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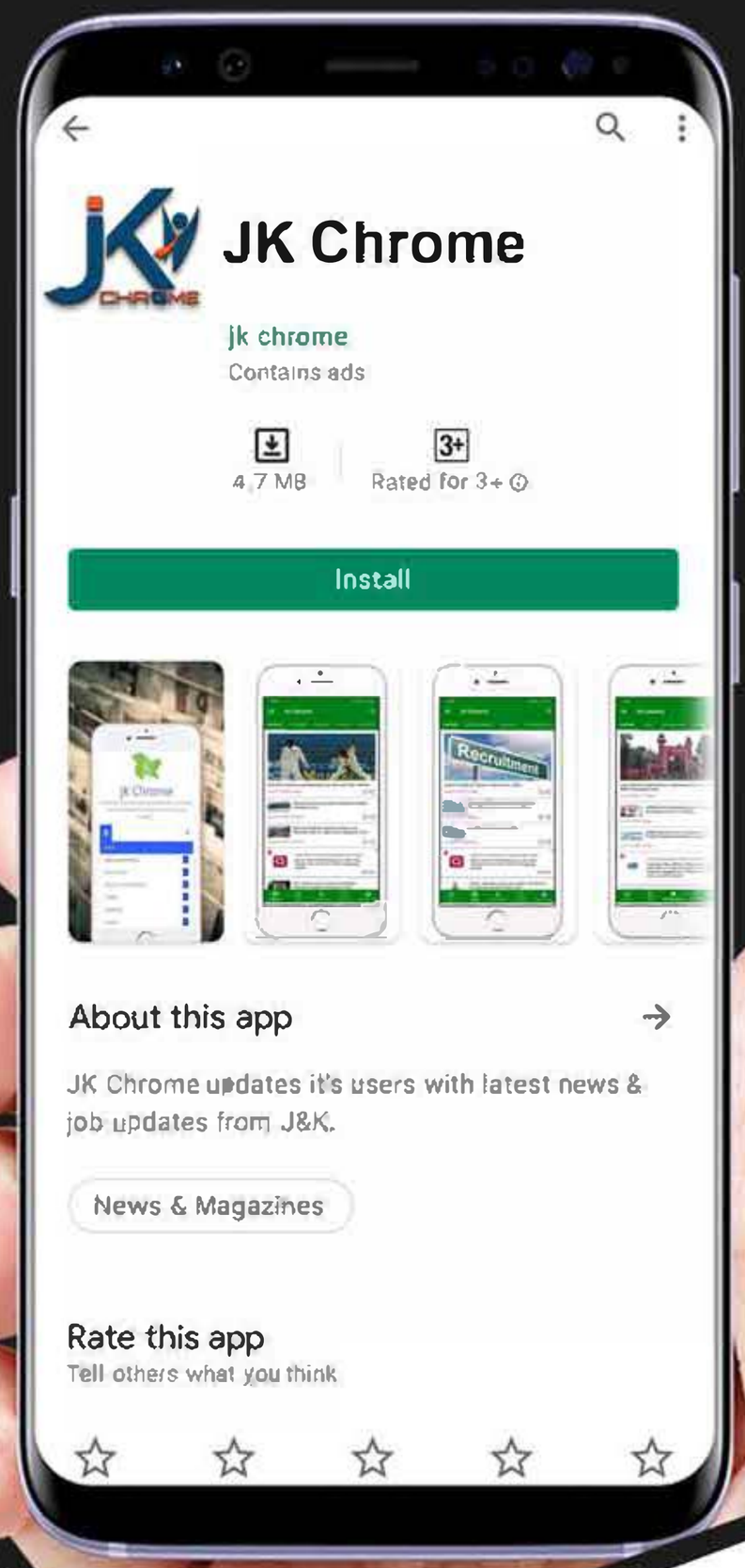

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NCERT Class 11 Geography gist – ORACLE IAS

Chapter 1- Geography as a Discipline

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.

Importance of Geography: Geography helps us to understand the diversity and the causes and factors that have created it. Through geography we understand how spherical earth is presented through a map and we get information about soil, minerals, weather, climate, population, means of transport and communication, local landscape, etc. It also tells us about rivers, mountains, plateaus, plains, deserts, seas, lakes and cultural facts.

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. The earth has always been seen as the abode of human beings and thus, scholars defined geography as, "the description of the earth as the abode of human beings".

Geographers do not study only the variations in the phenomena over the earth's surface (space) but also study the associations with the other factors which cause these variations. For example, cropping patterns differ from region to region but this variation in cropping pattern, as a phenomenon, is related to variations in soils, climates, demands in the market, capacity of the farmer to invest and technological inputs available to her/him.

Geography as a discipline is concerned with three sets of questions:

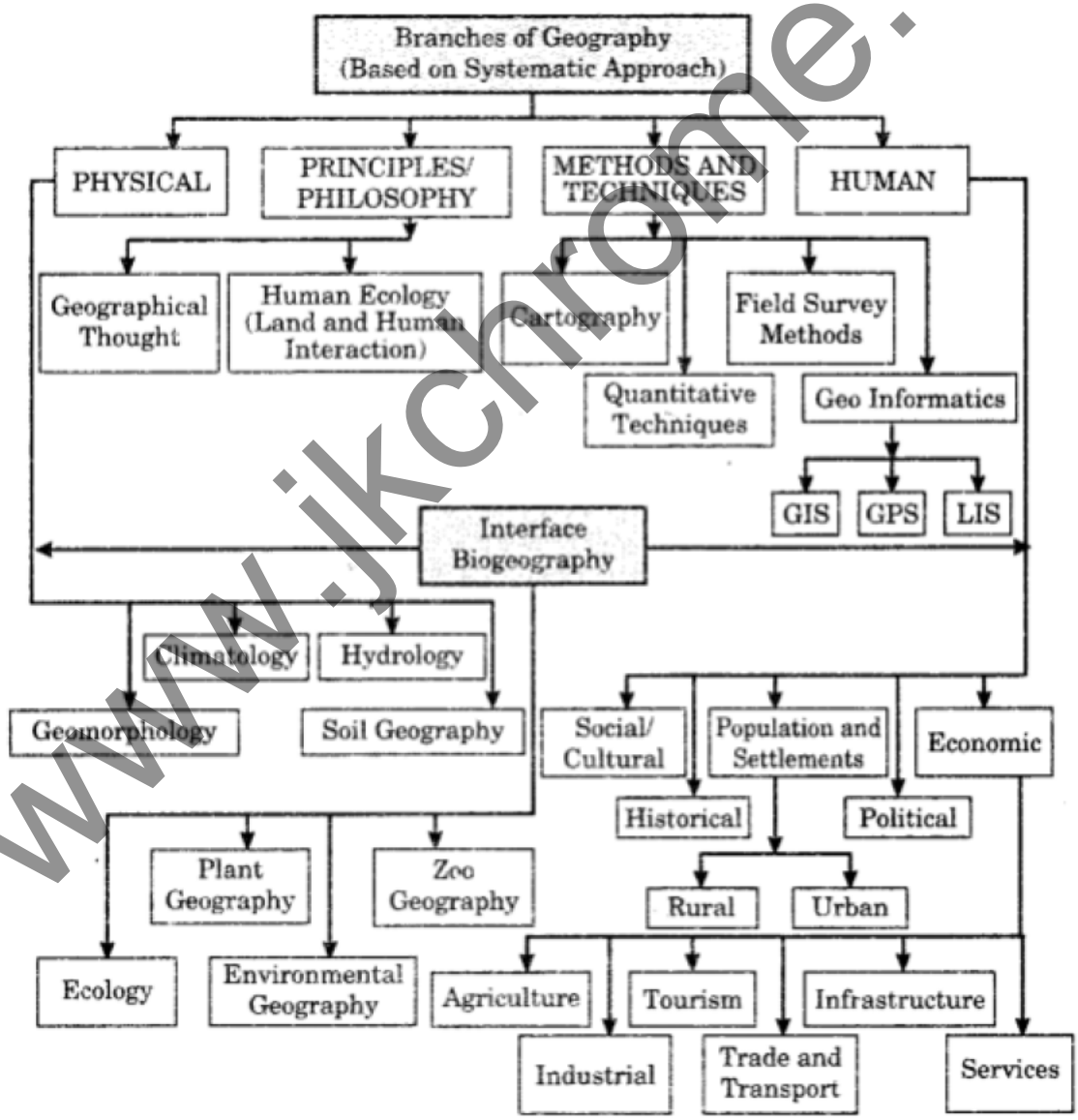
- Some questions are concerned with the identification of the patterns of natural and cultural features as found over the surface of the earth. These are the questions about "what"?
- Second type of questions are related to the distribution of the natural and human/ cultural features over the surface of the earth. These are the questions about where?
- The third question is related to the explanation or the causal relationships between features and the processes and phenomena.

Many disciplines from natural sciences such as geology, pedology, oceanography, botany, zoology and meteorology and a number of sister

disciplines in social sciences such as economics, history, sociology, political science, anthropology, etc. study different aspects of the earth's surface.

A geographer is required to have a broad understanding of all the related fields, to be able to logically integrate them. A geographer should have some proficiency in mathematics and art, particularly in drawing maps. Geography is very much linked with the study of astronomical locations and deals with latitudes and longitudes. The cartographic and quantitative techniques require sufficient proficiency in mathematics, statistics and econometrics.

All the social science disciplines, viz. sociology, political science, economics and demography study different aspects of social reality. The branches of geography, viz. social, political, economic and population and settlements are closely linked with these disciplines as each one of them has spatial attributes.



The major approaches to study geography have been

- Systematic and
- Regional.

The systematic geography was introduced by Alexander Von Humboldt, a German geographer (1769-1859) while regional geography approach was developed by another German geographer and a contemporary of Humboldt, Karl Ritter (1779-1859).

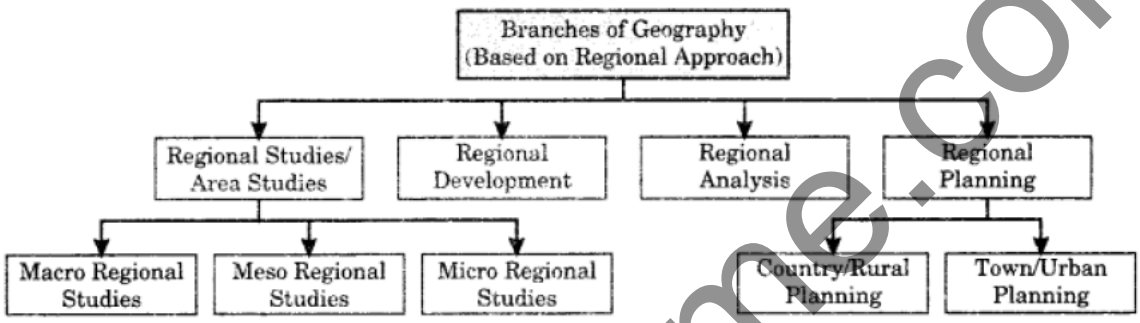


Fig: Branches of geography based on regional approach

Important Terms:

- Geography: Geography is concerned with the description and explanation of the areal differentiation of the earth's surface. (Richard Hartshome); In other words, Geography studies the differences of phenomena usually related in different parts of the earth's surface. (Hettner) GEOGRAPHY-XI
- Geo-morphology: It is concerned with the study of land forms, their evolution and related processes.
- Climatology: It is concerned with the study of structure of atmosphere and elements of weather and climates and climatic types and regions.
- Hydrology: It 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.
- Soil Geography: It is concerned with the study the processes of soil formation, soil types, their fertility status, distribution and use.
- Social/Cultural Geography: It is concerned with the study of society and its spatial dynamics as well as the cultural elements contributed by the society.

- Population Geography: It studies population growth, distribution, density, sex ratio, migration and occupational structure etc.
- Settlement Geography: It studies the characteristics of rural and urban settlements.
- Economic Geography: It studies economic activities of the people including agriculture, industry7, tourism, trade, and transport, infrastructure and services, etc.
- Historical Geography: It studies the historical processes through which the space gets organised. In other words, it studies how history has influenced the geography of a region.
- Political Geography: It studies the impact of political events and studies boundaries, space relations between neighboring political units, delimitation of constituencies, election scenario and develops theoretical framework to understand the political behavior of the population.
- Bio-geography: It has emerged as a result of the interface between physical geography and human geography. It has three branches: Plant Geography, Zoo Geography and Ecology.
- Plant Geography: It studies the spatial pattern of natural vegetation in their habitats.
- Zoo Geography: It studies the spatial patterns and geographic characteristics of animals and their habitats.
- Ecology: It is concerned with the scientific study of the habitats characteristic of species.
- Environmental Geography: It is concerned with environmental problems such as land gradation, pollution and environment conservation.

Chapter 2 -The Origin and Evolution of the Earth

Many hypotheses were put forth by different philosophers and scientists regarding the origin of the earth.

One of the earlier and popular arguments was by German philosopher Immanuel Kant which was revised by mathematician Laplace in 1796. It is

known as Nebular Hypothesis. According to this hypothesis the planets were formed out of a cloud of material associated with a youthful sun, which was slowly rotating.

In 1900, Chamberlain and Moulton considered that a wandering star approached the sun. As a result, a cigar-shaped extension of material was separated from the solar surface. As the passing star moved away, the material separated from the solar surface continued to revolve around the sun and it slowly condensed into planets. Later on, the arguments considered of a companion to the sun to have been coexisting. These arguments are called binary theories.

The most popular argument regarding the origin of the universe is the Big Bang Theory. It is also called expanding universe hypothesis. The Big Bang Theory considers the following stages in the development of the universe.

- In the beginning, all matter forming the universe existed in one place in the form of a"tiny ball" (singular atom) with an unimaginably small volume, infinite temperature and infinite density.
- At the Big Bang the "tiny ball" exploded violently. This led to a huge expansion. It is now generally accepted that the event of big bang took place 13.7 billion years before the present.
- 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.

A galaxy contains a large number of stars. Galaxies spread over vast distances that are measured in thousands of light-years. The diameters of individual galaxies range from 80,000-150,000 light years.

Akash Ganga or the milky way, our galaxy started 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.

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.

The Solar System:

	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Distance from Sun in million km	57.6	107.5	149.6	228	778.3	1427	2829	4496
Time taken to complete one revolution	88 days	225 days	365 ¼ days	687 days	4332 days	10759 days	30,685 days	60195 days
Density (Gram per square cm)	5.44	5.245	5.517	3.945	1.33	0.70	1.17	1.66
Radius (km)	4849.6	0.949	1.000	0.533	11.19	9.460	4.11	3.88
Satellites	0	0	1	2	16	About 18	About 17	8

The moon is the only natural satellite of the earth. 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 bbdy 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.

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 evolutipn of the atmosphere. Finally, the composition of the atmosphere was modified by the living world through the process of photosynthesis.

10. 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 f confined to the oceans for a long time.

Geological Time Scale:

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

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 geologicad formations much older than some 3,000 million years. It can be assumed that life began to evolve sometime 3,800 million years ago.

Important Terms:

- Light Year: A light year is equal to the number of kilometers traveled by light per second. It is a measure of distance and not of time. Light travels at a speed of 300,000 km/second. Therefore, the distances the light will travel in one year is taken to be as one light year.
- Planetesimals: The gas cloud starts getting condensed and the matter around the core develops into small- rounded objects. These small-rounded objects by the process of cohesion develop into what is called planetesimals.
- Universe: All matter, energy, heavenly bodies, and all that is there in space is as a group called the universe.
- Galaxy: Galaxy is a cluster of millions of stars and solar systems.
- Outer Planets: Jupiter Saturn Uranus Neptune and Pluto are called Outer Planets.
- Inner Planets: Mercury ,Venus, Earth and Mars are called Inner Planets.
- Big Bang Theory: The Big Bang Theory, also called as expand universe hypothesis. Edwin Hubble in 1920 provided the evidence that the universe is expanding. This theory is most universally accepted regarding origin of the earth.
- Binary theory: It is the principle of the origin of the earth given by Chamberlain and Moulton.
- Solar System: It consists of the sun, planets and their satellites and various other smaller heavenly bodies such as asteroids, comets and meteors.
- Nebular Hypothesis: It was a theory related to origin of the earth given by Immanuel Kant in 1755 and revised by Laplace in 1796.
- Nebula: Slow circular moving gaseous clouds are called nebula.

- The big splat: The origin of the moon as a satellite of the earth is the result of big collision which is called “the big splat”.
- Differentiation: The process through which the earth forming material got separated into different layers is called differentiation.
- Dwarf Planet: According to International Astronomical Union (IAU) on August 24,2006, a planet is a celestial body that
    - orbits around the sun
    - has sufficient mass so that it assumes a hydrostatic equilibrium (nearly round) shape. The non-satellites bodies fulfilling these two rules are called dwarf planets. Pluto is now considered a dwarf planet. Ceres, Eris, Makemake, Haumea are some other dwarf planets.
- Jovian: Jovian means jupiter-like.
- Akash Ganga: Akash Ganga or milky way is the name of the galaxy to which our earth belongs.
- Expansion of Universe: Expansion of universe means increase in the distance between galaxies.

Chapter 3- Interior of the Earth

- Gold mines in South Africa are as deep as 3 – 4 km. Going beyond this depth is not possible as it is very hot at this depth.
- The earth’s radius is 6,370 km.
- Earthquakes, volcanic eruptions and magma are major sources of the information on interior of the earth. The indirect sources include analysis of the information, meteors reaching the earth, gravitation, magnetic field, and seismic activity.
- We get to know through 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.

- 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.
- The velocity of waves changes as they travel through materials with different densities. The denser the material, the higher is the velocity.
- Seismographic waves are of two types: P waves and S waves.
- The seismographs located beyond 145° from epicenter, record the arrival of P-waves, but not that of S-waves.
- A zone between 105° and 145° from epicenter 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 epicenter.
- Earthquakes are of two types: a) Tectonic earthquake and b) Volcanic earthquake.
- The magnitude of earthquake is measured through Richter Scale. It 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 Crust 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.
- 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 Core is the innermost portion of the earth. The core- mantle boundary is located at the depth of 2,900 km. The outer core is in liquid

state while the inner core is in solid state. The depth of the core is from 2900 km to 6378 km.

- 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.

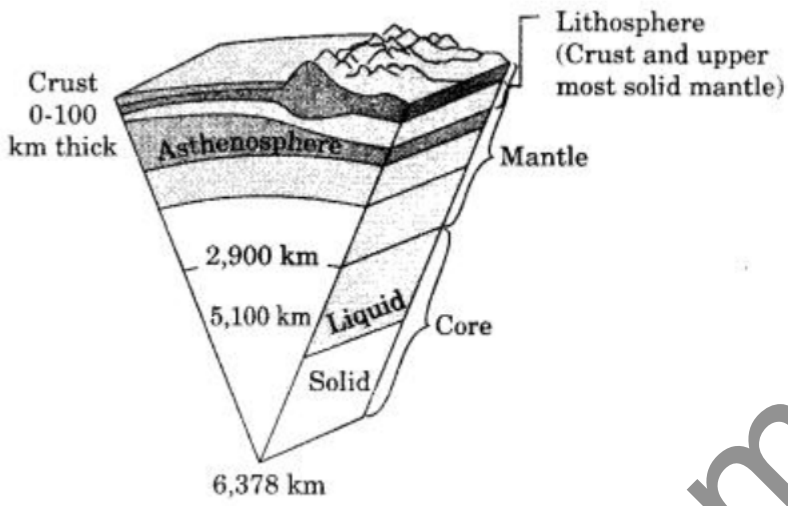


Fig: The interior of the earth

Important Terms:

- Earthquake: 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.
- Lithosphere: The lithosphere refers to the portion of depth up to 200 km from the surface of the earth,
- Volcano: A volcano is a place where gases, ashes and/or molten rock material – lava – escape to the ground.
- Active Volcano: A volcano is called an active volcano if the materials mentioned are being released or have been Released out in the recent past.
- Magma: As long as liquid rocks arena the upper portion of the mantle, it is called magma.
- Lava: When magma reaches the irust of the earth, it is called lava.
- Intrusive Forms: The lava that, cools within the crustal portions assumes different forms. These forms are called intrusive forms.

- Batholiths: A large body of magmatic material that cools in the deeper depth of the crust develops in the form of large domfss.'Batholiths are the cooled portion of magma chambers.
- Caldera: These are the most explosive of the earth's volcanoes. They are usually so explosive that when they erupt they fend to collapse on themselves rather than building any tall structure. The collapsed depressions are called calderas.
- 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.
- Lapolith: 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.
- Phacolith: 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.
- Sills: The near horizontal bodies gf 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.
- Hypocentre: The point where the energy is released is called the focus of an earthquake, alternatively, it is called the hypocentre.
- Epicentre: The point on the surface which is nearest to the focus of energy is called epicenterIt is the first one to experience the waves. It is a point directly above the focus.
- Crust: The Crust is the outermost solid part of the earth.
- Mantle: The portion of the interior beyond the crust is called the mantle.
- Gravity Anomalies: The difference in readings from the expected values is called gravity anomaly. Gravity anomalies give us information about the distribution of mass of the material in the crust of the earth.

- Shadow Zone: There exist some specific areas where the waves are not reported. Such a zone is called the 'shadow zone'.
- Richter Scale: The earthquake events are scaled either according to the magnitude or intensity of the shock. The magnitude scale is known as the Richter scale.
- Shield Volcanoes: 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.
- Composite Volcanoes: These volcanoes are characterised by eruptions of cooler and more viscous waves than basalt. These volcanoes often result in explosive eruptions.
- P-waves: P waves move faster and are the first to arrive at the surface. These are also called 'primary waves'.
- S-.waves: S-waves arrive at the surface with some time lag. These are called secondary waves.

Chapter 4 -Distribution of Oceans and Continents

Continents cover 29% of the surface of the earth and the remainder 71% is under oceanic waters.

Alfred Wegener—a German meteorologist 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 PANTHALA5SA, meaning all water.

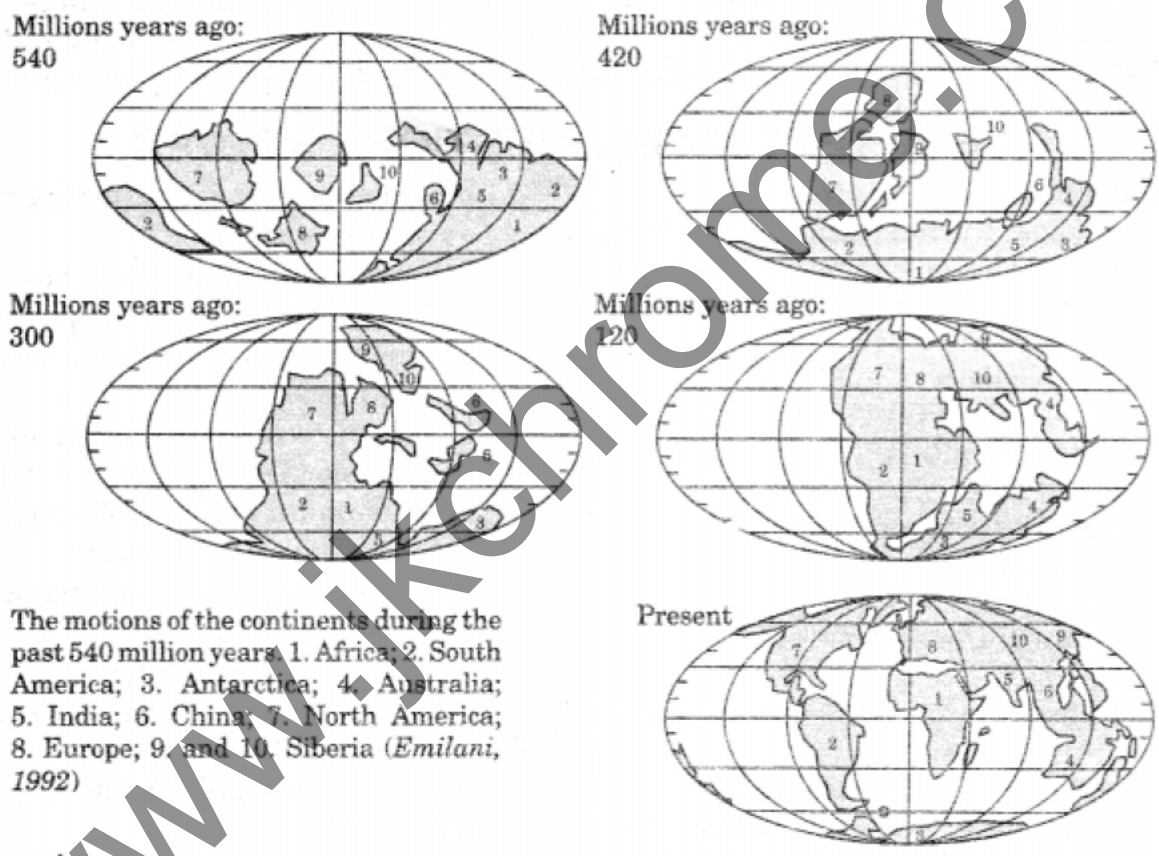
Wegener argued that, around 200 million years ago, the super continent, Pangaea, began to split. Pangaea first broke into two large continental masses as Laurasia and Gondwanaland forming the northern and southern components respectively. Subsequently, Laurasia and Gondwanaland continued to break into various smaller continents that exist today.

The radiometric dating methods developed in the recent period have facilitated correlating the rock formation from different continents across the vast ocean.

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.

Concept of sea floor spreading was proposed by Hess in 1981 who believed that new lava pushes out the plates from the mid-oceanic ridge

It was in 1967, McKenzie and Parker and also Morgan, independently collected the available ideas and came out with another concept termed Plate Tectonics.



The motions of the continents during the past 540 million years. 1. Africa; 2. South America; 3. Antarctica; 4. Australia; 5. India; 6. China; 7. North America; 8. Europe; 9. and 10. Siberia (*Emilani, 1992*)

Fig: Position of continents through geological past

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.

The theory of plate tectonics proposes that the earth's lithosphere is divided into seven major and some minor plates.

Important Terms:

- Convective flow: 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.
- PANGAEA: The super continent was named PANGAEA, which meant all earth.
- PANTHALASSA: The mega-ocean was called PANTHALASSA, meaning all water.
- Rim of Fire: The rim of the Pacific is also called rim of fire due to the existence of active volcanoes in this area.
- Convergent Boundaries: Where the crust is destroyed as one plate dived under another, it is called convergent boundaries.
- Subduction Zone: The location where sinking of a plate occurs is called a subduction zone.
- Divergent Boundaries: Where new crust is generated as the plates pull away from each other, these are called divergent boundaries.
- Spreading Sites: The sites where the plates move away from each other are called spreading sites.
- Transform Boundaries: Where the crust is neither produced nor destroyed as the plates slide horizontally past each other.
- Tectonic plate: It 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. .
- Tillite: It is the sedimentary rock formed out of deposits of glaciers.
- Sea Floor Spreading: The deep trenches have deep-seated earthquake occurrences while in the mid- oceanic 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 in 1961 to propose his hypothesis. It was called the “sea floor spreading”.

Chapter 5- Minerals and Rocks

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.

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.

There are many different kinds of rocks which are grouped under three families on the basis of their mode of formation. They are:

- Igneous Rocks — solidified from magma and lava;
- Sedimentary Rocks—the result of deposition of fragments of rocks by exogenous processes;
- Metamorphic Rocks — formed out of existing rocks undergoing recrystallisation.

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.

Granite, gabbro, pegmatite, basalt, volcanic breccia and tuff are some of the examples of . igneous rocks.

The word 'sedimentary' is derived from the Latin word sedimentum, which means settling.

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.

Important terms:

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

- Igneous Rocks: 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.
- Sedimentary Rocks: The word 'sedimentary' is derived from the Latin word sedimentum, which means settling.
- 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.
- Lithification: 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.
- Metamorphism: It is a process by which already consolidated rocks undergo recrystallisation and reorganization of materials within original rocks.
- Dynamic Metamorphism: Mechanical disruption and reorganization of the original minerals within rocks due to breaking and crushing without any appreciable chemical changes is called dynamic metamorphism.
- Rock Cycle: Rock cycle is a continuous process through which old rocks are transformed into new ones.
- Lineation: 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.
- Banding: 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.
- Banding Rocks: Rocks displaying banding are called banded rocks.

Chapter 6 -Geomorphic Processes

The earth's crust is dynamic. It is undergoing change continuously. Some powers have led to changes in form of the earth. These powers have been divided into two parts: internal and external.

Internal forces keep giving birth to new land forms. External forces keep changing the forms of exiting land forms. In other words, 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 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. Weathering, mass wasting, erosion and deposition are exogenic geomorphic processes.

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

- orogenic processes
- epeirogenic processes
- earthquakes
- plate tectonics.

Temperature and precipitation are the two important climatic elements that control various processes.

There are three major groups of weathering processes :

- chemical
- physical or mechanical
- biological 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.

Oxidation occurs where there is ready access to the atmosphere and oxygenated waters. The minerals most commonly involved in this process are iron, manganese, sulfur etc. In the process of oxidation rock breakdown occurs due to the disturbance caused by addition of oxygen. Red color of iron upon oxidation turns to brown or yellow.

Hydration is the chemical addition of water. Minerals take up water and expand; this expansion causes an increase in the volume of the material itself or rock. The process causes fatigue in the rocks and may lead to their disintegration,

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.

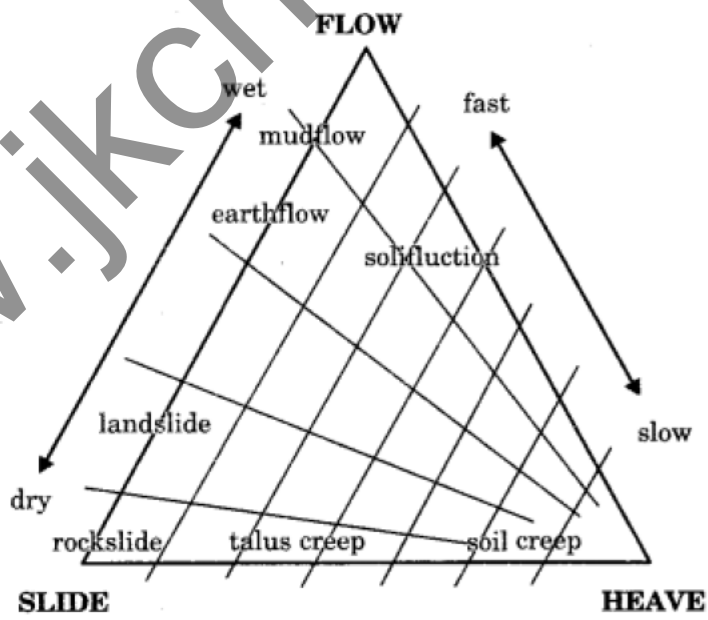


Fig: Relationships among different types of mass movements, their relative rates of movement and moisture limits (after Whitehead, 2001)

When oxidized 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.

Debris Avalanches and landslides 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.

In our country, debris avalanches and landslides occur very frequently in the Himalayas. There are many reasons for this. One, the Himalayas are tectonically active. They are mostly made up of sedimentary rocks and unconsolidated and semi-consolidated deposits. The slopes are very steep.

Important Terms:

- Landslides: These are 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.
- Gradation: The phenomenon of wearing down of relief variations of the surface of the earth through erosion is known as gradation.
- 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.
- Exogenic forces: The external forces are known as exogenic forces. These forces derive their energy from atmosphere determined by the ultimate energy from the sun and also the gradients created by tectonic factors.
- Endogenic forces: The internal forces are known as endogenic forces.
- Geomorphic agents: 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.
- Diastrophism: All processes that move, elevate or build up portions of the earth's crust come under diastrophism.
- Orogepy: It is a mountain building process

- Epeirogeny: It is continental building process.
- Volcanism: Volcanism includes the movement of molten rock called magma onto or toward the earth's surface and also formation of many intrusive and extrusive volcanic forms.
- Stress: 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.
- Weathering: Weathering is defined as mechanical disintegration and chemical decomposition of rocks through the actions of various elements of weather and climate.
- Denudation: The term 'denude' means to strip off or to uncover. Weathering, mass wasting/ movements, erosion and transportation are included in denudation.
- Solution: When something is dissolved in water or acids, the water or acid with dissolved contents is called 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.
- Hydration: Hydration is the chemical addition of water.
- Structure: The term structure includes such aspects of rocks as folds, faults, orientationand 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. ,
- Enrichment: When rocks undergo weathering, some materials are removed through chemical or physical leaching by groundwater and thereby the concentration of valuable materials increases. It makes the concentration of the same valuable material sufficient and economically viable to be exploited, processed and refined. This is called enrichment.
- Debris Slide: Rapid rolling or sliding of earth debris without backward rotation of mass is known as debris slide.

- Erosion: 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".
- Soil: A pedologist who studies soils defines soil as a collection of natural bodies on the earth's surface containing living and/or dead matter and supporting or capable of supporting plants. Soil is a dynamic medium in which many chemical, physical and biological activities go on constantly.
- Deposition: The erosional agents loose their velocity and hence energy on gentler slopes and the materials carried by them start to settle themselves. Therefore, 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.
- Slump: 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.
- Pedology: It is soil science.
- Pedologist: A pedologist is a soil-scientist.
- Parent Material: Parent material is a passive control factor in soil formation.
- Earth Flow: Movement of water-saturated clayey or silty earth materials down low-angle terraces or hillsides is known as earth flow.
- Nitrogen Fixation: 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.
- Desilication: Removal of silica from the soil is known as desilication.
- Exfoliation: It 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 is called exfoliation.

- Exfoliation domes: Large, smooth rounded domes are called exfoliation domes.
- Tors: In rocks like granites, smooth surfaced and rounded small to big boulders form due to such exfoliation. It is called tors.

Chapter 7- Land forms 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.

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 to new modifications in the land forms.

A landmass passes through stages of development somewhat comparable to the stages of life — youth, mature and old age. .

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.

The geomorphic agents acting over long periods of time produce systematic changes leading to sequential development of land forms. Each geomorphic agent produces its own assemblage of land forms.

Many varieties of land forms 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.

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.

The gentler the river channels in gradient or slope, the greater is the deposition.

Streams are few during youth 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.

During mature stage, streams are plenty with good integration. The flat and broad inter stream areas and swamps and marshes of youth disappear and the stream divides turn sharp. Waterfalls and rapids disappear.

Smaller tributaries during old age meander freely over vast floodplains showing natural levees, oxbow lakes, etc.

Any limestone or dolomitic region showing typical land forms 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.

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.

A glacier in its valley is slow unlike water flow. The movement could be a few centimeters to a few meters 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.

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.

Erosional forms dominate in the west coast. The east coast of India is a low sedimentary coast. Depositional forms dominate in the east coast.

Important Terms:

- Landforms: In simple words, small to medium tracts or parcels of the earth's surface are called land forms.
- Landscape: Several related landforms together make up landscapes.
- Geomorphology: Geomorphology deals with the reconstruction of the history of the surface of the earth through a study of its forms, the materials of which is made up of and the processes that shape it.

- Outwash Deposits: Some amount of rock debris small enough to be carried by such melt¬water streams is washed down and deposited. Such glacio- fluvial deposits are called outwash deposits.
- Gorge: A gorge is a deep valley with very steep to straight sides.
- Canyon: A canyon is characterised by steep step-like side slopes and may be as deep as a gorge.
- Delta Plains: The flood plains in a delta are called delta plains.
- Potholes: Over the rocky beds of hill-streams more or less circular depressions are formed because of stream erosion aided by the abrasion of rock fragments. They are called potholes.
- Plunge Tools: 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.
- Plunge Pools: 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.
- Incised Or Entrenched Meanders : Very deep and wide meanders can also be found cut in hard rocks. Such meanders are called incised or entrenched meanders
- Karst Topography: Any limestone or dolomitic region showing typical land forms produced by the action of groundwater through the processes of solution and deposition is called Karst topography.
- Paired Terraces: The river terraces may occur at the same elevation on either side of the rivers, these are called paired terraces.
- Unpaired 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 unpaired terraces.
- Glacial Till: The unassorted coarse and fine debris dropped by the melting glaciers is called glacial till.

- Ground Moraines: 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.
- Medial Moraine: The moraine in the centre of the glacial valley flanked by lateral moraines is called medial moraine.
- Barrier bars: Bars are submerged features and when bars show up above water, they are called barrier bars.
- Spit: Barrier bar which get keyed up to the headland of a bay is called a spit.
- Sea Stacks: 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.
- Wave-Cut Terrace: 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.
- Off-Shore Bar: 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.
- Parallel Retreat of Slopes Through Backwasting : Once, pediments are formed with a steep wash slope followed by cliff or free face above it, the steep wash slope and free faceretreat backwards. This method of erosion is termed as parallel retreat of slopes through backwasting.
- Pediments: Gently inclined rocky floors close to the mountains at their foot with or without a thin cover of debris, are called pediments.
- Pediplains: 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. These low featureless plains are called pediplains.
- Playas plains: These are by far the most prominent land forms 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.

- Alkali Flats: The playa plain covered up by salts is called alkali flats.
- Deflation hollows: 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.
- Caves: 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.
- Tunnels: Caves having openings at both the ends are called tunnels.
- Glaciers: Masses of ice moving as sheets over the land or as linear flows down the slopes of mountains in broad trough-like valleys (mountain and valley glaciers) are called glaciers.
- Fiords: Very deep glacial troughs filled with sea water and making up shorelines (in high latitudes) are called fiords.
- Tam Lakes: A lake of water can be seen quite often within the cirques after the glacier disappears. Such lakes are called cirque or tarn lakes.

Chapter 8 -Composition and Structure of Atmosphere

The air is an integral part of the earth's mass and 99 per cent of the total mass of the atmosphere is confined to the height of 32 km from the earth's surface.

The air is colorless and odorless and can be felt only when it blows as wind.

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

Carbon dioxide is meteor logically 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.

Due to burning of fossil fuels, the volume of other gases is constant but the volume of carbon dioxide has been rising in the past few decades. It has also increased the temperature of the air.

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

Water vapour is such 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 absorbs parts of the isolation 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.

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.

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.

The zone separating the troposphere from stratosphere is known as the tropopause. The air temperature at the tropopause is about minus 80°C over the equator and about minus 45°C over the poles.

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, 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.

Important Terms:

- Ions: Electrically charged particles are called ions.
- 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.
- Tropopause: The zone separating the troposphere from stratosphere is known as the tropopause.

- Mesopause: The upper limit of mesosphere is known as the mesopause.
- Troposphere: 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.
- Stratosphere: The stratosphere is found above the tropopause and extends up to a height of 50 km. This layer absorbs ultra-violet radiation and shields life on the earth from intense, harmful form of energy.
- Mesosphere: The mesosphere lies above the stratosphere, which extends up to a height of 80 km. In this layer, temperature starts decreasing with the increase in altitude and reaches up to minus 100°C at the height of 80 km.
- Ionosphere: 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.
- Exosphere: 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.

Chapter 9- Solar Radiation, Heat Balance and Temperature

We live at the bottom of a huge pile of air. We inhale and exhale but we feel the air when it is in motion. It means air in motion is wind.

Envelop of air is atmosphere which is formed of multitude gases. These gases support life over the earth's surface.

The earth's surface receives most of its energy in short wavelengths.

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, 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.

The earth receives its entire energy from the sun and reflect most of it back to the space. Therefore, we see that the earth neither remains cold nor hot for too long. And hence temperature at different places of the earth is different. This difference in temperature causes difference in pressure.

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, 't his 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.

The annual insolation received by the earth on 3rd January is slightly more than the amount received on 4th July.

The amount of solar radiation keeps changing daily, on the basis of weather and per year.

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.

The earth's axis makes an angle of 6614 with the plane of its orbit round the sun has a greater influence on the amount of insolation received at different latitudes.

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.

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.

The air in cpntact with the earth rises vertically on heating in the form of currents and further transmits the heat of the atmosphere. This process of vertical heating of the atmosphere is known as convection.

Out of 100 units of heat received, 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 remaining 65 units are absorbed, 14 units within the atmosphere and 51 units by the earth's surface.

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 strat a 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.

Blowing of cold air at the hills and mountains, 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.

Important Terms:

- Insolation: The energy received by the earth is known as incoming solar radiation which in short is termed as insolation.
- Aphelion: 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.

- Perihelion: On 3rd January, the earth is the nearest to the sun (147 million km). This position is called perihelion.
- 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.
- Conduction: 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.
- Convection: The air in contact with the earth rises vertically on heating in the form of currents and further transmits the heat of the atmosphere. This process of vertical heating of the atmosphere is known as convection.
- Advection: The convective transfer of energy is confined only to the troposphere. The transfer of heat through horizontal movement of air is called advection.
- Albedo: While passing through the atmosphere some amount of energy is reflected, scattered and absorbed. Only the remaining part reaches the earth surface. The reflected amount of radiation is called the albedo of the earth.
- Normal lapse rate: Normally, temperature decreases with increase in elevation. It is called normal lapse rate.
- Loo: Summer season local winds is called 'loo'. It is the result of advection.
- Isotherms: The Isotherms are lines joining places having equal temperature.
- Inversion of temperature: At times, the situations is reversed and the normal lapse rate is inverted. It is called Inversion of temperature.
- Air drainage: 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: Plank's law states that hotter a body, the more energy it will radiate and shorter the wavelength of that radiation.
- Specific heat: Specific heat is the energy needed to raise the temperature of one gram of substance by one Celsius.

Chapter 10- Atmospheric Circulation and Weather Systems

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.

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.

As one moves up the air gets varified and one feels breathless.

The atmospheric pressure is expressed in units of millibar or Pascal. Widely used unit is called kilopascal which is expressed as hpa.

At sea level the average atmospheric pressure is 1,013.2 millibar. 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.

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.

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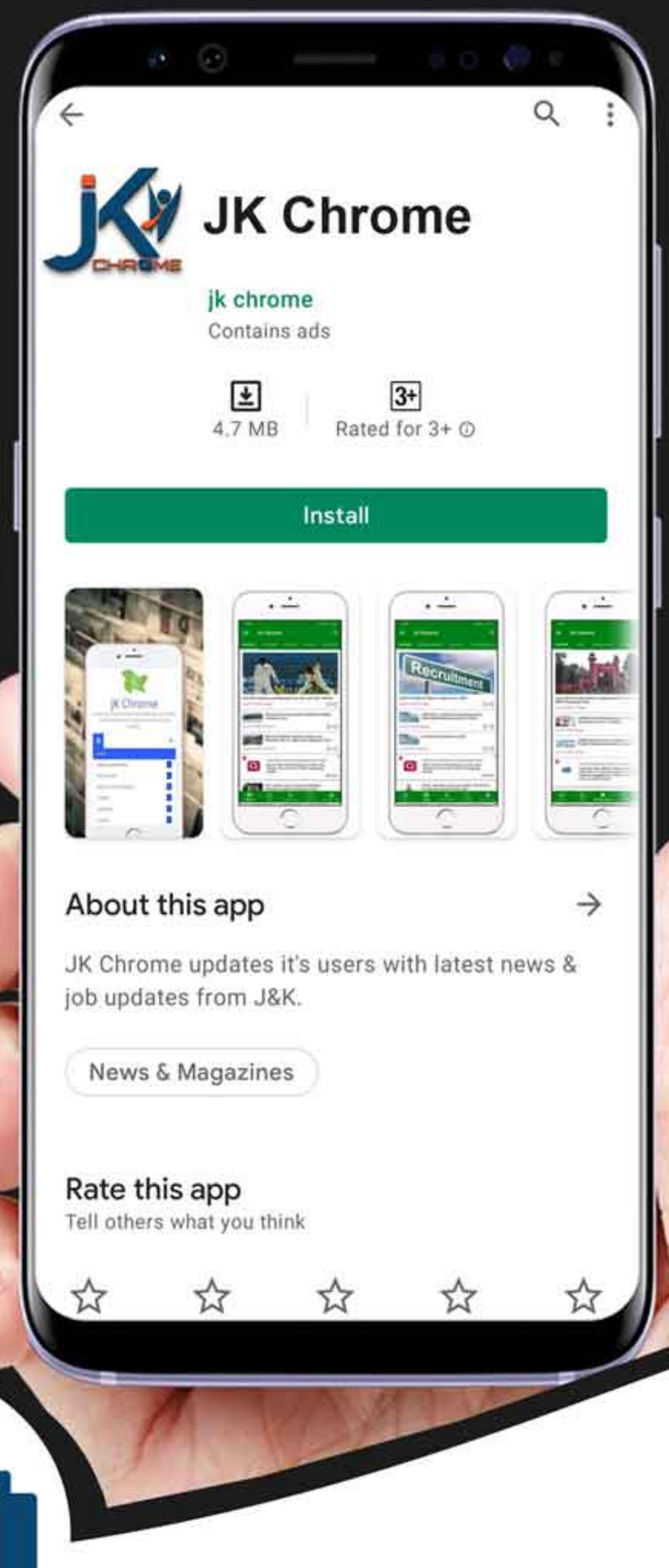

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Air is set in motion due to the differences in atmospheric pressure. The air in motion is called wind. The wind blows from high pressure to low pressure.

Frictional force 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.

The rotation of the earth about its axis affects the direction of the wind. This force is called the Coriolis force after the French physicist who described it in 1844.

It deflects the wind to the right direction in the northern hemisphere and to the left in the southern hemisphere. The deflection is more when the wind velocity is high.

The Coriolis force is directly proportional to the angle of latitude. It is maximum at the poles and is absent at the equator. The Coriolis force acts perpendicular to the pressure gradient force. The pressure gradient force is perpendicular to an isobar. The higher the pressure gradient force, the more is the velocity of the wind and the larger is the deflection in the direction of wind.

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.

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.

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. 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.

Important Terms:

- 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 millibar.
- Wind: The air in motion is called wind.
- 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.
- 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.
- Geostrophic wind: 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.
- General circulation of the atmosphere: The pattern of the movement of the planetary winds is called the general circulation of the atmosphere.
- Cell: 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.
- Hadley cells: A cell in the tropics is called Hadley cell.
- Ferrel cells: 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.
- Polar 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.

- Valley breeze: 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.
- Polar high: Near the poles the pressure is high and it is known as the polar high.
- El Nino: 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.
- Southern oscillation: The change in pressure condition over Pacific is known as the southern oscillation.
- ENSO: The combined phenomenon of southern oscillation and El Nino is known as ENSO.
- Katabatic wind: 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.
- Air mass: The air with distinctive characteristics in terms of temperature and humidity is called an air mass. It is
- defined as a large body of air having little horizontal variation in temperature and moisture.
- Source regions: The homogeneous surfaces which are formed over air masses are called the source regions.
- Fronts: When two different air masses meet, the boundary zone between them is called a front.
- Cold front: When the cold air moves towards the warm air mass, its contact zone is called the cold front.
- Warm front: If the warm air mass moves towards the cold air mass, the contact zone is called warm front.
- Occluded front: If an air mass is fully lifted above the land surface, it is called the occluded front.

- Extra tropical cyclone: The systems developing in the mid and high latitude, beyond the tropics are called the middle latitude or extra tropical cyclones.
- Landfall of the cyclone: The place where a tropical cyclone crosses the coast is called the landfall of the cyclone.
- A mature tropical cyclone: It 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.
- Tropical cyclones: Tropical cyclones are violent storms that originate over oceans in tropical areas and shift 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.
- Tornado: From severe thunderstorms sometimes spiralling wind descends like a trunk of an elephant with great force, with very low pressure at the centre, causing massive destruction on its way. Such a phenomenon is called a tornado.
- Water spouts: The tornado over the sea is called water spouts.

Chapter 11- Water in the Atmosphere

The air contains water vapour. It varies from zero to four per cent by volume of the atmosphere and plays an important role in the weather phenomena.

Water is present in the atmosphere in three forms namely—gaseous, liquid and solid.

The moisture in the atmosphere is derived from water bodies through evaporation and from plants through transpiration. Thus, there is a continuous exchange of water between the atmosphere, the oceans and the continents through the processes of evaporation, transpiration, condensation and precipitation.

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.

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.

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.

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.

After condensation the moisture of atmosphere or humidity gets converted into dew, fog, mist, frost and clouds.

The ideal conditions for formation of dew are clear sky, calm air, high relative humidity, and cold and long nights.

Frost forms on cold surfaces when condensation takes place below freezing point (0°C), i.e. the dew point is at or below the freezing point.

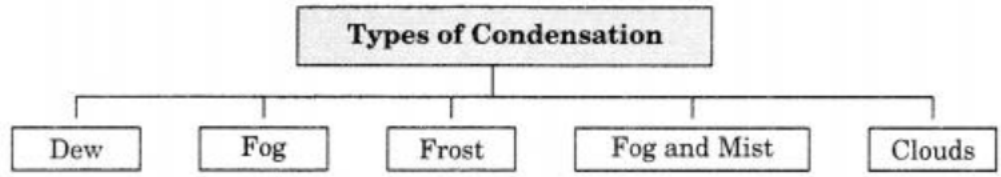
The only difference between the mist and fog is that mist contains more moisture than the fog. In mist each nuclei contains a thicker layer of moisture.

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.

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. According to their height, expanse, density and transparency or opaqueness clouds are grouped under four types :

- cirrus
- cumulus

- stratus
- nimbus.



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.

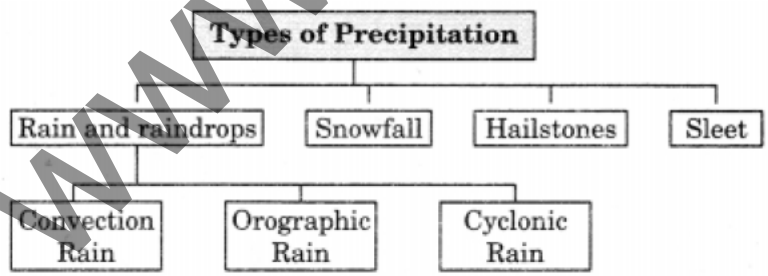
Cumulus clouds look like cotton wool. They are generally formed at a height of4,000-7,000 m. They exist in patches and can be seen scattered here and there. They have a flat base.

Stratus 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 clouds are black or dark gray. They form at middle levels or very near to the surface of the earth.

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 takes place when the air on being heated, becomes light and rises up in convection currents. As it rises, it expands and loses neat and consequently, condensation takes place and cumulous clouds are formed. With thunder and lightening, heavy rainfall takes place but this does not last long.



Orographic rain occurs 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.

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.

Between the latitudes 35° and 40° N and S of the equator, the rain is heavier on the eastern coasts and goes on decreasing towards the west. But, between 45° and 65° N and S of equator, the rainfall is first received on the western margins of the continents and it goes on decreasing towards the east.

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.

Distribution Of Clouds:

Classification of clouds on the basis of average height	Sub-categories or types of clouds	Features or characteristics
High Clouds 5 km to 14 km	Cirrus	Cirrus clouds are formed at high altitudes. They are soft and silk like shaped.
	Cirrostratus	They are thin and detatched clouds having a feathery appearance. They are always white in colour.
	Corrocumulus	These clouds look like small white circular shaped. They do not have any shadow
Medium Clouds	Altostratu	They are blue or brown in colour. They have fibres like look.
	Altocumulus	These are flattened circles like clouds which are organised like waves.
Low Clouds	Stratocumulus	Soft and brownish clouds in a group which have a shining.
	Nimobostratus	They are low and same layer clouds

		which look like fog but they are not stable on surface of the earth.
Clouds with extensive vertical development	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.
	Cumulonimbus	They are formed on mountains and cause rainfall.

Important Terms:

- Humidity: Water vapour present in the air is known as humidity.
- Evaporation: It is a process by which water is transformed from liquid to gaseous state. Heat is the main cause for evaporation.
- Latent heat of vaporisation: The temperature at which the water starts evaporating is referred to as the latent heat of vaporisation.
- Absolute humidity: 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.
- Relative humidity: The percentage of moisture present in the atmosphere as compared to its full capacity at a given temperature is known as the relative humidity.
- Dew points: The temperature at which saturation occurs in a given sample of air is known as dew 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.
- Condensation: The transformation of water vapour into water is called condensation. Condensation is caused by the loss of heat.

- Sublimation: 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.
- Precipitation: After the condensation of water vapour, the release of moisture is known as precipitation. This may take place in liquid or solid form.
- Rainfall: The precipitation in the form of water is called rainfall.
- Snowfall: When the temperature is lower than the 0°C, precipitation takes place in the form of fine flakes of snow and is called snowfall.
- 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. It is also known as the relief rain.
- Rain shadow area: The area situated on the leeward side, which gets less rainfall is known as the rain-shadow area.
- Cyclonic rain: Rain caused by a cyclone is called cyclonic rain.
- Hailstones: 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.
- 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 for long.
- Frost: Frost forms on cold surfaces when condensation takes place below freezing point (0°C), i.e. the dew point is 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.
- Smog: A condition when fog is mixed with smoke, is described as smog.

- 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.

Chapter 12- World Climate and Climate Change

Three broad approaches have been adopted for classifying climate. They are empirical, genetic and applied.

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.

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 Temperature	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.

Koeppen introduced the use of capital and small letters to designate climatic groups and types.

It was developed in 1918 and modified over a period of time, but Koeppen's scheme is still popular and in use. Koeppen recognized five major climatic groups, four of them are based on temperature and one on precipitation.

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.

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

- Af – Tropical wet climate;
- Am – Tropical monsoon climate;
- Aw – Tropical wet and dry climate.

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) 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.

Climatic Types:

Letter Code	Type	Characteristic
Af	Tropical Wet	No dry season. The driest month has at least 60 mm (2.4") of rain. Rainfall is generally evenly distributed throughout the year. All average monthly temperatures are greater than 18°C (64°F).
Am	Tropical Monsoon	Pronounced wet season. Short dry season. There are one or more months with less than 60 mm (2.4"). All average monthly temperatures are greater than 64°F (18°C). Highest annual temperature occurs just prior to the rainy season.
Aw	Tropical Wet and Dry	Winter dry season. There are more than two months with less than 60 mm (2.4") . All average monthly temperatures are greater than 18°C (64°F).
BSh	Subtropical Dry Semiarid (Steppe	Low-latitude dry. Evaporation exceeds precipitation on average but is less than potential evaporation. Average temperature is more than 18°C (64°F).
BSk	Mid-latitude Dry Semiarid (Steppe)	Mid-latitude dry. Evaporation exceeds precipitation on average but is less than potential evaporation. Average temperature is less than 18°C (64°F).
BWh	Subtropical Dry Arid (Desert)	Low-latitude desert. Evaporation exceeds precipitation on average but is less than half potential evaporation. Average temperature is more than 18°C (64°F). Frost is absent or infrequent.
BWk	Mid-latitude Dry Arid (Desert)	Mid-latitude desert. Evaporation exceeds precipitation on average but is less than half potential evaporation. Average temperature is less than 18°C (64°F). Winter has below freezing temperatures.
Cfa	Humid Subtropical	Mild with no dry season, hot summer. Average temperature of warmest months are over 22°C (72°F). Average temperature of coldest month is under 18°C (64°F). Year around rainfall but highly variable.
Cfb	Marine-Mild Winter	Mild with no dry season, warm summer. Average temperature of all months is lower than 22°C (72°F). At least four months with average temperatures over 50°F (10°C). Year around equally spread rainfall.
Cfc	Marine - Cool Winter	Mild with no dry season, cool summer. Average temperature of all months is lower than 22°C (72°F). There are one to three months with average temperatures over 50°F (10°C). Year around equally spread rainfall.
Csa	Interior Mediterranean	Mild with dry, hot summer. Warmest month has average temperature more than 72°F (22°C). At least four months with average temperatures over 50°F (10°C). Frost danger in winter. At least three times as much precipitation during wettest winter months as in the driest summer month.

Csb	Coastal Mediterranean	Mild with cool, dry summer. No month with average temperature of warmest months are over 22°C (72°F). At least four months with average temperatures over 50°F (10°C). Frost danger in winter. At least three times as much precipitation during wettest winter months as in the driest summer month.
Cwa	Dry Winter, Wet Summer	Mild with dry winter, hot and wet summer.
Dfa	Humid Continental Hot Summer, Wet All Year	Humid with hot summer.
Dfb	Humid Continental Mild Summer, Wet All Year	Humid with severe winter, no dry season, warm summer.
Dfc	Subarctic With Cool Summer, Wet All Year	Severe winter, no dry season, cool summer.
Dfd	Subarctic With Cold Winter, Wet All Year	Severe, very cold winter, no dry season, cool summer.
Dwa	Humid Continental Hot Summer, Wet All Year	Humid with severe, dry winter, hot summer.
Dwb	Humid Continental Mild Summer, Dry Winter	Humid with severe, dry winter, warm summer.
Dwc	Subarctic With Cool Summer, Dry Winter	Severe, dry winter, cool summer.
Dwd	Subarctic With Cold Winter, Dry Winter	Severe, very cold and dry winter, cool summer.
ET	Tundra	Polar tundra, no true summer.
EF	Ice Cap	Perennial ice.
H	Highland Climate	Can encompass any of the above classifications due to the mountainous terrain.

Dry climates are characterized 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.

Subtropical Steppe (BSh) and Subtropical Desert (BWh) climates have common precipitation and temperature characteristics. These are 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.

Maximum temperature in the summer is very high. The highest shade temperature of 58° C was recorded at A1 Aziziyah, Libya on 13 September 1922. The annual and diurnal ranges of temperature are also high.

Mediterranean climate occurs around Mediterranean sea, along the west coast of continents in subtropical latitudes between 30° – 40° latitudes.

Central California, Central Chile, along the coast in south eastern and south western Australia are examples of Mediterranean climate. These areas come under the influence of subtropical 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 climate occur in eastern United States of America, southern and eastern China, southern Japan, north eastern Argentina, coastal south Africa and eastern coast of Australia. The annual average 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.

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 centre of 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.

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 south-western 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.

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.

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 are carbon dioxide (C02), Chlorofluorocarbons (CFCs), methane (CH4), nitrous oxide (N20) and ozone (03). Some other gases such as nitric oxide (NO) and carbon monoxide (CO) easily react with GHGs and affect their concentration in the atmosphere.

The largest concentration of GHGs in the atmosphere is carbon dioxide. The emission of C02 comes mainly from fossil fuel combustion (oil, gas and coal).

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.

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.

Important Terms:

- Empirical Classification: It is based on observed data, particularly on temperature and precipitation.
- Genetic Classification: It attempts to organise climates according to their causes.
- Applied Classification: It is used when classification is done for specific purpose.

- Koeppen's scheme of classification of climate: It is 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.
- Ozone Hole: The depletion of ozone concentration in the stratosphere is called the ozone hole.
- Greenhouse gases: The gases that absorb long wave radiation are called greenhouse gases.
- Greenhouse effect: The processes that warm the atmosphere are often collectively referred to as the greenhouse effect.
- Daily range of temperature: The differences between the highest and lowest temperature of a place in a day is called daily range of temperature.
- Dust bowl: During the 1930's, severe drought occurred in southwestern Great Plains of the United States. These are described as the dust bowl.
- Greenhouse: 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.
- Sunspots: Sunspots are dark and cooler patches on the sun which increase and decrease in a cyclical manner.

Chapter 13- Water (Oceans)

It is said that water is life. Water is an essential component of all life forms that exist over the surface of the earth.

Water is a cyclical resource. It can be used and reused in the form of a cycle. Water keeps on moving from the ocean to land and land to ocean.

The hydro logical 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.

The distribution of water on earth is quite uneven. Many locations have plenty of water while others have very limited quantity.

Table 1: Water on the Earth's surface

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

The hydro logical cycle, is the circulation of water within the earth's hydrosphere in different forms i.e, the liquid, solid and the gaseous phases.

About 71 per cent of the planetary water is found in the oceans. The remaining is held as freshwater in glaciers and ice caps, 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.

The geographers have divided the oceanic part of the earth into five oceans, namely the Pacific, the Atlantic, the Indian, Southern ocean and the Arctic.

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.

The ocean floors can be divided into four major divisions:

- the Continental Shelf;
- the Continental Slope;
- the Deep Sea Plain;
- 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.

Table 2: Components and Processes of the Water Cycle

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

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 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 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.

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 6,000 m. These plains are covered with fine-grained sediments like clay and silt.

Oceanic Deeps or Trenches 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.

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, is an example.

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 CC per latitude.

The average salinity of the Indian Ocean is 35%. 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.

Table 3

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

The salinity fluctuates from 0 – 35%, seasonally. In hot and dry' regions, v'here evaporation is high, the salinity sometimes reaches to 70%. The salinity variation in the Pacific Ocean is mainly due to its shape and larger areal extent. Salinity decreases from 35% — 31% on the western parts of the northern hemisphere because of the influx of melted water from the Arctic region.

Important Terms:

- Continent 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.
- Thermocline: The boundary region, from where there is a rapid decrease of temperature, is called the thermocline.
- 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.
- 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.
- 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°.
- 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.
- Shelf break: The shelf typically ends at a very steep slope, called the shelf break.
- 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.

- Guyot: It is a flat topped seamount. It shows 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.
- Water cycle: All living organisms, the atmosphere and the lithosphere maintain between them a circulation of water in solid, liquid or gaseous form referred to as the water or hydro-logic cycle.
- 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.
- Salinity: 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.
- Halocline: It is a distinct zone where salinity increases sharply.

Chapter 14 -Movements of Ocean Water

The ocean water is dynamic. 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.

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 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 kilometers before rolling ashore, breaking and dissolving as surf. A wave's size and shape reveal its origin.

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 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).

The most common tidal pattern is semi-diurnal tide, featuring two high tides and two low tides each day. The successive high or low tides are approximately of the same height.

The height of rising water (high tide) varies appreciably depending upon the position of sun and moon with respect to the earth. 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.

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.

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.

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.

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.

Surface currents constitute about 10 per cent of all the water in the ocean, these waters are the upper 400 m of the ocean and 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.

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 blowring on the surface of the ocean pushes the water to move.

Ocean currents are classified into cold currents and warm currents on the basis of temperature. 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.

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.

Important Terms:

- Waves: Waves are actually the energy, not the water as such, which moves across the ocean surface.
- 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.
- Surges: Movement of water caused by meteorological effects (winds and atmospheric pressure changes) are called surges.

- Tide generating force: The 'tide-generating' force is the difference between two forces; i. e. the gravitational attraction of the moon and the centrifugal force.
- Tidal currents: When the tide is channelled between islands or into bays and estuaries they are called tidal currents.
- Ebb: The time between the high tide and low tide, when the water level is falling, is called the ebb.
- Flow or Flood: The time between the low tide and high tide, when the tide is rising, is called the flow or flood.
- Crest: The highest point of a wave is called the crest
- Trough: The lowest point of a wave is called trough.
- 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.
- 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.

- 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.
- Perigee: The time when the moon's orbit is closest to the earth is called perigee.
- Apogee: The time when the moon is farthest from earth is called apogee.
- Perihelion: When the earth is closest to the sun.
- Aphelion: When the earth is farthest from the sun
- Gyres: 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.

Chapter 15- Life on the Earth

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.

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

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.

A German zoologist Ernst Haeckel, who used the term as 'oekologie' in 1869, became the first person to use the term 'ecology'. The study of interactions between life forms (biotic) and the physical environment (abiotic) is the science of ecology. Hence, ecology can be defined as a scientific study of the interactions of organisms with their physical environment and with each other.

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.

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 micro-organisms.

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 are five major biomes — forest, desert, grassland, aquatic and altitudinal biomes.

The sun is the basic source of energy on which ail life depends. This energy' initiates life processes in the biosphere through photosynthesis, the main source of food and energy for green plants.

During photosynthesis, carbon dioxide is converted into organic compounds and oxygen. Out of the total solar insolation that reaches the earth's surface, only a very small fraction (0.1 per cent) is fixed in photosynthesis. More than half is used for plant respiration and the remaining part is temporarily stored or is shifted to other portions of the plant.

Oxygen is the main by-product of photosynthesis. 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.

Other than carbon, oxygen, nitrogen and hydrogen being the principal geochemical components of the biosphere, many other minerals 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.

Important Terms:

- Biosphere: The biosphere includes all the living components of the earth. It consists of all plants and animals, including all the micro-organisms that live on the planet earth and their interactions with the surrounding environment.
- Environment: The environment is made up of abiotic and biotic components.
- Ecology: 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.

- Ecological systems: 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.
- Habitat: A habitat in the ecological sense is the totality of the physical and chemical factors that constitute the general environment.
- Ecosystem: A system consisting of biotic and abiotic components is known as ecosystem.
- Ecological adaptation: 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.
- Abiotic factors: Abiotic factors include rainfall, temperature, sunlight, atmospheric humidity, soil conditions, inorganic substances (carbon dioxide, water, nitrogen, calcium, phosphorus, potassium, etc.).
- Biotic factors: Biotic factors include the producers, the consumers (primary, secondary, tertiary) and the decomposers.
- Producers: The producers include all the green plants, which manufacture their own food through photosynthesis.
- Primary consumers: The primary consumers include herbivorous animals like deer, goats, mice and all plant-eating animals.
- Carnivores: 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: 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 micro- organisms.
- Biome: 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.

- Food Chain: This sequence of eating and being eaten and the resultant transfer of energy from one level to another is known as the food-chain.
- Flow of energy: Transfer of energy that occurs during the process of a food chain from one level to another is known as flow of energy.
- Food web: The food- chains get interlocked with one another. This inter-connecting network of species is known as food web.
- Water cycle: All living organisms, the atmosphere and the lithosphere maintain between them a circulation of water in solid, liquid or gaseous form. This is known as the water or hydrologic cycle.
- 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.
- Denitrification: 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.
- Biogeochemical cycle: Bio refers to living organisms and geo to rocks, soil, air and water of the earth. These cyclic movements of chemical elements of the biosphere between the organism and the environment are referred to as biogeochemical cycles.
- 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.
- Succession: 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.

Chapter 16- Biodiversity and Conversation

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.

Genes are the basic building blocks of various life forms. The diversity in gene in a species is called genetic biodiversity.

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.

Genetic diversity has given a great contribution in development of human culture. In a similar way human species has also contributed in maintaining natural diversity at genetic, species and ecosystem level.

Different species of ecosystem are busy in one activity or the other. Without activities they can neither survive nor develop.

Ecosystem evolves and sustains without any reason. That means, every organism, besides extracting its needs, also contributes something of useful to other organisms.

Ecological 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. 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 is likely to be.

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.

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.

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. Over-exploitation 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 to the biodiversity of respective affected regions. Pesticides and other pollutants such as hydrocarbons and toxic heavy metals destroy the weak and sensitive species.

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: (a) Endangered species (b) Vulnerable species and (c) Rare species.

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.

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.

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 centers. 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 centers are located.

Hotpots are defined according to their vegetation. Plants are important because these determine the primary productivity of an ecosystem. Most, but not all, of the hotpots rely on species-rich ecosystems for food, firewood, cropland, and income from timber. In Madagascar, for example, about 85 per cent of the plants and animals are found nowhere else in the world. Other hotspots in wealthy countries are facing different types of dangers.

Important Terms:

- Biodiversity: Biodiversity 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.
- Species: Groups of individual organisms having certain similarities in their physical characteristics are called species.
- Genetic biodiversity: Genetic biodiversity refers to the variation of genes within species.
- Species diversity: Species diversity 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.
- Ecosystem diversity: The broad differences between ecosystem types and the diversity of habitats and ecological processes occurring within each ecosystem type constitute the ecosystem diversity.
- Hotspots: Some areas are richer in species than others. Areas rich in species diversity are called hotspots of diversity.
- Exotic species: Species which are not the natural inhabitants of the local habitat but are introduced into the system, are called exotic species.
- Sensitive species: Pesticides and other pollutants such as hydrocarbons and toxic heavy metals destroy the weak species. These are called sensitive species.
- Mega diversity centre: 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.

- IUCN: The International Union of Conservation of Nature and Natural Resources is an international organization which published information about species under the red list.
- Endangered species: Endangered species 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: Vulnerable species includes the species which are likely to be in danger o'f 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: Rare species are those species whose population is very small in the world and they are confined to limited areas or thinly scattered over a wider area.

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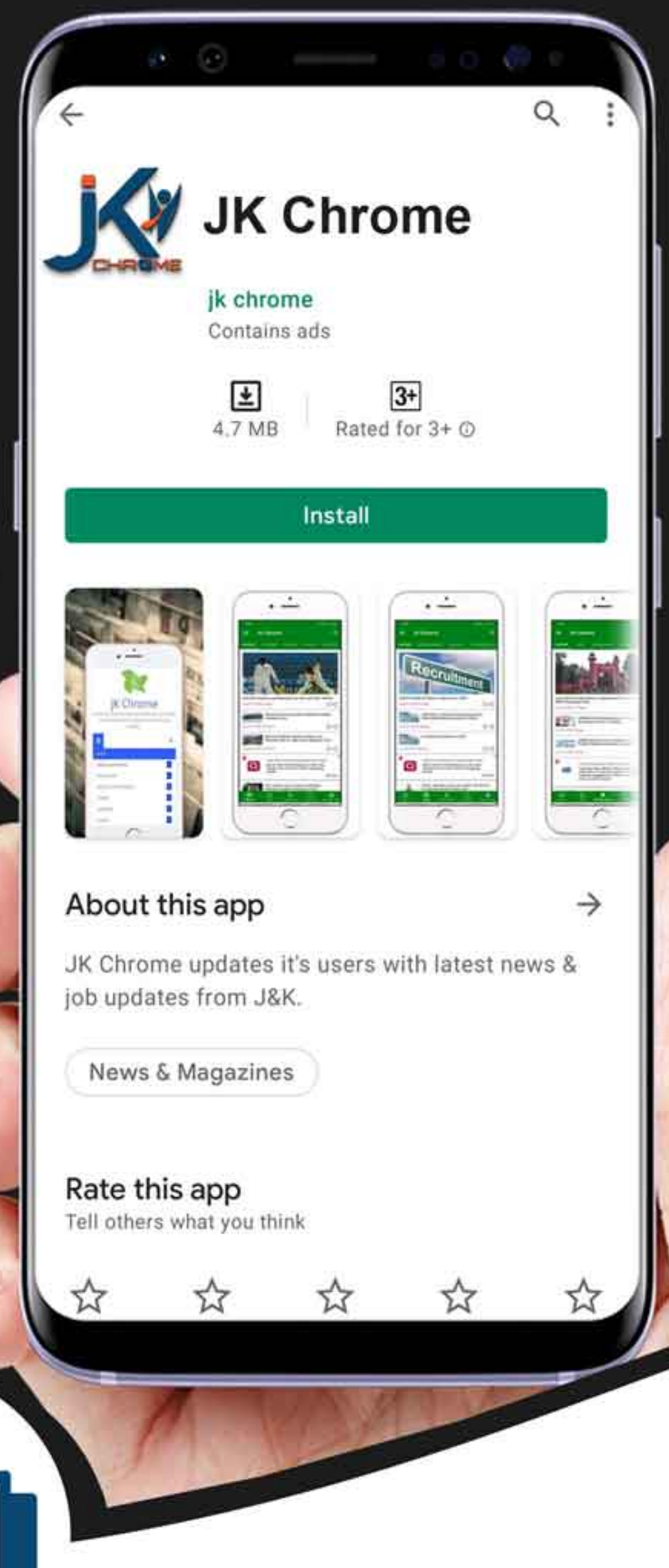

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