found. But in the higher reaches there is a transition to Alpine forests and pastures. Silver firs, junipers, pines, birch and rhododendrons, etc. occur between 3,000-4,000 m. However, these pastures are used extensively for transhumance by tribes like the Gujjars, the Bakarwals, the Bhotiyas and the Gaddis. The southern slopes of the Himalayas carry a thicker vegetation cover because of relatively higher precipitation than the drier north-facing slopes. At higher altitudes, mosses and lichens form part of the tundra vegetation. *The southern mountain forests* include the forests found in three distinct areas of Peninsular India viz; the Western Ghats, the Vindhyas and the Nilgiris. As they are closer to the tropics, and only 1,500 m above the sea level, vegetation is temperate in the higher regions, and subtropical on the lower regions of the Western Ghats, especially in Kerala, Tamil Nadu and Karnataka. The temperate forests are called *Sholas* in the Nilgiris, Anaimalai and Palani hills. Some of the other trees of this forest of economic significance include, magnolia, laurel, cinchona and wattle. Such forests are also found in the Satpura and the Maikal ranges.

Littoral and Swamp Forests

India has a rich variety of wetland habitats. About 70 per cent of this comprises areas under paddy cultivation. The total area of wet land is 3.9 million hectares. Two sites — Chilika Lake (Orissa) and Keoladeo National Park (Bharatpur) are protected as water-fowl habitats under the Convention of Wetlands of International Importance (Ramsar Convention). An international convention is an agreement among member states of the United Nations. The country's wetlands have been grouped into eight categories, viz.

(i) the reservoirs of the Deccan Plateau in the south together with the lagoons and other wetlands of the southern west coast;
(ii) the vast saline expanses of Rajasthan, Gujarat and the Gulf of Kachchh;
(iii) freshwater lakes and reservoirs from Gujarat eastwards through Rajasthan (Keoladeo National Park) and Madhya Pradesh;
(iv) the delta wetlands and lagoons of India's east coast (Chilika Lake);
(v) the freshwater marshes of the Gangetic Plain; (vi) the floodplains of the Brahmaputra; the marshes and swamps in the hills of northeast India and the Himalayan foothills;
(vi) the lakes and rivers of the montane region of Kashmir and Ladakh; and
(vii) the mangrove forest and other wetlands of the island arcs of the Andaman and Nicobar Islands. Mangroves grow along the coasts in the salt

They consist of a number of salt-tolerant species of plants. Crisscrossed by creeks of stagnant water and tidal flows, these forests give shelter to a wide variety of birds. In India, the mangrove forests spread over 6,740 sq. km which is 7 per cent of the world's mangrove forests. They are highly developed in the Andaman and Nicobar Islands and the Sunderbans of West Bengal. Other areas of significance are the Mahanadi, the Godavari and the Krishna deltas. These forests too, are being encroached upon, and hence, need conservation.

FOREST COVER IN INDIA

According to state records, the forest area covers 23.28 per cent of the total land area of the country. It is important to note that the forest area and the actual forest cover are not the same. The forest area is the area notified and recorded as the forest land irrespective of the existence of trees, while the actual forest cover is the area occupied by forests with canopy. The former is based on the records of the State Revenue Department, while the latter is based on aerial photographs and satellite imageries. In 2001, the actual forest cover was only 20.55 per cent. Of the forest cover, the share of dense and open forests was 12.60 per cent and 7.87 per cent rerspectively. Both forest area and forest cover vary from state to state. Lakshadweep has zero per cent forest area; Andaman and Nicobar Islands have 86.93 per cent. Most of the states with less than 10 per cent of the forest area lie in the north and northwestern part of the country.

These are Rajasthan, Gujarat, Punjab, Haryana and Delhi. Most of the forests in Punjab and Haryana have been cleared for cultivation. States with 10-20 per cent forest area are Tamil Nadu and West Bengal. In Peninsular India, excluding Tamil Nadu, Dadra and Nagar Haveli and Goa, the area under forest cover is 20-30 per cent. The northeastern states have more than 30 per cent of the land under forest. Hilly topography and heavy rainfall are good for forest growth. There is a lot of variation in actual forest cover, which ranges from 9.56 per cent in Jammu and Kashmir to 84.01 per cent in Andaman and Nicobar Islands. From the table showing the distribution of forests in India (Appendix IV), it is clear that there are 15 states where the forest cover is more than one-third of the total area, which is the basic requirement for maintaining the ecological balance. On the basis of the percentage of the actual forest cover, the states have been grouped into four regions:

Regionwise limits for coverage types

(i) The region of high concentration > 40% forests
(ii) The region of medium concentration 20%-40% forests
(iii) The region of low concentration 10% -20% forests
(iv) The region of very low concentration < 10% forests

FOREST CONSERVATION

Forests have an intricate interrelationship with life and environment. These provide numerous direct and indirect advantages to our economy and society. Hence, conservation of forest is of vital importance to the survival and prosperity of humankind. Accordingly, the Government of India proposed to have a nation-wide forest conservation policy, and adopted a forest policy in 1952, which was further modified in 1988. According to the new forest policy, the Government will emphasise sustainable forest management in order to conserve and expand forest reserve on the one hand, and to meet the needs of local people on the other. The forest policy aimed at :

- (i) bringing 33 per cent of the geographical areas under forest cover;
- (ii) maintaining environmental stability and to restore forests where ecological balance was disturbed;
- (iii) conserving the natural heritage of the country, its biological diversity and genetic pool;
- (iv) checks soil erosion, extension of the desert lands and reduction of floods and droughts;
- (v) increasing the forest cover through social forestry and afforestation on degraded land;

(vi) increasing the productivity of forests to make timber, fuel, fodder and food available to rural population dependant on forests, and encourage the substitution of wood;

(vii) creating of a massive peoples movement involving women to encourage planting of trees, stop felling of trees and thus, reduce pressure on the existing forest.

FORESTS AND LIFE

To a vast number of tribal people, the forest is a home, a livelihood, their very existence. It provides them food, fruits of all kinds, edible leaves, honey, nourishing roots and wild game. It provides them with material to build their houses and items for practicing their arts. The importance of forests in tribal economy is well-known as they are the source of sustenance and livelihood for tribal communities. It is commonly believed that the tribal communities live in harmony with nature and protect forests. Out of a total of 593 districts 187 (2001) have been identified as tribal districts. The tribal districts account for about 59.8 per cent of the total forest cover of the country whereas the geographical area of 187 tribal districts forms only 33.6 per cent of the total geographical area of the country. It demonstrates that tribal districts are generally rich in forest cover. Forest and tribals are very closely related. The age-old knowledge of tribals regarding forestry can be used in the development of forests. Rather than treating tribals as minor forest produce collectors they should be made growers of minor forest produce and encouraged to participate in conservation. Based on the forest conservation policy the following steps were initiated:

SOCIAL FORESTRY

Social forestry means the management and protection of forests and afforestation on barren lands with the purpose of helping in the environmental, social and rural development. The National Commission on Agriculture (1976) has classified social forestry into three categories. These are Urban forestry, Rural forestry and Farm forestry. Urban forestry pertains to the raising and management of trees on public and privately owned lands in and around urban centres such as green belts, parks, roadside avenues, industrial and commercial green belts, etc. Rural forestry lays emphasis on promotion of agro-forestry and community-forestry. Agro-forestry is the raising of trees and agriculture crops on the same land inclusive of the waste patches. It combines forestry with agriculture, thus, altering the simultaneous production of food, fodder, fuel, timber and fruit. Community forestry involves the raising of trees on public or community land such as the village pasture and temple land, roadside, canal bank, strips along railway lines, and schools etc. Community forestry programme aims at providing benefits to the community as a whole. Community forestry provides a means under which the people of landless classes can associate themselves in treeraising and thus, get those benefits which otherwise are restricted for landowners.

Farm Forestry

Farm forestry is a term applied to the process under which farmers grow trees for commercial and non-commercial purposes on their farm lands. Forest departments of various states distribute seedlings of trees free of cost to small and medium farmers. Several lands such as the margins of agricultural fields, grasslands and pastures, land around homes and cow sheds may be used for raising trees under non-commercial farm forestry.

WILDLIFE

You would have visited a zoo and may have seen animals and birds in captivity. Wildlife of India is a great natural heritage. It is estimated that about 4-5 per cent of all known plant and animal species on the earth are found in India. The main reason for this remarkable diversity of life forms is the great diversity of the ecosystem which this country has preserved and supported through the ages. Over the years, their habitat has been disturbed by human activities and as a result, their numbers have dwindled significantly. There are certain species that are at the brink of extinction. Some of the important reasons of the declining of wildlife are as follows:

(i) Industrial and technological advancement brought about a rapid increase in the exploitation of forest resources.
(ii) More and more lands were cleared for agriculture, human settlement, roads, mining, reservoirs, etc.
(iii) Pressure on forests mounted due to lopping for fodder and fuelwood and removal of small timber by the local people.
(iv) Grazing by domestic cattle caused an adverse effect on wildlife and its habitat.
(v) Hunting was taken up as a sport by the elite and hundreds of wild animals were killed in a single hunt. Now commercial poaching is rampant.
(vi) Incidence of forest fire. It is being felt that conservation of wildlife is of great significance to the national as well as the world heritage along with the promotion of ecotourism. What steps have been initiated by the government in this direction?

WILDLIFE CONSERVATION IN INDIA

The protection of wildlife has a long tradition in India. Many stories of *Panchtantra* and *Jungle Books*, etc. have stood the test of time relating to the love for wildlife. These have a profound impact on young minds. In 1972, a comprehensive Wildlife Act was enacted, which provides the main legal framework for conservation and protection of wildlife in India. The two main objectives of the Act are; to provide protection to the endangered species listed in the schedule of the Act and to provide legal support to the conservation areas of the country classified as National parks, sanctuaries and closed areas. This Act has been comprehensively amended in 1991, making punishments more stringent and has also made provisions for the protection of specified plant species and conservation of endangered species of wild animals.

There are 92 National parks and 492 wildlife sanctuaries covering an area of 15.67 million hectares in the country. Wildlife conservation has a very large ambit with unbounded potential for the wellbeing of humankind. However, this can be achieved only when every individual understands its significance and contributes his bit. For the purpose of effective conservation of flora and fauna, special steps have been initiated by the Government of India in collaboration with UNESCO's 'Man and Biosphere Programme'. Special schemes like Project Tiger (1973) and Project Elephant (1992) have been launched to conserve these species and their habitat in a sustainable manner. Project Tiger has been implemented since 1973.

The main objective of the scheme is to ensure maintenance of viable population of tigers in India for scientific, aesthetic, cultural and ecological values, and to preserve areas of biological importance as natural heritage for the benefit, education and enjoyment of the people. Initially, the Project Tiger was launched in nine tiger reserves, covering an area of 16,339 sq. km, which has now increased to 27 tiger reserves, encompassing 37,761sq. km of tiger habitats distributed in 17 states. The tiger population in the country has registered an increase from 1,827 in 1972 to 3,642 in 2001-2002.

Project Elephant was launched in 1992 to assist states having free ranging population of wild elephants. It was aimed at ensuring long-term survival of identified viable population of elephants in their natural habitat. The project is being implemented in 13 states. Apart from this, some other projects such as Crocodile Breeding Project, Project Hangul and conservation of Himalayan Musk deer have also been launched by the Government of India.

BIOSPHERE RESERVES

A Biosphere Reserve is a unique and representative ecosystem of terrestrial and coastal areas which are internationally recognised within the framework of

UNESCO's Man and Biosphere (MAB) Programme. The Biosphere Reserve aims at achieving the three objectives as. There are 14 Biosphere Reserves in India .Four Biosphere Reserves, namely
(i) Nilgiri; (ii) Nanda Devi;

Have been recognised by the UNESCO on World Network of Biosphere Reserves *Source: Annual Report* (2004-05), Ministry of Environment and Forests, Government of India

List of Biosphere Reserves

1. * Nilgiri - Part of Wynad, Nagarhole, Bandipur and udumalai, Nilambur, Silent Valley and Siruvani Hills (Tamil Nadu, Kerala and Karnataka)
2. * Nanda Devi - Part of Chamoli, Pithoragarh and Almora districts (Uttar Pradesh) and part of Garo Hills (Meghalaya)
3. Nokrek - Part of Garo Hills (Meghalaya)
4. Manas - Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamrup and Darrang districts (Assam)
5. * Sunderbans - Part of delta of Ganges and Brahmaputra river system (West Bengal)
6. * Gulf of Mannar - Indian part of Gulf of Mannar between India and Sri Lanka (Tamil Nadu)
7. Great Nicobar - Southernmost islands of the Andaman and Nicobar (A & N Islands)
8. Similipal - Part of Mayurbhanj district (Orissa)
9. Dibru-Saikhowa - Part of Dibrugarh and Tinsukia districts (Assam)
10. Dihang Dibang - Part of Siang and Debang valley in Arunachal Pradesh
11. Kanchenjunga - Parts of North and West Sikkim
12. Pachmari - Parts of Betul, Hoshangabad and Chindwara districts of Madhya Pradesh
13. Agasthyamalai - Agasthyamalai Hills in Kerala
14. Achanakmar- Amarkantak - Parts of Anupur and Dindori district of MP and parts of Bilaspur district of Chhattisgarh

SOILS

Soil is the most important layer of the earth's crust. It is a valuable resource. The bulk of our food and much of our clothing is derived from land-based crops that grow in the soil. The soil on which we depend so much for our day-to-day needs has evolved over thousands of years. The various agents of weathering and gradation have acted upon the parent rock material to produce a thin layer of soil. Soil is the mixture of rock debris and organic materials which develop on the earth's surface. The major factors affecting the formation of soil are relief, parent material, climate, vegetation and other life-forms and time. Besides these, human activities also influence it to a large extent. Components of the soil are mineral particles, humus, water and air.

The actual amount of each of these depend upon the type of soil. Some soils are deficient in one or more of these, while there are some others that have varied combinations. 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. In order to understand its importance, it is essential to attempt a scientific study of the soil. Classification of the soil is an effort to achieve this objective.

CLASSIFICATION OF SOILS

India has varied relief features, landforms, climatic realms and vegetation types. These have contributed in the development of various types of soils in India. 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 texture, colour, slope of land and moisture content in the soil. Based on sandy, clayey, silty and loam, etc. On the basis of colour, they were red, yellow, black, etc. Since Independence, scientific surveys of soils have been conducted by various agencies. Soil Survey of India, established in 1956, made comprehensive studies of soils in selected areas like in the Damodar Valley. The National Bureau of Soil Survey and the Land Use Planning an Institute under the control of the Indian Council of Agricultural Research (ICAR) did a lot of studies on Indian soils. In their effort to study soil and to make it comparable at the international level, 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. **ICAR recognizes following types of soils in India as per the USDA soil taxonomy**

(i) Inceptisols
(ii) Entisols
(iii) Alfisols
(iv) Vertisols
(v) Aridisols
(vi) Ultisols
(vi) Mollisols
(viii) some other types

On the basis of genesis, colour, composition and location, the soils of India have 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

Alluvial soils are widespread in the northern plains and the river valleys. These soils cover about 40 per cent of the total area of the country. They are depositional soils, transported and deposited by rivers and streams. Through a narrow corridor in Rajasthan, they extend into the plains of Gujarat. In the Peninsular region, they are found in deltas of the east coast and in the river valleys. The alluvial soils vary in nature from sandy loam to clay. They are generally rich in potash but poor in phosphorous. 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. *Bhangar* represents a system of older alluvium, deposited away from the flood plains. 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. The sand content decreases from the west to east.

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. Alluvial soils are intensively cultivated.

BLACK SOIL

Black soil covers most of the Deccan Plateau which includes parts of Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh and some parts of Tamil Nadu. In the upper reaches of the Godavari and the Krishna, and the north western part of the Deccan Plateau, the black soil is very deep. These soils are also known as the 'Regur Soil' or the 'Black Cotton Soil'. The black soils are generally clayey, deep and impermeable. They swell and become sticky when wet and shrink when dried. So, during the dry season, these soil develop wide cracks. Thus, there occurs a kind of *'self ploughing'*. Because of this character of slow absorption and loss of moisture, the black soil retains the moisture for a very long time, which helps the crops, especially, the rain fed ones, to sustain even during the dry season. Chemically, the black soils are rich in lime, iron, magnesia and alumina. They also contain potash. But they lack in phosphorous, nitrogen and organic matter. The colour of the soil ranges from deep black to grey.

RED AND YELLOW SOIL

Red soil develops on crystalline igneous rocks in areas of low rainfall in the eastern and southern part of the Deccan Plateau. 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 Orissa and Chattisgarh and in the southern parts of the middle Ganga plain. The soil develops a reddish colour due to a wide diffusion of iron in crystalline and metamorphic rocks. It looks yellow when it occurs in a hydrated form. The fine-grained red and yellow soils are normally fertile, whereas coarse-grained soils found in dry upland areas are poor in fertility. They are generally poor in nitrogen, phosphorous and humus.

LATERITE SOIL

Laterite has been derived from the Latin word *'Later'* which means brick. The laterite soils develop in areas with high temperature and high rainfall. These are the result of intense leaching due to tropical rains. With rain, lime and silica are leached away, and soils rich in iron oxide and aluminium compound are left behind. Humus content of the soil is removed fast by bacteria that thrives well in high temperature. These soils are poor in organic matter, nitrogen, phosphate and calcium, while iron oxide and potash are in excess. Hence, laterites are not suitable for cultivation; however, application of manures and fertilizers are required for making the soils fertile for cultivation.Red laterite soils in Tamil Nadu, Andhra Pradesh and Kerala are more suitable for tree crops like cashewnut. 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. The laterite soils are commonly found in Karnataka, Kerala, Tamil Nadu, Madhya Pradesh and the hilly areas of Orissa and Assam.

ARID SOILS

Arid soils range from red to brown in colour. 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. Due to the dry climate, high temperature and accelerated evaporation, they lack moisture and humus. Nitrogen is insufficient and the phosphate content is normal. Lower horizons of the soil are occupied by *'kankar'* layers because of the increasing calcium content downwards. 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. Arid soils are characteristically developed in western Rajasthan, which exhibit characteristic arid topography. These soils are poor and contain little humus and organic matter.

SALINE SOILS

They are also known as *Usara* soils. Saline soils contain a larger proportion of sodium, potassium and magnesium, and thus, they are infertile, and do not support any vegetative growth. 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. Their structure ranges from sandy to loamy. 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. 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. 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

They are found in the areas of heavy rainfall and high humidity, where there is a good growth of vegetation. Thus, large quantity of dead organic matter accumulates in these areas, and this gives a rich humus and organic content to the soil. Organic matter in these soils may go even up to 40-50 per cent. These soils are normally heavy and black in colour. At many places, they are alkaline also. 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

As the name suggests, forest soils are formed in the forest areas where sufficient rainfall is available. The soils vary in structure and texture depending on the mountain environment where they are formed. They are loamy and silty on valley sides and coarse-grained in the upper slopes. In the snow-bound areas of the Himalayas, they experience denudation, and are acidic with low humus content. The soils found in the lower valleys are fertile. It is evident from the foregoing discussions that soils, their texture, quality and nature are vital for the germination and growth of plant and vegetation including crops. Soils are living systems. Like any other organism, they too develop and decay, get degraded, respond to proper treatment if administered in time. These have serious repercussions on other components of the system of which they themselves are important parts.

SOIL DEGRADATION

In a broad sense, 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. Soil degradation is the main factor leading to the depleting soil resource base in India. The degree of soil degradation varies from place to placeaccording to the topography, wind velocity and amount of the rainfall.

SOIL EROSION

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. But generally, there is a balance between these two processes. The rate of removal of fine particles from the surface is the same as the rate of addition of particles to the soil layer. Sometimes, such a balance is disturbed by natural or human factors, leading to a greater rate of removal of soil. Human activities too are responsible for soil erosion to a great extent. As the human population increases, the demand on the land also increases. Forest and other natural vegetation is removed for human settlement, for cultivation, for grazing animals and for various other needs. Wind and water are powerful agents of soil erosion because of their ability to remove soil and transport it. Wind erosion is significant in arid and semi-arid regions. In regions with heavy rainfall and steep slopes, erosion by running water is more significant. 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. Sheet erosion takes place on level lands after a heavy shower and the soil removal is not easily noticeable. But it is harmful since it removes the finer and more fertile top soil. Gully erosion is common on steep slopes.

Gullies deepen with rainfall, cut the agricultural lands into small fragments and make them unfit for cultivation. A region with a large number of deep gullies or ravines is called a badland topography. Ravines are widespread, in the Chambal basin. Besides this, they are also found in Tamil Nadu and West Bengal. The country is losing about 8,000 hectares of land to ravines every year. Soil erosion is a serious problem for Indian agriculture and its negative effects are seen in other spheres also. Eroded materials are carried down to rivers and they lower down their carrying capacity, and cause frequent floods and damage to agricultural lands. Deforestation is one of the major causes of soil erosion. 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 overirrigation. The salt lodged in the lower profiles of the soil comes up to the surface and destroys its fertility. Chemical fertilisers 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 tonnes 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

If soil erosion and exhaustion are caused by humans; by corollary, they can also be prevented by humans. Nature has its own laws of maintaining balance. Nature offers enough opportunities for humans to develop their economy without disturbing the ecological balance. Soil conservation is a methodology to maintain soil fertility, prevent soil erosion and exhaustion, and improve the degraded condition of the soil. Soil erosion is essentially aggravated by faulty practices. The first step in any rational solution is to check open cultivable lands on slopes from farming. Lands with a slope for cultivation. If at all the land is to be used for agriculture, terraces should carefully be made. Over-grazing and shifting cultivation in many parts of India have affected the natural cover of land and given rise to extensive erosion.

It should be regulated and controlled by educating villagers about the consequences. Contour bunding, Contour terracing, regulated forestry, controlled grazing, cover cropping, mixed farming and crop rotation are some of the remedial measures which are often adopted to reduce soil erosion. Efforts should be made to prevent gully erosion and control their formation. Finger gullies can be eliminated by terracing. In bigger gullies, the erosive velocity of water may be reduced by constructing a series of check dams. Special attention should be made to control headward extension of gullies. This can be done by gully plugging, terracing or by planting cover vegetation. In arid and semi-arid areas, efforts should be made to protect cultivable lands from encroachment by sand dunes through developing shelter belts of trees and agro-forestry. Lands not suitable for cultivation should be converted into pastures for grazing. Experiments have been made to stabilise sand dunes in western Rajasthan by the Central Arid Zone Research Institute (CAZRI).

The Central Soil Conservation Board, set up by the Government of India, has prepared a number of plans for soil conservation in different parts of the country. These plans are based on the climatic conditions, configuration of land and the social behaviour of people. Even these plans are fragmental in nature. Integrated land use planning, therefore, seems to be the best technique for proper soil conservation. Lands should be classified according to their capability; land use maps should be prepared and lands should be put to right uses. The final responsibility for achieving the conservation of land will rest on the people who operate on it and receive the benefits.

NATURAL HAZARDS AND DISASTERS

You might have read about tsunami or seen the images of horror on television set immediately after it happened. You may also be aware of the severe earthquake in Kashmir on both sides of the Line of Control (LOC). The damage caused to human life and properties during these episodes has moved us all. What are these as phenomena and how they are caused? How can we save ourselves? These are some questions which come to our minds. This chapter will attempt to analyse some of these questions. Change is the law of nature. It is a continuous process that goes on uninterruptedly involving phenomena, big and small, material and nonmaterial that make our physical and sociocultural environment. It is a process present everywhere with variations in terms of magnitude, intensity and scale. Change can be a gradual or slow process like the evolution of landforms and organisms and it can be as sudden and swift as volcanic eruptions, tsunamis, earthquakes and lightening, etc. Similarly, it may remain confined to a smaller area occurring within a few seconds like hailstorms, tornadoes and dust storms, and it can also have global dimensions such as global warming and depletion of the ozone layer.

Besides these, changes have different meanings for different people. It depends upon the perspective one takes while trying to understand them. From the perspective of nature, changes are value-neutral (these are neither good nor bad). But from the human perspective, these are value-loaded. There are some changes that are desirable and good like the change of seasons, ripening of fruits, while there are others like earthquakes, floods and wars that are considered bad and undesirable. Observe the environment you live in and prepare a list of changes, which take place over a long period of time and those, which take place within a short period of time. Do you know why some changes are considered good and others bad? Prepare a list of changes, which you notice in your daily life and give reasons why some of these are considered good and others bad. In this chapter, we will read about some of these changes, which are considered bad and have haunted humankind for a long time. Disasters in general and natural disasters in particular, are some such changes that are always disliked and feared by humankind.

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". For a long time, geographical literature viewed disasters as a consequence of natural forces; and human beings were treated as nnocent and helpless victims in front of the mighty forces of nature. But natural forces are not the only causes of disasters. Disasters are also caused by some human activities.

There are some activities carried by human beings that are directly responsible for disasters. Bhopal Gas tragedy, Chernobyl nuclear disaster, wars, release of CFCs (Chlorofluorocarbons) and increase of green house gases, environmental pollutions like noise, air, water and soil are some of the disasters which are caused directly by human actions. There are some other activities of human beings that accelerate or intensify disasters indirectly. Landslides and floods due to deforestation, unscientific land use and construction activities in fragile areas are some of the disasters that are the results of indirect human actions. Can you identify some other human activities going on in and around your neighbourhood and schools that can lead to disasters in the near future? Can you suggest some measures to prevent it? It is a common experience that human-made disasters have increased both in their numbers and magnitudes over the years and co ed efforts are on at various levels to prevent and minimise their occurrences. Though the success has been only nominal so far, it is possible to prevent some of these disasters created by human actions. As opposed to this, very little is possible to prevent natural disasters; therefore, the best way out is to emphasise on natural disaster mitigation and management. 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. Most often it is observed that scholars use disasters and natural hazards as interchangeable. Both are related phenomena, yet quite distinct from each other. Hence, it is necessary to distinguish between the two. *Natural Hazards are elements of circumstances in the Natural environment that have the potential to cause harm to people or property or both.*

These may be swift or permanent aspects of the respective environmental settings like currents in the oceans, steep slope and unstable structural features in the Himalayas or extreme climatic conditions in deserts or glaciated areas. As compared to natural hazards, *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. Firstly, the magnitude, intensity, frequency and damages caused by natural disasters have increased over the years. 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 minimised. And 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. Previously, hazards and disasters were seen as two closely associated and interrelated phenomena, i.e. areas prone to natural hazards, were more vulnerable to disasters. Hence, people avoided tampering with the delicate balance that existed in a given ecosystem. People avoided intensification of their activities in such areas and that is how disasters were less damaging. Technological power has given large capacity to human intervention in nature. Consequently, now, human beings tend to intensify their activities into disaster prone areas increasing their vulnerability to disasters. Colonisation of flood plains of most of the rivers and development of large cities and port-towns like – Mumbai and Chennai along the coast, and touching the shore due to high land values, make them vulnerable to the occurrence of cyclones, hurricanes and tsunamis.

CLASSIFICATION OF NATURAL DISASTERS

Human beings the world over have experienced disasters and have faced and lived with them. Now people are becoming aware and various steps have been initiated at different levels for mitigating the effects of disasters. Identification and classification of disasters is being considered as an effective and scientific step to deal promptly and efficiently with the disasters. Broadly, natural disasters can be classified under four categories . India is one of those countries which has experienced most of the natural disasters. Every year it loses thousands of lives and property worth millions of rupees due to these natural calamities. In the following section, some of

Classification of Natural Disasters

Atmospheric - Blizzards, Thunderstorms, Lightning, Tornadoes, Tropical Cyclone, Drought, Hailstorm Frost, Heat Wave or *Loo.*Cold Waves, etc
Terrestrial – Earthquakes, Volcanic Eruptions, Landslides, Avalanches, Subsidence, Soil Erosion,
Aquatic – Floods, Tidal Waves, Ocean Currents, Storm Surge, Tsunami,
Biological - Plants and Animals as colonisers (Locusts, etc.). Insects infestation— fungal, bacterial and viral diseases such as bird flu, dengue, etc.

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:
(v) 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).* the highly devastating natural disasters have been discussed, particularly in the context of India.

NATURAL DISASTERS AND HAZARDS IN INDIA

India is vast and diverse in terms of its physical and socio-cultural attributes. It is largely due to its vast geographical area, 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'. 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. These observations can also be illustrated by focussing on some of the major natural disasters in India.

EARTHQUAKES

Earthquakes are by far the most unpredictable and highly destructive of all the natural disasters. 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. Indian plate is moving at a speed of one centimetre per year towards the north and northeastern direction and this movement of plates is being constantly obstructed by the Eurasian plate from the north. As a result of this, both the plates are said to be locked with each other resulting in accumulation of energy at different points of time.

Excessive accumulation of energy results in building up of stress, which ultimately leads to the breaking up of the lock and the sudden release of energy causes earthquakes along the Himalayan arch. Some of the most vulnerable states are Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, and the Darjiling and subdivision of West Bengal and all the seven states of the northeast. Apart from these regions, the central-western parts of India, particularly Gujarat (in 1819, 1956 and 2001) and Maharashtra (in 1967 and 1993) have also experienced some severe earthquakes. Earth scientists have found it difficult to explain the occurrence of earthquakes in one of the oldest, most stable and mature landmass of Peninsular block for a long time. Recently, some earth scientists have come up with a theory of emergence of a fault line and energy build-up along the fault line represented by the river Bhima (Krishna) near Latur and Osmanabad (Maharashtra) and the possible breaking down of the Indian plate. *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) Low damage risk zone
(v) Very low damage risk zone.

Out of these, the first two zones had experienced some of the most devastating earthquakes in India. 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, Uttaranchal, Western Himachal Pradesh (around Dharamshala) and Kashmir Valley in the Himalayan region and the Kuchchh (Gujarat). 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. 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.

Effects of Earthquakes

Fissures, Cracking, Waves, Settlements Slidings, Hydro-Dynamic Pressure, Landslides, Overturning, Tsunami, Liquefaction, Buckling Earth, Pressure Collapse, Apart from these, earthquakes also have some serious and far-reaching environmental consequences. Surface seismic waves produce fissures on the upper layers of the earth’s crust through which water and other volatile materials gush out, inundating the neighbouring areas. Earthquakes are also responsible for landslides and often these cause obstructions in the flow of rivers and channels resulting in the formation of reservoirs. Sometimes, rivers also change their course causing floods and other calamities in the affected areas.

Earthquake Hazard Mitigation

Unlike other disasters, the damages caused by earthquakes are more devastating. Since it also destroys most of the transport and communication links, providing timely relief to the victims becomes difficult. It is not possible to prevent the occurrence of an earthquake; hence, the next best option is to emphasis on disaster preparedness and mitigation rather than curative measures such as:

(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 minimising the adverse impacts of disasters.

(iii) Modifying the house types and buildingdesigns 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.

Tsunami

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 afterwaves 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. Therefore, a ship at sea is not much affected by *tsunami* and it is difficult to detect a tsunami in the deeper parts of sea. It is so because over deep water the tsunami has very long wave-length and limited wave-height. Thus, a tsunami wave raises the ship only a metre or two and each rise and fall takes several minutes. As opposed to this, when a tsunami enters shallow water, its wave-length gets reduced and the period remains unchanged, which increases the waveheight. 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.

After reaching the coast, the tsunami waves release enormous energy stored in them and water flows turbulently onto the land destroying port-cities and towns, structures, buildings and other settlements. Since the coastal areas are densely populated the world over, and these are also centres of intense human activity, the loss of life and property is likely to be much higher by a tsunami as compared to other natural hazards in the coastal areas. Unlike other natural hazards, the mitigation of hazards created by tsunami is difficult, mainly because of the fact that losses are on a much larger scale. 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.

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

Owing to its Peninsular shape surrounded by the Bay of Bengal in the east and the Arabian Sea in the west, the tropical cyclones in India also originate in these two important locations. Though most of the cyclones originate between 10°-15° north attitudes 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.

INDIAN SPACE PROGRAMMES

Indian Space Programme is commenced in 1962 with the constitution of Indian Space Research Committee under the Chairmanship of Vikram Sarabhai and in 1963 the establishment of Thumba Rocket projection centre with thw launching of two rockets received from America, In 1969 ISRO was established under the Department of Atomic Energy. In 1972 Space Programme was formulated with Space Department and Space Commission established for deciding and executing of space policy of India. Since 1975 with the launched of Aryabhatta, India has achieved a greate milestone in Space Programmes.

Following are some space centers

- **Sriharikota :** Satis Dhawan, for launching space rocket and vehicle.
- **Hassan :** Master Control Facility
- **Thiruvanantpuram :** Vikram Sarabhai Space Centre for launch of space vehicle.
- **Thumba :** ISRO Inertial System Unit
- **Mahindragiri :** Liquid Propulsion Test Facility
- **Bengaluru :** Space Commission, ISRO Headquarters
- **Ahemadabad :** Space Application Centre, Physical Research Laboratory Development and Educational Communication Unit
- **Tirupati :** National Mesophere – Stratosphere – Toposphere Radar Facility
- **Dehradun :** Indian Institute of Remote Sensing
- **New Delhi :** Department of Space Branch Secratariate
- **Jodhpur :** Western Regional Remote Sensing Centre
- **Lucknow:** Telemetri Tracking and Command Network
- **Nagpur :** Central Regional Remote Sensing Centre
- **Khadakpur :** Eastern Central Regional Remote Sensing Service Centre
- **Shilong :** North Eastern Space Application Centre
- **Always :** Amonium Perchlorate Experiment Plant
- **Hyderabad :** National Remote Sensing Agency
- **Balasore :** Meteorological Rocket Station
- **Mumbai :** ISRO Liasion Office
- **Port Blair :** Down Range Station
- **Udaipur :** Solar Observatory

TROPICAL CYCLONE

Tropical cyclones are intense low-pressure areas 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 energised by the release of latent heat on account of the condensation of moisture that the wind gathers after moving over the oceans and seas. There are differences of opinion among scientists about the exact mechanism of a tropical cyclone. However, some 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.

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

Inundation of land and human settlements by the rise of water in the channels and its spill-over presents the condition of flooding. Unlike other natural disasters, the causes of floods are well established. Floods are relatively slow in occurrences and often, occur in well-identified regions and within expected time in a year. Floods occur commonly when water in the form of surface run-off exceeds the carrying capacity of the river channels and streams and flows into the neighbouring low-lying flood plains. At times, this even goes beyond the capacity of lakes and other inland water bodies in which they flow. Floods can also be caused due to a storm surge (in the coastal areas), high intensity rainfall for a considerably longer time period, melting of ice and snow, reduction in the infiltration rate and presence of eroded material in the water due to higher rate of soil erosion. Though floods occur frequently over wide geographical area having disasterous ramifications in many parts of the world, floods in the South, Southeast and East Asian countries, particularly in China, India and Bangladesh, are frequent and equally disastrous. Once again, unlike other natural disasters, human beings play an important role in the genesis as well as spread of floods. Indiscriminate deforestation, unscientific agricultural practices, disturbances along the natural drainage channels and colonisation of flood-plains and river-beds are some of the human activities that play an important role in increasing the intensity, magnitude and gravity of floods.

Various states of India face heavy loss of lives and property due to recurrent floods. *Rashtriya Barh Ayog* (National Flood Commission) identified 40 million hectares of land as flood-prone in India. The Figure 7.6 shows the flood-affected areas in India. Assam, West Bengal and Bihar are among the high flood-prone states of India. Apart from these, most of the rivers in the northern states likePunjab and Uttar Pradesh, are also vulnerable to occasional floods. It has been noticed that states like Rajasthan, Gujarat, Haryana and Punjab are also getting inundated in recent decades due to flash floods. This is partly because of the pattern of the monsoon and partly because of blocking of most of the streams and river channels by human activities. Sometimes, Tamil Nadu experiences flooding during November- January due to the retreating monsoon. *Consequence and Control of Floods* 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 serious consequences on the national economy and society. Floods do not only destroy valuable crops every year but these also damage physical infrastructure such as roads, rails, bridges and human settlements. Millions of people are rendered homeless and are also washed down along with their cattle in the floods. Spread of diseases like cholera, gastro-enteritis, hepatitis and other water-borne diseases spread in the flood-affected areas. However, floods also make a few positive contributions. Every year, floods deposit fertile silt over agricultural fields which is good for the crops. Majuli (Assam), the largest riverine island in the world, is the best example of good paddy crops after the annual floods in Brahmaputra. But these are insignificant benefits in comparison to the grave losses. The Government of India as well as the state governments are well aware of the menace created by floods every year. How do these governments generally respond to the floods? Construction of flood protection embankments in the flood-prone areas, construction of dams, afforestation and discouraging major construction activities in the upper reaches of most of the flood-creating rivers, etc. are some steps that need to be taken up on urgent basis. Removal of human encroachment from the river channels and depopulating the flood plains can be the other steps. This is particularly true in western and northern parts of the country which experience *flash-floods*. 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-utilisation of water from the reservoirs and other storages, including the ground water. Drought is a complex phenomenon as it involves elements of meteorology like precipitation, evaporation, evapotranspiration, ground water, soil moisture, storage and surface run-off, 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. Various parts of India experience these droughts recurrently which result in some serious socio-economic and ecological problems.

Drought Prone Areas in India

Indian agriculture has been heavily dependent on the monsoon rainfall. Droughts and floods are the two accompanying features of Indian climate. According to some estimates, nearly 19 per cent of the total geographical area of the 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. Thus, droughts are widespread and common phenomena in most parts of the country, but these are most recurrent and severe in some and not so in others. On the basis of severity of droughts, India can be divided into the following regions:

Extreme Drought Affected Areas : *M*ost 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

Droughts have cascading effects on various other aspects of environment and society. Crop failure leading to scarcity of food grains *(akal)*, fodder *(trinkal)*, inadequate rainfall, resulting in shortage of water *(jalkal)*, and often shortage in all the three *(trikal)* is most devastating. Large-scale death of cattle and other animals, migration of humans and livestock are the most common sight to be seen in the droughtaffected areas. Scarcity of water compels people to consume contaminated water resulting in spread of many waterborne diseases like gastro-enteritis, cholera, hepatitis, etc. Droughts have both immediate as well as long-term disastrous consequences on the social and physical environments. Consequently, planning for drought has to take both aspects into consideration. Provision for the distribution of safe drinking water, medicines for the victims and availability of fodder and water for the cattle and shifting of the people and their livestock to safer places, etc. are some steps that need to be taken immediately. Identification of ground water potential in the form of aquifers, transfer of river water from the surplus to the deficit areas, and particularly planning for inter-linking of rivers and construction of reservoirs and dams, etc. should be given a serious thought.

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. Dissemination of knowledge about drought-resistant crops and proper training to practise the same can be some of the long-term measures that will be helpful in drought-mitigation. Rainwater harvesting can also be an effective method in minimising the effects of drought. Observe the methods adopted for rooftop rainwater harvesting in your locality and suggest measures to make it more effective.

LANDSLIDES

Landslide is the rapid sliding of large mass of bedrocks. Disasters due to landslides, are in general, far less dramatic than due to earthquakes, volcanic eruptions, tsunamis and cyclones but their impact on the natural environment and national economy is in no way less severe. Unlike other disasters that are sudden, unpredictable and are largely controlled by macro or regional factors, 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.

It is always difficult to define in a precise statement and generalise the occurrence and behaviour of a landslide. However, on the basis of past experiences, frequency and certain causal relationships with the controlling factors like geology, geomorphic agents, slope, land-use, vegetation cover and 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* Landslides have relatively small and localize area of direct influence, but roadblock, destruction of railway lines and channel blocking due to rock-falls have far-reaching consequences. Diversion of river courses due to landslides can also lead to flood and loss of life and property. It also makes spatial interaction difficult, risky as well as a costly affair, which, in turn, adversely affects the developmental activities in these areas.

MITIGATION

It is always advisable to adopt area-specific measures to deal with landslides. Restriction on the construction and other developmental activities such as roads and dams, limiting agriculture to valleys and areas with moderate slopes, and control on the development of large settlements in the high vulnerability zones, should be enforced. This should be supplemented by some positive actions like promoting large-scale afforestation programmes and construction of bunds to reduce the flow of water. Terrace farming should be encouraged in the northeastern hill states where *Jhumming* (Slash and Burn/Shifting Cultivation) is still prevalent.

DISASTER MANAGEMENT

Disasters due to cyclones, unlike the ones caused by earthquakes, tsunamis and volcanic eruptions are more predictable in terms of the time and place of their occurrences. Moreover, with the help of development of techniques to monitor the behaviour of cyclones, their intensity, direction and magnitude, it has become possible to manage the cyclonic hazard to some extent. Construction of cycloneshelters, embankments, dykes, reservoirs and afforestation to reduce the speed of the winds are some of the steps that can help in minimising the damages. However, increase in the loss of life and property in countries like India, Bangladesh, Myanmar, etc. in successive storms is largely due to high vulnerability of their population residing in the coastal areas.

Disaster Management Bill, 2005

The Disaster Management Bill, 2005, defines disaster as a catastrophe, mishap, calamity or grave occurrence affecting any area, arising from natural or man-made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, environment, and is of such nature or magnitude as to be beyond the coping capacity of the community of the affected area.

Disasters can be natural or the results of human activities, and all hazards need not turn into disasters since it is difficult to eliminate disasters, particularly natural disasters. Then the next best option is mitigation and preparedness. There are three stages involved in disaster mitigation and management:

(i) Pre-disaster management involves generating data and information about the disasters, preparing vulnerability zoning maps and spreading awareness among the people about these. Apart from these, disaster planning, preparedness and preventive measures are other steps that need to be taken in the vulnerable areas.

(ii) During disasters, rescue and relief operations such as evacuation, construction of shelters and relief camps, supplying of water, food, clothing and medical aids etc. should be done on an emergency basis.

(iii) Post-disaster operations should involve rehabilitation and recovery of victims.

HUMAN GEOGRPAHY OF INDIA

POPULATION

Distribution, Density, Growth and Composition the people are very important component of a country. India is the second most populous country after China in the world with its total population of 1,028 million (2001). India's population is larger than the total population of North America, South America and Australia put together. More often, it is argued that such a large population invariably puts pressure on its limited resources and is also responsible for many socio-economic problems in the country.

SOURCES OF POPULATION DATA

Population data are collected through Census operation held every 10 years in our country. The first population Census in India was conducted in 1872 but its first complete Census was conducted only in 1881. India has a highly uneven pattern of population distribution. The percentage shares of population of the states and Union Territories in the country show that Uttar Pradesh has the highest population followed by Maharashtra, Bihar, West Bengal and Andhra Pradesh. U.P., Maharashtra, Bihar, West Bengal, Andhra Pradesh along with Tamil Nadu, Madhya Pradesh, Rajasthan, Karnataka and Gujarat, together account for about 76 per cent of the total population of the country. On the other hand, share of population is very small in the states like Jammu & Kashmir (0.98%), Arunachal Pradesh (0.11%) and Uttaranchal (0.83%) inspite of theses states having fairly large geographical area. Such an uneven spatial distribution of population in India suggests a close relationship between population and physical, socioeconomic and historical factors. As far as the physical factors are concerned, it is clear that climate along with terrain and availability of water largely determines the pattern of the population distribution. Consequently, we observe that the North Indian Plains, deltas and Coastal Plains have higher proportion of population than the interior districts of southern and central Indian States, Himalayas, some of the north eastern and the western states. However, development of irrigation (Rajasthan), availability of mineral and energy resources (Jharkhand) and development of transport network (Peninsular States) have resulted in moderate to high concentration of population in areas which were previously very thinly populated .Among the socio-economic and historical factors of distribution of population, important ones are evolution of settled agriculture and agricultural development; pattern of human settlement; development of transport network, industrialisation and urbanisation. It is observed that the regions falling in the river plains and coastal areas of India have remained the regions of larger population concentration. Even though the uses of natural resources like land and water in these regions have shown the sign of degradation, the concentration of population remains high because of an early history of human settlement and development of transport network.

On the other hand, the urban regions of Delhi, Mumbai, Kolkata, Bangalore, Pune, Ahmedabad, Chennai and Jaipur have high concentration of population due to industrial development and urbanisation drawing a large numbers of rural-urban migrants. Density of Population Density of population, is expressed as number of persons per unit area. It helps in getting a better understanding of the spatial distribution of population in relation to land. The density of population in India (2001) is 313 persons per sq km and ranks third among the most densely populated countries of Asia following Bangladesh (849 persons) and Japan (334 persons). There has been a steady increase of about 200 persons per sq km over the last 50 years as the density of population increased from 117 persons/ sq km in 1951 to 313 persons/sq km in 2001. Spatial variation of population densities in the country which ranges from as low as 13 persons per sq km in Arunachal Pradesh to 9,340 persons in the National Capital Territory of Delhi.

Among the northern Indian States, West Bengal (903), Bihar (880) and Uttar Pradesh (690) have higher densities, while Kerala (819) and Tamil Nadu (480) have higher densities among the peninsular Indian states. States like Assam, Gujarat, Andhra Pradesh, Haryana, Jharkhand, Orissa have moderate densities. The hill states of the Himalayan region and North eastern states of India (excluding Assam) have relatively low densities while the Union Territories (excluding Andaman and Nicobar islands) have very high densities of population The density of population, as discussed in the earlier paragraph, is a crude measure of human and land relationship. To get a better insight into the human-land ratio in terms of pressure of population on total cultivable land, the *physiological* and the *agricultural* densities should be found out which are significant for a country like India having a large agricultural population.

Physiological density = total population / net cultivated area Agricultural density = total agricultural population / net cultivable area Agricultural population includes cultivators and agricultural labourers and their family members. Growth of Population Growth of population is the change in the number of people living in a particular area between two points of time. Its rate is expressed in percentage. Population growth has two components namely; natural and induced. While the natural growth is analysed by assessing the crude birth and death rates, the induced components are explained by the volume of inward and outward movement of people in any given area. However, in the present chapter, we will only discuss the natural growth of India’s population. The decadal and annual growth rates of population in India are both very high and steadily increasing over time. The annual growth rate of India’s population is 2.4 per cent. At this current rate of increase, it is estimated that the country’s population will double itself in another 36 years and even surpass population of China.

OTHER IMPORTANT NATIONAL INSTITUTE

- Central Institute of Medicinal and Aromatic Plants (CIMAP) – Lucknow (U.P.)
- Central Salt and Marine Chemicals Research Institue (CSMCRI) – Bhavhagar (Gujarat)
- Indira Gandhi National Tribal University (IGNTU) – Amarkantak (M.P.)
- Indian Institute of Crop Processing Technology – (IICPT) Thanjavur (Tamil Nadu)
- Indian Institute of Petroleum Technology (IIPT) – Dchradun (Uttarakhand)
- Indian Institute of Space Science and Technology (IISST) – Thiruvanthpuram (Kerala)
- Indira Gandhi National Musueum, Bhopal
- Kalpana Chawla Memorial Planetorium, Kapurthala
- Indian Zoological Survey Department, Kolkata
- Indian Botanical Survey Department, Kolkata
- Indian Forext Survey Department, Dehradun
- Indira Gandhi Forest Academi, Dehradun
- Central Arid Zone Research Institute, Jodhpur
- Indian Forest Management, Bhopal
- National Deciduous Forest Research Centre, Jabalpur
- Wood Science and Technology Centre, Bangalore
- Forest Genetic Centre, Coimbator
- National Institute of Food Technology and Management (NIFTEM), Kundli (Sonipat), Haryana
- Insect Warning Association, Jodhpur
- Central Potato Research Institute, Kufri (Shimla)
- National Plant Protection and Training Institute, Hyderabad
- Chaudhari Charan Singh National Institute of Agriculture Marketing, Jaipur
- Central Institute of Cotton Research, Nagpur
- Central Fodder Seed Production Farm, Hasserghata (Karnataka)
- Central Aquaculture and Oceanic Engineering Training Institutem Cochin
- Central Pollution Control Board, New Delhi
- Rainy Forest Research Institute, Jorhat
- Forest Heredatery and Plant Generation Institute, Coimbatore
- Bureau of Indian Standard, Delhi
- Indian Institute of Tropical Meteorology, Pune
- Indian Institute of Astrology Physics, Banglore
- Indian Institute of Geomagnetism, Mumbai
- Aryabhatta Research Observatory, Nainital

- National Engineering Academi of India, New Delhi
- Atomic Mineral Research Directorate, Hyderabad
- Plasma Research of Institute, Ahmedabad
- National Ocean and Information Service Centre of India, Hyderabad
- Indian Intra – country Waterways Authority, Noida
- Hindustan Shipyard Ltd, Vishakhapatnam
- Central Soil and Element Research Centre, New Delhi
- National Hydrology Institute, Roorki
- National Chemical and Fertilizers Ltd, Trombe
- Hindustan Antibiotics Ltd, Pimpri (Pune)
- Indian Bureau of Mines, Nagpur
- Hindustan Zink Ltd, Udayapur
- Central Water and Electricity Research Centre, Khadawasla (Pune)
- National Project Construction Corporation Ltd, New Delhi
- Indian Tsunamis Warning Centre, Hyderabad
- High Security Animal Disease Centre, Bhopal (Bird Flu Testing Laboratory)

POPULATION DOUBLING TIME

Population doubling time is the time taken by any population to double itself at its current annual growth rate. The growth rate of population in India over the last one century has been caused by annual birth rate and death rate and rate of migration and thereby shows different trends. There are four distinct phases of growth identified within this period: * Decadal growth rate**:** 2 1 2 p –p g = × 100 p Where P1 = population of the base year P2 = population of the present year

Phase I : The period from 1901-1921 is referred to as a period of stagnant or stationary phase of growth of India’s population, since in this period growth rate was very low, even recording a negative growth rate during 1911-1921. Both the birth rate and death rate were high keeping the rate of increase low. Poor health and medical services, illiteracy of people at large and inefficient distribution system of food and other basic necessities were largely responsible for a high birth and death rates in this period.

Phase II : The decades 1921-1951 are referred to as the period of steady population growth. An overall improvement in health and sanitation throughout the country brought down the mortality rate. At the same time better transport and communication system improved distribution system. The crude birth rate remained high in this period leading to higher growth rate than the previous phase. This is impressive at the backdrop of Great Economic Depression, 1920s and World War II.

Phase III : The decades 1951-1981 are referred to as the period of population explosion in India, which was caused by a rapid fall in the mortality rate but a high fertility rate of population in the country. The average annual growth rate was as high as 2.2 percent. It is in this period, after the Independence, that developmental activities were introduced through a centralised planning process and economy started showing up ensuring the improvement of living condition of people at large. Consequently, there was a high natural increase and higher growth rate. Besides, increased international migration bringing in Tibetans, Bangladeshis, Nepalies and even people from Pakistan contributed to the high growth rate.

Phase IV : In the post 1981 till present, the growth rate of country's population though remained high, has started slowing down gradually. A downward trend of crude birth rate is held responsible for such a population growth. This was, in turn, affected by an increase in the mean age at marriage, improved quality of life particularly education of females in the country. The growth rate of population is, however, still high in the country, and it has been projected by World Development Report that population of India will touch 1,350 million by 2025. The analysis done so far shows the average growth rate, but the country also has wide variation in growth rates from one area to another which is discussed below. Regional Variation in Population Growth The growth rate of population during 1991- 2001 in Indian States and Union Territories shows very obvious pattern. The States like Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Puducherry, and Goa show a low rate of growth not exceeding 20 per cent over the decade. Kerala registered the lowest growth rate (9.4) not only in this group of states but also in the country as a whole. A continuous belt of states from west to east in the north-west, north , and north central parts of the country has relatively high growth rate than the southern states. It is in this belt comprising Gujarat, Maharashtra, Rajasthan, Punjab, Haryana, Uttar Pradesh, Uttarakhand, Madhya Pradesh, Sikkim, Assam, West Bengal, Bihar, Chhattisgarh, and Jharkhand, the growth rate on the average remained 20-25 per cent.

Take the population growth data of the districts/selected districts of your respective state for total male and female population and represent them with the help of Composite Bar Graph. An important aspect of population growth in India is the growth of its adolescents. At present the share of adolescents i.e. up to the age group of 10-19 years is about 22 per cent (2001), among which male adolescents constitute 53 per cent and female adolescents constitute 47 per cent. The adolescent population, though, regarded as the youthful population having high potentials, but at the same time they are quite vulnerable if not guided and channelised properly. There are many challenges for the society as far as these adolescents are concerned, some of which are lower age at marriage, illiteracy – particularly female illiteracy, school dropouts, low intake of nutrients, high rate of maternal mortality of adolescent mothers, high rates of HIV/AIDS infections, physical and mental disability or retardedness, drug abuse and alcoholism, juvenile delinquency and commitence of crimes, etc. In view of these, the Government of India has undertaken certain policies to impart proper education to the adolescent groups so that their talents are better channelised and properly utilised. The National Youth Policy is one example which has been designed to look into the overall development of our large youth and adolescent population. The National Youth Policy of Government of India, launched in 2003, stresses on an allround improvement of the youth and adolescents enabling them to shoulder responsibility towards constructive development of the country. It also aims at reinforcing the qualities of patriotism and responsible citizenship. The thrust of this policy is youth empowerment in terms of their effective participation in decision making and carrying the responsibility of an able leader. Special emphasis was given in empowering women and girl child to bring parity in the male-female status. Moreover, deliberate efforts were made to look into youth health, sports and recreation, creativity and awareness about new innovations in the spheres of science and technology. It appears from the above discussion that the growth rate of population is widely variant over space and time in the country and also highlights various social problems related to the growth of population. However, in order to have a better insight into the growth pattern of population it is also necessary to look into the social composition of population. Population Composition Population composition is a distinct field of study within population geography with a vast coverage of analysis of age and sex, place of residence, ethnic characteristics, tribes, language, religion, marital status, literacy and education, occupational characteristics, etc. In this section, the composition of Indian population with respect to their rural-urban characteristics, language, religion and pattern of occupation will be discussed.

Rural – Urban Composition

Composition of population by their respective places of residence is an important indicator of social and economic characteristics. This becomes even more significant for a country where about 72 per cent of its total population lives in villages. The distribution of rural population is not uniform throughout the country. You might have noted that the states like Bihar and Sikkim have very high percentage of rural population. The states of Goa and Maharashtra have only little over half of their total population residing in villages. The Union Territories, on the other hand, have smaller proportion of rural population, except Dadra and Nagar Haveli (77.1 per cent). The size of villages also varies considerably. It is less than 200 persons in the hill states of north-eastern India, Western Rajasthan and Rann of Kuchchh and as high as 17 thousand persons in the states of Kerala and in parts of Maharashtra. A thorough examination of the pattern of distribution of rural population of India reveals that both at intra-State and inter- State levels, the relative degree of urbanization and extent of rural-urban migration regulate the concentration of rural population. You have noted that contrary to rural population, the proportion of urban population (27.8 per cent) in India is quite low but it is showing a much faster rate of growth over the decades. In fact since 1931, the growth rate of urban population has accelerated due to enhanced economic development and improvement in health and hygienic conditions. The distribution of urban population too, as in the case of total population, has a wide variation throughout the country. It is, however, noticed that in almost all the states and Union Territories, there has been a considerable increase of urban population. This indicates both development of urban areas in terms of socio-economic conditions and an increased rate of rural-urban migration. The rural-urban migration is conspicuous in the case of urban areas along the main road links and railroads in the North Indian Plains, the industrial areas around Kolkata, Mumbai, Bangalore – Mysore, Madurai – Coimbatore, Ahmedabad – Surat, Delhi – Kanpur and Ludhiana – Jalandhar. In the agriculturally tagnant parts of the middle and lower Ganga Plains, Telengana, non-irrigated Western Rajasthan, remote hilly, tribal areas of northeast, along the flood prone areas of Peninsular India and along eastern part of Madhya Pradesh, the degree of urbanisation has remained low.

LINGUISTIC COMPOSITION

India is a land of linguistic diversity. According to Grierson (Linguistic Survey of India, 1903 – 1928) there were 179 languages and as many as 544 dialects in the country. In the context of modern India, there are about 18 scheduled languages (1991 census) and a number of nonscheduled languages. See how many languages appear on a ten Rs note. Among the scheduled languages, the speakers of Hindi have the highest percentage (40.42). The smallest language groups are Kashmiri and Sanskrit speakers (0.01 per cent each). However, it is noticed that the linguistic regions in the country do not maintain a sharp and distinct boundary, rather they gradually merge and overlap in their respective border zones.

Linguistic Classification

The speakers of major Indian languages belong to four language families, which have their sub-families and branches or groups.

Religious Composition

Religion is one of the most dominant forces affecting the cultural and political life of the most of Indians. Since religion virtually permeates into almost all the aspects of people's family and community lives, it is important to study the religious composition in detail. The spatial distribution of religious communities in the country shows that there are certain states and districts having large numerical strength of one religion, while the same may be very negligibly represented in other states. Hindus are distributed as a major group in many states (ranging from 70 - 90 per cent and above) except the districts of states along Indo- Bangladesh border, Indo-Pak border, Jammu & Kashmir, Hill States of North-East and in scattered areas of Deccan Plateau and Ganga Plain.

Muslims, the largest religious minority, are concentrated in Jammu & Kashmir, certain districts of West Bengal and Kerala, many districts of Uttar Pradesh , in and around Delhi and in Lakshadweep. They form majority in Kashmir valley and Lakshadweep.

The Christian population is distributedmostly in rural areas of the country. The main concentration is observed along the Western coast around Goa, Kerala and also in the hill states of Meghalaya, Mizoram, Nagaland, Chotanagpur area and Hills of Manipur. Sikhs are mostly concentrated in relatively small area of the country, particularly in the states of Punjab, Haryana and Delhi. Jains and Buddhists, the smallest religious groups in India have their concentration only in selected areas of the country.

Religious Communities of India, 2001

Religious Groups, Population (in million) ,% of Total

Hindus 827.6 ,80.5	Muslims 138.2 ,13.5
Christians 24.1 , 2.3	Sikhs 19.2 ,1.9
Buddhists 8.0 , 0.9	Jains 4.2 , 0.4
Others 6.6 , 0.6	

The other religions of India include Zoroastrians, tribal and other indigenous faiths and beliefs. These groups are concentrated in small pockets scattered throughout the country.

COMPOSITION OF WORKING POPULATION

The population of India according to their economic status is divided into three groups, namely; main workers, marginal workers and non-workers.

Standard Census Definition

Main Worker is a person who works for atleast 183 days in a year. Marginal Worker is a person who works for less than 183 days in a year. It is observed that in India, the proportion of workers (both main and marginal) is only 39 per cent (2001) leaving a vast majority of 61 per cent as non-workers. This indicates an economic status in which there is a larger proportion of dependent population, further indicating possible existence of large number of unemployed or under employed people. The proportion of working population, of the states and Union Territories show a moderate variation from about 25 per cent in Goa to about 53 per cent in Mizoram. The states with larger percentages of workers are Himachal Pradesh, Sikkim, Chhattisgarh, Andhra Pradesh, Karnataka, Arunachal Pradesh, Nagaland, Manipur and Meghalaya. Among the Union Territories, Dadra and Nagar Haveli and Daman and Diu have higher participation rate. It is understood that, in the context of a country like India, the work participation rate tends to be higher in the areas of lower levels of economic development since number of manual workers are needed to perform the subsistence or near subsistence economic activities.

The occupational composition (see box) of India's population (which actually means engagement of an individual in farming, manufacturing trade, services or any kind of professional activities) shows a large proportion of primary sector workers compared to secondary and tertiary sectors. About 58.2 per cent of total working population are cultivators and agricultural labourers, whereas only 4.2% of workers are engaged in household industries and 37.6 % are other workers including nonhousehold industries, trade, commerce, construction and repair and other services. As far as the occupation of country's male and female population is concerned, male workers out-number female workers in all the three sectors.

Occupational Categories

The 2001 Census has divided the working population of India into four major categories:

1. Cultivators
2. Agricultural Labourers
3. Household Industrial Workers
4. Other Workers.

The number of female workers is relatively high in primary sector, though in recent years there has been some improvement in work participation of women in secondary and tertiary sectors.

Religion and Landscape

Formal expression of religions on landscape is manifested through sacred structures, use of cemetries and assemblages of plants and animals, groves of trees for religious purposes. Sacred structures are widely distributed throughout the country. These may range from inconspicuous village shrines to large Hindu temples, monumental masjids or ornately designed cathedrals in large metropolitan cities. These temples, masjids, gurudwaras, monastries and churches differ in size, form, space – use and density, while attributing a special dimension to the total landscape of the area.

Consequently, the participation rate in secondary and tertiary sector has registered an increase. This indicates a shift of dependence of workers from farm-based occupations to nonfarm based ones, indicating a sectoral shift in the economy of the country. The spatial variation of work participation rate in different sectors in the country (Appendix–v) is very wide. For instance, the states like Himachal Pradesh and Nagaland have very large shares of cultivators. On the other hand states like Andhra Pradesh, Chhattisgarh, Orissa, Jharkhand, West Bengal and Madhya Pradesh have higher proportion of agricultural labourers. The highly urbanised areas like Delhi, Chandigarh and Puducherry have a very large proportion of workers being engaged in other services. This indicates not only availability of limited farming land, but also large scale urbanisation and industrialisation requiring more workers in non-farm sectors.

INSTITUTE OF NATIONAL IMPORTANCE

(Reservation will not be applied here)

- Bhabha National Institute, Mumbai
- Bhabha Atomic Research Centre, Trombe
- Indira Gandhi Atomic Research Centre, Kalpakkam
- Raja Ramanna Centre fro Technology, Indore
- Institute for Plasms Research, Gandhinagar
- Variable Energy Cyclotron Centre, Kolkata
- Institute of Physics, Bhubaneswar
- Institute of Mathematica Science, Chennai
- Harishchandra Research Institute, Allahabad
- Tata Memorial Centre, Mumbai
- National Brain research Centre, Gurgaon
- Physical Research Laboratory, Thiruanantpuram
- Indian Institute of Remote Sensing, Dehradun
- Homi Bhabba National Institute, Mumbai
- Tata Institute of Fundamental research, Mumbai
- North Eastern Indira Gandhi Insitute of Health and Medical College, Shillong
- Nehru Centre for Advanced Scientific Research, Banglore

MIGRATION

People have been moving from one village to another, from villages to towns, from smaller towns to bigger towns and from one country to another. Migration has been an integral part and a very important factor in redistributing population over time and space. India has witnessed the waves of migrants coming to the country from Central and West Asia and also from Southeast Asia. In fact, the history of India is a history of waves of migrants coming and settling one after another in different parts of the country.

Indian Diaspora

During colonial period (British period) millions of the indentured labourers were sent to Mauritius, Caribbean islands (Trinidad, Tobago and Guyana), Fiji and South Africa by British from Uttar Pradesh and Bihar; to Reunion Island, Guadeloupe, Martinique and Surinam by French and Dutch and by Portuguese from Goa, Daman and Diu to Angola, Mozambique to work as plantation workers. All such migrations were covered under the time-bound contract known as Girmit Act (Indian Emigration Act). However, the living conditions of these indentured labourers were not better than the slaves.

The second wave of migrants ventured out into the neighbouring countries in recent times as professionals, artisans, traders and factory workers, in search of economic opportunities to Thailand, Malaysia, Singapore, Indonesia, Brunei and African countries, etc. and the trend still continues. There was a steady outflow of India's semi-skilled and skilled labour in the wake of the oil boom in West Asia in the 1970s. There was also some outflow of entrepreneurs, storeowners, professionals, businessmen to Western Countries. Third wave, of migrant was comprised professionals like doctors, engineers (1960s onwards), software engineers, management consultants, financial experts, media persons (1980s onwards), and others migrated to countries such as USA, Canada, UK, Australia, New Zealand and Germany, etc. These professional enjoy the distinction of being one of highly educated, the highest earning and prospering groups. After liberalisation, in the 90s education and knowledge–based Indian emigration has made Indian Diaspora one of the most powerful diasporas in the world. In all these countries, Indian diaspora has been playing an important role in the development of the respective countries. Actually migration was recorded beginning from the first Census of India conducted in 1881. This data were recorded on the basis of place of birth. However, the first major modification was introduced in 1961 Census by bringing in two additional components viz; place of birth i.e. village or town and duration of residence (if born elsewhere). Further in 1971, additional information on place of last residence and duration of stay at the place of enumeration were incorporated. Information on reasons for migration were incorporated in 1981 Census and modified in consecutive Censuses. In the Census the following questions are asked on migration:

- Is the person born in this village or town? If no, then further information is taken on rural/urban status of the place of birth, name of district and state and if outside India then name of the country of birth.
- Has the person come to this village or town from elsewhere? If yes, then further questions are asked about the status (rural/urban) of previous place of residence, name of district and state and if outside India then name of the country. In addition, reasons for migration from the place of last residence and duration of residence in place of enumeration are also asked. In the Census of India migration is enumerated on two bases:

(i) place of birth, if the place of birth is different from the place of enumeration (known as life-time migrant);

(ii) place of residence, if the place of last residence is different from the place of enumeration (known as migrant by place of last residence). Can you imagine the proportion of migrants in the population of India? As per 2001 census, out of 1,029 million people in the country, 307 million (30 per cent) were reported as migrants by place of birth. However, this figure was 315 million (31 per cent) in case of place of last residence.

STREAMS OF MIGRATION

A few facts pertaining to the internal migration (within the country) and international migration (out of the country and into the country from other countries) are presented here. Females predominate the streams of short distance rural to rural migration in both types of migration. Contrary to this, men predominate the rural to urban stream of inter-state migration due to economic reasons. Apart from these streams of internal migration, India also experiences immigration from and emigration to the neighbouring countries.
Indian migration, four streams are identified:

(a) rural to rural (R-R); (b) rural to urban (R-U);
(c) urban to urban (U-U); and (d) urban to rural (U-R).

In India, during 2001, out of 315 million migrants, enumerated on the basis of the last residence, 98 million had changed their place of residence in the last ten years. Out of these, 81 million were intrastate migrants. The stream was dominated by female migrants. Most of these were migrants related to marriage. Census 2001 has recorded that more than 5 million person have migrated to India from other countries. Out of these, 96 per cent came from the neighbouring countries: Bangladesh (3.0 million) followed by Pakistan (0.9 million) and Nepal (0.5 million). Included in this are 0.16 million refugees from T ibet, Sri Lanka, Bangladesh, Pakistan, Afghanistan, Iran, and Myanmar. As far as emigration from India is concerned it is estimated that there are around 20 million people of Indian Diaspora, spread across 110 countries.

SPATIAL VARIATION IN MIGRATION

Some states like Maharashtra, Delhi, Gujarat and Haryana attract migrants from other states such as Uttar Pradesh, Bihar, etc. Maharashtra occupied first place in the list with 2.3 million net in-migrants, followed by Delhi, Gujarat and Haryana. On the other hand, Uttar Pradesh (-2.6 million) and Bihar (-1.7 million) were the states, which had the largest number of net out-migrants from the state. Among the urban agglomeration (UA), Greater Mumbai received the higher number of in migrants. Intra-states migration constituted the largest share in it. These differences are largely due to the size of the state in which these Urban Agglomeration are located. From the given news items try to identify the political and economic causes of migration.

CAUSES OF MIGRATION

People, generally are emotionally attached to their place of birth. But millions of people leave their places of birth and residence. There could be variety of reasons. These reasons can be put into two broad categories:

(i) **push factor**, these cause people to leave their place of residence or origin; and

(ii) **pull factors**, which attract the people from different places. In India people migrate from rural to urban areas mainly due to poverty, high population pressure on the land, lack of basic infrastructural facilities like health care, education, etc. Apart from these factors, natural disasters such as, flood, drought, cyclonic storms, earthquake, tsunami, wars and local conflicts also give extra push to migrate. On the other hand, there are pull factors which attract people from rural areas to cities. The most important pull factor for majority of the rural migrants to urban areas is the better opportunities, availability of regular work and relatively higher wages. Better opportunities for education, better health facilities and sources of entertainment, etc. are also quite important pull factors. On the basis of the figures, it can be seen that reason for migration of males and females are different. For example, work and employment have remained the main cause for male migration (38 per cent) while it is only three per cent for the females. Contrary to this, about 65 per cent of females move out from their parental houses following their marriage. This is the most important cause in the rural areas of India except in Meghalaya where reverse is the case. In comparison to these marriage migration of the male, is only 2 per cent in the country.

CONSEQUENCES OF MIGRATION

Migration is a response to the uneven distribution of opportunities over space. People tend to move from place of low opportunity and low safety to the place of higher opportunity and better safety. This, in turn, creates both benefits and problems for the areas, people migrate from and migrate to. Consequences can be observed in economic, social, cultural, political and demographic terms.

INDIAN HERITAGES UNDER UNESCO LIST

Heritage – Year

1. Ajanta – 1983
2. Ellora Caves – 1983
3. Agra Fort – 1983
4. Taj Mahal, Agra – 1983
5. Sun Temple of Konark – 1984
6. Mahabalipuram Temple – 1994
7. Kajiranga National Park – 1985
8. Manas Wildlife Sanctuary – 1985
9. Keoladev National Park – 1985
10. Church Convets of Goa – 1986
11. Khajuraho Temple – 1986
12. Humpy – 1986
13. Fatehpur Sikri – 1986
14. Pattadkal – 1986
15. Elephanta Caves – 1987

16. Bridheshwar Temple – 1987
17. Sundervan National Park – 1987
18. Nanda Devi Naional Park Valley of Flowers – 2005
19. Bussha Stupa of Saanchi – 1989
20. Humanyu Tomb of Delhi – 1993
21. Kutub Minar, Delhi – 1993
22. Darjeeling Himalayan Railways Nilgiri – 1999
    Mountain Railways Kalka – Simla Railways
23. Bodhgaya Mahabodhi Temple Compound – 2002
24. Bhimbetka Caves, MP – 2003
25. Champaner – Pavagarh Park, Gujarat – 2004
26. Chhatrapati Shivaji Terminal (Mumbai) – 2004
    Lal Quila of Delhi – 2007

ECONOMIC CONSEQUENCES

A major benefit for the source region is the remittance sent by migrants. Remittances from the international migrants are one of the major sources of foreign exchange. In 2002, India received US$ 11 billion as remittances from international migrants. Punjab, Kerala and Tamil Nadu receive very significant amount from their international migrants. The amount of remittances sent by the internal migrants is very meagre as compared to international migrants, but it plays an important role in the growth of economy of the source area. Remittances are mainly used for food, repayment of debts, treatment, marriages, children's education, agricultural inputs, construction of houses, etc. For thousands of the poor villages of Bihar, Uttar Pradesh, Orissa, Andhra Pradesh, Himachal Pradesh, etc. remittance works as life blood for their economy. Migration from rural areas of Eastern Uttar Pradesh, Bihar, Madhya Pradesh and Orissa to the rural areas of Punjab, Haryana, Western Uttar Pradesh accounted for the success of their green revolution strategy for agricultural development. Besides this, unregulated migration to the metropolitan cities of India has caused overcrowding. Development of slums in industrially developed states such as Maharashtra, Gujarat, Karnataka, Tamil Nadu and Delhi is a negative consequence of unregulated migration within the country.

Demographic Consequences

Migration leads to the redistribution of the population within a country. Rural urban migration is one of the important factors contributing to the population growth of cities. Age and skill selective out migration from the rural area have adverse effect on the rural demographic structure. However, high out migration from Uttaranchal, Rajasthan, Madhya Pradesh and Eastern Maharashtra have brought serious imbalances in age and sex composition in these states. Similar imbalances are also brought in the recipients states.

SOCIAL CONSEQUENCES

Migrants act as agents of social change. The new ideas related to new technologies, Family planning, girl's education, etc. get diffused from urban to rural areas through them. Migration leads to intermixing of people from diverse cultures. It has positive contribution such as evolution of composite culture and breaking through the narrow considerations and widens up the mental horizon of the people at large. But it also has serious negative consequences such as anonimity, which creates social vacuum and sense of dejection among individuals. Continued feeling of dejection may motivate people to fall in the trap of anti-social activities like crime and drug abuse.

ENVIRONMENTAL CONSEQUENCES

Overcrowding of people due to rural-urban migration has put pressure on the existing social and physical infrastructure in the urban areas. This ultimately leads to unplanned growth of urban settlement and formation of slums shanty colonies. Apart from this, due to over-exploitation of natural resources, cities are facing the acute problem of depletion of ground water, air pollution, disposal of sewage and management of solid wastes.

OTHERS

Migration (even excluding the marriage migration) affects the status of women directly or indirectly. In the rural areas, male selective out migration leaving their wives behind puts extra physical as well mental pressure on the women. Migration of 'women' either for education or employment enhances their autonomy and role in the economy but also increases their vulnerability. If remittances are the major benefits of migration from the point of view of the source region, the loss of human resources particularly highly skilled people is the most serious cost. The market for advanced skills has become truly a global market and the most dynamic industrial economies are admitting and recruiting significant proportions of the highly trained professionals from poor regions. Consequently, the existing underdevelopment in the source region gets reinforced.

HUMAN DEVELOPMENT

Development of a few regions, individuals brought about in a short span of time leads to poverty and malnutrition for many along with large scale ecological degradation. Apparently, it is believed that "Development is freedom" which is often associated with modernisation, leisure, comfort and affluence. In the present context, computerisation, industrialisation, efficient transport and communication network, large education system, advanced and modern medical facilities, safety and security of individuals, etc. are considered as the symbols of development.

Every individual, community and government measures its performance or levels of development in relation to the availability and access to some of these things. But, this may be partial and one-sided view of development. It is often called the western or euro-centric view of development. The poor are being subjected to three inter-related processes of declining capabilities; i.e.

(1) social capabilities – due to displacement and weakening social ties (social capital),

(2) environmental capabilities – due to pollution and,

3 personal capabilities – due to increasing incidence of diseases and accidents. This, in turn, has adverse effects on their quality of life and human development. Based on the above experiences, it can be said that the present development has not been able to address the issues of social injustice, regional imbalances and environmental degradation. On the contrary, it is being widely considered as the prime cause of the social distributive injustices, deterioration in the quality of life and human development, ecological crisis and social unrest Thus, it was thought to take up human development as a separate issue against the prevalent western views of development which considers development as the remedy to all the ills including human development, regional disparities and environmental crisis. Most systematic effort towards this was the publication of the First Human Development Report by United Nations Development Programme (UNDP) in 1990. Since then, this organisation has been bringing out World Human Development Report every year. This report does not only define human development, make amendments and changes its indicators but also ranks all the countries postcolonial country like India, colonisation, marginalisation, social discrimination and regional disparity, etc. show the other face of development. Thus, for India, development is a mixed bag of opportunities as well as neglect and deprivations. There are a few areas like the metropolitan centres and other developed enclaves that have all the modern facilities available to a small section of its population. At the other extreme of it, there are large rural areas and the slums in the urban areas that do not have basic amenities like potable water, education and health infrastructure available to majority of this population. The situation is more alarming if one looks at the distribution of the development opportunities among different sections of our society. It is a wellestablished fact that majority of the scheduled castes, scheduled tribes, landless agricultural labourers, poor farmers and slums dwellers, etc. are the most marginalised lot. A large segment of female population is the worst sufferers among all. It is also equally true that the relative as well as absolute conditions of the majority of these marginalised sections have worsened with the development happening over the years. Consequently, vast majority of people are compelled to live under abject poverty and subhuman conditions. There is yet another inter-related aspect of development that has direct bearings on the deteriorating human conditions. It pertains to the environmental pollution leading to ecological crisis.

WHAT IS HUMAN DEVELOPMENT?

"Human development is a process of enlarging the range of people's choices, increasing their opportunities for education, health care, income and empowerment and covering the full range of human choices from a sound physical environment to economic, social and political freedom." Thus, enlarging the range of people's choices is the most significant aspect of human development. People's choices may involve a host of other issues, but, living a long and healthy life, to be educated and have access to resources needed for a decent standard of living including political freedom, guaranteed human rights and personal self-respect, etc. are considered some of the non-negotiable aspects of the human development.

According to the Human Development Report 1993, "progressive democratisation and increasing empowerment of people are seen as the minimum conditions for human development". Moreover, it also mentions that "development must be woven around people, not the people around development" as was the case previously. Human Development in India India with a population of over 1.09 billion is ranked 127 among 172 countries of the world in terms of the Human Development Index (HDI). With the composite HDI value of O.602 India finds herself grouped with countries showing medium human development(UNDP 2005). Low scores in the HDI is a matter of serious concern but, some reservations have been expressed about the approach as well as indicators selected to calculate the index values and ranking of the states/countries. Lack of sensitivity to the historical factors like colonisation, imperialism and neo-imperialism, socio-cultural factors like human rights violation, social discrimination on the basis of race, religion, gender and caste, social problems like crimes, terrorism, and war and political factors like nature of the state, forms of the government (democracy or dictatorship) level of empowerment are some factors that are very crucial in determining the nature of human development. These aspects have special significance in case of India and many other developing countries. Using the indicators selected by the UNDP, the Planning Commission of India also prepared the Human Development Report for India. It used states and the Union Territories as the units of analysis. Subsequently, each state government also started preparing the state level Human Development Reports, using districts as the units of analysis. Although, the final HDI by the Planning Commission of India has been calculated by taking the three indicators, yet, this report also discussed other indicators like economic attainment, social empowerment, social distributive justice, accessibility, hygiene and various welfare measures undertaken by the state. Some of the important indicators have been discussed in the following pages.

Highest Waterfalls

Waterfall – Country	**Waterfall – Country**
Angel – Venezuela	Tugela – South Africa
Yosemite – Califormia	Mardalsfossen – Norway
Sutherland – New Zealand	Reichenbach – Switzerland
Wollomombi – Australia	Ribbon – California
Gavarnie – France	Tyssefallene – Norway

INDICATORS OF ECONOMIC ATTAINMENTS

Rich resource base and access to these resources by all, particularly the poor, down trodden and the marginalised is the key to productivity, well-being and human development. Gross National Product (GNP) and its per capita availability are taken as measures to assess the resource base/ endowment of any country. For India, it is estimated that its GDP was Rs. 3200 thousand crores (at current Price) and accordingly, per capita income was Rs. 20,813 at current prices. Apparently, these figures indicate an impressive performance but, prevalence of poverty, deprivation, malnutrition, illiteracy, various types of prejudices and above all social distributive injustices and large-scale regional disparities belie all the so-called economic achievements. There are a few developed States like Maharashtra, Punjab, Haryana, Gujarat and Delhi that have per capita income more than Rs. 4,000 (figure at 1980-81 prices) per year and there are a large number of poorer States like Uttar Pradesh, Bihar, Orissa, Madhya Pradesh, Assam, Jammu and Kashmir, etc. which have recorded per capita income less than Rs. 2,000. Corresponding to these disparities, the developed states have higher per capita consumption expenditure as compared to the poorer states. It was estimated to be more than Rs. 690 per capita per month in States like Punjab, Haryana, Kerala, Maharashtra and Gujarat and below Rs. 520 per capita per month in States like Uttar Pradesh, Bihar, Orissa and Madhya Pradesh, etc. These variations are indicative of some other deepseated economic problems like poverty,unemployment and under-employment. The disaggregated data of poverty for the states show that there are States like Orissa and Bihar which have recorded more than 40 per cent of their population living below the poverty line.

The States of Madhya Pradesh, Sikkim, Assam, Tripura, Arunachal Pradesh, Meghalaya, Nagaland have more than 30 per cent of their population below poverty line. “Poverty is a state of deprivation. In absolute terms it reflects the inability of an individual to satisfy certain asic needs for a sustained, healthy and reasonably productive living.” Employment rate for educated youth is 25 per cent. Jobless growth and rampant unemployment are some of the important reasons for higher incidences of poverty in India. Indicators of a Healthy Life Life free from illness and ailment and living a reasonably long life span are indicative of a healthy life. Availability of pre and post natal health care facilities in order to reduce infant mortality and post delivery deaths among mothers, old age health care, adequate nutrition and safety of individual are some important measures of a healthy and reasonably long life. India has done reasonably well in some of the health indicators like decline in death rate from 25.1 per thousand in 1951 to 8.1 per thousand in 1999 and infant mortality from 148 per thousand to 70 during the same period. Similarly,

it also succeeded in increasing life expectancy at birth from 37.1 years to 62.3 years for males and 36.2 to 65.3 years for females from 1951 to 1999. Though, these are great achievements, a lot needs to be done. Similarly, it has also done reasonably well in bringing down birth rate from 40.8 to 26.1 during the same years, but it still is much higher than many developed countries. The situation is more alarming when seen in the context of gender specific and rural and urban health indicators. India has recorded declining female sex ratio. The findings of 2001 Census of India are very disturbing particularly in case of child sex ratio between 0-6 age groups. The other significant features of the report are, with the exception of Kerala, the child sex ratio has declined in all the states and it is the most alarming in the developed state of Haryana and Punjab where it is below 800 female children per thousand male children.

COUNTRY HDI VALUE

Norway 0.963
Australia 0.955
Sweden 0.949
Switzerland 0.947
U.S.A. 0.944
Japan 0.943
U.K. 0.939
France 0.938
Germany 0.93
Argentina 0.863
Cuba 0.817
Russia 0.795
Brazil 0.792

COUNTRY HDI VALUE

Thailand 0.778
Sri Lanka 0.751
Iran 0.736
Indonesia 0.697
Egypt 0.659

INDIA 0.602

Myanmar 0.578
Pakistan 0.527
Nepal 0.526
Bangladesh 0.52
Kenya 0.474
Zambia 0.394
Chad 0.341
Niger 0.281

STATE % OF POPULATION BELOW POVERTY LINE

Andhra Pradesh 15.77
Arunachal Pradesh 33.47
Assam 36.09
Bihar 42.60
Goa 4.40
Gujarat 14.07
Haryana 8.47
Himachal Pradesh 7.63
West Bengal 27.02
Andaman & Nicobar 20.99
Chandigarh 5.75
Jammu & Kashmir 3.48
Karnataka 20.04
Kerala 12.72
Madhya Pradesh 37.43
Maharashtra 25.02
Manipur 28.54
Meghalaya 33.87
Mizoram 19.47
Dadra & Nagar Haveli 17.14
Daman & Diu 4.44
Delhi 8.23
Nagaland 32.67
Orissa 47.15
Punjab 6.16
Rajasthan 15.28
Sikkim 36.55
Tamil Nadu 21.12
Tripura 34.44
Uttar Pradesh 31.15
Lakshadweep 15.60
Pondichery 21.67

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WORLD'S MAJOR LANGUAGE

Language	Population (in millions)
1. Chinese / Mandarin	874
2. Hindi	366
3. Spanish	358
4. English	341
5. Arabi	256
6. Bengli	207

* Tamil is the oldest living language in the world

INDICATORS OF SOCIAL EMPOWERMENT

"Development is freedom". Freedom from hunger, poverty, servitude, bondage, ignorance, illiteracy and any other forms of domination is the key to human development. Freedom in real sense of the term is possible only with the empowerment and participation of the people in the exercise of their capabilities and choices in the society. Access to knowledge about the society and environment are fundamental to freedom. Literacy is the beginning of access to such a world of knowledge and freedom. Represent the literacy rates for states having more than the national average by bar diagram after arranging the data in descending order. Why is the total literacy rates in Kerala, Mizoram, Lakshadweep and Goa are higher than other states? Can literacy reflect the status of Human Developments? Debate. Table 3.3 showing the percentage of literates in India reveals some interesting features:

- Overall literacy in India is approximately 65. 4 per cent (2001). while female literacy is 54.16 per cent.
- Total literacy as well as female literacy is higher than the national average in most of the states from south India.
- There are wide regional disparities in literacy rate across the states of India.

There is a state like Bihar which has very low (47.53 per cent) literacy and there are states like Kerala and Mizoram which have literacy rates of 90.92 and 88.49 per cent respectively. Apart from the spatial variations, percentage of literates in the rural areas and among the marginalised sections of our society such as females, scheduled castes, scheduled tribes, agricultural labourers, etc. is very low. It is worth mentioning here that though, there has been improvement in the percentage of literates among the marginalised section yet the gap between the richer and the marginalized sections of the population has increased over the years. Human Development Index in India In the backdrop of the above-mentioned important indicators the Planning Commission calculated the human development index by taking states and union territories as the unit of analysis. India has been placed among the countries showing medium human development. Kerala with the composite index value of 0.638 is placed at the top rank followed by Punjab (0.537), Tamil Nadu (0.531) Maharashtra (0.523) and Haryana (0.509). As expected, states like Bihar (0.367), Assam (0.386), Uttar Pradesh (0.388), Madhya Pradesh (0.394) and Orissa (0.404) are at the bottom among the 15 major states in India. There are several socio-political, economic and historical reasons for such a state of affairs. Kerala is able to record the highest value in the HDI largely due to its impressive performance in achieving near hundred per cent literacy (90.92 per cent) in 2001. In a different scenario the states like Bihar, Madhya Pradesh, Orissa, Assam and Uttar Pradesh have very low literacy. For example, total literacy rate for Bihar was as low as 60.32 per cent during the same year. States showing higher total literacy rates have less gaps between the male and female literacy rates. For Kerala, it is 6.34 per cent, while it is 26.75 per cent in Bihar and 25.95 per cent in Madhya Pradesh.

State HDI Value

Andhra Pradesh 0.416
Assam 0.386
Bihar 0.367
Gujarat 0.479
Haryana 0.509
Karnataka 0.478
Kerala 0.638
Madhya Pradesh 0.394
Maharashtra 0.523
Orissa 0.404
Punjab 0.537
Rajasthan 0.424
Tamil Nadu 0.531
Uttar Pradesh 0.388
West Bengal 0.472

Apart from the educational attainment, the levels of economic development too play significant impacts on HDI. Economically developed states like Maharashtra, Tamil Nadu and Punjab and Haryana have higher value of HDI as compared to states like Assam, Bihar, Madhya Pradesh, etc. Regional distortions and social disparities which developed during the colonial period continue to play an important role in the Indian economy, polity and society. The Government of India has made coed efforts to institutionalise the balanced development with its main focus on social distributive justice through planned development.

It has made significant achievements in most of the fields but, these are still below the desired level. PopulationE, nviri ronmenta ndD evelopment Development in general and human development in particular is a complex concept used in social sciences. It is complex because for ages it was thought that development is a substantive concept and once it is achieved it will address all the socio-cultural and environmental ills of the society.

Though, development has brought in significant improvement in the quality of life in more than one way but increasing regional disparities, social inequalities, discriminations, deprivations, displacement of people, abuse of human rights and undermining human values and environmental degradation have also increased. Considering the gravity and sensitivity of the issues involved, the UNDP in its Human

Development Report 1993, tried to amend some of the implicit biases and prejudices which were entrenched in the concept of development. People's participation and their security were the major issues in the Human Development Report of 1993. It also emphasised on progressive democratisation and increasing empowerment of people as minimum conditions for human development. The report recognised greater constructive role of 'Civil Societies' in bringing about peace and human development. The civil society should work for building up opinion for reduction in the military expenditure, demobilization of armed forces, transition from defence to production of basic goods and services and particularly disarmament and reduction in the nuclear warheads by the developed countries. In a nuclearised world, peace and well-being are major global concerns. At the other extreme of this approach lie the views expressed by the Neo-Malthusians, environmentalists and radical ecologists. They believe that for a happy and peaceful social life proper balance between population and resources is a necessary condition. According to these thinkers, the gap between the resources and population has widened after eighteenth century.

There have been marginal expansion in the resources of the world in the last three hundred years but there has been phenomenal growth in the human population. Development has only contributed in increasing the multiple uses of the limited resources of the world while there has been enormous increase in the demand for these resources. Therefore, the prime task before any development activity is to maintain parity between population and resources. Scholar like Sir Robert Malthus was the first one to voice his concern about the growing scarcity of resources as compared to the human population. Apparently this argument looks logical and convincing, but a critical look will reveal certain intrinsic flaws such as resources are not a neutral category.

It is not the availability of resources that is as important as their social distribution. Resources everywhere are unevenly distributed. Rich countries and people have access to large resource baskets while the poor find their resources shrinking. Moreover, unending pursuit for the control of more and more resources by the powerful and use of the same for exhibiting ones prowess is the prime cause of conflicts as well as the apparent contradictions between population resource and development.

Indian culture and civilisation have been very sensitive to the issues of population, resource and development for a long time. It would not be incorrect to say that the ancient scriptures were essentially concerned about the balance and harmony among the elements of nature. Mahatma Gandhi in the recent times advocated the reinforcement of the harmony and balance between the two. He was quite apprehensive about the on-going development particularly the way industrialisation has institutionalised the loss of morality, spirituality, self-reliance, non-violence and mutual cooperation and environment. In his opinion, austerity for individual, trusteeship of social wealth and non-violence are the key to attain higher goals in the life of an individual as well as that of a nation. His views were also re-echoed in the Club of Rome Report "Limits to Growth" (1972), Schumacher's book "Small is Beautiful" (1974), Brundtland Commission's Report "Our Common Future" (1987) and finally in the "Agenda-21 Report of the Rio Conference" (1993).

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IMPORTANT DAYS

India Tourism Day – 25 January
World Wetland Day – 14 March
World Forest Day – 21 March
World Water Day – 22 March
World Meteorology Day – 23 March
National Meritime Day – 05 April
World Health Day – 07 April
World Scientist and Universe Day – 14 April
World Heritage Day – 18 April
Earth Day – 22 April
World Intellectual Property Day–26 April
World Migratory bird Day – 08 May
National technology Day – 11 May
Bio – diversity Day – 22 May
Mount Everest Day – 29 May
World Environment Day – 05 June
World Refugee Day – 20 June
National Statistic Day – 29 June
Word Population Day – 11 July
Rajeev Gandhi Nonconventional Energy Day – 20 August
International Literary Day – 08 September
Ozone Conservation Day–16 Sept.
World Tourism Day–27 September
World Nature Day–03 Oct.
World Animal Welfare Day–04 October
World Forest Animal Day–06 Oct.
World Food Day – 16 October
National Education Day–11 Nov.
World Environment Conservation day – 26 November
SAARC Day – 8 December
International Mountain Day–11 Dec.
National Energy Conservation Day – 14 December
National Consumer Day–24 Dec.

* Birth Day of Abul Kalam Azad

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